### Advantage 1: Space Col

#### Expansion of PTD key to global space sustainability key to long term colonization efforts.

**Babcock ’19** — Hope M. Babcock, Professor of Law, Georgetown University Law Center, B.A., Smith College, L.L.B., Yale University; (2019; “ARTICLE: THE PUBLIC TRUST DOCTRINE, OUTER SPACE, AND THE GLOBAL COMMONS: TIME TO CALL HOME ET”; University of Michigan Libraries, Nexis Uni; *Syracuse University Law Review*, Vol. 69; //LFS—JCM – Recutish like diff section ISEE)

[\*259] The doctrine also appears to be infinitely malleable. Original uses of the doctrine were restricted to only that "aspect of the public domain below the low-water mark on the margin of the sea and the great lakes, the waters over those lands, and the waters within rivers and streams of any consequence," 520and covered only traditional uses of those lands, like fishing and navigation. 521 Over time, the scope and application of the doctrine broadened to protect more public resources and different uses. 522 Thus, the doctrine expanded to protect new trust resources, such as dry sand beaches, inland lakes, groundwater, dry riverbeds, and wildlife, 523and passive uses of those resources, like scientific study. 524The original link to navigable water and tidelands disappeared. 525 Supporters of the [\*260] doctrine successfully advocated that it be applied to "wildlife, parks, cemeteries, and even works of fine art," 526 while arguing more recently its application to the atmosphere. 527

A doctrine that imposes a perpetual duty on the sovereign to preserve trust resources, prevents their alienation for private benefit, assures public access to them, and can be invoked by anyone seems particularly useful as a management tool in outer space. 528The fact that public access to trust resources is so central to the doctrine makes it reflective, not contradictory, of international space law's bar against appropriation of outer space and of the principle of space being the "province of all mankind." 529 It avoids the problems of alienation and exclusion associated with any of the management approaches associated with some form of private property and requires neither the creation of a new administrative authority nor the presence of a close-knit group of like-minded people. 530 Members of the public, both rich and poor, can invoke and enforce the doctrine as easily as the sovereign. 531 It is cost effective to the extent that no separate apparatus is required to implement it, and the doctrine has shown itself to be highly adaptable and innovative as different needs arise. 532 It could also fill the gap in international law with respect to managing celestial property. Therefore, of all the management approaches studied here, the PTD seems the most suited to keep order in space until a regulatory regime is imposed.

However, the doctrine provides no incentives for development of trust resources; rather, it might be used to limit or curtail that development, making it an imperfect, perhaps even counter-productive solution by itself to the extent that such development might be [\*261] beneficial. 533Modifying the doctrine to allow limited use of private property management approaches, like tradable development claims, might buffer that effect - a form of overlapping hybridity between one type of property, a commons, and a management regime from another, private property, enabled by application of the PTD.

Conclusion

"Only a legal system that accommodates both the human need for resources and the necessary preservation of mankind's common heritage can fulfill these criteria."534 The future is now with regard to the development of outer space and its resources - it is no longer a question of whether humans will engage in these activities, but how soon they will. Technically advanced countries and private commercial enterprises are probing outer space and preparing for landing on an asteroid or the moon to extract their resources. 535Speculators are selling deeds to the moon's surface and preparing to exploit the tourism potential that space offers. 536 But, the legal framework for managing these initiatives is almost nonexistent. 537International treaties came into being before all this activity began in earnest and national laws that might apply are stunted by jurisdictional quandaries like the absence of national boundaries in outer space. 538Thus, there is an urgency to figure out how to control what happens in outer space before its resources are irreparably damaged or permanently monopolized by powerful countries and individuals.

In the absence of regulation, much of the current debate centers on what property regime should be applied in outer space. 539The assumption is that by only allowing private property rights in space, countries and commercial enterprises will undertake the risks and costs of space development. 540However, unless international space law changes, it may prevent this from happening. If it changes, strong management controls will be necessary to prevent destruction or over-consumption of celestial resources, as well as monopolization and competitive behavior by participants, which could lead to hostilities and inequities.

[\*262] This Article examines various private property regimes, including those of less than full fee ownership, to see if any would avoid the conflict with the international prohibition on appropriation of outer space and its resources. It concludes that none will because each retains the right to exclude and each is insensitive to the treaties' equity concerns. In contrast, considering outer space to be common is consistent with international space law in both respects.

Hypothesizing that private property in outer space may yet prevail, this Article investigates different private property management approaches, such as the right of first possession, lotteries, and tradable development rights, to see if any would be cost effective, easy to implement and equitable, and would also prevent over-consumption, monopolization or the slide into rivalrous behavior. The Article concludes that each comes up short in some respect. Social norms as a management tool for property held in common, although compliant with international law, are also not up to the task. Instead, although ancient, the PTD, with its malleability, easy and cost-effective implementation and enforcement, non-consumption principle, and consistency with the goals that animate international space treaties, seems best suited to the task of protecting the public's interests in the global commons that is outer space as it has done for centuries in Earth-bound commons.

But, as its principal terrestrial use has been to protect trust resources from development, the doctrine needs some modification to encourage development of celestial resources. Hence, this Article suggests that modifying the PTD to allow the application of private property management tools, like tradable development rights, will not only allow development, but also will assure that when it happens, it will not be just profitable for a few, but will also be sustainable and equitable.

#### Colonization solves inevitable extinction.

Kovic '19 [Marko; March 2019; co-founder president of the Zurich Institute of Public Affairs Research; "The future of energy," https://osf.io/preprints/socarxiv/aswz9/download]

Existential risks are risks that might lead to the extinction of humankind [1]. Natural existential risks (such as asteroids that might crash into Earth) are basically constant. The risks of a giant asteroid crashing into Earth today is the same as it was 500 years ago. Anthropogenic, man-made existential risks, on the other hand, are growing in number and severity. They are a side-effect of technological progress: The more we develop technologically, the greater man-made existential risks become. Nuclear weapons, to name only one example, are a direct consequence of scientific and technological progress.

There are different approaches to existential risk mitigation. One approach is to develop targeted strategies for specific existential risks. If we want to reduce the existential risk posed by nuclear weapons, then we can and should develop specific strategies for that risk.

Another approach is to develop and pursue what can be called meta-strategies that target all existential risks at once. One of most effective meta-strategies for tackling existential risks in general is space colonization: If we manage to establish permanent and self-sustainable human habitats beyond Earth, then our proverbial existential eggs are not all in one basket anymore. For example, if disaster strikes on Earth, but there are billions of humans living on Venus and Mars, humankind would continue to exist even with Earth-humans gone.

Because of existential risks, a long-term future in which humankind still exists almost certainly has to be a future in which humankind has succeeded in colonizing space. Today, even though we regularly venture into space, we do not yet have space colonization capabilities. There are a number of technological challenges that we need to overcome in order to become capable of space colonization. One of those challenges is energy. There are several reasons why.

### Plan

#### States ought to establish an international public trust obligation towards protection of outer space as a refusal of the appropriation of outer space by private entities.

### Advantage 2: Debris

#### Current international guidelines are failing – immediate space regulations are key to prevent Kessler

Broom 1/12 [Douglas Broom Henley Business School, 1-12-2022, "As private satellites increase in number, what are the risks of the commercialization of space?," World Economic Forum, https://www.weforum.org/agenda/2022/01/what-are-risks-commercial-exploitation-space/]/ISEE

