# 1NC R4 Harvard

## 1

#### Interp: If the affirmative defends anything other than “Resolved: The appropriation of outer space by private entities is unjust.” then they must provide a counter-solvency advocate for their specific advocacy in the 1AC. (To clarify, you must have an author that states we should not do your aff, insofar as the aff is not a whole res phil aff)

#### Violation

#### Prefer

#### 1. Limits – there are infinite things you could defend outside the exact text of the resolution which pushes you to the limits of contestable arguments, even if your interp of the topic is better, the only way to verify if it’s substantively fair is proof of counter-arguments. Nobody knows your aff better than you, so if you can’t find an answer, I can’t be expected to. Our interp narrows out trivially true advocacies since counter-solvency advocates ensure equal division of ground for both sides.

#### 2. Research – Forces the aff to go to the other side of the library and contest their own view points, as well as encouraging in depth-research about their own position. Having one also encourages more in-depth answers since I can find responses. Key to education since we definitionally learn more about positions when we contest our own.

## 2

#### Interp: Debaters must have recordings of their speeches and send them if requested

#### Violation: They didn't record, that was cx

#### A] Cheating – debaters can fake internet drop offs and then steal prep which decks reciprocity. O/Ws since it destroys competitive incentives and educational value since they are structurally ahead

#### B] Accidents possible, external conditions like power going out, wifi dropping off, or excessive background noise make it impossible to hear in real time, recordings ensure that a speech isn’t given twice, which allows them to remodify and change their strat or incite judge intervention which is the worst violation of procedural fairness

#### C] Key to check clipping cards and make cheaters lose with literal proof

#### No regress, its disclosed on my wiki

#### D] Novice accessibility – send recordings to novices to learn technical debate, that outweighs, accessibility is an impact filter to all arguments

Graphical user interface, application

Description automatically generated with medium confidence

#### Education is a voter since it is the only portable and durable skill that influences our subject formation. Fairness is a voter since a] debate is a game, competition equity matters proven by desire for wins, b] is worthless without rules and equal access.

#### Drop the debater – a] deters future abuse through a loss and b] set better norms for debate since you are less likely to repeat a practice you can lose for

#### Competing interps – [a] reasonability is arbitrary and encourages judge intervention since there’s no clear model of debate, [b] it creates a race to the top where we create the best possible norms for debate through offense [c] offense defense paradigm is the best method for evaluation since you can compare benefits under both interps easier.

#### No RVIs – a] illogical, you don’t win for proving that you meet the burden of being fair, if logic isn’t true then you should hack against them, b] RVIs incentivize baiting theory and prepping it out which leads to maximally abusive practices

## 3

#### Japan’s space industry is driven by private actors.

Jaxa 18 2-8-2018 "Focal Point on commercial space exploration in Japan" https://media.nature.com/full/nature-cms/uploads/ckeditor/attachments/8865/00\_Editorial\_UK.pdf (Japan Aerospace Exploration Agency is the Japanese national aerospace and space agency. Through the merger of three previously independent organizations, JAXA was formed on 1 October 2003.)//Elmer

“The world’s space industry is in the throes of a major transformation,” says Masayasu Ishida. An energetic Tokyoite, Ishida is a principal at the management consulting firm A.T. Kearney and co-founder and president of the Spacetide Foundation, an organization dedicated to promoting space businesses globally. Historically, space has been the exclusive domain of government and multinational projects, but increasingly private enterprises are venturing above in a movement dubbed ‘new space’. Entrepreneurs such as Jeff Bezos, Elon Musk and Richard Branson have captured the headlines, but this movement is not restricted to famous entrepreneurs or huge corporations. Increasingly, small to medium-sized businesses are becoming involved. Ishida, who has written a book on promoting the space industry to the private sector, is excited about Japan’s involvement in new space. “I think Japan has the potential to be one of the world’s new-space industry hubs,” he says. “Future space exploration needs innovative technologies like robotics, artificial intelligence, advanced communication, and new materials, which will be brought by non-space industries,” he explains. “Japan is home to many of the world’s leading industries, and has a variety of technological assets. Their involvement could be of help in the global space exploration effort.” Yasuhiro Yukimatsu, deputy director-general of the National Space Policy Secretariat, Cabinet Office, notes that Japanese companies and universities have developed micro-, nano- and even pico-satellite technology, which allows countries that have yet to join the space community affordable access to space. Ishida concurs: “Japanese space-related business players have unique technologies and are working on projects such as small launchers, space debris removal, and space resource mining.” JAPAN IN SPACE Japan has a proud history of ‘old space’ government-funded exploration. It was the fourth country to venture into space, and the third one to send spacecraft to both Mars and the Moon. It has the distinction of being the only country to have brought a sample back from an extraterrestrial body besides the Moon, when Hayabusa landed in the Australian outback in 2010 with a sample collected from the surface a deep-space asteroid. But times are changing. “For the industry to realize sustainable growth, a shift from the government to the private sector is urgently needed,” says Masanori Tsuruda from the Ministry of Economy, Trade and Industry (METI). This shift is driven in part by shrinking government budgets for big projects as well as the many emerging possibilities for enterprises to profit from space.

#### Japan space commitment re-vitalizes and modernizes the US-Japan Alliance.

Wright 20 John Wright 2-4-2020 "Where No Alliance Has Gone Before: US-Japan Military Cooperation in Space" <https://thediplomat.com/2020/02/where-no-alliance-has-gone-before-us-japan-military-cooperation-in-space/> (Major John Wright is a U.S. Air Force officer, pilot, and a Mike and Maureen Mansfield Fellow. He is a Foreign Area Officer who specializes in Japan, and recent author of the book “Deep Space Warfare: Military Strategy Beyond Orbit.” The views expressed in this article are solely those of the author, and not necessarily those of the U.S. Air Force, U.S. Government, Mansfield Foundation, or any other government or government entity.)//Elmer

