### Topicality:

#### Interpretation: The affirmative must defend the resolution

#### Violation: The Affirmative does not defend the resolution and does actions beyond the resolution

#### They don’t meet their own definition of appropriation

#### 1] Strat Skew – completely destroys my prep

#### 2] Education – non topical affs are completely irrelevant and confuses people and leads to debates over topicality rather than debates over the topic

#### Private Entities are key to space exploration – NASA is not good enough

Follett, Andrew. “Private Firms Are the Key to Space Exploration.” National Review, National Review, 21 Aug. 2021, https://www.nationalreview.com/2021/08/private-firms-are-the-key-to-space-exploration/?utm\_source=recirc-desktop&utm\_medium=article&utm\_campaign=river&utm\_content=more-in-tag&utm\_term=second.

America’s public-sector space program recently had a rough couple of weeks that perfectly exemplify why it desperately [needs](https://www.nationalreview.com/2021/03/bernies-lost-on-space/) a free-market overhaul. On July 29, the International Space Station (ISS) suffered a serious loss of control after a Russian spacecraft docked with it, accidentally [causing the station to make a full 540-degree rotation and a half](https://www.nytimes.com/2021/08/02/science/nasa-space-station-zebulon-scoville.html) before coming to a stop upside down, when the astronauts got it under control. Like most NASA programs, the ISS is massively over budget. Costs were initially projected at $12.2 billion, but the bill [ultimately reached a stunning $150 billion](https://scholarworks.wm.edu/cgi/viewcontent.cgi?article=1593&context=honorstheses). American taxpayers paid around 84 percent of that. What happened to the American dream of human space exploration? Put simply, the government happened. NASA devolved into a jobs program to bring home the space bacon. Then, on August 10, NASA’s inspector general [released a report](https://oig.nasa.gov/docs/IG-21-025.pdf) deeming plans to send astronauts back to the moon in 2024 unfeasible because of significant delays in developing the mission’s spacesuits. Right now the suits are being built by 27 different companies that successfully lobbied the government for a piece of the action. SpaceX’s Elon Musk has rightly noted that NASA has “[too many cooks in the kitchen](https://twitter.com/elonmusk/status/1425100378459279370).” The difference between NASA’s cumbersome designed-by-committee suits and SpaceX’s suits — created by a single contractor — [is remarkable](https://twitter.com/AlexanderPayton/status/1425181840462200833), even to the naked eye. The report unconvincingly blames NASA’s failure to develop a new spacesuit over the last 14 years solely on shifting technical requirements. It recommends “ensuring technical requirements for the next-generation suits are solidified before selecting the acquisition strategy to procure suits for the ISS and Artemis programs.” Instead of dealing with the problem, the Biden administration is trying to distract attention from the space agency’s mismanagement by [announcing plans](https://www.cnn.com/2021/04/09/world/nasa-artemis-person-of-color-crew-scn/index.html) to land the first person of color on the moon . . . even though NASA has been incapable of sending astronauts of any color into space under its own power since July 2011. NASA has been reduced to begging the Russians for a ride. The agency’s troubled Constellation program, meant to replace the Space Shuttle fleet, was canceled after tens of billions of dollars had already been spent. But NASA’s troubles are, depressingly, likely to get even worse. In November the James Webb Space Telescope (JWST) will finally launch, after taxpayers have [forked over $9.7 billion](https://www.gao.gov/products/gao-21-406). It was originally supposed to launch in 2007 on a budget of $500 million. That means the project is over a decade behind schedule and costing almost 20 times its initial budget. Perhaps the telescope, meant to locate potentially habitable planets around other stars and perhaps even extraterrestrial life, could instead search for a calendar . . . or fiscal sanity . . . in the stars? JWST isn’t the first NASA space telescope to suffer cost overruns and