Space is getting more crowded and more commercialized. This is leading to a growing risk of collisions between satellites and space junk, and means that new regulations on the use of space are urgently needed. Those are some of the conclusions of the World Economic Forum’s Global Risks Report 2022, which warns that if satellites fail, whether due to natural or human events, the consequences for life on Earth could be profound. Global navigation and communication systems are heavily dependent on space technology, the report says, but so too are energy and water supplies, financial infrastructure, broadband internet and television and radio services. Yet if a single piece of space junk strikes just one satellite, it could cause a cloud of debris that takes out many more and results in a “cascading effect” on critical services. That’s according to one theory, called the Kessler Effect. The risks inherent in outer space becoming ever more congested. “With such possibilities becoming likelier in a congested space, the lack of updated international rules around space activity increases the risk of potential clashes,” the report says. Crowded space Around 11,000 satellites have been launched since Sputnik 1 became the first human-made object to orbit the Earth in 1957, but almost seven times that number are planned to join them over the coming decades, the report notes. There are also an estimated half a million pieces of debris in orbit, presenting a growing threat to our use of space. A piece of space junk even hit the International Space Station (ISS) in May 2021, making a hole in a robotic arm. Only 3% of those surveyed for the Global Risks Report say that mitigation measures to prevent conflict in space are effective, while 59% think they are still at an early stage and 17% believe they have not even started. Space regulation falling behind Since 1967, 110 countries have ratified the United Nations Outer Space Treaty, which bans the stationing of weapons of mass destruction in space. But the report points out that space regulation has not kept pace with evolving technologies and new military threats. It says there is a “pressing need” for an international body to govern the launching and servicing of satellites, to establish space traffic control and provide common enforcement principles to back them up. The 1972 Space Liability Convention covers only spacecraft, but the report says that clarity is needed on how to deal with the likes of Sir Richard Branson’s Virgin Galactic ships, which launch from a plane and use wings to help them land. Private investment in space technology is increasing the need for space traffic control. Virgin Galactic is just one example of a growing trend towards private investment in space technology. Elon Musk’s SpaceX rockets are already delivering satellites and supplies for government agencies such as NASA, including Christmas gifts to the ISS crew. Early space exploration was the exclusive province of governments. But the Global Risk Report says some governments “are encouraging private space activity to further national ‘territorial’ claims, or to foster the development of high-value jobs … as well as enhancing their military or defence-oriented presence”. In the United States, SpaceX’s Starship rocket has been selected to carry NASA astronauts to the moon as part of the Artemis programme, which also aims to send humans to Mars. Starship will be the first US-manned lunar mission since Apollo 17 landed in December 1972. Increased private investment in space is driving down the cost of launching satellites. Increased private investment in space is also driving down the cost of launching satellites into orbit, says the report. Lower costs mean more organizations can launch smaller satellites, opening up the prospect of innovations such as space-based energy generation and even tourism. Space arms race Among the less welcome aspects of new space technologies is the development of hypersonic weapons – missiles that are so fast and agile they can evade conventional defences. The report says a “hypersonic arms race” is already underway. There are an estimated half a million pieces of debris in orbit. “Gaps in space governance render arms races even more likely,” says the report. “New rules are unlikely in the near future, as there is little agreement over key issues such as boundaries, control over space objects, or dual-use systems. Any further decline in cooperation on space governance will only exacerbate risks,” it adds. Warning that critical space technology is vulnerable to hazards other than space junk, the report calls for space powers to work together to avoid conflict and agree standards and norms for space operations. “Critically, and like other realms where technology is developing at a faster pace than its regulation, bringing private-sector actors into the agreement processes will help ensure that such pacts reflect both commercial and technical realities,” the report concludes.

#### PTD solves --- nothing else keeps up with private sector growth

**Rauenzahn et al., 20** (Brianna Rauenzahn is a JD candidate at Penn and writer for the regulatory review, Jasmine Wang is a writer for the regulatory review, Jamison Chung, Peter Jacobs, Aaron Kaufman, and Hannah Pugh, 6-6-2020, accessed on 9-12-2021, The Regulatory Review, "Regulating Commercial Space Activity", https://www.theregreview.org/2020/06/06/saturday-seminar-regulating-commercial-space-activity/, HBisevac)

But the transformation of spaceflight from a **public endeavor to a commercial industry** raises questions about how to **regulate the activities of private entities** in space. In 2014, the National Aeronautics and Space Administration (NASA) outsourced the task of transporting its astronauts, granting billion-dollar contracts to SpaceX and Boeing in a program called Commercial Crew. NASA astronauts Doug Hurley and Bob Behnken became the first crew to enter space under this public-private program. Over the next few decades, NASA plans to rely on this commercial partnership to pursue even more **ambitious goals**: returning to the moon and sending astronauts to Mars. But private companies have their own aspirations for outer space. Musk hopes to use SpaceX to start a human colony on Mars. Amazon’s Jeff Bezos also has his sights set on space colonization, and firms such as Bigelow Aerospace and Axiom Space plan to develop their own space stations. Some investors see opportunities in space tourism and mining. But these for-profit goals raise serious concerns about who can claim ownership of space resources and what law will govern private activity in uncharted frontiers. International space law is governed by a 1967 agreement known as the Outer Space Treaty⁠. The treaty allows all nations to use and explore the moon and celestial bodies, prohibits claims of sovereignty, and it requires nations to oversee the activities of private space companies. But existing space law has **not kept up with the growth in the private sector**, and the United States lacks a comprehensive regulatory regime. In anticipation of a growing commercial space industry, some experts and scholars call for more robust regulation. This week’s Saturday Seminar focuses on possible legal frameworks for governing commercial activity in outer space. In a working paper for the Mercatus Center, Laura Montgomery argues that the Federal Aviation Administration (FAA) and other federal agencies overreach their authority when they rely on Article VI of the Outer Space Treaty to deny private actors access to space. Montgomery contends that because Article VI is not self-executing, under existing U.S. Supreme Court precedent, it is not enforceable federal law. She argues that federal regulatory agencies cannot prohibit or regulate private space activities on the basis of enforcing the treaty. Montgomery similarly finds that Congress did not delegate authority to the FAA to deny private actors’ access to space. Instead, the legislative branch determines which activities by private actors “require Article VI authorization and supervision.” In a recent Air Force Law Review article responding to Laura Montgomery’s argument that Article VI of the Outer Space Treaty is unenforceable, the U.S. Department of Defense’s John S. Goehring claims that the United States has a direct responsibility to regulate such activity. Signatories to Article VI of the Outer Space Treaty—including the United States—have an affirmative obligation to authorize and continually supervise both governmental and non-governmental space activities, according to Goehring. Although he agrees with Montgomery that this obligation should not lead to the United States regulating “a musician playing the harp on the moon,” Goehring asserts that “activities such as launch, re-entry, operation and control of objects in orbit” should fall under governmental oversight. Adopting a regulatory view that ignores this obligation could have longstanding national security repercussions, he claims. Congress should encourage responsible behavior in space for the sake of U.S. national security, Goehring argues, rather than undermining Article VI. Daily space system operations often result in the presence of **space debris**, which can include anything from fallout left behind by satellite explosions and collisions to human generated waste from previous space missions. As commercial space traffic increases, the U.S. regulatory system must adapt and build a **strong foundation** for future debris mitigation, Marlon Sorge of the Aerospace Corporation argues. In a recent paper with the Center for Space Policy and Strategy, Sorge asserts that the federal government should re-evaluate its existing regulatory structure to maximize the potential benefits of commercial space activity and focus on debris mitigation. Through his proposed “one-stop-shop” model, Sorge explains that centralizing regulatory functions under one body could enable more efficient coordination between agencies as they tackle the rapid emergence of the commercial space sector. In a recent article in the Journal of Air Law and Commerce, Andrea J. Harrington of the U.S. Air Force Air Command and Staff College argues that there are not enough protections for space-related objects and sites under current international and cultural heritage law. Currently, there are no treaties that directly address the treatment and protection of space-related cultural heritage. U.S. government entities and nonprofits have proposed national protections for the Apollo landing sites, such as NASA’s Recommendations to Space-Faring Entities. Harrington claims that, although important, these recommendations are just “baby steps” since they do not apply to foreign actors. To preserve existing and future space-related cultural heritage, Harrington calls for a multistep process that would culminate in binding bilateral and multilateral treaties, which could eventually lead to the development of broad protections in customary international law. Without strong governing principles, “**outer space could turn into the ‘Wild West’** of the twenty-first century,” Georgetown University Law Center’s Hope Babcock writes in an article published in the Syracuse Law Review. Because people will inevitably capitalize on celestial resources, there ought to be consensus on which property regime should apply, she asserts. Finding that pure private property regimes would encourage competitive behavior that would exacerbate hostilities and inequalities between nations, Babcock argues instead for a modified version of the **public trust doctrine**. Such a regime would incorporate some private property management tools, allowing for sustainable and equitable extraterrestrial development, according to Babcock.