With the United States’ December 21, 2019 creation of a separate and sovereign branch of its military completely devoted to space, the U.S. Space Force, the global race to emancipate a portion of national military power from terrestrial shackles and place it firmly into orbit is on. The announcement also unleashed a somewhat unexpected cascading effect: the increased attention paid to military space activities by U.S. allies and partners, who have no choice but to follow where the U.S. military moves its gravitational pull. In particular, Japan has made announcements in recent days that indicate its intention to remain in lockstep with the United States, at least in terms of defense. On January 5, 2020, scarcely two weeks following the U.S. Space Force announcement, the Japanese government indicated it plans to rename the Japan Air Self Defense Force to the Japan Aerospace Defense Force. Not coincidentally, on January 21, during a speech given on the occasion of the 60th anniversary of the U.S.-Japan Alliance, Prime Minister Shinzo Abe vowed to make the alliance “a pillar for safeguarding peace and security in both outer space and cyberspace.” While words are good, actions are better. In a less-noticed but more consequential move, the Ministry of Defense is finalizing a bill to be placed before the Diet that asks to craft a space operations-exclusive military unit staffed with 20 personnel. While this paltry number of people can barely be expected to efficiently run their task of monitoring space debris and “suspicious satellites,” the move is a significant step for a nation that often struggles with global defense developments due to Japan’s unique domestic restrictions and legal concerns. In many ways, it is surprising to see Japan, a nation that still sorties 1960s-era F-4 aircraft (though there are plans to replace them with F-35s), and is fielding their very first military Remote Piloted Aircraft (a model the United States has been flying for nearly 20 years) in 2021, take its defense posture in space seriously. These initiatives have several implications. First, the Japanese government’s attitude toward space and its place in the U.S.-Japan alliance reflects what’s at stake during the next major conflict, which will surely involve space. As an increasing number of government and commercial systems depend on space assets and space support, space can no longer be ignored as a future theater; the time is now to incorporate space into alliance strategy. This strategy, however, needs to catch up. Currently, Japan refers to space as a “new domain” in the 2018 National Defense Program Guidelines and briefly discusses space defense in the annual 2019 Defense of Japan white paper. Space is completely left out of the now-outdated 2015 Guidelines for U.S.- Japan Defense Cooperation. Enjoying this article? Click here to subscribe for full access. Just $5 a month. Second, Japan’s emphasis is a good move for the alliance as a whole, and enhances its survivability. If Japan takes measurable steps to join its ally and if Japan meaningfully contributes to space security, space is less likely to become another seam where the alliance could come undone. Further, there is a strategic advantage to taking a stance on both position and form when it comes to space. While other nations will struggle to “get serious” about space, and will need to decide between size, scope, and capability of their forces, Japan has confirmed its political and defensive outlook toward space, which means it has also acknowledged space’s effect on combined alliance defense. This is good, since the political dangers posed in space are very real. Despite the existence of the well-intentioned but toothless Outer Space Treaty of 1967, which prohibits use of force activities in space, the obvious future is that space will act as yet another stage upon which the political games of earthbound nation-states will play out. Nation-state competition will not disappear as states found and fund forces to travel, explore, and exploit the inky blackness of space; rather, competition will intensify, as discoveries with both economic and defense applications are made, and as states better understand how vulnerable they are without proper space defense and deterrence. This is the political reality of space, and the fact that both members of the U.S.-Japan alliance understand this means the alliance has much less danger of breaking apart upon first contact with space-centric competition. If anything, mutual interest in the same environment will lead to cooperative efforts and a strengthened alliance here on Earth. Notably, the odds of military confrontation in space have also increased. By funneling U.S. military space power into the highest echelon of military independence and funding (an independent service), escalation and competition is not far behind. It will not be surprising if we see several other competitors forming their own service-level forces by year’s end, though their actual forms will likely vary greatly. The fact that the United States has “jumped” to a service-sized solution to military space competition, and not a smaller organization like a corps or geographic command, means other nations have no real strategic options but to match the U.S. precedent as close as they can in size and capability. The U.S.-Japan alliance must prepare for this eventuality. Japanese government decisions to strengthen its space defense capabilities thus come from a mix of terrestrial strategy, political realities, and prudent alliance management. However, significant challenges remain. For one thing, today’s nation-states (including the United States) are understandably gun-shy about sharing space defense capabilities and space-centric technology, which means alliance military space activity will naturally move at the speed of the slowest member. For another, we do not yet know just what space-on-space conflict will look like between combatants who possess similar space-based strength, which makes warfare difficult to plan for and will present an immediate challenge to alliance coordination should such a conflict occur. Despite these doubts, recent Japanese government announces are positive and will help usher both the alliance and U.S.-Japan relations through its current comparatively rocky period of trade spats and quibbles over military basing. Without a doubt, the political impact of allied space defense could easily result in the U.S.-Japan alliance extending its prerogatives beyond Earth’s territorial confines.

#### Strong US-Japan alliance prevents a range of existential threats.

Hamre 16 John Hamre, President and CEO of the Center for Strategic and International Studies, Former Under Secretary of Defense, and Richard Armitage, President of Armitage International, Former U.S. Deputy Secretary of State, co-chairs of the U.S.-Japan Commission on the Future of the Alliance, et al., “The U.S.-Japan Alliance to 2030: Power and Principle”, Report of the Commission on the Future of the Alliance, 2/29/2016, p. 1-5