setbacks. The Hubble Space Telescope (HST) was originally intended to launch in 1983, but technical issues delayed the launch until 1990 because the main mirror was incorrectly manufactured. JWST is very likely to fail because it is supposed to unfold itself “origami style” in space in an extremely technically complicated process. If difficulties arise, JWST lacks [HST’s generous margin for error](https://www.scientificamerican.com/article/is-the-james-webb-space-telescope-too-big-to-fail/) because of its location far beyond earth’s orbit at the Sun-Earth L2 LaGrange point. NASA currently lacks the capability to send a team of astronauts out that far to fix any problems. Even if NASA could get out to JWST, the telescope doesn’t have a grappling ring for an astronaut to grab onto and thus could potentially kill astronauts attempting to fix it. It is hard to imagine a better example of the private sector’s amazing ability to outcompete government bureaucracy and mismanagement than NASA’s planned Shuttle replacement, the Space Launch System. It is estimated to [cost more than $2 billion per flight](https://arstechnica.com/science/2019/11/nasa-does-not-deny-the-over-2-billion-cost-of-a-single-sls-launch/). That’s on top of the $20 billion and nine years the agency has already spent developing the vehicle. Contrast that with the comparatively inexpensive $300 million spent by SpaceX to develop the Falcon 9 in a little over four years, and the fact that each Falcon 9 costs [around $62 million](https://www.fool.com/investing/2020/10/05/how-much-cheaper-are-spacex-reusable-rockets-now-w/#:~:text=SpaceX%2C%20the%20pioneering%20rocket%20launch,four%20and%20a%20half%20years.). One SLS launch could pay for over 32 SpaceX launches. Private ventures such as SpaceX are more efficient because they have a lot more incentive to avoid excessive costs and focus on solutions: Their own money is at stake, and people spend their own money more carefully than they spend taxpayer dollars collected from others. Multiple private American space firms are currently pursuing accomplishments beyond those of NASA, and they are more advanced and ambitious than the entire government space programs of China and the European Union combined. So one possible solution to NASA’s woes would be to greatly increase its reliance on commercial launch providers. And one way to do that would be to return to the system that made civil aviation great: prizes to reward private-sector innovation. Charles Lindbergh flew across the Atlantic Ocean in pursuit of the [privately funded Orteig prize](http://www.charleslindbergh.com/plane/orteig.asp), valued at almost $395,000 in today’s money. Another famous example was the X Prize, which rewarded Burt Rutan’s company Scaled Composites with [over $14 million](https://www.nbcnews.com/id/wbna6167761) in today’s money for becoming the first nongovernmental organization to launch a reusable and manned space vehicle, SpaceShipOne. The X Prize succeeded in creating over $100 million in investment by private corporations and individuals. Aerospace experts [expect](https://www.nationalreview.com/2012/02/mars-prize-robert-zubrin/) that establishing a $10 billion prize for successfully landing a crew on Mars and returning it safely to earth could very well lead to a successful landing. That’s a bargain compared with the [$500 billion cost estimates](https://ntrs.nasa.gov/api/citations/20200000973/downloads/20200000973.pdf) NASA puts out for the same objective. And of course in the worst-case failure scenario for a prize program, taxpayers would pay nothing until the mission was complete. A system based on private enterprise incentivized by a fixed prize would end government cost overruns and waste. The cause of space exploration is simply too important to leave to the public sector

#### Space expo creates innovation and leads to better tech knowledge

**I**nternational **S**pace **E**xploration **C**oordination **G**roup. (20**13**, September). //ear Benefits Stemming from Space Exploration. **Nasa.Gov**. Retrieved December 8, 2021, from <https://www.nasa.gov/sites/default/files/files/Benefits-Stemming-from-Space-Exploration-2013-TAGGED.pdf> ISECG is a collab between NASA and other governments space programs.