#### Global mitigation and remediation in conjunction are necessary to solve the Kessler effect.

Rada Popova 18, European Space Agency Co-Manager, PhD, Faculty of Law @ Universitat zu Koln, postgraduate degree from the Hague Academy for International Law, “The Legal Framework for Space Debris Remediation as a Tool for Sustainability in Outer Space,” *Aerospace*, MDPI, doi:10.3390/aerospace5020055 \*adr = active debris removal, \*\*sdr = space debris remediation, \*\*OOS = on orbit servicing

In outer space, any launch creates space debris. Since the first man-made object was launched into space in 1957, more than 5600 launches have taken place [2]. In addition, incidents and collisions create additional space debris. As a result, human activities have caused significant negative effects on outer space, as during the past six decades near-Earth orbits have been filled with functional and non-functional objects, the overwhelming majority of which are debris. Of course, this observation is not relevant for the whole of outer space. For the purposes of this article, and of space law in general, the subject of interest is naturally restricted to the orbital regions that are accessible for man-made spacecraft and are used for space activities. The farthest space mission so far—Voyager-I—has left the solar system and entered interstellar space. Nevertheless, most human activities take place in low-Earth orbit (LEO) in an altitude between 200 and 2000 km used for the International Space Station, Earth observation satellites as well as some telescopes, medium-Earth orbit (MEO) in an altitude approximately between 2000 and 36,000 km mostly used for navigation, geodetic and communication satellites as well as geostationary Earth orbit (GEO) at approximately 36,000 km. Currently, there are 1738 functional satellites, of which 1071 are in LEO, 531 in GEO, 97 in MEO and 39 in elliptical orbits [3]. Currently, only 6% of the catalogued orbital population are functional objects. The number of non-functional objects that are trackable and contained in the Space Surveillance Network catalogue show that there are more than 21,000 larger than 10 cm. For smaller sizes, the estimates are based on statistical models, such as the NASA Standard Breakup Model [4] and in-situ measurements. The estimates include 150 million objects larger than 1 mm and 600,000 objects up to 1 cm. Moreover, 700,000 to 750,000 pieces of space debris larger than 1 cm have resulted from more than 200 on-orbit defragmentations [5]. As a consequence of the vast orbital velocity in LEO (8 km/s = 28,800 km/h), impacts with the smallest objects of 1 mm might cause degradation and damage to functional spacecraft. So far, shielding options have been developed, but they are only effective for fragments not larger than 1 cm. Impacts with larger objects have the potential to destroy functional satellites. This is linked to the decisive factor for the constant growth in debris: the ‘Kessler syndrome’—a cascade effect describing the fact that collisions between space debris result in an exponential growth in the orbital debris population which, once collisional break-up begins, will increase even if no new launches take place [6,7]. In the near future, a further “growth factor” which might additionally influence space debris propagation are so-called ‘mega-constellations’ that will consist of hundreds of small satellites with a short operational lifetime and restricted manoeuvring capability [8,9,10]. Table 1 lists recently announced satellite constellations aiming to provide global internet communications which have attracted much publicity. Some commonalities include: (1) the orbital altitudes above the popular 800–900 km Sun-synchronous orbits where atmospheric drag is non-existent; and (2) the compact mass of objects below 500 kg which suggests low-thrust electrical propulsions for orbital manoeuvers. The list of announced constellations could easily be extended. However, it is unlikely that all announced plans turn into reality. In such global business scenarios, typically the first-in-the-market along with two or three competitors apportion the market among themselves. This happened in the 1990s, when several global communication LEO constellation systems were announced of which only Iridium, Globalstar and Orbcomm made it into orbit. Keeping in mind that approximately 1000 active satellites are in LEO today, with the announced OneWeb mega-constellation this number will almost double [11], and if all three constellations on the list are launched, this would result in a tenfold increase in the LEO satellite population. The scope of challenges posed by orbital debris pollution is further underlined by the restricted cataloguing possibilities and the relative effectiveness of space situational awareness systems. The catalogue maintained by the US Space Surveillance Network provides information on 16,000 objects [13]. The Space Awareness System of the European Space Agency (ESA) can track objects bigger than 10 cm in low-Earth orbits and 0.3–1 m in geostationary orbits [14]. Thus, only a small fraction of the overall debris population can be detected. Furthermore, even if a collision probability can be calculated, manoeuvring may not be feasible, e.g., due to restricted time for reaction or lack of manoeuvring capabilities or control over the satellite. Unlike the environment of the Earth that might be cleaned-up and restored to a previous state, outer space is governed by celestial mechanics which make it practically impossible to clean-up debris through natural orbital decay and thereby bring the orbital environment to its original state. The natural decay of space debris is dominated by the drag caused by the residual atmosphere. The effect is dependent on the mass, the cross-sectional area, and the orbital position of the space object. Space debris at 800 km may remain in orbit for the next few centuries [15] and space debris orbiting at more than 1500 km will practically remain in outer space forever as there is not enough drag from Earth’s atmosphere any more at this altitude [16]. All of these factors make for an alarming picture. In general, one can distinguish between collisions (in which two objects are involved) and break-up events (which can occur if a satellite is breaking up by itself because of residual fuel in the tanks or a self-destruct mechanism). Although so far only a few on-orbit collisions have occurred [17] (e.g., the 2007 anti-satellite missile test conducted by China on its Feng-Yun 1C satellite and the 2009 collision between the inactive Russian satellite Cosmos 2251 and the active US satellite Iridium 33), a dramatic growth in the space debris population has been caused by these accidents. Alone the 2009 collision led to the creation of a space debris cloud of 2000 pieces of debris larger than 10 cm and thousands of smaller pieces which might remain in orbit for years [18]. The number of collisions that will lead to further incidents will grow over time. This risk is particularly high for near-polar LEO orbits at around 800–900 km and the GEO region, as approximately 62% of functional satellites are in LEO and 31% in GEO [3,19]. As LEO is the region of greatest concern for the uncontrolled growth of debris, currently, the following mechanisms are considered vital to mitigate the debris population to a sustainable level: (1) post-mission disposal; (2) passivation; and, (3) active debris removal. While a few years ago, less than 50% of the missions in GEO were compliant with space debris mitigation standards [20], in 2016, more than 80% successful clearance attempts were undertaken in GEO and 66% in LEO [21]. It has been estimated that compliance with mitigation rules, e.g., through ensuring that 90% of the launches are in compliance with the 25-year rule of post-mission disposal as provided by the Space Debris Mitigation Guidelines of the Inter-Agency Space Debris Coordination Committee (IADC) [22] and no new on-orbit explosions occur, will not be enough to reverse the negative trend in the most used orbits. These findings were studied in detail by the IADC in simulation campaigns among the participating partners, and recently confirmed by reference simulation in the frame of the H2020-ReDSHIFT project [23]. Furthermore, even if up to 10 large objects are removed from low-Earth orbit per year, the debris growth in LEO is still likely to evolve negatively in the next 200 years [1]. Long-term reference scenarios conducted recently within the H2020-ReDSHIFT project used a space debris population from LEO to GEO and a projection time frame of 200 years. Assuming 2–3 self-induced in-orbit explosions over the next 15 years, a post-mission disposal success rate of 60% (on 25-year orbits in LEO and to graveyard orbits in GEO) and collision avoidance against all objects in LEO, the results show that remediation of two objects per year decreases 12% of the final population [24]. Thus, it is expected that a combination of mitigation and remediation measures is needed to overcome the negative trends which will, with time, evolve into a catastrophic state if no effective action is undertaken. While an established (voluntary) framework for non-binding mitigation measures and some state practice exists through the adoption of specific measures for space debris mitigation in the national space laws of some states [25], the legal implementation of space debris remediation (SDR) is still in the making. The reasons for the slow pace of this development are, on the one hand, of a technological nature and, on the other, are due to the complex legal problems posed by SDR. In the following sub-section, an overview of the legal framework and the main challenges for establishing rules on SDR will be given. 