## COPUOS CP

### Shell

#### Text: The United Nations Committee on the Peaceful Uses of Outer Space (COPUOS)’s Legal Subcommittee ought to do (the aff)

#### Normal means for treaties involves solely the signatory countries

Berkeley Law Library 16

Berkeley Law (It’s the handbook from the Berkeley law library, just a basic definition), 2016-2-23 (date from source code), "Treaties and International Agreements," Berkeley Law Library, https://www.law.berkeley.edu/library/guide.php?id=65, // HW AW

Treaties can be referred to by a number of different names: international conventions, international agreements, covenants, final acts, charters, protocols, pacts, accords, and constitutions for international organizations. Usually these different names have no legal significance in international law. **Treaties may be bilateral (two parties) or multilateral (between several parties) and a treaty is usually only binding on the parties to the agreement.** An agreement "enters into force" when the terms for entry into force as specified in the agreement are met. Bilateral treaties usually enter into force when both parties agree to be bound as of a certain date.

#### The CP competes off of actor spec – they had complete control over how and who implements the aff, especially in this topic since the actor was not specified in the resolution. The actor is a key, debatable element and a change poses an opportunity cost, which is sufficient for competition.

#### COPUOS has jurisdiction and has passed treaties on similar topics in the past

UNOOSA

UNOOSA (united nations outer space committee), 2021 (no date but written about the 2021 conference), "COPUOS 2021 Session," UNOOSA, <https://www.unoosa.org/oosa/en/ourwork/copuos/index.html> // HW AW

The Committee on the Peaceful Uses of Outer Space (COPUOS) was set up by the General Assembly in 1959 to govern the exploration and use of space for the benefit of all humanity: for peace, security and development. The Committee was tasked with reviewing international cooperation in peaceful uses of outer space, studying space-related activities that could be undertaken by the United Nations, encouraging space research programmes, and **studying legal problems arising from the exploration of outer space**. The Committee was **instrumental in the creation of the five treaties and five principles of outer space**. International cooperation in space exploration and the use of space technology applications to meet global development goals are discussed in the Committee every year. Owing to rapid advances in space technology, the space agenda is constantly evolving. The Committee therefore provides a unique platform at the global level to monitor and discuss these developments. The Committee has two subsidiary bodies: the [Scientific and Technical Subcommittee](https://www.unoosa.org/oosa/en/ourwork/copuos/stsc/2020/index.html), and the [Legal Subcommittee](https://www.unoosa.org/oosa/en/ourwork/copuos/lsc/2019/index.html), both established in 1961. The Committee reports to the [Fourth Committee of the General Assembly](http://www.un.org/en/ga/fourth/), which adopts an annual resolution on international cooperation in the peaceful uses of outer space.

#### **COPUOS is losing legitimacy due to an inability to reach consensus and thereby pass policies – the plan restores faith, discourages weak agreements, solves space debris, sustainability, and security issues**

Masson-Zwaan 19

Tanja Masson-Zwaan (deputy director of institute of air and space at Leiden University), 2019, "SYNOPSIS ON THE NEW SPACE RACE: NEW STATES IN SPACE " Cambridge, https://www.cambridge.org/core/services/aop-cambridge-core/content/view/E68383DE71B60A711EE1E4578CA303A8/S2398772319000138a.pdf/new\_states\_in\_space.pdf, // HW AW

The “old” space race started in 1957 and involved mainly the United States and the Soviet Union. These states led the development of the initial international agreements adopted in the framework of the UN Committee on the Peaceful Uses of Outer Space (COPUOS).1 Within less than two decades, between 1967 and 1984, five international treaties were adopted and entered into force.2 At the time, COPUOS had less than twenty-five member states and agreement was reached relatively easily. Gradually, the group of space actors grew, but space activity remained state-centered and involved a relatively small number of states, while private-entity involvement was mostly limited to the telecommunication sector in the United States. Today, the landscape is entirely different. Not only are more and more states interested and involved in exploring and using outer space, but private entities also have entered the scene, and the trend of privatization and commercialization of space activities is expected to gain more speed in years to come. As the number of states active—or wishing to become active—in outer space has grown, so has the membership of COPUOS, which today counts nearly ninety states.3 It has thus **become more difficult to reach consensus, which has been the working method of COPUOS from the start**. As a consequence of the growing number and diversity of stakeholders, in recent decades the **agreements among states about the use and exploration of outer space have taken the form of principles and other UN resolutions, rather than legally binding treaties**. At the same time, a growing number of new topics require states’ attention. With constant advances in technology, new capacities and activities emerge at high speed, such as ever-smaller satellites, large constellations of hundreds or even thousands of satellites, the prospect of suborbital flights, reusable launch vehicles, on-orbit servicing, and the use of resources from asteroids or the Moon. These developments were not foreseen in the early days of space exploration. Although the UN space treaties and resolutions provide the basic legal framework, some form of further elaboration is now needed to provide clear and predictable standards to govern these new activities. Issues such as the continuing congestion of outer space, the problems related to the mitigation and remediation of space debris, the long-term sustainability of space activities, space traffic management, space situational awareness, and the security of critical space infrastructure will also increasingly require the attention of the international community of states. In this changed landscape with new states, private entities, new activities, and new concerns, it is useful to look at how emerging space nations view the rules that were laid down in the past, the issues that will require regulation in the future, and whether there are any special concerns that influence their positions.4 The main principles of international space law are embodied in the Outer Space Treaty of 1967 (OST). The treaty has been widely adopted and states have consistently acted in accordance with its principles.5 In addition, states have not publicly contested those principles, proposed amendments, or withdrawn from the treaty. Thus, at least parts of the treaty could be considered to have reached the status of customary international law, meaning that they are binding on all states, including nonparties. The following sections highlight principles that are not likely to be contentious for new space states and then identify current principles and future issues that may raise more concerns.

#### Revitalizing COPUOS solves great power space conflict – it is the single organization that has enough member states, legitimacy, and empirical success to ensure peace – it stopped the first space race, it can do it again

McMillan 7-14-21

Anne Mcmillan (journalist trained in law, chai tea enthusiast), 7-14-2021, "The final frontier – 21st century space race," International Bar Association, <https://www.ibanet.org/the-final-frontier> , // HW AW

As far as international oversight is concerned, the UN Committee on the Peaceful Uses of Outer Space (COPUOS) is the main forum governing the exploration and use of space. But it has failed to achieve an agreement on the interpretation of the broad concepts outlined in the OST, and legal developments since 1979 have been in the form of soft law guidelines and principles. Perhaps multinational initiatives led by individual states, such as the recent US-sponsored Artemis Accords, signal an alternative route. These envisage a series of bilateral agreements between the US and individual countries in the context of planned future exploration of the Moon, Mars, comets and asteroids. Nacimiento thinks such initiatives could help to develop space law. ‘There is some indication that international space law may develop in a different form, meaning not necessarily within the United Nations Committee on the Peaceful Uses of Outer Space and via multilateral international treaties. The Artemis Accords signed in October 2020 are one very recent example of how space law could develop in the future.’ However, not all states support the US-led initiative and so far the Artemis accords have only been signed by eight countries. Predictably China and Russia are prominent critics, objecting in particular to a suggestion in Artemis to create ‘safety zones’ around national lunar exploration sites, arguing that this amounts to a creeping claim of sovereignty. Nacimiento concedes that the provision for such zones under Artemis ‘could be in conflict with existing international law prohibiting any form of national appropriation of celestial bodies. It remains to be seen how these Accords work in practice and if they develop into generally recognized principles of cooperation.’ Although much of Artemis reflects existing international law, its future is likely to depend on as much as law itself. The mere fact that the process is led by the US seems to have stoked the fires of competing states, with the head of Russia’s space agency dubbing it ‘too US-centric’. Consequently, China and Russia signed an agreement this year to set up a rival system for exploration of the Moon, planning to establish a joint ‘International Lunar Research Station’. This, like the US-led effort, seeks to attract international partners. Monthly number of objects in Earth orbit by object type As China-Russia cooperation increases, Russia-US cooperation is waning. For many years the International Space Station has been a beacon for international cooperation in space, notably as a forum for detente between Russia and the US. However, it will eventually be de-orbited, possibly as soon as 2024, and with its demise will go a touchstone of cooperation between historical rivals. Clearly, events in space exploration have moved on since the 1967 OST which reduced tensions between Russia and the US. But now, with China as a significant new player, we seem to be witnessing a reignition of the space race. ‘The UN, notably its COPUOS, is still the best forum for all discussions on where the OST and the rest of the framework might need further elaboration, interpretation and implementation, comprising basically all the spacefaring nations,’ says von der Dunk. Based on experience, are international bodies helping to reduce friction in space?