The U.S.-Japan Alliance has helped to provide security and prosperity to the Asia-Pacific region and the broader international community for more than half a century. The Alliance enabled the United States and Japan to prevail in the Cold War, based on the principles of deterrence, democratic values, and free market dynamism. Today, the U.S.-Japan Alliance is as strong as it has been at any time during its existence. The Commission believes the Alliance will need all of its current strength and more, since the international security environment over the next 15 years will be as challenging and uncertain as any the United States and Japan have faced. In addition to challenges from a rising China and aggrieved Russia, the United States and Japan both have vital interests in the Middle East, which is an increasingly unstable and violent region. Global challenges such as terrorism, nuclear proliferation, and climate change will also require wise policy and firm action. One central characteristic of this emerging strategic dynamic will be intensified competition for power and influence across ideological, economic, and security spheres between liberal democracies on the one hand and ambitious or aggrieved authoritarian regimes on the other. The Commission believes that this competition need not—and in fact is unlikely to—result in war. Moreover, there are many areas in which countries from across the ideological spectrum can and will increase mutual cooperation, including macroeconomic coordination, countering violent Islamic extremism, responding to climate change, and reversing nuclear proliferation by states such as North Korea. Nevertheless, there remain fundamental questions about international norms where leading democracies like the United States and Japan will hold starkly different views from more authoritarian states. These include: the rights of citizens to choose their own governments; the rights of minorities within nations; the independent role of the judiciary and the press; the role of the private sector in the economy; freedom of navigation and flight in international sea and air space; and freedom of the Internet. In Asia, the United States and Japan will have to shape the strategic environment by encouraging responsible Chinese behavior and imposing costs for destabilizing activities. To that end, the United States and Japan will have to build up their own power, and use it wisely and firmly, to preserve a world order that favors both allies’ shared values. The United States and Japan have taken a number of very important actions in the recent past to strengthen the Alliance. These include Japan’s issuance of its first national security strategy, establishment of a National Security Council (NSC) and an associated permanent staff organization, increases in the defense budget, and passage of security legislation authorizing closer cooperation with the United States. The United States has stated an intention to rebalance U.S. strategic attention and military forces towards the Asia-Pacific region. Both countries have concluded updated bilateral Defense Guidelines for closer security cooperation and have reached an agreement for wider and deeper economic cooperation through the Trans-Pacific Partnership (TPP). These achievements provide a solid foundation for the continued actions that the Commission recommends in this report. The United States and Japan have unmatched strengths for the competitive environment they will face. Together the two allies account for 28 percent of the world’s gross domestic product (GDP) and 43 percent of the world’s wealth. The economies of both countries use and produce the highest levels of technology, and have the research and development systems to stay at the cutting edge of discovery and innovation. Their citizenries are well educated, hardworking, and innovative. Their armed forces are among the world’s most advanced and are well led and trained. Their values of freedom and democracy have a universal appeal that has been repeatedly demonstrated in all parts of the world and particularly in Asia. The U.S.-Japan Alliance has endured for 60 years and adapted to meet an array of new internal and external challenges. The Commission believes that the United States and Japan must develop a shared vision of the world both nations seek in the next 15 years. Democracies need a vision to inspire their own citizens and to synchronize the efforts of their governments and private organizations. As partners in an increasingly interconnected and competitive world, the United States and Japan must also offer a vision that will gain the support of other countries. The Commission proposes the following vision for the U.S.-Japan Alliance: The United States and Japan seek a world in 2030 in which all nations are secure, peaceful, prosperous, and free. Working to build this world, the United States and Japan will make national contributions that reflect each nation’s respective capabilities, legal obligations, and traditions, but will always remain united on shared goals. The United States and Japan are global powers with global responsibilities, but their Alliance will continue to focus as it always has on the peace and prosperity of the Asia-Pacific region. Peace and Security: The United States and Japan will work together to:  preserve peace and stability in the Asia-Pacific region based on the Mutual Security Treaty through bilateral efforts to maintain a favorable balance of power and to deter and, if necessary, to defeat armed aggression and attempts at coercion against their own interests, and those of their allies and friends;  defend and preserve the existing order based on established international rules and norms;  seek peaceful, negotiated resolution of issues between nations, free from military force or coercion;  support multilateral organizations in developing solutions to global challenges; and  lead and participate in international actions against state and non-state actors that use terrorist tactics and criminal actions or otherwise threaten the safety of their citizens and those of their allies and friends. Prosperity: The United States and Japan will work together to:  support the unimpeded international flow of investment, goods, and services to raise the prosperity of all nations, especially those at lower levels of development;  provide assistance both through international organizations and directly to developing nations to improve all the aspects of economic development and governance, private sector competence, and human capacity, including women’s empowerment;  strengthen existing institutions such as the World Bank and International Monetary Fund that provide development assistance and seek to promote principles of good governance; and  play leading roles in reducing environmental threats to the health, and potentially the safety, of their own citizens and others around the world. Freedom: The United States and Japan will work together to:  support advancement of the principles expressed in the United Nations (UN) Universal Declaration of Human Rights;  ensure the observance of these principles in their own countries;  speak out and take clear public stands in the support of those principles; and  work over the long term, and when opportunities arise in the short term, to advance those principles in authoritarian countries as well as failing states. In this report, the Commission recommends a set of coordinated policies that will move the Alliance closer to achieving its shared vision of a peaceful, secure, prosperous, and free world. As major economic powers and democracies, Japan and the United States should continuously stress two foundational pillars of the Alliance. First, leaders and opinion makers in the United States and Japan need to strengthen and sustain public support in both countries for active international leadership, using the full range of foreign policy tools, including military capabilities when necessary. In the United States, the wars in Iraq and Afghanistan have caused debates in both the Republican and Democratic parties about the utility of force, particularly with respect to the Middle East. In Japan, although security legislation was enacted in 2015 to allow the exercise of the right to collective self-defense, there is persistent and substantial opposition to a more active security role for the military, and misgivings about the use of military force—even for purely defensive purposes. The Commission recognizes that military power cannot be the sole or even the primary instrument of national security policy. However, the potential employment of military force is often necessary to support diplomacy, deter aggression, and keep the peace; and the utilization of the armed forces, whether in the form of advisers, peacekeepers, or combat units, will remain essential to deal with some threats to peace and security in the future. The United States and Japan must have fully-funded, modern, and highly capable military forces, and they must be willing to employ them in support of the peaceful, secure, prosperous, and free world that they seek. Leaders in both countries have a responsibility to explain these realities to their publics. Second, in order to provide the foundation for the policies outlined in this report, both countries need to take action to support their economies, to resume economic growth in the case of Japan, and to sustain recovery from the recession of 2008 in the case of the United States. Without higher rates of economic growth, the United States and Japan will face significantly greater difficulties managing the international challenges that are likely to emerge over the coming 15 years. Both countries have the fiscal and monetary policy tools necessary to stimulate growth, but both must also undertake structural changes that require continued political attention. In the case of Japan these include: growing the workforce in the face of a falling national birth rate; increasing productivity through more widespread adoption of information technology; and reversing the growth of the highest debt levels of any advanced country. In the case of the United States these include: modernizing the country’s aging physical and cyber infrastructure; containing the costs of medical care and social security payments for the large generation now retiring; and providing real energy security by coupling the increased production of domestic oil and gas with reduced dependence of the transportation sector on oil. Both countries must also improve their educational systems to create the digital workforce of the future. II. The Strategic Environment through 2030 For the first time in nearly a quarter century, the world is witnessing multiple momentous challenges to the international order. China’s emergence, Russia’s resurgence, and the Islamic State of Iraq and the Levant’s (ISIL’s) barbarity are forcing the United States and Japan to address simultaneous, diverse threats to the international order. Within Asia, increasing prosperity and economic interdependence coincide with intensifying friction among the major powers. Changes in relative power, rapid expansion in the military budgets of some states, territorial disputes, historical animosities, irregular threats, and nuclear proliferation all present serious risks to regional security. Managing these challenges will require an understanding of how long-term trends, such as demographics, technology, and climate change, are likely to affect the strategic environment. Asia is the world’s most dynamic region, so understanding current trends and potential future discontinuities is essential if the United States and Japan are to adopt an overall strategy that is capable of adapting effectively to rapid shifts in the security environment. While regional trends in the Asia-Pacific region favor continued growth and economic integration, there are pockets of uncertainty that could threaten both economic progress and political stability. These include: obstacles to China’s economic transition from its past export-led growth model to a domestically driven model; the shrinking working age population in Japan, South Korea, China, Taiwan, and Singapore; and the over-reliance of countries such as Taiwan, South Korea, Malaysia, Thailand, and Australia on Chinese momentum to drive their own growth. Economic growth and integration in Asia have been driven by intra-regional trade as well as global investment flows and production networks, underpinned by the international financial institutions established at Bretton Woods and sustained since then with the active support of Japan and the United States. However, as the international economy has diversified, the original managers of global financial governance, such as the G-7, have lost ground to more inclusive but less effective groupings, such as the G-20. Moreover, progress on global trade liberalization at the World Trade Organization (WTO) has stalled. China is challenging the existing international financial institutions with the Asian Infrastructure Investment Bank (AIIB) and its new “One Belt, One Road” initiatives. At the same time, the Trans-Pacific Partnership (TPP), led by the United States and Japan, has the potential to reboot international trade liberalization and governance. Passage of TPP in Japan, the United States, and the ten other participating countries would boost economic growth in Asia by reducing barriers, establishing standards for ensuring protection of intellectual property in new areas such as e-commerce, empowering China’s economic reformers as Beijing is drawn by preferential tariffs to join TPP, animating negotiations on the Transatlantic Trade and Investment Partnership (TTIP), and perhaps eventually helping to revitalize the pursuit of global free trade agreements through the WTO. Governance of global trade and finance is in flux, but the forces of liberalization and integration are still present. Beyond these economic concerns the dangers of climate change and ecological degradation threaten the region. The ability of the major Asia-Pacific economies to cooperate in the face of all these transnational challenges will have important implications for the future strategic environment. While China and the United States are the world’s leading emitters of greenhouse gases (in that order), Japan is the world’s superpower in clean technology and energy efficiency. There are encouraging signs of U.S. and Chinese initiatives to curb greenhouse gas emissions as well as the recent agreement at the 2015 Paris Climate Conference, but these promises remain aspirational and unenforceable, requiring further efforts at bilateral, regional, and global cooperation to reduce carbon emissions.