2.2. The Legal Framework for Space Activities The legal framework for outer space activities consists of five international treaties (the 1967 Outer Space Treaty (OST) [26], the 1968 Rescue Agreement [27], the 1972 Liability Convention [28], the 1975 Registration Convention [29], and the 1979 Moon Agreement [30]) adopted in the period between 1967 and 1979, resolutions of the General Assembly of the United Nations adopted since 1982, and the national space legislation of more than 20 countries. Since 1996, a tendency can be observed to adopt sets of measures and instruments on the international level that re-interpret concepts entailed in earlier Treaties [31]. The Outer Space Treaty is sometimes referred to as a “Constitution” of space law as it contains the basic principles for space activities, provides the basis for the next four treaties, and has gained significant support, with 107 signatories as of January 2018 [32]. Thereby the Outer Space Treaty is considered to contain principles of customary international law, which bind not only state parties to the treaty but also non-signatories [33]. Such customary principles are Articles I–IV, VI, VII, VIII and arguably also Art. IX OST and have served as a basis for the development of the further treaties on space law. International law designates outer space and celestial bodies the status of a global common—a domain beyond national jurisdiction which is not subject to national sovereignty. This is laid down in Art. I para. 1 of the 1967 Outer Space Treaty [26], according to which the use and exploration and use of outer space should be regarded as the ‘province of all mankind’. While it is difficult to define this notion in concrete terms, there is no doubt that outer space should be open to the use of all states, regardless of their current economic or technological development [34]. Thus, the use of outer space as a global common, including economic and non-economic uses as well as scientific exploration of outer space and celestial bodies, should be free—in the sense of remaining accessible for all states and their nationals on the same terms, without discrimination of any kind. Accessibility as a means to carry out space activities should be preserved not only in the short-term perspective, but on a long-term basis as the dependency of humans on outer space will only grow in the future. As a consequence, the sustainability of space activities must be ensured. It is, therefore, worthwhile discussing whether, if such activities are endangered by the negative consequences of orbital pollution, the rights of states to freely exercise their activities in outer space as stipulated in the Outer Space Treaty can be safeguarded. ● The Freedoms vs. the Usability of Outer Space The principles contained in the Outer Space Treaty and the subsequent four treaties on space law set out a framework for human activities in space that can be characterized as a system of freedoms and limitations. Art. I of the OST provides that there shall be freedom of the exploration, use and scientific investigation of outer space and celestial bodies. “Use” means both the economic and non-economic use of outer space [35]. The term “exploration”, however, stipulates not so much consuming or profiting from space but rather the discovery of something new or yet unknown. Scientific investigation might but must not necessarily overlap with “exploration” as scientific activities might be aimed also at already discovered objects or areas. The term “freedom” means that all addressees of these provisions (primarily states and also nationals of states, in as much as states entitle them to do so through national space legislation) are entitled to use, explore or scientifically investigate outer space without the need to ask for permission from other states or an international entity. At the same time, this means that such activities shall not be hampered, e.g., by harmful interference or other impairment. However, the freedoms of outer space are not absolute, as they are not limitless. Limitations are certain exceptions contained in Article I of the OST itself as well as in other treaty provisions of the corpus iuris spatialis. Such as, inter alia, the common benefit clause (Art. I para 1 OST), Art. III OST and Article 2 UN Charter, Art. IV para 1 OST, Art. VII OST and Art. 2 and 3 Liability Convention. Some of these limitations are specifically relevant for the sustainable use and exploration of outer space and celestial bodies, and thus for SDR, as sustainability is an indispensable condition for the usability of outer space. It is thereby required that the use of outer space by present generations takes place on the basis of responsibility towards future generations, which is reiterated by the specific nature of outer space as a global common. ● The notion of the “province of mankind” In Art I para 1 of the OST and Art. 4 of the Moon Agreement the use and exploration of space and celestial bodies are declared to be the “province of mankind”. Although no definition of the term “mankind” has been provided, this notion is an expression of the equal right of all states (regardless of the fact that they are space-faring or developing countries) and all generations (present and future) in the use and exploration of outer space and celestial bodies [36]. ● The Common Heritage of Mankind (CHM) concept (Art I para 1 OST, Art. 11 MOON) The purpose of this doctrine, which is not restricted only to space law, is the protection of certain areas of great importance outside national territory and ensuring their integrity for future generations. It is reflected the United Nations Convention on the Law of the Sea [37] and can also be found in the Preamble of the Antarctic Treaty [38] without being explicitly mentioned there. As with the province of mankind clause, the notion of CHM brings forward the particular status of outer space as a domain which should be open and preserved for all states and generations. ● Military uses of outer space Another important limitation to the freedoms of outer space is contained in Art. IV of the OST. Certain military uses of outer space, such as the placement of nuclear weapons and weapons of mass destruction in orbit around the Earth, their installment as well as the establishment of military bases and the testing of weapons on celestial bodies or their stationing anywhere in space, are prohibited. Furthermore, para 2, Art. IV provides that outer space may be used for “peaceful purposes only”. While the exact meaning of the term “peaceful purposes” is contested, the leading opinion interprets it as non-aggressive, meaning that some military activities are acceptable if exercised lawfully (e.g., the right to self-defence, Art. 51 UN Charter) [39]. This provision is relevant especially as e.g., anti-satellite testing and other military destructive activities can produce a considerable amount of debris. ● The environmental protection of outer space A further limitation is contained in Art. IX of the OST, which is considered the basis for the environmental protection of outer space. By providing that states parties “shall conduct all their activities in outer space, including the Moon and other celestial bodies, with due regard to the corresponding interests of all other states” [40], this provision reaffirms the common character of outer space. Furthermore, it provides that the “harmful contamination” of outer space and celestial bodies shall be avoided (Art. IX sent. 2 OST) and, in case activities can potentially cause “harmful interference with activities of other states parties”, consultations should be undertaken before the activity is carried out or continued (Art. IX sent. 3 and 4 OST). Although the concepts used in Art. IX are difficult to define, it expresses the idea that there shall be protection of space activities from all forms of interference that might cause harm or pose a risk of harm to other states [40]. Thereby, Art. IX of the OST contains the principle of co-operation (Art. IX sent. 1 OST) which is also found in Articles III and X of the OST and was further developed in the other four treaties on space law. However, no specific requirements for states as to how to exercise their activities in a manner that would ensure that the standard of care towards of activities of other states are provided. Thus, the legal framework provides for some general direction for co-operation between the users of outer space but concrete instruments on how to ensure sustainability need to be formulated in more detail. In fact, the treaties on space law neither expressly prohibit the creation of space debris nor impose an obligation on states and their space actors to remove space objects from orbit. Mitigation measures have so far only been adopted as voluntary, non-binding instruments and have been partly adopted in the national laws of some states [25]. In sum, it can be stated that a general obligation to protect the environment of outer space results from the common interest of the community of states to access and use outer space. If a narrow interpretation of the theory of erga omnes obligations is followed, it is the currently 107 State parties to the OST [32] which represent the community having a common interest in the protection of the usability of outer space. If the view is followed, that due to the broad support and the principle-based character of some of its norms, the Outer Space Treaty has at least partly customary character, it can be argued that the 107 State Parties represent the global community so that the global community has a legal interest in the environmental protection of outer space., but a concrete, binding way of action for SDR cannot be derived from existing space law [41]. 2.3. The Future of the Outer Space Environment 2.3.1. Sustainability as a Condition for the Usability of Outer Space What, then, can be done? In the context of the work of the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS), the sustainability of outer space is defined by the stability and safety of its environment which shall be “open for exploration, use and international cooperation by current and future generations (…)” [42], based on non-discrimination. Thus, sustainability is a condition for any future access to and use of outer space. On the technical level, both mitigation and remediation concepts have been developed in order to facilitate the protection of near-Earth space from space debris aiming to “maintain the conduct of space activities indefinitely in the future” [43]. Out of the factors playing a role in the creation and distribution of space debris (orbit dynamics, air-drag on the residual atmosphere, on-orbit explosions, collisions, surface degradation slag from solid rocket motor firings, launch rates of future missions, operational practices and mitigation practices) a few will be tackled here that are the direct result of man-made activities. In the style of the “leave no trace” paradigm of sustainable outdoor activities in nature here on Earth, several guidelines have been formulated as well for space activities; for instance, guidelines for the disposal of defunct satellites which are to be removed from LEO within 25 years after their end-of-life. In practice, this typically is realized by a final orbit maneuver which lowers the perigee as much as possible to ensure it will re-enter within 25 years. Such an action at the end of a mission is also beneficial with respect to another paradigm, which calls for a minimum impact on the environment. In a last orbit maneuver, all the leftover fuel can be used, which is one element of the passivation of satellites at their end-of-life. In general, passivation covers all forms of stored energy on board, let it be kinetics of the gyros, charge of batteries, and also fuel in the tanks. Passivation aims at the minimization of self-induced break-ups and it is expected that the number of explosions can be controlled very well by proper passivation and their severity can be significantly reduced (because e.g., the residual fuel cannot self-ignite when the tank corrodes and lead to a complete destruction). That said, post-mission disposal considerations are to be seen in opposition to the space mission operators’ desire to extend the nominal mission operation. Naturally, this is also a sustainable approach. It is usually better in terms of global sustainability to continue using old equipment (and accepting additional maintenance to a certain economic level) instead of throwing it away and replacing it. In space, however, maintenance is not easily done. Therefore, the risk of a critical failure on-board a satellite increases towards longer mission durations. From the sustainability point of view, it remains unclear when it is best to simply extend a mission and accept the higher risk of losing control over the satellite and not being able to perform disposal at all or to terminate the mission with a proper disposal maneuver and passivation. The aforementioned example highlights that, as in other domains, there is a usually a conflict of interest between the immediate needs of spacecraft operators and the higher good of preserving the space environment in accordance with the treaties on space law. Space mission designers will always assess the collision probability due to space debris and define a tolerated risk threshold for their assets. In case the desired target orbit is already too densely populated with debris, it is possible to re-design and move to other, higher orbits. What is yet to be done is to strike an agreement at a global level to define acceptable inflictions on the space environment that are tolerable. An analogy can be drawn to the consensus on the two-degree goal in climate change. Maybe it is possible to discuss and formulate similarly memorable and easily understandable goals for the outer space environment. Although it is unlikely that the final sentence will state “Two collisions per year are tolerable”, such goals would provide the necessary foundation for further action. 