To a great extent, the benefits from space exploration are rooted in the generation of new knowledge, which is the first reward and which has inherent value to humankind. Technological knowledge, generated when high‐performance space systems are developed to address the extreme challenges of space missions, yields many innovations that benefit the public. Scientific knowledge acquired from space expands humankind's understanding of nature and frequently unlocks creative and useful Earth‐based applications for society. In the longer term, the knowledge accumulated over many missions and the expansion of human presence into the Solar System help people gain perspective on the fragility and rarity of life in the Universe and on humankind's accomplishments, potential, and destiny. Space exploration stimulates the creation of both tangible and intangible benefits for humanity. Tangible impacts include all the innovation‐related applications and benefits resulting from investments in these programmes, such as new devices and services that spin off into the marketplace. In addition, space exploration leads to advances in science and technology, and furthers workforce development and industrial capabilities, thus leading to an overall stimulation of private companies and industries, all of which contributes significantly to the economic progress of space‐faring nations. Space exploration is also known to attract young people into careers in science and technology to the general benefit of society and the economy (see chapter 2.1). Space exploration also results in various intangible impacts due to the social and philosophical dimensions that address the nature and meaning of human life. Intangible benefits include the enriching of culture, the inspiration of citizens, and the building of mutual understanding as a result of international cooperation among space‐faring nations. The fundamental benefits generated by space exploration are grouped in this document as follows: (i) innovation; (ii) culture and inspiration; and (iii) new means to address global challenges. The delivery of these benefits to society provides the main rationale for investment in space exploration. An illustration on how these benefits are delivered by space agencies is given in the box below. Space exploration’s capacity to continue delivering significant benefits to humanity was recognized by high‐level government representatives from around the world when they convened in Lucca, Italy, in November 2011. They concluded that space exploration provides

#### IL - Technology developed in space innovation is key to resolve climate change

**Derr**, E. (20**21**, **September 17**). Space is Crucial to Understanding Climate Change. Nuclear Energy Institute. Retrieved December 9, 2021, from <https://www.nei.org/news/2021/space-is-crucial-to-understanding-climate-change> //ear Emma Derr works as a Manager, Digital Communications at Nuclear Energy Institute, which is a Membership Organizations company with an estimated 133 employees; and founded in 1994. They are part of the Digital Marketing team within the Marketing Department and their management level is Manager. Emma is currently based in Washington, D.C., United States.