## Restaurant DA

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#### Restaurant package coming now, but floor time is key and in short supply

Mcpherson 1-15-22

Lindsey Mcpherson, (Senior reporter [@rollcall](https://twitter.com/rollcall) covering House and Senate legislative maneuvering. ), jan 15 2022, "Restaurants could get another $40 billion financial lifeline," press reader, https://www.pressreader.com/usa/rome-news-tribune/20220115/282372632976658, // HW AW

WASHINGTON — A bipar­tisan Sen­ate group is nego­ti­at­ing a bill to provide about $40 bil­lion in fresh fund­ing for pan­demic-battered res­taur­ants, Sen­ate Small Busi­ness Chair­man Ben­jamin L. Cardin said Wed­nes­day. While the details aren’t final, the Mary­land Demo­crat told report­ers that sen­at­ors are con­sid­er­ing an aid pack­age for strug­gling busi­nesses that could more than double the amount of pan­demic aid funneled to res­taur­ants, bars and oth­ers in the food ser­vice industry. “It’s pretty urgent to get done,” Cardin told report­ers. “**The prob­lem is floor time** and how do you get to it, and also mak­ing sure we have adequate bipar­tisan sup­port.” “It’s pretty urgent to get done,” Cardin told report­ers. “The prob­lem is floor time and how do you get to it, and also mak­ing sure we have adequate bipar­tisan sup­port.” The res­taur­ant industry has been clam­or­ing for more fed­eral aid since burn­ing through $28.6 bil­lion Con­gress provided as part of a pan­demic relief pack­age last year. Only about a third of the res­taur­ants that applied for aid last year received a grant under the Res­taur­ant Revital­iz­a­tion Fund, leav­ing nearly 200,000 res­taur­ants and bars strug­gling to stay afloat without aid. More than 90,000 res­taur­ants and bars nation­wide have closed since the begin­ning of the pan­demic and **more than 86% of own­ers say they may close if they don’t receive a grant,** accord­ing to a recent sur­vey from the Inde­pend­ent Res­taur­ant Coali­tion. Law­makers of both parties intro­duced vari­ous bills last year offer­ing up to $120 bil­lion for res­taur­ant aid, But none gained enough trac­tion to win a floor vote in either cham­ber. Cardin intro­duced a bill last sum­mer that would have provided $48 bil­lion in addi­tional Relief. Cardin declined to give many details about the dis­cus­sions but said $40 bil­lion is the ball­park fig­ure law­makers have dis­cussed for new res­taur­ant aid. He said the new pack­age would include aid to other busi­nesses, includ­ing live enter­tain­ment ven­ues and gyms. “We are look­ing bey­ond just res­taur­ants,” he said, while declin­ing to offer a price tag for the entire pack­age. The Com­munity Gyms Coali­tion poin­ted out in a state­ment Wed­nes­day that gyms and fit­ness stu­dios haven’t got­ten any fed­eral relief, unlike res­taur­ants and live enter­tain­ment ven­ues. “Small gyms are con­tinu­ing to suf­fer dis­pro­por­tion­ately from the pan­demic,” the coali­tion said. “We are count­ing on both Con­gress and the Biden admin­is­tra­tion to move quickly to save tens of thou­sands of gyms and fit­ness stu­dios across the coun­try.” “Mis­sis­sippi Sen. Roger Wicker, Cardin’s chief Repub­lican part­ner in the new effort, declined to com­ment Wed­nes­day. “There’s one issue and one issue only I’m talk­ing about this week, and that’s sav­ing the Sen­ate from attack on 200 years of tra­di­tion,” he said, refer­ring to the upcom­ing fight over the Sen­ate’s fili­buster rule relat­ing to vot­ing rights legis­la­tion. Cardin wouldn’t say what legis­lat­ive vehicle would be used, whether a stand-alone bill or as part of a lar­ger spend­ing pack­age. Law­makers are con­sid­er­ing attach­ing pan­demic-related aid such as more money for test­ing, vac­cine dis­tri­bu­tion and school ret­ro­fits in an omni­bus fiscal 2022 appro­pri­ations bill. **“We are mak­ing a lot of pro­gress,” Cardin said. “The ques­tion is, how will it come to the floor?”**

#### The plan is a political firestorm---regulating private space is unpopular---lawmakers want to encourage private space industries to encourage innovation and avoid government liability.

Loren Grush 15, science reporter for The Verge, the technology and culture brand from Vox Media, where she specializes in news about Space and Space law, 2015, “Private space companies avoid FAA oversight again, with Congress' blessing,” https://www.theverge.com/2015/11/16/9744298/private-space-government-regulation-spacex-asteroid-mining

The Senate passed the bill [H.R. 2262](https://www.congress.gov/bill/114th-congress/house-bill/2262), also known as the US Commercial Space Launch Competitiveness Act, last week, and both the House and the Senate have expressed support for it. House Majority Leader Kevin McCarthy has [scheduled the bill for final approval this afternoon](http://www.majorityleader.gov/floor/#daily). After it passes, it goes to the president for his official signature. PRIVATE SPACE TRAVEL IS STILL CONSIDERED YOUNG Many prominent commercial space companies — including SpaceX, Blue Origin, and Virgin Galactic — [have applauded H.R. 2262](https://science.house.gov/sites/republicans.science.house.gov/files/documents/FINAL%20WTS_SPACE%20Act%20of%202015.pdf). The legislation means that private space travel is still considered young, and lawmakers have given the industry more time to experiment and gather data."It allows the industry to grow, to test, and to develop without this overshadow of the regulatory hammer coming down on them," Eric Stallmer, president of the Commercial Spaceflight Federation, a non-profit aimed at promoting commercial spaceflight development, told *The Verge*. It also means that people participating in private spaceflight do so at their own risks, and there are no government regulations in place specifically to keep them safe. Space travel isn’t that safe, of course; nearly 1 in 10 rockets fail, though most vehicles that go into space these days don’t have crew members on board. The FAA is concerned about the spacecraft that will carry people, though, which is why the agency doesn’t seem supportive of the learning period extension. In February of 2014, George Nield, head of the FAA Office of Commercial Space Transportation, [testified before the House Subcommittee on Space](http://docs.house.gov/meetings/SY/SY16/20140204/101703/HHRG-113-SY16-Wstate-NieldG-20140204.pdf) that he thinks it's time for the period to expire. Nield said he understands that many in the industry fear overregulation by the FAA, but that his office is more concerned with ensuring crew safety than issuing "burdensome" standards. "We want to enable safe and successful commercial operations," he testified. REGULATORY LEARNING PERIOD The advent of private spaceflight began in the 1960s, but the industry has only started growing rapidly this decade. To address this expansion, Congress passed the Commercial Space Launch Amendments Act in 2004. It granted the private sector a "learning period" free of regulation. The learning period was set to expire in December 2012 but was granted two short extensions. H.R. 2262 will extend the period for a further eight years, through September 30th, 2023. THE FAA STILL HAS SOME AUTHORITY TO REGULATE THE COMMERCIAL SECTOR During the learning period, the FAA still has some authority to regulate the commercial sector. The agency is responsible for issuing licenses for rocket launches and for vehicles re-entering Earth's atmosphere. The agency’s main concern is to ensure that launch vehicles aren’t immediate threats to the uninvolved public and property. Under this legislation, the FAA is restricted from issuing licenses specifically pertaining to the safety of a spacecraft's crew or passengers. Right now, people who participate in commercial spaceflight do so through "informed consent" — meaning they know that they're partaking in an endeavor that could [easily kill them](http://www.popsci.com/article/technology/virgin-galactic-crash-may-lead-new-regulations-private-spaceflight). Before these participants can fly, they must sign a document that says spaceflight is inherently dangerous and they understand the risks associated with it. The end of the learning period would allow the FAA to issue standards related to crew safety — but it also means the agency could issue standards for anything else in relation to commercial spaceflight. For example, the agency could dictate specifically how engines or vehicles should be designed and built, similar to how the FAA oversees the commercial aviation industry. *NTSB investigators stand next to the crash site of SpaceShipTwo. (NTSB)* The FAA hasn't expressed interest in doing this, but Nield noted in his 2014 testimony that the agency wants to regulate spaceflight activities that take place in orbit; for instance, the FAA wants to issue standards for collision avoidance. The agency also hinted it might try to regulate commercial crew safety following last year's Virgin Galactic crash, in which a pilot was killed during a test flight of the company's SpaceShipTwo vehicle. The initial regulatory learning period allowed the FAA to issue regulations in direct response to a serious commercial space travel accident, and the SpaceShipTwo crash was the first commercial flight to result in a fatality. [The FAA told *Bloomberg*](http://www.bloomberg.com/news/articles/2014-11-07/should-space-travel-be-like-climbing-everest-or-airlines-) that the agency may want additional regulations following an accident investigation, without saying what those might entail. H.R. 2262 still maintains the FAA's ability to issue regulations in the event of a fatal accident, however those regulations must specifically address the accident itself and wouldn't apply to the entire industry. Stallmer, of the Commercial Spaceflight Federation, argued that there will be a time when more regulations are needed — after this learning period is over, without saying when that would be. He hopes that any new standards will stem from extensive dialogue between the government and commercial sectors, as companies continue to learn more about the business of rocket science. "And as the industry grows, we’ll have the knowledge we need so we can eventually have efficient and common sense regulations," said Stallmer. SPACE STATION AND ASTEROID MINING *The International Space Station (NASA)* H.R. 2262 also issues a number of other key provisions, [which can be found here](http://www.gpo.gov/fdsys/pkg/BILLS-114hr2262eas/pdf/BILLS-114hr2262eas.pdf). For one, the bill officially extends operations of the International Space Station through 2024. President Obama had already approved this ISS extension, but Congress must sign off on it in order for it to be final. "A new president could come and say, 'To hell with this space station,'" said Stallmer. "This puts into law that the space station will continue to be a national laboratory." And then there’s the asteroid mining. Under one provision of H.R. 2262 called the Space Resource Exploration and Utilization Act of 2015, commercial companies get the rights to any resources that they collect from celestial bodies. The provision is important for companies like the asteroid mining company Planetary Resources, which recently partnered with Virgin Galactic. "Now, if you go out somewhere in space and you pick [something] up, it’s yours," said Chris Lewicki, the president and chief engineer of Planetary Resources. "IF YOU GO OUT SOMEWHERE IN SPACE AND YOU PICK [SOMETHING] UP, IT’S YOURS." The bill mostly refines what was originally laid out in the Outer Space Treaty, a document signed by 104 companies in 1967 that eventually became the basis for international space law. The treaty forbids anyone from claiming asteroids or planets as new government territories, but it does grant non-government entities the rights "explore and use" outer space. That means companies can go collect any space materials they can find and bring back home with them. Now, H.R. 2262 guarantees that they will own those materials.