2.3.2. The Need to Act As any significant accident in outer space leads to irreparable damage in orbital stability, it is not enough to mitigate the production of new space debris. In particular, the fact that in higher altitudes objects may remain over hundreds or even thousands of years, means that a potentially catastrophic effect for functional objects remains. Mitigation can indeed contribute to stabilizing the outer space environment, but further measures are necessary. For example, in LEO mitigation measures can only slow down the pace of growth but are not enough to stop it. Therefore, further measures aiming at reducing the existing space debris population through remediation are needed if the most used orbits are to remain usable. For example, a long-term scenario with five ADR missions per year clearly shows that remediation for large objects would lower the number of collisions in densely populated orbital regions from 10 to 5 and is, thus, advantageous [23]. While it has been estimated that the (isolated) application of SDR measures will not lead to a rapid change in the negative trends, there could be an apparent benefit to operational space objects in the long-term if ADR [active debris removal] is performed in conjunction with space debris mitigation [44]. 3. The Definition and Scope of Space Debris Remediation Remediation mainly aims at removing existing pieces of orbital debris through active debris removal (ADR). Active debris removal involves the removal of intact but non-functional and/or uncontrolled objects (i.e., defunct satellites and rocket bodies). Moreover, these efforts could be supplemented by so-called on-orbit servicing of satellites (OOS). OOS aims at ameliorating the capabilities of satellites on orbit which have become non-functional through refueling and upgrading in order, first, to diminish the break-up risks and thus the creation of space debris, and second, to extend the satellite’s life. As such measures relate to existing space objects, OOS can be considered partly a mitigation measure [45]. On-orbit servicing might also develop into repurposing or scavenging of valuable components from defunct satellites. Such concepts are currently being investigated by DARPA’s Phoenix program [46,47], and certainly need to overcome challenges in automation and robotics in space operations and would benefit from standard interface ports for docking and modular designs [48]. Unlike mitigation measures, which aim at reducing the number of objects to be launched in orbit in the future, space debris remediation is designed to act against the consequences of orbital congestion with debris and aims at removing objects that are not functional anymore and thus represent a risk to space activities. So far, space debris remediation measures have been proposed but not yet applied in practice. The effectiveness of the different disposal methods depends strongly on the type, mass and orbital position of the satellite. Such concepts for the removal objects from orbits include tethering, tugging, beaming with an electrostatic tractor (for GEO) [49], ion-beaming through relocation and lasering, net capturing [50], docking with a nozzle (especially in GEO), harpooning, de-orbiting with a drag augmentation sail, and de-orbit kits [51]. There are, however, also passive debris removal concepts. They involve the pre-launch instalment of systems such as drag augmentation devices which can deploy sails to accelerate the natural decay of satellites [52]; electrodynamic tethers [53,54] for de-orbiting, and thrust propulsion systems enabling de- or re-orbiting. Moreover, the concept of laser debris removal foresees installing plasma jets on objects in order to enable controlled re-entry [55,56,57]. The focus of proposed remediation measures lies within the removal of larger objects and not of small objects as they act as triggers for the cascading effect. This has been shown through the results of the 2007 Fengyun 1C anti-satellite test by China in 2007 which “was adding more than 3300 trackable objects to the US Space Surveillance Network catalogue, increasing its size by 25% in just one incident” [58,59]. 3.1. The Deficiencies of the Legal Framework Related to Space Debris Remediation (SDR) While it is expected that the necessary advanced technology for ~~SDR~~ [Space Debris Remediation] will become available in the foreseeable future, there are various legal problems that might challenge its practical implementation. The existing treaty law provides some main legal principles which set the legal framework for human activities in outer space. However, instruments for the protection of the space environment from space debris are not specifically provided for. Neither is space debris defined or its production prohibited, nor are the mitigation and remediation of space debris considered in the binding law. Thus, the creation and the non-removal of space debris is not recognized to be an unlawful act. The following deficiencies of law with relation to SDR must be highlighted: It is not yet clear how a substantial risk should be defined so as to decide which fragments should be removed first. Art. II and III of the Registration Convention provide that space objects have to be registered in a national register and be carried on a register maintained by the United Nations General Secretary. Art. IV requires that data describing the name of the launching state(s), the designator of the space object, the date and territory of launch, the general function of the space object, as well as basic orbital parameters of the space objects (nodal period, inclination, apogee and perigee) are provided. However, these elements do not provide for the functionality and current status of the space object and, thus, cannot serve as criteria to determine its eligibility for removal. The legal framework does not provide standards to decide on whether an object constitutes space debris. Moreover, the legal regime for space activities does not define what space debris is. Therefore, it could be questionable what the criteria to define a space object as debris should be: its functionality, its controllability? For example, it could be aimed at first removing objects which cannot be attributed to a state registry—e.g., because their origin cannot be identified, which would be the case for the majority of small debris fragments. The question of attribution through registration is closely linked to the jurisdiction of states over their space objects. While outer space and celestial bodies are free from sovereignty, according to Art. VIII of the OST states shall retain jurisdiction and control over the space objects carried on their registry. The notion “jurisdiction” means that states withhold the power to legally enforce over their space objects and “control” is the factual element which ensures that the possibility to technically control the satellite lies within the state registry. As a consequence, registered space objects can only be subjected to SDR by the state registry itself or with its permission. Another relevant question is how to gain authorization to remove in cases where, for example, the state or registry neither consents to undertake the removal not does it provide authorization to a third party due to security concerns. As there is no legal obligation for states to remove their objects, this seems to be one of the most significant obstacles for SDR. Another case to be addressed is if the state registry is unknown, e.g., because the space object has not been registered or the state registry is not identifiable. Could a state of necessity be applicable in urgent cases so that the removal, even without permission, remain lawful? Self-help in a state of necessity [60,61] could be invoked to justify measures aiming at “cleaning-up” the environment of outer space if the conditions for such justification are given [62], e.g., in order to safeguard an essential interest from a “grave and imminent peril”. Interests not only of single states, but also of the international community as a whole have been recognized by the International Law Commission (ILC) as a ground to invoke necessity. The International Court of Justice, in the Gabčíkovo-Nagymaros Project Case [63], observed that self-help in a state of necessity as a ground for precluding wrongfulness can only be accepted under strictly defined exceptional conditions. Such conditions could, in the context of global common interests in the protection and sustainability of outer space, be an imminent threat to the space environment in order to preserve its usability. Therefore, provided that the growth in the number of activities will most probably induce the occurrence of accidents in outer space, it is conceivable that the concept of a state of necessity might gain relevance in the future and play a role in establishing legal rules for SDR. Also, the specific liability regime for space activities as established by Art. VII of the OST [26] and further elaborated in the 1972 Liability Convention [28] poses many questions for SDR operations. First, only states can be held liable for damages caused by space objects (Art. VII OST). Liability is, thereby, twofold: according to Art. II of the Liability Convention, for damages occurred in airspace or on the surface of the Earth, states have to pay compensation on the basis of “absolute liability”. Therefore, no fault must be proven. The conditions that need to be given are a damage to property, life or health caused by a space object of a launching