## 4

#### Text – States ought to ratify the moon treaty except for privately built Space Elevators

#### Space Elevators constitute Appropriation – they impede orbits.

Matignon 19 Louis de Gouyon Matignon 3-3-2019 "LEGAL ASPECTS OF THE SPACE ELEVATOR TRANSPORTATION SYSTEM" <https://www.spacelegalissues.com/space-law-legal-aspects-of-the-space-elevator-transportation-system/> [PhD in space law (co-supervised by both Philippe Delebecque, from Université Paris 1 Panthéon-Sorbonne, France, and Christopher D. Johnson, from Georgetown University || regularly write articles on the website Space Legal Issues so as to popularise space law and public international law]//Elmer

An Earth-based space elevator would consist of a cable with one end attached to the surface near the equator and the other end in space beyond geostationary orbit. An orbit is the curved path through which objects in space move around a planet or a star. The 1967 Treaty’s regime and customary law enshrine the principle of non-appropriation and freedom of access to orbital positions. Space Law and International Telecommunication Laws combined to protect this use against any interference. The majority of space-launched objects are satellites that are launched in Earth’s orbit (a very small part of space objects – scientific objects for space exploration – are launched into outer space beyond terrestrial orbits). It is important to precise that an orbit does not exist: satellites describe orbits by obeying the general laws of universal attraction. Depending on the launching techniques and parameters, the orbital trajectory of a satellite may vary. Sun-synchronous satellites fly over a given location constantly at the same time in local civil time: they are used for remote sensing, meteorology or the study of the atmosphere. Geostationary satellites are placed in a very high orbit; they give an impression of immobility because they remain permanently at the same vertical point of a terrestrial point (they are mainly used for telecommunications and television broadcasting). A geocentric orbit or Earth orbit involves any object orbiting Planet Earth, such as the Moon or artificial satellites. Geocentric (having the Earth as its centre) orbits are organised as follow: 1) Low Earth orbit (LEO): geocentric orbits with altitudes (the height of an object above the average surface of the Earth’s oceans) from 100 to 2 000 kilometres. Satellites in LEO have a small momentary field of view, only able to observe and communicate with a fraction of the Earth at a time, meaning a network or constellation of satellites is required in order to provide continuous coverage. Satellites in lower regions of LEO also suffer from fast orbital decay (in orbital mechanics, decay is a gradual decrease of the distance between two orbiting bodies at their closest approach, the periapsis, over many orbital periods), requiring either periodic reboosting to maintain a stable orbit, or launching replacement satellites when old ones re-enter. 2) Medium Earth orbit (MEO), also known as an intermediate circular orbit: geocentric orbits ranging in altitude from 2 000 kilometres to just below geosynchronous orbit at 35 786 kilometres. The most common use for satellites in this region is for navigation, communication, and geodetic/space environment science. The most common altitude is approximately 20 000 kilometres which yields an orbital period of twelve hours. 3) Geosynchronous orbit (GSO) and geostationary orbit (GEO) are orbits around Earth at an altitude of 35 786 kilometres matching Earth’s sidereal rotation period. All geosynchronous and geostationary orbits have a semi-major axis of 42 164 kilometres. A geostationary orbit stays exactly above the equator, whereas a geosynchronous orbit may swing north and south to cover more of the Earth’s surface. Communications satellites and weather satellites are often placed in geostationary orbits, so that the satellite antennae (located on Earth) that communicate with them do not have to rotate to track them, but can be pointed permanently at the position in the sky where the satellites are located. 4) High Earth orbit: geocentric orbits above the altitude of 35 786 kilometres. The competing forces of gravity, which is stronger at the lower end, and the outward/upward centrifugal force, which is stronger at the upper end, would result in the cable being held up, under tension, and stationary over a single position on Earth. With the tether deployed, climbers could repeatedly climb the tether to space by mechanical means, releasing their cargo to orbit. Climbers could also descend the tether to return cargo to the surface from orbit.

#### Private Companies are pursuing Space Elevators.

Alfano 15 Andrea Alfano 8-18-2015 “All Of These Companies Are Working On A Space Elevator” <https://www.techtimes.com/articles/77612/20150818/companies-working-space-elevator.htm> (Writer at the Tech Times)//Elmer

Space elevators are solid proof that any mundane object sounds way cooler if you stick the word "space" in front of it. But there's much more than coolness at stake when building a space elevator – this technology has the potential to revolutionize space transportation, and the Canadian private space company Thoth Technology that was recently awarded a patent for its space elevator design isn't the only company in the game. One of the other major players is a U.S.-based company called LiftPort Group, founded by space entrepreneur Michael Laine in 2003. Its plan for a space elevator is vastly different from the one for which Thoth received a patent, however. Whereas Thoth's plans entail tethering a 12-mile-high inflatable space elevator to the Earth, LiftPort is shooting for the moon. Originally, LiftPort had planned to build an Earth elevator, too, but it abandoned the idea in 2007 in favor of building a lunar elevator. The basic design for a lunar elevator is an anchor in the moon that is attached to a cable that extends to a space station situated at a very special point. Known as a Lagrange Point, this is the gravitational tipping point between the Earth and the moon, where their gravitational pulls essentially cancel one another out. A robot could then travel up and down the tether, ferrying cargo between the moon and the station. Out farther in space, a counterweight would balance out the system. Both types of space elevator are intended to increase space access, but in very different ways. Thoth's Earth elevator aims to make launches easier by starting off 12 miles above the Earth's surface. LiftPort's space elevator aims to increase access to the moon in particular, because it is much easier to launch a rocket to the Lagrange Point and dock it at a space station than it is to get to the moon directly. There's a third major company based in Japan called Obayashi Corp. whose plans look like a hybrid of Thoth's and LiftPort's. Obayashi is not a space company, however – it's actually a construction company. Like Thoth, Obayashi plans to build an Earth elevator. But its Earth elevator would consist of a cable tethered to the blue planet, a robotic cargo-carrier, a space station, and a counterweight. It essentially looks like LiftPort's plans, but stuck to the Earth instead of to the moon.