#### Restaurants failing means collapse of the economy – it takes other sectors down with it

CAEDC 21

Cumberland Area Economic Development Corporation, (a company which decides which parts of the economy are most important. They have a bunch of articles about what different sectors mean to the economy), 4-1-2021, "The Importance of Restaurants to Local Community," https://cumberlandbusiness.com/news/the-importance-of-restaurants-to-local-community/, // HW AW

The Importance of Restaurants to Local Community In an increasingly complicated economic reality, restaurants are a stronghold of local communities. The restaurant industry fosters regional job growth, supports [local agriculture](https://cumberlandbusiness.com/news/the-importance-of-agribusiness/) and keeps your hard-earned money in your community. When you choose to shop or dine at a local business or restaurant, you generate almost four times more economic benefits for your local community. Choose a local restaurant and make memories while supporting your hometown’s economic development. Local restaurants are an impactful gathering place for communities, where relationships form and memories are made. They preserve agriculture and recipes from generation to generation and are the lifeblood of regional food culture. When you choose to dine at a local restaurant, you invest your money right back into the hands of your community and preserve local recipes and agriculture. The benefits of a restaurant don’t end there, either. Local eateries have a big impact on all of the following factors. Local Taxes **Approximately 10% of America’s economy is affected by the restaurant industry alone, which is a massive financial power**. When you choose to support local restaurants, you’re putting those funds toward strengthening your hometown. Eating at local restaurants allows them to stay open and thrive in your area. As a result, the restaurants’ tax revenue will benefit your local economy. Local Jobs Restaurants are an industry that is continually hiring and creating new jobs. **The restaurant industry employs as much as 10% of the American workforce,** so spending your money at a local restaurant goes straight into feeding members of your community. The restaurant industry is also currently creating new middle-class jobs at three times the growth of any other industry. Local restaurants are **community cornerstones where many young people get their first jobs and where adults begin fulfilling careers**. Agriculture As food becomes more mass-produced and imported from other countries, local varieties of produce begin dying out and the American agriculture sector takes a hit. Local restaurants promote regional produce production and help farms near you. Eating at a local restaurant gives you the opportunity to taste the most delicious ingredients your area has to offer. Local restaurants may even switch out their menus regularly to highlight seasonal produce.

#### Economic decline causes global nuclear war

Stein Tønnesson 15, Research Professor, Peace Research Institute Oslo; Leader of East Asia Peace program, Uppsala University, 2015, “Deterrence, interdependence and Sino–US peace,” International Area Studies Review, Vol. 18, No. 3, p. 297-311

Several recent works on China and Sino–US relations have made substantial contributions to the current understanding of how and under what circumstances a combination of nuclear deterrence and economic interdependence may reduce the risk of war between major powers. At least four conclusions can be drawn from the review above: first, those who say that interdependence may both inhibit and drive conflict are right. Interdependence raises the cost of conflict for all sides but asymmetrical or unbalanced dependencies and negative trade expectations may generate tensions leading to trade wars among inter-dependent states that in turn increase the risk of military conflict (Copeland, 2015: 1, 14, 437; Roach, 2014). The risk may increase if one of the interdependent countries is governed by an inward-looking socio-economic coalition (Solingen, 2015); second, the risk of war between China and the US should not just be analysed bilaterally but include their allies and partners. Third party countries could drag China or the US into confrontation; third, in this context it is of some comfort that the three main economic powers in Northeast Asia (China, Japan and South Korea) are all deeply integrated economically through production networks within a global system of trade and finance (Ravenhill, 2014; Yoshimatsu, 2014: 576); and fourth, decisions for war and peace are taken by very few people, who act on the basis of their future expectations. International relations theory must be supplemented by foreign policy analysis in order to assess the value attributed by national decision-makers to economic development and their assessments of risks and opportunities. If leaders on either side of the Atlantic begin to seriously fear or anticipate their own nation’s decline then they may blame this on external dependence, appeal to anti-foreign sentiments, contemplate the use of force to gain respect or credibility, adopt protectionist policies, and ultimately refuse to be deterred by either nuclear arms or prospects of socioeconomic calamities. Such a dangerous shift could happen abruptly, i.e. under the instigation of actions by a third party – or against a third party. Yet as long as there is both nuclear deterrence and interdependence, the tensions in East Asia are unlikely to escalate to war. As Chan (2013) says, all states in the region are aware that they cannot count on support from either China or the US if they make provocative moves. The greatest risk is not that a territorial dispute leads to war under present circumstances but that changes in the world economy alter those circumstances in ways that render inter-state peace more precarious. If China and the US fail to rebalance their financial and trading relations (Roach, 2014) then a trade war could result, interrupting transnational production networks, provoking social distress, and exacerbating nationalist emotions. This could have unforeseen consequences in the field of security, with nuclear deterrence remaining the only factor to protect the world from Armageddon, and unreliably so. Deterrence could lose its credibility: one of the two great powers might gamble that the other yield in a cyber-war or conventional limited war, or third party countries might engage in conflict with each other, with a view to obliging Washington or Beijing to intervene.

## Moon Mines CP

#### CP text: Governments ought to

#### collaborate with private entities in lunar plant research and appropriation

#### institute law for property ownership in outer space

#### implement a phased approach to mining

#### Healthy competition between companies is a necessity for lunar research and new property ownership laws ensure sustainable and safe mining

Kornuta et. al 19

David Kornuta (project coordinator at United Launch Alliance) et. al (see [the publication](https://www.sciencedirect.com/science/article/abs/pii/S2352309318300099#!)); “Recommendations”, *Commercial lunar propellant architecture: A collaborative study of lunar propellant production*; *Aerospace Engineering*, University of Illinois; 2019; <https://experts.illinois.edu/en/publications/commercial-lunar-propellant-architecture-a-collaborative-study-of>; HW-EMJ