state to persons or states. (Art. I lit. (a) Liability Convention). Thus, attributability suffices, as long as it is known which the launching state is. For damages in outer space, liability is fault-based (Art. III Liability Convention). Therefore, besides attributability, the fault of the launching state—thus the non-observation of a certain legal duty of care—also needs to be proven. This means that if a private entity undertakes an ADR operation and damage is caused to the space object of a third party, the liability is attributed to the launching state(s) of the removed object and not to the third party conducting the operation, whereas in Art. I lit. (c) Liability Convention, а ‚launching State’ is defined as the State which launches or procures the launching of a space object, or a State from whose territory or facility an object is launched. The costs incurred, thus, have to be carried by the launching state. However, for the regulation of SDR, it is questionable whether the standard for fault liability should be the same as for conducting a SDR operation. Furthermore, no change or transfer of ownership of space objects is foreseen in the space law treaties. Art. VIII of the OST foresees that jurisdiction and control shall be retained by the state registry. None of the space law treaty provisions includes a regulation regarding a possible transfer of ownership and control over satellites. Thus, once a state has launched a space object, even if it has been thereafter sold to another entity or state, the original launching state remains liable for all potential damages caused by this space object. Any deviating clause must be concluded bilaterally between the launching state and the purchaser and it is only binding between these two parties. Thus, in the case of an accident that occurred during an ADR mission on a transferred satellite, the original launching state will be held liable for any potential damage, although it might have not had any control possibilities over the satellite. The launching state can then only hold recourse against the purchaser according to their bilateral agreement for the compensation paid to the damaged party. In practice, only a few transfers have taken place: e.g., of AsiaSat-1, APSTAR-I and APSTAR-IA from the United Kingdom to China in 1997, and of MARCOPOLO 1/BSB-1A from a British company to a Swedish national in 1999 [64]. Nevertheless, with the vast development of the commercial space market and the financial viability of satellite purchases triggered by the new space market, the legal issues related to change of ownership will gain more importance. Another relevant concern of launching states and entities with regard to ADR and OOS missions is security, especially for military satellites. As satellite infrastructure is a strategic asset, it is questionable whether state registries which do not possess enough financial and technological capabilities to remove their objects by themselves would give consent to third parties to undertake SDR. Furthermore, ADR systems entail a capability which is not restricted only to space debris and they could be used, if such an intent is given, for the removal or diversion also of assets. This dual characteristic, both civil and military, makes ADR a sensitive capability and presents a hurdle to reaching agreement between states for its implementation in practice and to raise funding in cooperation for the development of ADR techniques. 3.2. SDR and the Role of Non-Binding Instruments The lacunae in the binding law regarding effective mechanisms for the protection of the common right to use and explore the outer space environment from the negative consequences of man-made debris have not remained completely unaddressed by the international community. The prevention and reaction against space debris have become a main topic on the agenda of UNCOPUOS, IADC and other organisations that have considered possible mechanisms to impose obligations on states for their non-functional objects. For example, the missing definition and clarification of the legal nature of space debris in the treaties on space law has been taken up by the 2007 UNCOPUOS Space Debris Mitigation Guidelines [65] which provide that space debris are: “all man-made objects, including fragments and elements thereof, in Earth orbit or re-entering the atmosphere, that are non-functional”. Also, the Space Debris Working Group of ESA has proposed an approach to define space debris by dividing human-made space objects in two categories: (a) functional active satellites under control; and (b) space debris that includes deactivated satellites, rocket upper stages and/or parts thereof, paint flakes etc. Thereby, space debris is characterized by the fact that it is man-made and does not serve any purpose. However, there is no agreement on whether space debris should be considered to be space objects, as per the definition of “space object” of Art. I lit. (d) of the Liability Convention and Art. I lit. (c) of the Registration Convention [29], which, as it only clarifies that “The term ‘space object’ includes component parts of a space object as well as its launch vehicle and parts thereof”, is rather a circular definition. The technical guidelines for space debris mitigation by the IADC, [22] an intergovernmental organisation consisting of 12 national space agencies and ESA [66], as well as the UNCOPUOS Guidelines on Space Debris Mitigation, are applicable to “mission planning and the operation of newly designed spacecraft and orbital stages and, if possible, to existing ones”. Such measures include: (1) limiting the debris released during normal operations, (2) minimizing of the potential for break-up during operational phases, (3) limiting the probability of accidental collision in orbit, (4) avoidance of intentional destruction and other harmful activities, (5) minimizing potential for post-mission break-ups resulting from stored energy, and (6) limiting the long-term presence of spacecraft and launch vehicle orbital stages in the low-Earth orbit region after the end of their mission [22,65]. Further non-binding instruments concerning the protection of the outer space environment from space debris were developed in the 2004 European Code of Conduct for Space Activities [20] which is applicable to projects of European space agencies, projects conducted in Europe, as well as by European entities outside Europe and to all space systems and launch vehicles orbiting or intended for orbiting the Earth. The 2014 ESA Space Debris Mitigation Policy for Agency Projects [67] is applicable to the procurement of all ESA space systems and all operations under the responsibility of ESA. Since 2010, in the framework of UNCOPUOS a specific working group has been dedicated to the long-term sustainability of outer space activities. The Working Group has been tasked with formulating guidelines aiming at the long-term sustainable use of outer space. Thereby, current practices, operating procedures, technical standards, and policies relevant to space sustainability are considered as the backdrop to the legal framework governing space activities. A set of “best practices” for long-term sustainability in outer space has been drafted [68,69] and the proposed guidelines are in the process of being finalized [70,71]. These guidelines are voluntary and include measures for, among others, sharing information on space objects and orbital events; conjunction assessment during all orbital phases of controlled flight; practical approaches for pre-launch assessment of possible conjunctions of newly launched space objects with space objects already present in near-Earth space; safety and security concerns for terrestrial infrastructure; criteria and procedures for the preparation and conduct of space activities aimed at the active removal of space objects from orbit; procedures and requirements for the safe conduct of operations resulting in the destruction of in-orbit space objects; criteria and procedures for the active removal of space objects and for the intentional destruction of space objects, specifically as applied to non-registered objects; risks associated with the uncontrolled re-entry of space objects; and measures of precaution when using sources of laser beams passing through outer space [72]. Summarizing, the Space Debris Mitigation Guidelines and other related instruments for the protection of the outer space environment from space debris depict environmentally relevant technical measures for future missions. As these instruments are not legally binding, they do not create rules of international law, the violation or non-observation of which would give rise to an international responsibility of states for creating or for not mitigating space debris. Thus, compliance with such measures is only of a voluntary nature and cannot be legally enforced. Another weakness of the mitigation guidelines, content-wise, is the fact that they do not impose very restrictive mitigation strategies, although the constant growth of space debris would require this. For example, it could be considered whether the 25-year rule is up to date in the backdrop of expected mega-constellations and the obvious reluctance of the international community to come up with binding rules on space debris mitigation. Nevertheless, these non-binding instruments do not fully lack relevance as they can serve as a model for the development of national space laws which impose concrete obligations for implementing mitigation measures on private space actors. Moreover, these instruments can also be seen as an expression of the willingness of the international community to formulate, even if only on a voluntary basis, certain technical standards for space activities in order to prevent the creation of space debris. Thus, they may serve as a basis for the development of a legal framework for space debris remediation. 3.3. Legal Avenues to Facilitate SDR One legal avenue to incorporate SDR mechanisms in the existing legal framework could be through national legislation. The example of space debris mitigation instruments being included in the national authorization requirements for space operators could serve as a model also for SDR. Some states, such as Argentina, Chile, the Netherlands, Poland, Spain and Switzerland have confirmed their adherence to the UNCOPUOS Guidelines. There are also states, such as Australia, Germany and Japan which have not enacted national legislation, but have elaborated state policies or standards for space debris mitigation for their national space agencies [25]. Furthermore, SDR and OOS measures could be implemented nationally as part of authorization or licensing requirements. This has already been the case with the national adherence to space debris mitigation guidelines. Thus, certain conditions can be prescribed to operators in space legislation: the legal basis for prescribing such conditions is Art VI of the OST which gives a “mandate” to states to authorize activities while, according to Art. IX of the OST, taking into account the activities of other states in outer space as per Art. IX.