Space developments in the last two decades have greatly contributed to our [understanding of our planet’s climate](https://climate.nasa.gov/evidence/). 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](https://www.thespacereview.com/article/4230/1) were essential inputs into the Intergovernmental Panel on Climate Change’s (IPCC) recent [report](https://www.ipcc.ch/report/ar6/wg1/#SPM) 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](https://www.transportation.gov/pnt/what-positioning-navigation-and-timing-pnt#:~:text=While%20PNT%20encompasses%20so%20much,GPS%20is%20a%20major%20component.&text=%E2%80%9CA%20U.S.%2Downed%20utility%20that,segment%2C%20and%20the%20user%20segment.) (PNT) can help identify efficient transportation routes and sources of emissions, ultimately aiding mitigation efforts. Time Progression of the Ozone Hole Over Antarctica This series of images shows the size and shape of the thinning ozone layer over Antarctica each year from 1979-2019. Red and yellow areas indicate the ozone hole. Credit to nasa.gov. NASA’s [Earth System Observatory](https://www.nasa.gov/press-release/new-nasa-earth-system-observatory-to-help-address-mitigate-climate-change), the next generation of Earth science satellites that will launch in the next decade, reflect the importance of Earth imaging. This constellation of satellites is designed to provide information about our planet ranging from the location of forest fires to the sea level rise to our agricultural processes. It will be able to collect data at the regional and local levels and connect critical interactions between the atmosphere, land, ocean and ice, significantly bolstering our understanding of the Earth’s climate. Another large [focus](https://www.axios.com/white-house-nasa-earth-science-satellites-climate-c560c9d8-2dfd-4964-bfcf-fd6cb54117e5.html) of the initiative is predicting severe weather and answering questions surrounding aerosols, which are particles in the atmosphere that are a key source of uncertainty in predicting climate change. Alongside adding funding to FEMA, the Biden Administration [announced](https://www.whitehouse.gov/briefing-room/statements-releases/2021/05/24/fact-sheet-biden-administration-invests-1-billion-to-protect-communities-families-and-businesses-before-disaster-strikes/) the development of the Earth System Observatory, indicating its support for the program in understanding how climate change is impacting communities. Space exploration is foundational to climate science because it provides us with more information about the Earth, our solar system and the role of gases in our atmosphere, and nuclear energy has played an important role powering our missions into space. In 1969, NASA launched [Nimbus III](https://rps.nasa.gov/missions/8/nimbus-iii/), a nuclear-powered spacecraft, that is the first U.S. satellite to gather vital oceanographic data, such as measurements of sea ice and the ozone layer. The spacecraft also measured atmospheric temperature, water vapor and ozone, as well as the amount of ultraviolet radiation reaching our atmosphere from the sun. [Cassini](https://solarsystem.nasa.gov/missions/cassini/overview/), a nuclear-powered probe into Saturn and its moons, released the Huygens probe which collected important data about what earth may have looked like in its state before humans evolved. The mission revealed Titan to be one of the most Earth-like worlds we’ve encountered and has shed light on the history of our home planet. Nuclear energy has powered dozens of interplanetary missions, which have gathered critical information about our universe. These make up some of the most successful and inspiring missions in U.S. space exploration history. Climate and space technologies build off of each other, as evidenced by solar photovoltaic panels first gaining a foothold in the space industry. Nuclear energy can be positioned to experience such a catalyst with [new investments](https://www.nei.org/news/2021/nuclear-taking-us-faster-and-farther-into-space) in nuclear space technologies. As climate change intensifies, space exploration and Earth observation will become [increasingly important](https://www.axios.com/space-critical-to-climate-science-2051-0361889a-5ae9-47eb-960f-e83f1b6779c7.html) to gathering critical data. We must meet the moment by investing in these missions and recognizing nuclear power’s important role in space technologies.

#### Warming causes extinction and judge if you do not buy that there are several laundry lists of impacts that warming causes

#### Too many barriers to successful asteroid mining – err neg because the commercial space industry is overly optimistic

Scoles 17 (Sarah. 1/23. Contributing writer at WIRED Science, a contributing editor at Popular Science, and the author of the book ​Making Contact: Jill Tarter and the Search for Extraterrestrial Intelligence. “ASTEROID MINING SOUNDS HARD, RIGHT? YOU DON’T KNOW THE HALF OF IT” <https://www.wired.com/2017/01/asteroid-mining-sounds-hard-right-dont-know-half/>) 8/27/19 RK