Recommendations146 For Government230 In order to establish a successful lunar propellant plant and fully realize all of its associated benefits requires private and government collaboration. The combined strengths of these players can be leveraged to create the healthiest and most sustainable space endeavor ever undertaken. A freely competed commercial propellant plant employing the US industrial base supported by PPP with Congress, NASA, DARPA, and other US government agencies represents humanities most capable partnership for propelling Earth based economies into the expanses of space. The following section will outline some of the fundamental roles that the US government should take to create this lasting space capability. The challenge is finding ways for the USG to encourage and stimulate the development of a commercial economy without managing it as a common economy. The role of NASA should include providing scientific exploration of the Permanently Shadowed Regions (PSR) of the Moon, assisting in developing early stage technologies and serving as an anchor customer of in-space propellant by proposing a price, quantity, and location of use. US government laboratories should assist in the development of required technology by providing support to commercial companies. Both NASA and other US government laboratories can also help facilitate demonstrations including fully Integrated System Tests (IST)s of a pilot plant. Finally, Congress should play a pivotal role in the creation of regulation and law that is enabling for a Commercial Lunar Propellant Architecture. All of these recommendations are discussed in more detail in the following sub-sections. Develop Precursor “Prospecting” Missions231 Prospecting (or scientific exploration) of the lunar polar regions is critical to building the foundation for a commercial lunar propellant plant. In addition to quantifying the abundance and concentration of the water ice deposits, there is a need to understand the environment as well. The designs of the extraction and transport systems are highly dependent on knowing what conditions actually exist at the mining site. The focal areas for precursor prospecting missions to explore should be: 1. Resource-related properties. We know from the Clementine, LCROSS, Chandrayaan-1, and LRO data232 that there is water ice in significant quantities in lunar polar craters. What is unknown is the distribution of water there, how deep it goes, and how well the regolith conducts heat (which would help with getting heat down to ice deeper in the regolith). 2. The surface environment. In order to transport equipment around to build the site, as well as transporting the product around, it is important to get more details on surface conditions, such as: how firm or soft is the surface; how easily is dust stirred up; what sizes of obstacles are likely to be encountered. 3. Stability. The surface of the Moon is not static. Micrometeorite impacts are frequent enough to create a small but measurable dust content233. Regolith on the sloping crater walls might collapse periodically similar to avalanches—especially with the increased vibrations coming from construction and transport activities. These conditions need to be assessed to design a safe facility, manage the dust problem, and include adequate protection from micrometeorite impact. The detailed recommendations for lunar volatile prospecting have been addressed in the CSM publication that was developed during the 2018 Space Resources Roundtable workshop. These recommendations can be found in the Lunar Polar Prospecting Workshop: Findings and Recommendations [172]234. Develop Prototype Pilot Plant on Earth235 The commercial lunar propellant plant will require a multi-billion-dollar capital investment. One-step in attracting this level of investment and proving the technology might be a smaller, lower-cost pilot plant on Earth. Given how a plant would have to be customized for lunar operations (modularization, weight reduction, safety, redundancy, and sparing, robotic assembly) a pilot plant would have a very positive impact on risk reduction and investor confidence. Most of the robotic operations could be demonstrated on Earth. Once the properties of the resource on the Moon were measured, extraction operations could be performed separately in a cryogenic vacuum chamber. It might also be desirable to install a pilot plant on the Moon itself, prior to starting construction of the industrial-scale commercial production facility. Institute Public Private Partnership236 We believe the establishment of a lunar ice mining operation is a great opportunity for a PPP. As was the case with NASA’s Commercial Orbital Transportation Services (COTS) program, all the elements for success are present. "Significant cost reductions from the norm of cost-plus contracting are possible for new space system elements in NASA’s exploration scenarios. ... There is no basis to conclude that public private partnerships end at low Earth orbit, prohibited or incapable of going beyond that point to deep space, the Moon or Mars." [173]237 First is a legitimate government need for the service. As stated earlier, NASA’s program to return to the Moon as well as operate in cislunar space assembling Mars exploration vehicles will benefit tremendously by the availability of low cost propellant on the Moon. As described in the Demand section, propellant purchased on the lunar surface represents a tremendous savings compared to bringing it from Earth. In addition, NASA will need oxygen and purified water, both products of the mining operation. Second is a defined commercial market for the product. As shown earlier, the commercial GEO satellite industry may drive the purchase of large quantities of propellant in LEO. If this demand is successfully met, other demands will emerge. For example, SpaceX has baselined refueling for its Big Falcon Rocket (BFR) rocket. Though the BFR uses methane fuel, LO2 represents a large fraction of its propellant mass. Blue Origin is also interested in refueling both its third stage and Blue Moon lander use LO2/LH2 propellants. With these two ingredients, the PPP can be structured as a fixed NASA investment into a commercially led mining operation development with a NASA commitment to purchase commodities in some amount. By specifying a price and quantity guaranteeing propellant purchases on the lunar surface, the wheels of American innovation and creativity can be set in motion to create capabilities NASA could not afford on its own. Capabilities that will underwrite a massive expansion of the human species into an entirely new environment. Annually increasing the price until the market responds with the needed capability is one method that could be used to overcome unseen difficulties along the way. To avoid picking winners and let the free market work more efficiently, it might be sufficient for NASA to commit to buy commodities (without investment) to stimulate the private sector to make the investment on its own. Many of these ideas have been discussed extensively. See, for example, the Lunar COTS proposal from [174]238 Promote Healthy Competition239 Though there are many positive impacts to the efficiency, cost reduction, and growth of a freely competed market, there can also be destructive effects depending on the diversity and abundance of customers. Historically, in cases where there is a single high stakes, high value customer to be won, fierce competition can evolve that sometimes hinders the growth of an economic ecosystem. Table 25 [152] depicts the differences between healthy competition (cooperative challenges) and cutthroat competition (competitive challenges). Although either of these approaches can be pursued within a privately competed lunar mine, healthy competition can be encouraged and established early on if the initial government customer strategically structures their propellant procurement process. Examples from other industries show the benefits of openness and information sharing. One positive example is the microwave communications industry. Microwave conferences began to be held in 1953, with competitors sharing the results of their research and collaborative discussions of new trends and developments. As a result, microwave transmission was the dominant form of high-data-rate communications for decades. For lunar propellant production, it is also true that the benefits of a collaborative and healthily competed commercial capability substantially outweighs an approach that is dominated by a single “winner”. Multiple vendors can increase the likelihood of a robust and reliable future supply chain that funds continuous innovation and capacity enhancement. Technological and operational capabilities can also benefit from the diversity of approaches a competitive ecosystem can draw. “Jeff Bezos, founder of Blue Origin and Amazon, comments that…competition should not be cutthroat to determine future monopoly…but creating an ecosystem for other entrepreneurs to thrive upon.” [142]240 Early on, healthy competition can be promoted through the purchasing strategy of the government customers described in the Lunar Surface and EML1 Customers section. The total demand proposed by these initial government customers should be divided among multiple commercial providers. Although this may make it more challenging to close the business case for these early companies, it will encourage them to develop even more lightweight, efficient, and creative solutions. In addition, it will stimulate the establishment of multiple providers that will pursue and cultivate new customers and uses for their products. Once additional customers, both government and commercial, are established, free market competition will continue to evolve with the lunar propellant industry. Facilitate Technology Development241 Various US Government laboratories have technologies that would be very useful in the commercial lunar propellant plant. These technologies could augment the development efforts within US aerospace companies. Partnerships with the US Government or its departments could accelerate the plant design. Some examples of applicable efforts: Air Force Research Laboratory: modular and “plug-and-play” satellite design Naval Research Laboratory: automated space robotic operations Jet Propulsion Laboratory: mobility on planetary surfaces Langley Research Center: in-space assembly techniques and hardware Marshall Space Flight Center: in-space manufacturing Some cooperative efforts between government and industry have resulted in additional capabilities that could be used. NASA’s Tipping Point program has invested in three efforts that could provide robotic assembly and construction capabilities (see the Lunar Surface Construction, Maintenance, and Repair section of this paper). DARPA’s RSGS program242 is developing autonomous failure response algorithms that could be adapted for use during facility construction and operation. In addition, the following technology areas identified in this paper would greatly benefit from government support: Volatile sublimation and capture in a vacuum High efficiency electrolysis Improved cryogenic management systems for in-space storage Ultralight, high efficiency solar panel masts Ultralight deployable solar reflectors Microwave and laser power beaming MW class space rated fission reactors Extreme cold and dust tolerant robotic actuators/components Autonomous control systems and machine learning In-space rendezvous, grappling, and propellant transfer Lunar communications architecture Refuelable, large, LO2/LH2 autonomous lunar landers Refuelable LO2/LH2 in-space transport Propellantless ascent options from the lunar surface Aerobraking and aerocapture in Earth’s atmosphere Institute Law for Property Ownership243 Because legal certainty allows a private entity the ability to know its costs and its potential return on investment, to attract investors, and to plan, U.S. recognition of a private entity’s property interests would advance exploration, investment, and U.S. leadership. Congress should consider codifying the principles of adverse possession as a means of ensuring legal certainty. Typically, adverse possession principles provide an analytical tool for figuring out if a person occupying someone else’s land should be allowed to take it from the original owner. However, some of the elements may be useful for robotic lunar mining as well. For example, Congress could enact legislation recognizing that a company’s human or robotic presence and control over a particular portion of terrain if the presence and control was continuous, open and notorious, actual, and exclusive for three years (or some other number), meant the company was recognized as the owner of the land. This particular proposal would require more analysis to flesh it out fully, and to review such historical analogs at the U.S. 19th century Homesteading and Mining Acts. For Private Sector244 The US industrial base is fully capable of tackling the technical challenges of a lunar propellant plant. In addition, a free market strategy for implementing this capability is critical to its longevity. Private organizations need to establish sustainable business models in order to maintain operations. Costs and commodity prices are bound by investors’ and customers’ availability and willingness to pay. Stakeholders in private enterprise hold companies accountable to generate revenue and produce returns while maintaining competitive edge. Therefore, it is recommended that this effort have significant private sector involvement and investment to ensure the sustained interest and active business development required at the foundation of an entirely new industry with government creating the environment where commercial entities can flourish. The following sections will outline recommendations to the private sector concerning leadership, competition, investment, and participation in the development of space law. Establish Leadership within the Private Sector245 The development and implementation of a commercial lunar propellant plant is a long-term investment strategy with incredible growth potential. As described throughout this study, the hardware solutions are well on their way to maturity. However, these hardware solutions are being developed by a multitude of companies for a variety of applications. It is only through the vision of the commercial lunar propellant plant that they are currently stitched together. To ensure that the development and implementation of this system is successful, it is necessary for leadership and organization of the many constituent parts of the architecture. It is highly recommended that this leadership be established within the private sector to maintain competitive, innovative, profit generating solutions throughout all phases of development. To reap the benefits of free market competition, multiple companies should be encouraged to take on the role of system integrators for competing lunar propellant mines. These private entities may or may not exist today but are necessary to administrate the many subcontractors similar to those identified in this study. In addition, the administrating companies would interface with investment firms, government agencies, and international organizations to generate funding, facilitate technology development, and establish the customer base required to close the business case. In order for these “Commercial Lunar Propellant Companies” to be successful, government support would also be crucial. To encourage and stimulate these privatized activities, the government should incorporate the operation into future space architectures, continue to fund development of applicable technologies, implement the legal framework to support commercial lunar activity, and establish a baseline lunar propellant demand and price as the anchor customer. This relationship was described in detail in the For Government section above. With a foundation in the free market, and with continued support from NASA and the US government, the commercial lunar propellant plants will establish the first permanent foothold for US economic opportunities on the Moon. Strategize for Investment Appeal246 The following sections discusses several strategic recommendations that an emerging commercial lunar mining company should utilize to better posture themselves for investment appeal. These strategies include high fidelity financial modeling, establishing insurability, diversifying applications, and incremental deployment. In addition to promoting investment appeal, these strategies are critical steps towards the realization of this emergent industry. A third party economic study of the commercial lunar propellant plant is essential to proving financial feasibility to the investment community and should be created. A high fidelity financial model contracted to an unbiased, reputable institution would be ideal. Within the high fidelity model, detailed inputs from the constituent companies should be stitched together. This data should include detailed cost, scheduling, and financial information provided for unbiased review and incorporation into the model. The model should treat each element of the lunar propellant plant as a subcontracted item that would be provided by the most capable companies. This high fidelity economic model will be a major element in communicating the investment value of the commercial lunar propellant plant as an integrated system. There is a close relationship between the willingness of investors to contribute to product development and the assessments of insurance underwriters. Investors will generally favor opportunities that are judged insurable. An early dialogue with the insurance underwriting community will be beneficial in the system design process. For example, understanding what are considered the highest consequence failures by the insurers will assist the designers in including the appropriate amounts of redundancy and the selection of components that meet the required standards. It is easier to attract investment to technology development for a mining enterprise if those technologies are not unique to that enterprise. The development program should emphasize the use of technologies that will have multiple applications. For example, space robotics can be used in markets other than lunar propellant—servicing of orbiting satellites, construction of large space structures, and in-space manufacturing. Developing technologies that can also be applied to terrestrial