#### Scenario 1: Solar Storms

#### Stable satellites are key to solving grid collapse from solar storms

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From the fabric of the global economy to families planning tonight’s dinner, communications networks — and the power grid that underlies them — are woven more tightly through our lives than ever before. But those networks all could be **gone in a flash**. A **geomagnetic storm** triggered by a **burst of solar energy** could overwhelm the nation’s power grid and shut down cell towers and communication networks. Similarly, a human-built electromagnetic pulse (EMP) weapon could temporarily wipe out the networks that connect and sustain us. This would be much worse than a power outage: Along with the lights, information itself would be blacked out. Experts are not taking this lightly. From **space-based research about the sun's energy** to new efforts that could safeguard power stations against an attack, science is fighting back to keep our connections open. Occasionally, the sun unleashes pent-up energy in the form of a solar flare or a coronal mass ejection (CME), which is a blast of plasma. **Satellite data** helps scientists **predict these solar eruptions**, but there are still plenty of questions about how the sun works; answering them would improve forecasts of space weather. Earth’s magnetic field protects us against the sun’s firehose of energy, but sometimes the sun overpowers the planet’s defenses. When that happens, solar radiation heats the upper atmosphere and charges it with electricity, which is what causes auroras at the northern and southern poles. When the coronal mass ejection arrives a day or so later, it interacts with and dramatically changes Earth’s magnetic field, explains Thomas Berger, a solar physicist in Boulder, Colo., home of NOAA’s Space Weather Prediction Center. The atmosphere’s uppermost layer is already warmer, and now it’s battling a cloud of plasma that creates currents in the atmosphere and on the ground. “That’s when the power grids start to feel things," Berger says. "When you create a giant current in the ionosphere, you also create currents in the ground. And the power grid is anchored in the Earth — grounded, as they call it. In the worst-case scenario, the CME would damage equipment, which would need to be replaced before you can bring power back to the grid.” Earth already experienced this worst-case scenario, but nobody alive today was there to see it. The 1859 Carrington Event was a geomagnetic storm triggered by an eruption of charged particles that streamed toward Earth. It was in the early days of telegraphs, well before countries were electrified. But particles from the sun were powerful enough to send a charge through telegraph lines that shocked operators and lit telegraph paper on fire. If this happened now without warning, **the results could be catastrophic**. Power plants, substations, and transmission lines for entire cities or regions could be fried. People might be without power for days or weeks, leading to food shortages and **untold crises**. The effects on the economy would also be devastating: Just one day without power in New York City could cost $1 billion, according to a 2013 report from the American Society of Civil Engineers. Across the federal government, at least 27 separate programs are working on ways to prevent this scenario. Power transformers are the backbone of the grid. Some transformers at power stations increase voltage so that it can be transmitted many miles, while others “step down” voltage so it can enter homes at safe levels. Large ones can take months to repair or rebuild, resulting in long-term blackouts, according to the Electric Power Research Group. In an emergency, federal agencies could set up temporary transformers to act as a stopgap, much like FEMA sets up temporary housing after disasters. The Department of Homeland Security has a Recovery Transformer program devoted to designing and building a type of easily deployable transformer that can be installed anywhere in an emergency. And the Department of Energy (DOE) is working on a “strategic transformer reserve” — a supply of extra transformers that can be trucked throughout America if necessary. Equipment to protect large power transformers costs about $350,000 per circuit, according to the Foundation for Resilient Societies. Safeguarding the grid against solar storms and EMPs would cost between $10 billion and $30 billion, the foundation says. Utilities are already working on solutions, says Rob Manning, vice president for transmission at the Electric Power Research Institute. Some are building capacitor banks, which could work like batteries to absorb and dissipate excess energy. Or they can install electricity-dampening devices called Faraday cages, which are like force fields that can surround critical pieces of equipment and protect them from currents. The DOE is also building better flywheels that can spin faster or slower depending on their charge. A flywheel could physically drain excess electricity off the grid, turning the sun’s electrons into movement and heat. Special dampening devices can also drain away or block excess current, but none of these is a perfect solution, Manning says. “There are some devices that will ground that current out and remove it from the system, but it creates some unintended consequences,” Manning says. “It’s like taking a drug that fixes a problem you might have, but it has unintended side effects.” **The best way to protect against solar storms is to forecast them in advance and shut down the grid before it's struck**. DHS has a Solar Storm Mitigation project that's designed to “enhance awareness of potential disruptions” caused by solar rays. Researchers are improving solar forecasts to provide at least a few hours of warning. The Deep Space Climate Observatory (DSCOVR) provides crucial data about the timing and speed of solar bursts, says NOAA’s Berger: “DSCOVR is really like a tsunami buoy.” And even better warning systems are coming. A new sun-orbiting satellite launching in 2018, called the Parker Solar Probe, will study the corona in unprecedented detail, providing new information about how the sun’s atmosphere gets so hot and spits out harmful CMEs. NOAA scientists are also working on a new satellite, unofficially called the Space Weather Follow-On Mission, that would study the sun’s magnetic fields — if it receives federal funding. Down on Earth, scientists are trying to understand the planet’s electrical conductivity, which would help them predict how surges of power from space would spread underground. But the sun isn’t the only source of danger to the grid. An EMP could wreak as much havoc on society as a traditional bomb blast, albeit with less loss of life. The casualties from an EMP would occur as a result of a lack of power, water, and medicine. The most ruinous type of EMP would come in the form of a high-altitude nuclear detonation, where it would create a series of blast waves radiating in all directions, impacting electrical equipment on the ground, in the air, and in orbit. A nuclear weapon detonated in the upper atmosphere over, say, Kansas, could affect the entire continental U.S., according to researchers at the Foundation for Resilient Societies. Just like a solar storm, an EMP would send raging currents into the electrical grid, frying transformers, circuit breakers, and substations. But scientists aren’t exactly sure what would happen to the vast range of devices on the grid, from cell towers to smartphones, Manning says. “It depends on where you are. Your cell phone might survive just fine, but the cell towers would not. So you would have a very nice calculator with a limited battery life,” Manning says. “We would expect some parts of the grid would suffer enough that we would experience voltage collapse, and you would expect blackouts. But there is the possibility that the grid may survive quite well, and the challenge may be more related to your cellphone, to home electronics, water systems, things like that.” Part of the challenge is understanding how transformers and circuit breakers would respond to the heat and high voltages of an EMP. If they’re exposed to extreme heat for just an instant, they might be fine, much the same way that people can quickly walk across hot coals without getting burned. But a longer-lasting flash would cause real damage. The Electric Power Research Institute is in the middle of a three-year study exploring these questions. The Department of Energy is also studying possible effects of high-energy EMPs. Odds are an EMP attack would be on a local scale, which means the grid would likely be fine overall, notes Scott Aaronson, senior director of national security policy at the Edison Electric Institute. There's no single point of failure in the country’s electrical system. The grid is somewhat of a misnomer because it’s really hundreds of independently operated utilities, each of which manages resources in its own way. Private industry owns 85 percent of the U.S.'s critical electrical infrastructure. “To incidents on a smaller scale, the grid is extraordinarily resilient," Aaronson says. "There are 50,000 substations, and hundreds of control centers. The failure of one, or even several of those, has very limited impact on the broader set of infrastructure.” He argues an EMP is less of a concern than everyday problems — from solar storms to Earth generated lightning, to the most mundane threats. “I can promise you, at this very minute there is a squirrel meeting his or her demise by chewing through a power line somewhere,” Aaronson says. "Your cell phone might survive just fine, but the cell towers would not. So you would have a very nice calculator with a limited battery life.” Others take a more dystopian view. In 2015, Peter Pry, executive director of the Electromagnetic Pulse Task Force on National Homeland Security, testified before Congress that prolonged damage to the grid could kill 90 percent of Americans, “through **starvation, disease, and societal collapse**.” The Department of Homeland Security considers space weather and power grid failure as “**significant risk events**.” Thomas Popik, chairman of the Foundation for Resilient Societies, testified last year before the Federal Energy Regulatory Commission that allocating 5 percent of the U.S. defense budget to infrastructure projects would help protect the grid and save lives. “If a densely populated area such as Washington, D.C. lost all electric power, and no outside assistance was available, and people could not evacuate by car because gasoline station pumps were inoperable due to lack of power, and municipal water and sanitation services stopped working, **what percent of the population would still be alive after one month?**” he questioned. Aaronson argues that this is “a fiction,” and that he finds himself in the middle. “I tend to view this as a threat that we need to prevent from happening in the first place,” he says. To that end, **space weather forecasting** — and international diplomacy — **are our best weapons in the fight to save the grid.**

#### AND space weather catastrophes ensure extinction

**Rosen, 16** (Julia Rosen is a science reporter for the Los Angeles Times with a PhD in geology, accessed on 10-20-2021, Science.org, 7-14-2016, “Here's how the world could end—and what we can do about it", https://www.science.org/content/article/here-s-how-world-could-end-and-what-we-can-do-about-it-rev2, HBisevac)

As end-of-humanity scenarios go, that bleak vision from Fritz Leiber’s 1951 short story “A Pail of Air” is a fairly remote possibility. Scholars who ponder such things think a self-induced catastrophe such as nuclear war or a bioengineered pandemic is most likely to do us in. However, a number of other extreme **natural hazards**—including threats from **space** and geologic upheavals here on Earth—could still **derail life** as we know it, **unraveling** advanced **civilization**, **wiping out billions** of people, or potentially even **exterminating** our species. Yet there’s been surprisingly little research on the subject, says Anders Sandberg, a catastrophe researcher at the University of Oxford’s Future of Humanity Institute in the United Kingdom. Last he checked, “there are more papers about dung beetle reproduction than human extinction,” he says. “We might have our priorities slightly wrong.” Frequent, moderately severe disasters such as earthquakes attract far more funding than low-probability apocalyptic ones. Prejudice may also be at work; for instance, scientists who pioneered studies of asteroid and comet impacts complained about confronting a pervasive “giggle factor.” Consciously or unconsciously, Sandberg says, many researchers consider catastrophic risks the province of fiction or fantasy—not serious science. A handful of researchers, however, persist in thinking the unthinkable. With enough **knowledge** and proper **planning**, they say, it’s possible to prepare for—or in some cases prevent—rare but **devastating** **natural disasters**. Giggle all you want, but the **survival** of human civilization could be **at stake**. Threat one: **Solar storms** One threat to civilization could come not from too little sun, as in Leiber’s story, but from too much. Bill Murtagh has seen how it might start. On the morning of 23 July 2012, he sat before a colorful array of screens at the National Oceanic and Atmospheric Administration’s Space Weather Prediction Center in Boulder, Colorado, watching twin clouds of energetic particles—known as a **coronal mass ejection (CME)**—erupt from the sun and barrel into space. A mere 19 hours later, the solar buckshot blazed past the spot where Earth had been just days before. If it had hit us, scientists say, we might still be reeling. Now the assistant director of space weather at the White House Office of Science and Technology Policy in Washington, D.C., Murtagh spends much of his time pondering solar eruptions. CMEs don’t harm human beings directly, and their effects can be spectacular. By funneling **charged particles** into Earth’s **magnetic field**, they can trigger **geomagnetic storms** that ignite dazzling auroral displays. But those storms can also induce dangerous electrical currents in long-distance power lines. The currents last only a few minutes, but they can **take out electrical grids** by destroying high-voltage transformers—particularly at high latitudes, where Earth’s magnetic field lines converge as they arc toward the surface. The worst CME event in recent history struck in 1989, frying a transformer in New Jersey and leaving 6 million people in Quebec province in Canada without power. The largest one on record—the Carrington Event of 1859, named after the U.K. astronomer who witnessed the accompanying solar flare—was up to 10 times more intense. It sent searing currents racing through telegraph cables, sparking fires and shocking operators, while the northern lights danced as far south as Cuba. “It was awesome,” says Patricia Reiff, a space physicist at Rice University in Houston, Texas. But if another storm that size struck today’s infrastructure, she says, “there would be tremendous consequences.” Some researchers fear that another Carrington-like event could destroy tens to hundreds of transformers, plunging vast portions of entire continents into the dark for weeks or months—perhaps even years, Murtagh says. That’s because the custom-built, house-sized replacement transformers can’t be bought off the shelf. Transformer manufacturers maintain that such fears are overblown and that most equipment would survive. But Thomas Overbye, an electrical engineer at the University of Illinois, Urbana-Champaign, says nobody knows for sure. “We don’t have a lot of data associated with large storms because they are very rare,” he says. What’s clear is that **widespread blackouts** could be **catastrophic**, especially in countries that depend on highly developed electrical grids. “We’ve done a marvelous job creating a **great vulnerability** to this threat,” Murtagh says. Information technologies, fuel pipelines, water pumps, ATMs, everything with a plug would be **rendered useless**. “That’s going to affect our ability to govern the country,” Murtagh says.