#### They’re feasible.

Smith 17 Vincent Smith 6-21-2017 "3 Challenges for Engineering A Space Elevator" <https://www.engineering.com/story/3-challenges-for-engineering-a-space-elevator> (Engineer)//Elmer

There's a lot of junk orbiting Earth. Thousands of hours have been poured into previous NASA missions, ensuring the least possible contamination by even the tiniest motes of dust and dirt. The kinds of instrumentation that would monitor a space elevator would need to be similarly discerning. However, the fact that it would be a permanent fixture means that sooner or later, a space elevator would cross paths with meteors and even remnants of previous space missions left behind as space debris. The extreme of this phenomenon even has a name: Kessler Syndrome, where the density of low earth debris becomes so large that nothing can pass it safely into outer space. This cascading problem of space debris collisions was featured in the film Gravity. As Bullock and Clooney can tell you, this phenomenon could cause catastrophic damage to the overall structure (or knock it off balance, returning to our 'oscillation' concerns). Edwards recognized this, and devoted an entire section of his report to addressing it. According to the report, part of dealing with this obstacle is recognizing and tracking low-earth orbit objects large enough to do damage to the structure. According to Section 10.3 of the report, “A study was done at Johnson Space Center on the construction of a system that could track objects down to 1cm in size with 100m accuracy using effectively current technology. This is very close to the tracking network we would need for the space elevator.” For situations in which avoidance is not always possible (the amount of low-earth orbit debris increases significantly from altitudes of approximately 300 to 1,000 miles), Edwards posits that increasing the thickness of the cable will make it robust enough to withstand all but the largest of objects, which could be tracked and avoided ahead of time using the systems previously mentioned. Even for these exceptional pieces of debris, Edwards illustrates in a section simply labeled “Meteors” that only (i) direct impact by an object (ii) over 3cm in diameter, (iii) with enough force to stay on the initial plane of impact (as opposed to being deflected or redirected by contact with the elevator apparatus), would create the kind of catastrophic damage that we associate with a complete severing of the cable. Designing the cable with curvature and panels specifically for deflection has been proposed by both Edwards as well as several other survivability reports, including this one, put together for the 2010 International Space Elevator Consortium (ISEC). Definitive answers as to the effectiveness of these measures are hopefully forthcoming, but it's at least comforting to know that there are first, second, and third lines of defense prepared for just such occasions.

#### Regardless of completion, Elevators spur investment in Nanotechnology

Liam O’Brien 16. University of Wollongong. 07/2016. “Nanotechnology in Space.” Young Scientists Journal; Canterbury, no. 19, p. 22.

Nanotechnology is at the forefront of scientific development, continuing to astound and innovate. Likewise, the space industry is rapidly increasing in sophistication and competition, with companies such as SpaceX, Blue Origin and Virgin Galactic becoming increasingly prevalent in what could become a new commercial space race. The various space programs over the past 60 years have led to a multitude of beneficial impacts for everyday society. Nanotechnology, through research and development in space has the potential to do the same. Potential applications of nanotechnology in space are numerous, many of them have the potential to capture and inspire generations to come. One of these applications is the space elevator. By using carbon nanotubes, a super light yet strong material, this concept would be an actual physical structure from the surface of the Earth to an altitude of approximately 36 000 km. The tallest building in the world would fit into this elevator over 42 000 times. The counterweight, used to keep the elevator taught, is proposed to be an asteroid. This would need to be at a distance of 100 000 km, a quarter of the distance to the moon. The benefits of such a structure would be enormous. 95% of a space shuttle's weight at take-off is fuel, costing US$ 20 000 per kilogram to send something into space. However, with a space elevator the cost per kilogram can be reduced to as little as US$ 200. Exploration to other planets can begin at the tower, and travel to and from the moon could become as simple as a morning commute to work. Solar sails provide the means to travel large distances and incredible speeds. Much like sails on a boat use wind, the solar sail uses light as a source of propulsion. Ideally these sails would be kilometres in length and only a few micrometres in thickness. This provides us with the ability to travel at speeds previously unheard of. Using carbon nanotubes once again, a solar sail has the capability to travel at 39 756 km/s which is 13% of the speed of light! This sail could reach Pluto in an astonishing 1.7 days, and Alpha Centauri in just 32 years. Space travel to other planets, other stars, could be possible with solar sails. The Planetary Society is funding for a space sail of itself, and has successfully launched one into orbit. NASA has also sent a sail into orbit, allowing it to burn up in the atmosphere after 240 days. Investing time and resources into nanotechnology for space exploration has benefits for society today. Materials such as graphene are being used in modern manufacturing at an increasing rate as the applications become utilised. Carbon nanotubes will change the way we think about materials and their strength. These nanotubes have a tensile strength one hundred times that of steel, yet are only a sixth of the weight. Imagine light weight vehicles using less petrol and energy as well as being just as strong as regular vehicles. With potentials to revolutionize the way we think about space travel, nanotechnology has a bright future. As a new field of science, it has the capability to push the human race to the outer reaches of our galaxy and hopefully one day to other stars. It will inspire generations of explorers and dreamers to challenge themselves and advance the human race into the next era. As Richard Feynman said in his 1959 talk 'There's Plenty of Room at the Bottom' "A field in which little has been done, but in which an enormous amount can be done. There is still plenty more to achieve.

#### Nanomaterials solve Warming and Water Scarcity.

Khullar 17 Bhavya Khullar 9-4-2017 "Nanomaterials Could Combat Climate Change and Reduce Pollution" <https://www.scientificamerican.com/article/nanomaterials-could-combat-climate-change-and-reduce-pollution/> (Former Programme Officer with the Food Safety and Toxins Unit, Centre for Science and Environment (CSE))//Elmer