operations opens up an even greater variety of markets. Examples of applicable terrestrial markets include uses in deep-sea resource exploration, remote research, mining, and military operations, as well as the automation of complex industrial processes. Investors are more willing to fund technology development if they can see multiple avenues for return on their investment. Investment is likely to be attracted incrementally as the production capability gains in maturity. A terrestrial demonstration facility will show that the selected technologies can work together. Building and operating a demonstration or pilot plant (as describe in the Develop Prototype Pilot Plant section), will be key to raising confidence by proofing the system. A pilot plant on the Moon could also be important to attract investment, with the additional attraction that it would have some revenue generation capability, although less than the full-scale plant. Promote Investment Opportunities247 Akin to early investments in internet startups in the 1990’s, the emerging space economy offers high reward investments. With a multitude of different systems and services necessary for the lunar propellant production plant, there is substantial opportunity for investment. Dependent on investment timeline, acceptable risk, and desired company profile, an investor can choose the type of venture that will best suit them in this emerging space operation. Among the potential suppliers of the hardware required for the lunar propellant architecture, there is a wide variety of company maturity, size, and ambition. To simplify, these variations can be classified into four categories of investment opportunity. These categories are described below in order of least risk to highest risk. The first category consists of the legacy companies with current operations and mature technologies in the space sector. These companies have been established for over 20 years and usually have business operations in a variety of different fields. Companies in this stage are relatively low risk investments, but many are publicly traded companies with lower potential rewards from the growth of the space economy on a per shareholder basis. The second category consists of space companies recently founded yet mature with focused operations solely on the space economy, such as ULA, SpaceX or Blue Origin. These companies have established their technologies and have proven flight systems which lowers the potential risk for investors, while still allowing for larger potential rewards in the future than legacy companies. The third category is established startups. Companies that fall into this category usually have some established space technologies developed, well-defined business plans, and a strong core team in place. Not all of these companies have substantial investment yet. These companies are usually looking to move past the design phase, develop or further prototypes, or develop complementary technologies. This is a higher risk investment opportunity than the first two, but there are substantially large potential rewards for successful investments. Companies in this stage include Made In Space, Ispace, Astrobotic, NanoRacks, Masten Space Systems, and Lunar Outpost. The fourth opportunity to invest is in seed stage companies. There are many companies in this category and differentiating the good investments from the bad can take some work. Investors should look for the companies that have technically feasible ideas, strong teams to develop the needed technology, and fleshed out business plans. While not always the case, successful investments in early stage companies can reap higher rewards in the future. In an effort to provide a survey of how feasible ISRU on the Moon is, the CisLunar Marketplace Workshops have compiled a substantial database of enabling technologies and their current TRL. Augmented by industry and expert input, that database is the foundation of this study and ongoing discussions. As described in this study, the technologies necessary for lunar propellant production are currently developed or in development. This bolsters the investment prospects for all four stages of space companies. Today, the technologies needed for space resource utilization with low TRL provide excellent opportunity for investment. Given the high maturity of complementary technologies, the support of visionary investors, focus from established and well-respected companies, and talented young startups, it is our recommendation that investment opportunities into space resources and supporting infrastructure be viewed as promising and worth the risk. Because lunar propellant production is equally valuable as a monetary or capability investment, it is equally valuable to private or government investors as well. The companies that succeed in this venture will not only help shape the space economy but also advance space exploration while improving life here on Earth for generations to come, and potentially reap substantial returns. Active Role in Space Law248 Companies intending to extract space resources from the Moon or any other celestial body will need legal certainty that: They will have exclusive rights over a certain surface area of a celestial body where the resources extraction will take place Their operations will be protected from interference from competing companies They will have ownership rights over any extracted resources Since Article II of the Outer Space Treaty is broadly seen as prohibiting ownership rights (whether sovereign or private ownership rights), mining companies should be prepared to work with international organizations (such as the Hague Working Group on Space Resources). These organizations are currently seeking to formulate a method of providing companies with exclusive mining rights (which could be something less than property rights). Regarding non-interference with existing mining operations, existing international law already contains a requirement that space operators carry out their activities with “due regard” for the activity of others. However, international organizations are similarly occupied with creating a clearer international understanding of how interference can be best avoided. Industry input is critical as these details are worked out. With respect to the ownership of extracted resources, international law is rather clear that the mining company may assert such ownership rights. This interpretation of international law has been bolstered by domestic legislation in both the United States and Luxembourg. That said, companies should continue to monitor and be involved in any new legal developments on this topic. Technical249 The concept for commercial propellant production and distribution we have described in this paper is based on the adaptation of existing technologies—hardware, software, and operational concepts. The basic science of extraction, processing, transport, storage, and delivery systems exist. Their application to a low gravity, cold lunar crater environment using only robotics for maintenance is the great challenge. Technology development effort for the project should follow three tracks: Detailed modular design concepts for extraction and transport, based on information gained from precursor prospecting and environmental characterization missions Detailed modular concepts for power, processing, storage and delivery, that modify terrestrial system components for space flight and the lunar environment Algorithms and software that automate all phases of the project The “modular” requirement for system parts comes from the need to assemble, maintain and repair everything using robots. Modularity simplifies robotic hardware and software, and it makes parts storage and delivery much more flexible. Leverage Existing Systems250 The lunar propellant plant is similar in many ways to chemical plants on Earth. All such plants have chambers where the essential chemistry takes place; tanks for holding feedstock, intermediate and final products; plumbing and vehicles for moving products around the facility; power supplies and distribution; and control systems that automate most of the processes and actuate safety features. To re-engineer a terrestrial chemical plant for the lunar propellant application, major tasks will include: Modularization. Chemical plants are often highly integrated, with large components weighing several tons. A lunar plant design will need to be broken into smaller parts that can be robotically moved from the landing site to the installation site, and robotically assembled with ease. Weight reduction. Builders of terrestrial plants are relatively unconstrained by the masses of components, other than limits of available lifting gear. Because launch and space transport are highly weight-constrained, designers should consider options such as operation at lower pressures (which reduces the weight of chambers and pipes), even if some reduction in efficiency would occur. Safety in design. Some properties of the lunar environment pose hazards to which terrestrial plants are not exposed. Most important are radiation and micrometeorites. Plant systems must be tolerant to these hazard sources. Redundancy and sparing. Investors, insurers, and customers will insist on a high level of assurance that production will be continuous and reliable. Repair times will be much more dependent on redundancy and sparing than for terrestrial plants. Having to wait for component delivery from Earth to restore production after a failure will be unattractive to investors. On-site spares, redundant components, automated responses, and robotic services will be key. Apply Automation251 Robotic operations follow one of four general modes: scripted, teleoperated, supervised autonomy and full autonomy. Choice of which mode to use depends on the availability of information (e.g. positions and orientation of components) and connectivity. Design of the lunar propellant installation will assign these modes to the various robotic operations during site preparation, construction, operation, maintenance, and repair. Fully autonomous operation sounds difficult, but it has been demonstrated in space252. Other automation features that need to be included in the design will be: Fault detection, identification and response. Robots will encounter components that are not in the nominal configuration (e.g. bent connectors). They themselves will also experience failures (e.g. electrical shorts, suspension problems). If such anomalies can be resolved without involving humans on Earth, the efficiency will be greatly improved. Process monitoring and control. Terrestrial chemical plants often include human oversight, both in control centers and around the plant. Lunar plant control must be completely automated, because the facility will have only intermittent connectivity with humans on Earth or at NRHO (which will only be intermittently occupied in any event). Without fully automated operation, failures that occur at times without human oversight could propagate and have serious consequences. Establish Standards253 Each subsystem of the lunar extraction and production facility will have to interface with other systems throughout its life cycle. These interfaces should be standardized in order to reduce costs (Standards as Cost Savings) and improve efficiency. The overall complexity of this facility is comparable to that of the ISS. Even on ISS, examples such as NASA’s International Docking System (IDS) demonstrate the necessity of standardization in space. A list of interfaces that must be considered in the design of the lunar propellant plant includes:  Pre-launch interfaces with ground support equipment (mechanical and electrical)  Launch vehicle interface (launch restraints, restraint release power, telemetry)  Lunar lander interface (at least mechanical)  Interface with transport robot (at least mechanical, probably also power for survival heat)  Interfaces with other facility subsystems (mechanical, power, control, telemetry, fluids, thermal) A design challenge for most components will be the wide variety of environments that they experience—launch vibrations, landing forces, lunar day and night, abrasion from regolith, transport by robot and in some cases the extreme cold of the shadowed craters. The interface designs will be driven by the need to accommodate all of these environments. Propellant transfer interfaces need multiple fluid paths, mechanical, power, data and command interfaces as well. Any space vehicle receiving or transferring lunar propellant will need a fuel and an oxidizer interface for primary and attitude control propellants. There may also be a need to exchange ullage as well as propellant. As described in the Rendezvous and Capture section, Altius Space Machines has a Phase II SBIR to develop a cryogenic transfer interface. Implementing these types of interfaces as standards is crucial to efficient implementation of the lunar propellant architecture. The benefit of standardizing these interfaces includes simplicity of planning, reduced cost, and enhanced reliability. Relevant research is being performed by the DLR for modular design of satellites. In a project called Intelligent Building Blocks for On-Orbit Satellite Servicing and Assembly (iBOSS)254, an Intelligent Space System Interface has been developed. Potentially, generalizing such promising interface designs may be greatly beneficial in engineering the assembly of the lunar plant. However, there is a danger to overly specific interface standardization, namely the potential inability to accommodate new features. An insight may be drawn from the 120V wall plug. It is a standardized design, but does not greatly constrain the equipment that it powers. “Flexible standardization” is the ideal approach for a system of the complexity of the lunar propellant plant. Path Forward255 A commercial lunar propellant system will be a vast undertaking. A phased approach is recommended, each phase serving to increase maturity of the technologies, attract increased levels of investment, and develop markets and customers. An example of a phased development program is: Phase 0: Establish business viability. In order to secure adequate funding, the following items must be completed prior to, or in parallel with, to the subsequent phases: NASA and others propose propellant demand, price, and location of use as customer base Prospecting and science exploration of lunar polar regions Improved space law to facilitate commercial utilization of lunar resources Commercial lunar propellant companies form for managing the many subcontractors Third party high fidelity financial models Secure investment for technology development and maturity Technology applied to terrestrial markets to generate revenue Implementation of international lunar communications architecture Phase I: Individual technology demonstrations. Organizations will continue to raise the TRL of critical hardware elements through technology demonstrations. This phase can be greatly accelerated with PPP: Demonstrating sublimation from regolith simulant Robotic demonstrations of plant assembly techniques Reusable lunar lander development Hydrogen/oxygen-fueled vehicles for operations in Earth orbit, such as LEO-to-GEO tugs Additional technology demonstrations outlined within previous sections of this study Phase II: Subscale terrestrial demonstration plant. Although conducted on Earth, elements of this IST could be conducted in simulated Permanently Shadowed Regions (PSR) environments including: Assembly demonstrations of all components of the plant Robotic operations in cryogenic conditions Efficient subscale processing plant with lightweight components System interface validation Vacuum chamber IST with cold wall for end-to-end system verification Phase III: Subscale lunar production plant. The following activities will boost the TRL of the integrated lunar propellant production plant to 9: May be scaled to fit on a single launch vehicle for delivery to PSR Designed for limited operations or production Demonstrates collection, transport, processing, and storage of cryogenic propellant Propellant produced can support robotic exploration and sample return missions Becomes seed for full-scale production plant Phase IV: Full-scale commercial lunar production facility. Initiates US industrialization on another terrestrial body. Establishes sustained presence on the Moon. Technology has been fully vetted Customer base is well established Required resource mapping complete Investment has been secured The legal framework is in place All infrastructure is delivered to the lunar surface Full-scale propellant production in support of space missions underway Transport from lunar surface to space is in place Phase V: Iterative system enhancement. In the decades following the establishment of the lunar propellant plant, new technologies will be integrated into the system to improve performance, decrease operating costs, and enable effective utilization of its products. Utilization of lunar propellant to expand the facility (Bootstrapping Deployment section) Installation of tracks and roadways for robotic operations (Surface Mobility section) Propellantless ascent systems for delivery to orbit (Propellantless Ascent section) Efficient LEO delivery (Aerobraking/Aerocapture for LEO Delivery section) Unforeseen new technologies driven by healthy commercial competition to innovate Phase ∞: Well established lunar propellant industry. The Moon and its resources become a gateway to the solar system. Its resources are used for space exploration as well as to benefit life on Earth. Robust and highly scalable space economy (Enabled Industries section) Improved scientific understanding of the Moon and beyond (Science Benefits sections) Enables solutions to Earth’s energy crisis (Energy section) Supports space habitation (Supporting Human Settlement and Existential Threats sections) Is the first step in humanity’s journey through the cosmos (Grand Science and Exploration) Establishing a commercial lunar propellant plant is fundamental to the exponential growth and prosperity of humankind. This effort requires industry, government, and academic collaboration on a scale more extensive than humanity’s greatest historic engineering achievements. Like those achievements, the challenge is great but the value is even greater. Producing far more than just near term economic gains, this Commercial Lunar Propellant Architecture enables entirely new opportunities for human civilization.