#### Scenario 2: Miscalc

#### Debris triggers miscalculated war.

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

The increasingly crowded space in Earth's low orbit could set the stage for an international armed conflict, says a new study. Researchers from the Russian Academy of Sciences warn that accidents stemming from the steady rise in space junk floating around the planet could incite political rows and even warfare, with nations potentially mistaking debris-caused incidents as the results of intentional aggressive acts by others. In a paper published in Acta Astronautica, the team suggests that space debris in the form of spent rocket parts and other fragments of hardware hurtling at high speed pose a "special political danger" that could dangerously escalate tensions between nations. According to the study, destructive impacts caused by random space junk cannot easily be told apart from military attacks. "The owner of the impacted and destroyed satellite can hardly quickly determine the real cause of the accident," the authors write. The risks of such an event occurring are compounded by the sheer volume of debris now orbiting Earth. Recent figures from NASA indicate that there are more than 500,000 pieces of space junk currently being tracked in orbit, travelling at speeds up to 28,160 km/h (17,500 mph). The majority of those objects are small – around the size of a marble – but some 20,000 of them are bigger than a softball. In addition to these 500,000 or so fragments – which are big enough for scientists to know about them – NASA estimates that there are millions of undetectable pieces of debris in orbit that are too small to be monitored. But even extremely small fragments such as these pose a threat – in fact, they're considered a greater risk than trackable debris, as their invisible status means spacecraft and satellites can't do anything to avoid them until it's too late. As NASA observed in 2013: "Even tiny paint flecks can damage a spacecraft when travelling at these velocities. In fact a number of space shuttle windows have been replaced because of damage caused by material that was analysed and shown to be paint flecks… With so much orbital debris, there have been surprisingly few disastrous collisions." While we may have been lucky in the past, we can't rely on that to continue. The study by the Russian team cites the repeated sudden failures of defence satellites in past decades that were never explained. The researchers attribute two possible causes: either unrecorded collisions with space junk, or aggressive actions from adversaries. "This is a politically dangerous dilemma," the authors write.

#### **It goes nuclear.**

Johnson 14 – **(**Les Johnson is a Baen science fiction author, popular science writer, and NASA technologist. 2014, “Living without satellites” <https://www.baen.com/living_without_satellites>)

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

### Framing

#### Util :

#### Its good ---

#### 1] Effective debate necessitates primary focus on material violence— anything else ignores oppression.

Dr. Tommy J. Curry 14, [Dr. Curry is a Prof of Philosophy at Texas A&M University, Ray A. Rothrock Fellow 13'-16' and currently the USC Shoah Foundation 2016-17 A.I. and Manet Schepps Foundation Teaching Fellow, first Black JV National Debate champion (for UMKC) and half of the first all-Black CEDA team to win Pi Kappa Delta] 2014, “The Cost of a Thing: A Kingian Reformulation of a Living Wage Argument in the 21st Century,” <http://www.academia.edu/9798210/The_Cost_of_a_Thing_A_Kingian_Reformulation_of_a_Living_Wage_Argument_in_the_21st_Century> \*\*Brackets in original

Despite the pronouncement of debate as an activity and intellectual exercise pointing to the real-world consequences of dialogue, thinking, and (personal) politics when addressing issues of racism, sexism, economic disparity, global conflicts, and death, many of the discussions concerning these ongoing challenges to humanity are fixed to a paradigm which sees the adjudication of material disparities and sociological realities as the conquest of one ideal theory over the other. In “Ideal Theory as Ideology,” Charles Mills outlines the problem contemporary theoretical-performance styles in policy debate and value-weighing in Lincoln-Douglass are confronted with in their attempts to get at the concrete problems in our societies. At the outset, Mills concedes that “ideal theory applies to moral theory as a whole (at least to normative ethics as against metaethics); [s]ince ethics deals by definition with normative/prescriptive/evaluative issues, [it is set] against factual/descriptive issues.” At the most general level, the conceptual chasm between what emerges as actual problems in the world (e.g.: racism, sexism, poverty, disease, etc.) and how we frame such problems theoretically—the assumptions and shared ideologies we depend upon for our problems to be heard and accepted as a worthy “problem” by an audience—is the most obvious call for an anti-ethical paradigm, since such a paradigm insists on the actual as the basis of what can be considered normatively. Mills, however, describes this chasm as a problem of an ideal-as-descriptive model which argues that for any actual-empirical-observable social phenomenon (P), an ideal of (P) is necessarily a representation of that phenomenon. In the idealization of a social phenomenon (P), one “necessarily has to abstract away from certain features” of (P) that is observed before abstraction occurs. This gap between what is actual (in the world), and what is represented by theories and politics of debaters proposed in rounds threatens any real discussions about the concrete nature of oppression and the racist economic structures which necessitate tangible policies and reorienting changes in our value orientations. As Mills states: “What distinguishes ideal theory is the reliance on idealization to the exclusion, or at least marginalization, of the actual,” so what we are seeking to resolve on the basis of “thought” is in fact incomplete, incorrect, or ultimately irrelevant to the actual problems which our “theories” seek to address. Our attempts to situate social disparity cannot simply appeal to the ontologization of social phenomenon—meaning we cannot suggest that the various complexities of social problems (which are constantly emerging and undisclosed beyond the effects we observe) are totalizable by any one set of theories within an ideological frame be it our most cherished notions of Afro-pessimism, feminism, Marxism, or the like. At best, theoretical endorsements make us aware of sets of actions to address ever developing problems in our empirical world, but even this awareness does not command us to only do X, but rather do X and the other ideas which compliment the material conditions addressed by the action X. As a whole, debate (policy and LD) neglects the need to do X in order to remedy our cast-away-ness among our ideological tendencies and politics.’ How then do we pull ourselves from this seeming ir-recoverability of thought in general and in our endorsement of socially actualizable values like that of the living wage? It is my position that Dr. Martin Luther King Jr.’s thinking about the need for a living wage was a unique, and remains an underappreciated, resource in our attempts to impose value reorientation (be it through critique or normative gestures) upon the actual world. In other words, King aims to reformulate the values which deny the legitimacy of the living wage, and those values predicated on the flawed views of the worker, Blacks, and the colonized (dignity, justice, fairness, rights, etc.) used to currently justify the living wages in under our contemporary moral parameters.

#### 2] Actor spec—

#### a. governments have to aggregate since all collective actions incur tradeoffs that help some and hurt other, means based side constraints freeze action.

#### b. no intent foresight distinction— governments can’t have intent since they’re made up of multiple actors with separate motivations, ie some congress people might vote for something to gain votes while other actually think the bill is good.

#### Takes out and turns calc indicts, consequentialism might be hard but it’s not impossible, and the alternative is no action which is worse; and actor spec outweighs since different actors have different ethical standings.

#### 3] Weighability— only consequentialism explains degrees of wrongness— you can only explain why breaking a promise to take a dying person to the hospital is worse than breaking a promise to meet for lunch by appealing to consequences.