August 18, 2017 — The list of environmental problems that the world faces may be huge, but some strategies for solving them are remarkably small. First explored for applications in microscopy and computing, nanomaterials—materials made up of units that are each thousands of times smaller than the thickness of a human hair—are emerging as useful for tackling threats to our planet’s well-being. Scientists across the globe are developing nanomaterials that can efficiently use carbon dioxide from the air, capture toxic pollutants from water and degrade solid waste into useful products. “Nanomaterials could help us mitigate pollution. They are efficient catalysts and mostly recyclable. Now, they have to become economical for commercialization and better to replace present-day technologies completely,” says Arun Chattopadhyay, a member of the chemistry faculty at the Center for Nanotechnology, Indian Institute of Technology Guwahati. HARVESTING CO2 To help slow the climate-changing rise in atmospheric CO2levels, researchers have developed nanoCO2 harvesters that can suck atmospheric carbon dioxide and deploy it for industrial purposes. “Nanomaterials can convert carbon dioxide into useful products like alcohol. The materials could be simple chemical catalysts or photochemical in nature that work in the presence of sunlight,” says Chattopadhyay, who has been working with nanomaterials to tackle environmental pollutants for more than a decade. Many research groups are working to address a problem that, if solved, could be a holy grail in combating climate change: how to pull CO2 out of the atmosphere and convert it into useful products. Chattopadhyay isn’t alone. Many research groups are working to address a problem that, if solved, could be a holy grail in combating climate change: how to pull CO2 out of the atmosphere and convert it into useful products. Nanoparticles offer a promising approach to this because they have a large surface-area-to-volume ratio for interacting with CO2 and properties that allow them to facilitate the conversion of CO2into other things. The challenge is to make them economically viable. Researchers have tried everything from metallic to carbon-based nanoparticles to reduce the cost, but so far they haven’t become efficient enough for industrial-scale application. One of the most recent points of progress in this area is work by scientists at the CSIR-Indian Institute of Petroleum and the Lille University of Science and Technology in France. The researchers developed a nanoCO2 harvester that uses water and sunlight to convert atmospheric CO2 into methanol, which can be employed as an engine fuel, a solvent, an antifreeze agent and a diluent of ethanol. Made by wrapping a layer of modified graphene oxide around spheres of copper zinc oxide and magnetite, the material looks like a miniature golf ball, captures CO2 more efficiently than conventional catalysts and can be readily reused, according to Suman Jain, senior scientist of the Indian Institute of Petroleum, Dehradun in India, who developed the nanoCO2harvester. Jain says that the nanoCO2 harvester has a large molecular surface area and captures more CO2 than a conventional catalyst with similar surface area would, which makes the conversion more efficient. But due to their small size, the nanoparticles have a tendency to clump up, making them inactive with prolonged use. Jain adds that synthesizing useful nanoparticle-based materials is also challenging because it’s hard to make the particles a consistent size. Chattopadhyay says the efficiency of such materials can be improved further, providing hope for useful application in the future. CLEANSING WATER Most toxic dyes used in textile and leather industries can be captured with nanoparticles. “Water pollutants such as dyes from human-created waste like those from tanneries could get to natural sources of water like deep tube wells or groundwater if wastewater from these industries is left untreated,” says Chattopadhyay. “This problem is rather difficult to solve.” An international group of researchers led by professor Elzbieta Megiel of the University of Warsaw in Poland reports that nanomaterials have been widely studied for removing heavy metals and dyes from wastewater. According to the research team, adsorption processes using materials containing magnetic nanoparticles are highly effective and can be easily performed because such nanoparticles have a large number of sites on their surface that can capture pollutants and don’t readily degrade in water. Chattopadhyay adds that appropriately designed magnetic nanomaterials can be used to separate pollutants such as arsenic, lead, chromium and mercury from water. However, the nanotech-based approach has to be more efficient than conventional water purification technology to make it worthwhile. In addition to removing dyes and metals, nanomaterials can also be used to clean up oil spills. Researchers led by Pulickel Ajayan at Rice University in Houston, Texas, have developed a reusable nanosponge that can remove oil from contaminated seawater. The technology shows promise, but it’s not yet ready for prime time. “While the nanosponge is a good material to deal with oil spills, these results are confined to the laboratory,” says Ashok Ganguli, director of the Institute of Nano Science and Technology in Mohali, Punjab, India. “Large-scale synthesis is required if we have to remove oil from seawater which is spread over several miles.” Although scientists have yet to successfully synthesize nanomaterials for cleaning oil spills at a scale large enough for practical application, “this may become possible with more research and industry partnerships,” Chattopadhyay says.

#### Warming causes Extinction

Kareiva 18, Peter, and Valerie Carranza. "Existential risk due to ecosystem collapse: Nature strikes back." Futures 102 (2018): 39-50. (Ph.D. in ecology and applied mathematics from Cornell University, director of the Institute of the Environment and Sustainability at UCLA, Pritzker Distinguished Professor in Environment & Sustainability at UCLA)//Re-cut by Elmer