### Public Trust Doctrine

#### Public trust doctrine is a terrible method – outdated, unenforceable, forecloses other effective action

Lazarus JD 86

Richard J Lazarus (harvard law professor witta law degree from harvard), 1986 " Changing Conceptions of Property and Sovereignty in Natural Resources: Questioning the Public Trust Doctrine," Iowa Law Review, https://www.repository.law.indiana.edu/cgi/viewcontent.cgi?article=3055&amp;context=facpub, // HW AW

Over the last fifteen years, the public trust doctrine has been the object of a remarkable revival in natural resources law. At the time of its "Renaissance" it served to highlight important societal values not then in focus. Accelerating changes in the law suggest that it is now time to bring that revival to a close-to lift the public trust doctrine "patch" from the emerging fabric of modern natural resources law. Operation of the doctrine inevitably depends on the judicial application of labels that obscure the true factors behind the judicial decision. Moreover, those **legal categories upon which the doctrine inexorably relies may have been meaningful once, but they have become arbitrary and wooden with age.** Natural resources law has for too long been inflicted with a host of such false legal categorizations, **inhibiting its developments in times of new information and changing social values**. Indeed, the recent history of natural resources law is most prominently marked by a continuous struggle to be freed of historical shackles so that natural resources law can properly be fused with and into modern notions of tort and property law. Simply put, **the public trust doctrine, even if aimed at promoting needed resource conservation and environmental protection goals, is a step in the wrong direction.** The doctrine amounts to a romantic step 476. The historical underpinnings upon which the public trust doctrine is based, especially Roman law, have in recent years come under sharp attack by commentators, thus further weakening the long-term viability of the doctrine. See supra note 10. 477. L. FULLER, supra note 164, at viii. 71 IOWA LAWREVIEW 631 [19861 backward toward a bygone era at a time when we face modern problems that demand candid and honest debate on the merits, including consideration of current social values and the latest scientific information. The complex and pressing resource allocation and environmental protection issues we currently face will continue to tax severely the most concerted societal efforts and the best legal and scientific minds. Dramatic shifts in legal rules, primarily in traditional notions of private property, will continue to be necessary, challenging the patience and understanding of the public, to whom the law must ultimately justify its legitimacy. Although perhaps unfortunate, short of a major redirection of this nation's social and economic infrastructure, 478 little, if any, room is left in these tasks ahead for the mythopoeism of the public trust doctrine.

### Climate

#### Space exploration is k2 ending climate change

**Derr 21** (Digital Communications Manager at Nuclear Energy Institute creative communicator, eagle-eyed researcher, and content strategist with a passion for community-building and human rights. Has experience developing communications campaigns, editing and writing short and long-form content, and leading social media published scholarly writer in the fields of art history and public policy deeply invested in social justice and devotes her free time to causes working towards alleviating hunger and povertyhttps://www.nei.org/news/2021/space-is-crucial-to-understanding-climate-change)//HWLND

Space developments in the last two decades have greatly contributed to our understanding of our planet’s climate. Satellite imaging, space exploration, and new technologies give us an idea of the big picture and how we can adapt to address climate change. For example, satellites in space have played a critical role in our understanding of the causes of global warming by providing us with a large body of data to examine the variations in the Earth’s orbit. Data from these capabilities were essential inputs into the Intergovernmental Panel on Climate Change’s (IPCC) recent report that focused on how the physical science of climate change informs likely impacts under five different emissions scenarios. The report also found that climate change is happening quicker than we thought, making the need to reduce emissions imminent. To address this, space infrastructure such as positioning, navigation, and timing (PNT) can help identify efficient transportation routes and sources of emissions, ultimately aiding mitigation efforts.