In summary, six of the nine proposed planetary boundaries (phosphorous, nitrogen, biodiversity, land use, atmospheric aerosol loading, and chemical pollution) are unlikely to be associated with existential risks. They all correspond to a degraded environment, but in our assessment do not represent existential risks. However, the three remaining boundaries (**climate change**, global **freshwater** cycle, **and** ocean **acidification**) do **pose existential risks**. This is **because of** intrinsic **positive feedback loops**, substantial lag times between system change and experiencing the consequences of that change, and the fact these different boundaries interact with one another in ways that yield surprises. In addition, climate, freshwater, and ocean acidification are all **directly connected to** the provision of **food and water**, and **shortages** of food and water can **create conflict** and social unrest. Climate change has a long history of disrupting civilizations and sometimes precipitating the collapse of cultures or mass emigrations (McMichael, 2017). For example, the 12th century drought in the North American Southwest is held responsible for the collapse of the Anasazi pueblo culture. More recently, the infamous potato famine of 1846–1849 and the large migration of Irish to the U.S. can be traced to a combination of factors, one of which was climate. Specifically, 1846 was an unusually warm and moist year in Ireland, providing the climatic conditions favorable to the fungus that caused the potato blight. As is so often the case, poor government had a role as well—as the British government forbade the import of grains from outside Britain (imports that could have helped to redress the ravaged potato yields). Climate change intersects with freshwater resources because it is expected to exacerbate drought and water scarcity, as well as flooding. Climate change can even impair water quality because it is associated with heavy rains that overwhelm sewage treatment facilities, or because it results in higher concentrations of pollutants in groundwater as a result of enhanced evaporation and reduced groundwater recharge. **Ample clean water** is not a luxury—it **is essential for human survival**. Consequently, cities, regions and nations that lack clean freshwater are vulnerable to social disruption and disease. Finally, ocean acidification is linked to climate change because it is driven by CO2 emissions just as global warming is. With close to 20% of the world’s protein coming from oceans (FAO, 2016), the potential for severe impacts due to acidification is obvious. Less obvious, but perhaps more insidious, is the interaction between climate change and the loss of oyster and coral reefs due to acidification. Acidification is known to interfere with oyster reef building and coral reefs. Climate change also increases storm frequency and severity. Coral reefs and oyster reefs provide protection from storm surge because they reduce wave energy (Spalding et al., 2014). If these reefs are lost due to acidification at the same time as storms become more severe and sea level rises, coastal communities will be exposed to unprecedented storm surge—and may be ravaged by recurrent storms. A key feature of the risk associated with climate change is that mean annual temperature and mean annual rainfall are not the variables of interest. Rather it is extreme episodic events that place nations and entire regions of the world at risk. These extreme events are by definition “rare” (once every hundred years), and changes in their likelihood are challenging to detect because of their rarity, but are exactly the manifestations of climate change that we must get better at anticipating (Diffenbaugh et al., 2017). Society will have a hard time responding to shorter intervals between rare extreme events because in the lifespan of an individual human, a person might experience as few as two or three extreme events. How likely is it that you would notice a change in the interval between events that are separated by decades, especially given that the interval is not regular but varies stochastically? A concrete example of this dilemma can be found in the past and expected future changes in storm-related flooding of New York City. The highly disruptive flooding of New York City associated with Hurricane Sandy represented a flood height that occurred once every 500 years in the 18th century, and that occurs now once every 25 years, but is expected to occur once every 5 years by 2050 (Garner et al., 2017). This change in frequency of extreme floods has profound implications for the measures New York City should take to protect its infrastructure and its population, yet because of the stochastic nature of such events, this shift in flood frequency is an elevated risk that will go unnoticed by most people. 4. The combination of positive feedback loops and societal inertia is fertile ground for global environmental catastrophes **Humans** are remarkably ingenious, and **have adapted** to crises **throughout** their **history**. Our doom has been repeatedly predicted, only to be averted by innovation (Ridley, 2011). **However**, the many **stories** **of** human ingenuity **successfully** **addressing** **existential risks** such as global famine or extreme air pollution **represent** environmental c**hallenges that are** largely **linear**, have immediate consequences, **and operate without positive feedbacks**. For example, the fact that food is in short supply does not increase the rate at which humans consume food—thereby increasing the shortage. Similarly, massive air pollution episodes such as the London fog of 1952 that killed 12,000 people did not make future air pollution events more likely. In fact it was just the opposite—the London fog sent such a clear message that Britain quickly enacted pollution control measures (Stradling, 2016). Food shortages, air pollution, water pollution, etc. send immediate signals to society of harm, which then trigger a negative feedback of society seeking to reduce the harm. In contrast, today’s great environmental crisis of climate change may cause some harm but there are generally long time delays between rising CO2 concentrations and damage to humans. The consequence of these delays are an absence of urgency; thus although 70% of Americans believe global warming is happening, only 40% think it will harm them (http://climatecommunication.yale.edu/visualizations-data/ycom-us-2016/). Secondly, unlike past environmental challenges, **the Earth’s climate system is rife with positive feedback loops**. In particular, as CO2 increases and the climate warms, that **very warming can cause more CO2 release** which further increases global warming, and then more CO2, and so on. Table 2 summarizes the best documented positive feedback loops for the Earth’s climate system. These feedbacks can be neatly categorized into carbon cycle, biogeochemical, biogeophysical, cloud, ice-albedo, and water vapor feedbacks. As important as it is to understand these feedbacks individually, it is even more essential to study the interactive nature of these feedbacks. Modeling studies show that when interactions among feedback loops are included, uncertainty increases dramatically and there is a heightened potential for perturbations to be magnified (e.g., Cox, Betts, Jones, Spall, & Totterdell, 2000; Hajima, Tachiiri, Ito, & Kawamiya, 2014; Knutti & Rugenstein, 2015; Rosenfeld, Sherwood, Wood, & Donner, 2014). This produces a wide range of future scenarios. Positive feedbacks in the carbon cycle involves the enhancement of future carbon contributions to the atmosphere due to some initial increase in atmospheric CO2. This happens because as CO2 accumulates, it reduces the efficiency in which oceans and terrestrial ecosystems sequester carbon, which in return feeds back to exacerbate climate change (Friedlingstein et al., 2001). Warming can also increase the rate at which organic matter decays and carbon is released into the atmosphere, thereby causing more warming (Melillo et al., 2017). Increases in food shortages and lack of water is also of major concern when biogeophysical feedback mechanisms perpetuate drought conditions. The underlying mechanism here is that losses in vegetation increases the surface albedo, which suppresses rainfall, and thus enhances future vegetation loss and more suppression of rainfall—thereby initiating or prolonging a drought (Chamey, Stone, & Quirk, 1975). To top it off, overgrazing depletes the soil, leading to augmented vegetation loss (Anderies, Janssen, & Walker, 2002). Climate change often also increases the risk of forest fires, as a result of higher temperatures and persistent drought conditions. The expectation is that **forest fires will become more frequent** and severe with climate warming and drought (Scholze, Knorr, Arnell, & Prentice, 2006), a trend for which we have already seen evidence (Allen et al., 2010). Tragically, the increased severity and risk of Southern California wildfires recently predicted by climate scientists (Jin et al., 2015), was realized in December 2017, with the largest fire in the history of California (the “Thomas fire” that burned 282,000 acres, https://www.vox.com/2017/12/27/16822180/thomas-fire-california-largest-wildfire). This **catastrophic fire** embodies the sorts of positive feedbacks and interacting factors that **could catch humanity off-guard and produce a** true **apocalyptic event.** Record-breaking rains produced an extraordinary flush of new vegetation, that then dried out as record heat waves and dry conditions took hold, coupled with stronger than normal winds, and ignition. Of course the record-fire released CO2 into the atmosphere, thereby contributing to future warming. Out of all types of feedbacks, water vapor and the ice-albedo feedbacks are the most clearly understood mechanisms. Losses in reflective snow and ice cover drive up surface temperatures, leading to even more melting of snow and ice cover—this is known as the ice-albedo feedback (Curry, Schramm, & Ebert, 1995). As snow and ice continue to melt at a more rapid pace, millions of people may be displaced by flooding risks as a consequence of sea level rise near coastal communities (Biermann & Boas, 2010; Myers, 2002; Nicholls et al., 2011). The water vapor feedback operates when warmer atmospheric conditions strengthen the saturation vapor pressure, which creates a warming effect given water vapor’s strong greenhouse gas properties (Manabe & Wetherald, 1967). Global warming tends to increase cloud formation because warmer temperatures lead to more evaporation of water into the atmosphere, and warmer temperature also allows the atmosphere to hold more water. The key question is whether this increase in clouds associated with global warming will result in a positive feedback loop (more warming) or a negative feedback loop (less warming). For decades, scientists have sought to answer this question and understand the net role clouds play in future climate projections (Schneider et al., 2017). Clouds are complex because they both have a cooling (reflecting incoming solar radiation) and warming (absorbing incoming solar radiation) effect (Lashof, DeAngelo, Saleska, & Harte, 1997). The type of cloud, altitude, and optical properties combine to determine how these countervailing effects balance out. Although still under debate, it appears that in most circumstances the cloud feedback is likely positive (Boucher et al., 2013). For example, models and observations show that increasing greenhouse gas concentrations reduces the low-level cloud fraction in the Northeast Pacific at decadal time scales. This then has a positive feedback effect and enhances climate warming since less solar radiation is reflected by the atmosphere (Clement, Burgman, & Norris, 2009). The key lesson from the long list of potentially positive feedbacks and their interactions is that **runaway climate change,** and runaway perturbations have to be taken as a serious possibility. Table 2 is just a snapshot of the type of feedbacks that have been identified (see Supplementary material for a more thorough explanation of positive feedback loops). However, this list is not exhaustive and the possibility of undiscovered positive feedbacks **portends** even greater **existential risks**. The many environmental crises humankind has previously averted (famine, ozone depletion, London fog, water pollution, etc.) were averted because of political will based on solid scientific understanding. We cannot count on complete scientific understanding when it comes to positive feedback loops and climate change.