### 1NC – AT: Debris Advantage

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

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

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

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

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

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

Even with a 90% implementation of the commonly-adopted mitigation measures [...] the l e o debris population is expected to increase by an average of 30% in the next 200 years. The population growth is primarily driven by catastrophic collisions between 700 and 1000 km altitudes and such collisions are likely to occur every 5 to 9 years.89

#### Status quo solves – mitigation and remediation compliance growing.

Colombo et. al 18—Camilla Colombo, PhD, visiting academic in Spacecraft Engineering within Engineering and Physical Sciences at the University of Southampton; Francesca Letizia, PhD, Space Debris Engineer at ESA Space Debris Office; Mirko Trisolini, PhD, Postdoctoral researcher at the Politecnico di Milano Department of Aerospace Engineering; Hugh Lewis, PhD, Professor within Engineering and Physical Sciences at the University of Southampton (“Space Debris: Risk Mitigation,” from Frontiers of Space Risk: Natural Cosmic Hazards & Societal Challenges, Chapter 5, p 128-136)

5.4 MITIGATION MEASURES The space debris problem is nowadays internationally recognized, therefore mitigation measures are being taken and guidelines discussed. These can be divided into two classes: The avoidance or protection measures and the active and passive debris removal measures. The avoidance or protection measures include the design of satellites to withstand impacts by small debris, or the selection of safe procedures for operational spacecraft such as orbits with less debris, specific attitude configurations, or implementing active avoidance maneuvers to avoid collisions. On the other hand, measures for debris removal currently consist in limiting the creation of new debris (by prevention of in-orbit explosions and ensuring spacecraft subsystems reliability), to free some orbital implementing end-of-life disposal maneuvers protected regions, or to reenter in the atmosphere. Active debris removal is also being considered as a mean to stabilize the growth of space debris by removing from orbit some selected noncompliant objects. The e.Deorbit mission will target an ESA-owned derelict satellite in low orbit, capture it with a net or robotic arm technology, and reenter with a controlled atmospheric reentry (Biesbroek et al. 2014). Acknowledging the fact that the projected growth in the number of satellites orbiting the Earth will increase in the future, space agencies and international organizations have been discussing and building a set of guidelines to ensure the sustainability of future space activities. The InterAgency Debris Coordination Committee (IADC) was founded in 1993 by ESA (Europe), NASA (the United States), the Japan Aerospace Exploration Agency (JAXA, Japan), and the Roscosmos Russian Federation. As of January 2017, the IADC also includes the Italian Space Agency (ASI, Italy), the Centre National d'Études Spatiales (CNES, France), the China National Space Administration (CNSA, China), the Canadian Space Agency (CSA, Canada), the German Aerospace Centre (DLR, Germany), the Korea Aerospace Research Institute (KARI, South Korea), the Indian Space Research Organisation (ISRO, India), the National Space Agency of Ukraine (NSAU, Ukraine), and the UK Space Agency (UKSA, United Kingdom). This international cooperation decided a set of space debris mitigation measures (Inter-Agency Space Debris Coordination Commitee, 2002), which includes: 1. Limitation of debris released during normal operations. 2. Minimization of the potential for on-orbit breakups (resulting from stored energy after the completion of mission operations, or during the operational phases of the mission and by avoiding intentional destruction and other harmful activities). 3. Post Mission Disposal in particular in geosynchronous regions and for objects passing through the LEO region. 4. Prevention of on-orbit collisions. The IADC guidelines were presented to the United Nations Committee on the Peaceful Uses of Outer Space (UN COPUOS) and contributed to the creation of the Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space to be considered for the mission planning, design, manufacture and operational phases of spacecraft and launch vehicle orbital stages” (United Nations Office for Outer Space Affairs 2010): 1. Limit debris released during normal operations. 2. Minimize the potential for breakups during operational phases. 3. Limit the probability of accidental collision in orbit. 4. Avoid intentional destruction and other harmful activities. 5. Minimize potential for post-mission breakups resulting from stored energy 6. Limit the long-term presence of spacecraft and launch vehicle orbital stages in the low Earth orbit region after the end of their mission. 7. Limit the long-term interference of spacecraft and launch vehicle orbital stages with the geosynchronous region after the end of their mission. 5.4.1 Mitigation Guidelines for Post Mission Disposal In this section we focus on the third of the measures dictated by the IADC, namely Post Mission Disposal. A “25-year rule” was defined to limit the presence of satellites in the LEO region to no more than 25 years after their decommissioning. The 25-year limit was selected to ensure that a reasonable reduction in lifetime could be achieved without greatly affecting satellite resources. After 25 years a satellite has to be removed from the LEO protected region by placing it in a graveyard orbit or by disposing of it through atmospheric reentry. According to the IADC Space Debris Mitigation Guidelines (Inter-Agency Space Debris Coordination Commitee 2002) if "a spacecraft or orbital stage is to be disposed of by re-entry into the atmosphere, debris that survives to reach the surface of the Earth should not pose an undue risk to people or property.” The low Earth orbit protected region (LEO region) is the spherical shell region that extends from the Earth's surface up to an altitude of 2000 km. The geosynchronous protected region (GEO region) is a segment of a spherical shell with a lower and upper altitude boundary of 200 km below and above the geostationary altitude of 35,786 km, and which is constrained by a latitude sector extending between plus and minus 15 degrees from south to north (Inter-Agency Space Debris Coordination Committee 2002; United Nations Office for Outer Space Affairs 2010). At altitudes below 600 kilometers, spacecraft with a conventional area-to-mass ratio (i.e., conventional satellites have a value of area-tomass ratio around 0.012 m?/kg) will reenter within a few years due to atmospheric drag. Intervention to remove and prevent further creation of debris above that altitude should therefore be the primary focus of passive mitigation measures. As described in the document on the “Requirements on Space Debris Mitigation for ESA Projects” (ESA 2008) and the "ESA Space Debris Mitigation Compliance Verification Guidelines” (ESA 2015), end-of-life measures can be distinguished in: (1) Disposal, (2) passivation, and (3) reentry. Required measures for disposal currently cover spacecraft in LEO and GEO through a series of Operational Requirements (OR) (ESA 2008): "OR-01. Space systems operating in the LEO protected region shall be disposed of by reentry into the Earth's atmosphere within 25 years after the end of the operational phase." "OR-02. Space systems operating in the GEO protected region shall be disposed of by permanently removing them from the GEO protected region.” The GEO disposal orbit should be almost circular (i.e., eccentricity less of equal to 0.005) and with a minimum perigee altitude above the geostationary altitude, which is given as a function of the solar radiation pressure coefficient of the space system at the beginning of its life and its cross-sectional area. This is done to take into account the eccentricity oscillation due to the effects of solar radiation pressure and to ensure that such oscillation would not make the orbit interfere with the GEO protected regions. "OR-03. Where practicable and economically feasible, space systems outside the LEO and GEO protected regions shall implement means of end-of-life orbit disposal to avoid long-term interference with operational orbit regions, such as the Galileo orbit." OR-04. Launcher stages shall also perform end-of-life disposal maneuvers by targeting "direct reentry as part of the launcher sequence.” Alternatively, they should be injected into a LEO orbit with a maximum reentry time of 25 years. As other space systems, they should be removed from LEO and GEO protecting region and orbit that interfere with other operational orbits such as the one of the Galileo orbit. OR-05. Passivation of the system (spacecraft or launcher stage) has to be completed within 2 months of the end of mission. End-of-life measures for reentry include: OR-06. "For space systems that are disposed of by reentry," an "analysis has to be performed to determine the characteristics of fragments surviving to ground impact, and assess the total casualty risk to the population on ground assuming an uncontrolled reentry.” OR-07. Such a casualty risk has to be lower than 10-4 if an uncontrolled reentry is targeted; otherwise if the casualty risk is higher than the threshold of 10-4, "a controlled reentry must be performed such that the impact footprint can be ensured over an ocean area, with sufficient clearance of landmasses and traffic routes." The rate of compliance of missions to the end-of-life mitigation guidelines was analyzed by the ESA Space Debris Office in 2017). Between 2006 and 2015, the rate of compliance of LEO missions (including naturally compliant missions and satellites performing end-of-life maneuvers) was 53.3% for the payloads (corresponding to 60.3% of the payload mass), reaching end of life in the LEO protected region (Frey and Lemmens 2017). The compliant objects, with a lifetime after decommissioning of less than 25 years, include naturally compliant objects due to their initial altitude well inside the Earth's atmosphere (this constitutes the biggest part of the compliant share), compliant objects after a deorbit maneuver, or spacecraft having performed a maneuver leading to a direct reentry. In terms of mass, this share is constantly sloping downward. Between 2007 and 2016, 71.6% of the rocket bodies reaching end of life in the LEO protected region was compliant, and this fraction has remained virtually unchanged for 8 years in a row despite an increase in end-of-life maneuver activity. 5.4.2 Passive End-of-Life Disposal In order to meet the mitigation guidelines LEO satellites at the end of their life would use the remaining propellant to perform either a perigeelowering maneuver (to decrease the orbit perigee well inside the Earth's atmosphere to guarantee a reentry within 25 years) or a direct reentry. Spacecraft in GEO are instead currently re-orbited to quasi circular orbits outside the GEO protected ring, with a perigee line aligned with the SunEarth direction (where possible) in order to bind the long-term oscillations in the eccentricity caused by solar radiation pressure. Recently, ESA funded projects on the design of disposal trajectories for medium Earth orbits (MEO) (Alessi et al. 2014; Rossi et al. 2015), highly elliptical orbits (HEO), and libration Earth orbits (LPO) (Armellin et al. 2014; Colombo et al. 2014; Colombo et al. 2015). These have demonstrated the possibility of exploiting natural orbit perturbations for designing passive mitigation strategies for debris disposal. Disposal strategies enhancing the effects of orbit perturbations have been further analyzed in LEO (Alessi et al. 2017), in MEO (Rosengren et al. 2015; Alessi et al. 2016; Armellin and San-Juan; Daquin et al. 2016; Gkolias et al. 2016), in GEO (Colombo and Gkolias 2017), and in HEO (Colombo et al. 2014; Armellin et al. 2015). Indeed, it was shown that, rather than performing an expensive maneuver to lower the perigee, the optimal maneuver should be given in a way to change the disposal orbit to another neighborhood orbit where the effect of orbit perturbations causes the orbit perigee to enter into the atmosphere. Indeed, the effects of luni-solar perturbation causes long-term oscillation on the eccentricity, which can be exploited so that the spacecraft's trajectory over a long period (from 5 to 70 years, depending on the initial orbit) could lead to natural reentry. This effect can be enhanced by solar radiation pressure, especially if considering a spacecraft equipped with large solar panels or a deployable reflective surface (Lücking et al. 2012, 2013). Moreover, resonances with the Earth's nonuniform potential can enhance the eccentricity growth effects. 5.4.2.1 An Example of End-of-Life Deorbiting Exploiting Luni-Solar Perturbations One of the most beautiful demonstrations of how natural dynamics can be enhanced is given by the INTEGRAL mission designed by ESA, the United States, Russia, the Czech Republic, and Poland. The INTErnational Gamma-Ray Astrophysics Laboratory, launched in 2002, gathered some of the most energetic radiation from space (Eismont et al. 2003). A reentry of this spacecraft with a pure impulsive maneuver would have not been possible due to the limited amount of propellant left onboard. In an ESA-funded study, the end-of-life disposal of INTEGRAL mission--expected to end in 2016-was designed with a time window for disposal between January 1, 2013 and January 1, 2029. Reentry solutions with a delta-velocity requirement below 40-50 m/s were found (Colombo et al. 2014). The main perturbations acting on the dynamics of the reentry were luni-solar perturbations, which affect the evolution of eccentricity, inclination, and anomaly of the perigee measured with respect to the Earth-Moon plane. It was shown that depending on the set of initial elements, which depends on the date the reentry maneuver is performed, the proposed maneuver would then aim at further increasing or decreasing the eccentricity. In particular, if we focus on the natural evolution of the eccentricity under luni-solar perturbation and Earth's oblateness, when the nominal eccentricity is low, the optimal reentry maneuver further decrease the eccentricity value; as a consequence, the following long-term propagation will reach a higher eccentricity, corresponding to a reentry. In this case, the maneuver is more efficient (i.e., lower delta velocity is required) (Colombo et al. 2014). Once the initial disposal maneuver is performed, the spacecraft evolves under natural perturbations and the reentry can then be semicontrolled. The high inclination of HEOs represents an advantage as the final reentry phase can target regions at higher latitudes on the Earth's surface thereby reducing the ground hazard. In the case of HEOs, reentry is caused by luni-solar perturbation (not air drag), therefore the orbit reenter with quite a high eccentricity (high apogee and low perigee) and does not circularize. Due to the oscillations in eccentricity, the next optimal window for injecting the spacecraft into a reentry trajectory is between 2013 and the first half of 2018 for a final reentry in 2028. After that, the required maneuver would increase until reaching a next window for performing the maneuver between the second half of 2021 and the first half of 2026, for a reentry in 2028. These analytical studies were used for high fidelity parametric analyses performed by the ESA (Merz et al. 2015) to investigate the effect of a maneuver at apogee to change the perigee altitude. The final maneuver sequence was given at the beginning of 2015 and split into three major burns plus a touch-up for final fine-tuning. The spacecraft is now on its course to reentry in 2028 (see Figure 5.11).

### 1NC – AT: Space War/Kessler Syndrome

#### The probability of collisions are relatively low, leaving us with a large window of opportunity to intercept these events Colin Stuart 7/9/21

{Colin Stuart, astronomy author & speaker, journalist for The Guardian, New Scientist, Wall Street Journal & European Space Agency, “Space Junk: Is it a disaster waiting to happen?”, <https://www.sciencefocus.com/news/space-junk-is-it-a-disaster-waiting-to-happen/>}

A UN report from 2013 projected that catastrophic **collisions** may **occur once every five to nine years** over the next two centuries. It’s already happening. In 2009 an Iridium communications satellite collided with the derelict Russian Kosmos 2251 satellite destroying both spacecraft. That event happened at about the same altitude as one of the biggest dangers: the eight-tonne Earth observation satellite Envisat. **It will remain in orbit for the next 150 years and there’s a 15 to 30 per cent chance that it will collide with another piece of space junk in that time. Kessler syndrome doesn’**t necessarily have to **play out quickly**. These **impacts** could be the first domino, with crashes **ramp**ing **up** significantly **over time.**

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

Fange 17

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

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

#### No space war – MAD and Economics Wordsworth 15

Wordsworth, Rich. "Why We'll Never Fight a Real-Life Star Wars Space Conflict." Gizmodo UK. December 18, 2015. Accessed October 09, 2016. <http://www.gizmodo.co.uk/2015/12/why-well-never-fight-a-real-life-star-wars-space-conflict/>. JD\

So Why Won’t It Happen? Well, never say never. You might not make to the end of this paragraph before the sky lights up and the world goes dark. But there are some good reasons to be optimistic that won’t happen. One reassuring factor is that the more other countries develop their militaries, the more dependent on networks they become as well. China is developing its own drone programme, and so is Russia, which will both presumably be dependent on satellites to operate. And the more their (and our) economies and business interests develop, the more everyone will rely on satellites to further their economic ambitions. In the event that countries were to start knocking out each other’s satellites on a large scale, the consequences across the board – for everyone – would be disastrous. It would also be expensive in the short term. Getting things into orbit – peaceful or otherwise – still isn’t cheap, which is why only a handful of countries regularly do so. And if you want to blow up a network of many satellites today (as you would have to in a first strike, to ensure other satellites couldn’t pick up the slack), launching small satellites or missiles into orbit is the only practical way to do that – arming satellites with their own weaponry just isn’t financially or technologically feasible on a grand scale. We are, happily, a long way from a Death Star.

#### Their internal link is about anti-satellite warfare, that’ll never happen – it’s too expensive, satellite MADS deters, hacking is easier, and no country is considering it. – look at johnson 13

#### Wordsworth 15

Rich Wordsworth, Why We'll Never Fight a Real-Life Star Wars Space Conflict, 18 Dec 2015, Gizmodo.com EE

Well, never say never. You might not make to the end of this paragraph before the sky lights up and the world goes dark. But there are some good reasons to be optimistic that won’t happen. One reassuring factor is that the more other countries develop their militaries, the more dependent on networks they become as well. China is developing its own drone programme, and so is Russia, which will both presumably be dependent on satellites to operate. And the more their (and our) economies and business interests develop, the more everyone will rely on satellites to further their economic ambitions. In the event that countries were to start knocking out each other’s satellites on a large scale, the consequences across the board – for everyone – would be disastrous. It would also be expensive in the short term. Getting things into orbit – peaceful or otherwise – still isn’t cheap, which is why only a handful of countries regularly do so. And if you want to blow up a network of many satellites today (as you would have to in a first strike, to ensure other satellites couldn’t pick up the slack), launching small satellites or missiles into orbit is the only practical way to do that – arming satellites with their own weaponry just isn’t financially or technologically feasible on a grand scale. We are, happily, a long way from a Death Star. “I don’t think [a large first strike] would be financially too costly [if you’re] thinking about kinetic energy weapons and the air-based or ground-based lasers,” says Jasani. “It’s viable. But if you say, ‘I’m going to put an [ASAT] weapon [permanently] in orbit’, we are then getting into very expensive and very complicated technology. So my guess is that in the foreseeable future, what we are going to focus on are the kinetic energy weapons and possibly lasers that could blind satellites or affect, for example, the solar panels. That kind of technology will be delivered in the foreseeable future, rather than having lasers in orbit [like] the Star Wars kind of thing.” But there’s another, possibly even more persuasive reason that a kinetic war in space may not happen: it’s just so much easier – and less damaging – to mess with satellites without getting close to them. “Jamming from the ground is not difficult,” says Quintana. “If you look at the Middle East, pick a country where there’s a crisis and the chances are that the military in that country has tried to jam a commercial satellite to try and avoid satellite TV channels broadcasting anti-government messages.” “My guess is that by the time we are ready for space warfare, I think you may not be banking on your hit-to-kill ASATs, but more on [non-destructive] high-energy laser-based systems,” Jasani agrees. “[Space debris] affects all sides, not just the attacked side. The attacking side will have its own satellites in orbit, which might be affected by the debris [of its own attack].” And if you really need to remove an enemy’s satellite coverage, you can always try to flatten or hack the control stations on the ground, leaving the satellites talking with no-one to listen. “I don’t think physically blowing things up from the ground is something that people are looking at again,” says Quintana. “Countries and governments try to find means other than physical conflict to achieve their strategic ends. So as space becomes more commercial and more civilian and as more scientific satellites go up, then you’ll find that states will not seek to directly attack each other, but will seek other means. “It may just be that they will try to cyber-attack the satellites and take them over, which has been done in the past. It’s much easier to physically or cyber-attack the ground control station than it is to attack the satellite itself - so why would you not look to do that as a first port of call and achieve the same ends?” Ultimately, then, what might keep us safe from a war in space isn't the horror of explosives in orbit, but a question of cost and convenience.