#### Space Elevators solve Space Debris – reduces Rocket Launches

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All objects in HEO reside beyond the geostationary orbit (GEO). The orbital period at GEO (w'hich is aligned with the Earth's equator) is equal to the Earth’s rotational period. As a result, from a ground observer’s perspective the satellite resides at a fixed point in the sky, with clear advantages for uses such as global communication. Activities at HEO are considerably less than at LEO and MEO. Earth's orbital environment does contain a natural component - the meteoroids. These pose little to no threat to space operations - the true threat is self-derived. The current limitations of spacefaring technology ensure that every launch is accompanied by substantial amounts of space debris. This debris ranges in size from dust grains to paint flecks to large derelict spacecraft and satellites. According to NASA’s Orbital Debris Program Office, some 21.000 objects greater than 10 cm in size are currently being tracked in LEO. with the population below 10 cm substantially higher. Most debris produced at launch tends to be deposited with no supplemental velocity - hence these objects tend to follow the initial launch trajectory, which often orbits with high eccentricity and inclination. However, these orbits do intersect with the orbits of Earth’s artificial satellite population, resulting in impacts w'hich tend to produce further debris. The vast majority of the low-size debris population is so-called fragmentation debris. This is produced during spacecraft deterioration, and in the most abun- dance during spacecraft break-up and impacts. The first satellite-satellite collision occurred in 1961. resulting in a 400% increase in fragmentation debris (Johnson et al.. 2008). Most notably, a substantial source of fragmentation debris was the deliberate destruction of the Fengyun 1C satellite by the People’s Republic of China, which created approximately 2.000 debris fragments. As with collisions of ‘natural debris’, debris-debris collisions tend to result in an increased count of debris fragments. Since the late 1970s, it has been understood that man-made debris could pose an existential risk to space operations. Kessler and Cour-Palais (1978) worked from the then-population of satellites to extrapolate the debris production rate over the next 30 years. Impact rates on spacecraft at any location. /, can be calculated if one knows the local density of debris p, the mean relative velocity vrei\* and the cross-sectional area ct: [[EQUATION 13.5 OMITTED]] Each impact increases p without substantially altering vrel or o. We should there- fore expect the impact rate (and hence the density of objects) to continue growing at an exponential rate: [[EQUATION 13.6 OMITTED]] Kessler and Cour-Palais (1978) predicted that by the year 2000, p would have increased beyond the critical value for generating a collisional cascade. As new collisions occur, these begin to increase ^jjp, which in turn increases resulting in a rapid positive feedback, with p and I reaching such large values that LEO is rendered completely unnavigable. This has not come to pass - LEO remains navigable, partially due to a slight overprediction of debris produced by individual launches. The spectre of a collisional cascade (often referred to as Kessler syndrome) still looms over human space exploration, as debris counts continue to rise. Without a corresponding dedicated effort to reduce these counts, either through mitigating strategies to reduce the production of debris during launches, or through removal of debris fragments from LEO. we cannot guarantee the protection of the current flotilla of satellites, leaving our highly satellite-dependent society at deep risk. What strategies can be deployed to remove space debris? Almost all debris removal techniques rely on using the Earth’s atmosphere as a waste disposal sys- tem. Most debris is sufficiently small that atmospheric entry would result in its complete destruction, with no appreciable polluting effects. Atmospheric entry requires the debris fragments to be decelerated so that their orbits begin to intersect with lower atmospheric altitudes. Once a critical altitude is reached, atmospheric drag is sufficiently strong that the debris undergoes runaway deceleration and ultimately destruction. There are multiple proposed techniques for decelerating debris. Some mechani- cal methods include capturing the debris using either a net or harpoon, and applying a modest level of reverse thrust. These are most effective for larger fragments, and especially intact satellites (Forshaw et al., 2015). Attaching sails to the debris is also a possibility if the orbit is sufficiently low for weak atmospheric drag. The Japanese space agency JAXA’s Kounotori Integrated Tether Experiment (KITE) will trail a long conductive cable. As a current is passed through the cable, and the cable traverses the Earth’s magnetic field, the cable experiences a magnetic drag force that will de-orbit the spacecraft. Orbiting and ground-based lasers can decelerate the debris through a variety of means. For small debris fragments, the radiation pressure produced by the laser can provide drag. A more powerful laser can act on larger debris fragments through ablation. As the laser ablates the debris, the resulting recoil generated by the escaping material produces drag and encourages de-orbit. A more lateral solution is to ensure that launches and general space-based activity no longer generate debris. These approaches advocate lower-energy launch mechanisms that do not rely on powerful combustion. The most famous is the space elevator (see Aravind. 2007). Originally conceived by Tsiolkovsky, the ele- vator consists of an extremely durable cable extended from a point near the Earth’s equator, up to an anchor point located at GEO (most conceptions of the anchor point envision an asteroid parked in GEO). ‘Climber’ cars can then be attached to the cable and lifted to LEO, MEO and even GEO by a variety of propulsion methods. Most notably, the cars can be driven to GEO without the need for chemical rockets or nuclear explosions - indeed, a great deal of energy can be saved by having coupled cars, one ascending and one descending. Space elevators would solve a great number of problems relating to entering (and leaving) Earth orbit, substantially reducing the cost of delivering payload out of the Earth's atmosphere. The technical challenges involved in deploying a cable tens of thousands of kilometres long are enormous, not to mention the material science required to produce a cable of sufficient tensile strength and flexibility in the first place. The gravitational force (and centrifugal force) felt by the cable will vary significantly along its length. As cars climb the cable, the Coriolis force will move the car (and cable) horizontally also, providing further strain on the cable material. The relatively slow traversal of the biologically hazardous Van Allen Belt on the route to GEO is also a potential concern for crewed space travel. Whatever the means, a spacefaring civilisation (or at least, a civilisation that utilises its local orbital environment as we do) must develop a non-polluting solution to space travel, whether that is via the construction of a space elevator, a maglev launch loop, rail gun, or some other form of non-rocket acceleration. If it cannot perform pollution-free spacecraft launches (or fully clean up its pollution), then it will eventually succumb to Kessler syndrome, with potentially drastic consequences for future space use, with likely civilisation-ending effects (Solution C.13).