THE COMMERCIAL SPACE industry pushes a particular brand of optimism. Its urge to inspire manifests as soaring soundtracks to three-minute mission-promo videos, press releases with words like “humanity,” and slick graphics of spacecraft that don’t exist yet but could any day now. In the particular case of asteroid mining, business leaders are selling a future in which materials plucked from space rocks make up for Earth’s shortfalls and support a thriving civilization. Everyone is rich, all are happy, and no one wants for anything. O pioneers! We are them! OK, fine, that’s an exaggeration. But the toned-down version of asteroid mining’s prospects is still hyperreal. "Our vision is to catalyze humanity's growth, both on and off the Earth," says Peter Diamandis, co-founder of mining company Planetary Resources, in a PR video. A graphical spacecraft, presumably future-theirs, flies away from our planet while he speaks. "At the end, the entire human race will be the beneficiary, as we expand our reach beyond the Earth, into the solar system," he continues. But traveling the road to space-based industry will require giant leaps. Like picking the most lucrative asteroids—the ones with lots of water and precious metals—from far afield. And negotiating spacecraft near their complicated gravitational fields. To do that, companies will have to leave the comfy confines of Earth's orbit, where they currently do all their experimenting. In May, Planetary Resources raised $21 million of venture capital for an Earth-observation program called Ceres. Ten small satellites will fly low around the planet, taking twice-daily images of Earth in wavelengths ranging from mid-infrared to visible—images that will “benefit multiple industries including agriculture, oil & gas, water quality, financial intelligence and forestry.” These satellites will, essentially, be prospecting Earth, using the same sensors Planetary Resources has developed to prospect asteroids. The utility, says president and CEO Chris Lewicki, is dual. “We are taking pictures of the Earth and using them not only to understand how our technology works but also to understand more about our planet,” he says. True enough, but it's also about the balance sheet: Earth-facing spacecraft, as all that venture capital suggests, are big money. Which is important for a company that has to continue existing until it can actually mine asteroids. The other big name in the industry, Deep Space Industries, is also in the Earth-observation business, kind of: It sells its spacecraft technologies to other companies, some of whom want to use them to peer down at our planet. Like HawkEye 360, a company that plans to monitor and map radio-wave broadcasts in near real-time. Deep Space Industries is the prime contractor developing and making the satellites that will become HawkEye's Pathfinder prototype. “Earth observation is kind of the hot thing in space right now,” says Meagan Crawford, Deep Space Industries' chief operating officer. “It’s where most of the value is being created.” But unlike Planetary Resources, Deep Space Industries isn’t planning its own world-watching missions, even if they plan to profit from others’. Their personal path to an asteroid is straighter: They hope to launch the prototype Prospector-X this year to see how its propulsion performs, how its avionics stand up to space radiation, and how its optical navigation system fares against obstacles. It will be in Earth orbit, but it’s not on the Earth-observation beat. It’s meant to show that the follow-on Prospector-1 will work—hopefully going to an asteroid by the end of the decade, the same timescale on which Deep Space is also working. “We think the best way to determine what these asteroids are really like is to go touch and feel and interact with one,” Crawford says. Spacecraft shortfalls Becoming a prime prospector of Earth doesn’t quite translate to asteroids, as the two space-body types are quite different. For one, Earth is, like, right here. Asteroids are way out there, moving very fast. And that makes getting to know them hard. The companies need to know about a specific rock's composition before embarking on a mining mission—something they can't accomplish with the same sensors they are deploying in Earth orbit, the same ones they hope to use to get detailed information once they are actually close to an asteroid. Scientific missions specced to learn more about what asteroids are made of, like NASA's newly funded Lucy and Psyche, will help the companies get the knowledge they need to get power. But Crawford admits that "the biggest missing piece for asteroid mining is scientific knowledge of target asteroids." Asteroids’ specifics are still fuzzy. That’s why space agencies keep sending missions like Lucy and Psyche, as well as the already-launched OSIRIS-REx, Dawn, and Hayabusa to them: because we don’t know a super lot about their details, beyond predictive models based on broad categories. “We don’t have a lot of experience with the real characteristics of asteroids,” says Zoe Szajnfarber, who studies the dynamics of technological innovation at George Washington University. What if a company chose a target asteroid based on predictions, only to find, upon arrival, that it holds much less water and platinum than checkbooks and customers hoped? Too bad, so sad. “If you make the choice to go to the one asteroid, that’s where you’re going,” says Szajnfarber. “It’s almost impossible to have enough fuel to change your mind and go to a different one.” Then, once you get there, there’s the problem of gravity. The companies' craft may master constellation- or formation-flying around our planet. But Earth, as globes have suggested for centuries, is basically a sphere. And its mass is pretty evenly distributed. Gravity is basically the same everywhere in a spacecraft’s orbit. Keeping spacecraft in line in such a boring gravitational field is “easy.” But have you seen pictures of asteroids? Those pockmarked potato colonies with weird peaks and valleys have complicated gravity and composition. The companies will have to climb over both these early obstacles before they get to even bigger ones: that part where they have to build robots that can mine and spacecraft that can bring the haul back into humanity’s reach. They can’t do any of it by planetary navel-gazing alone. But they are going to do planetary navel-gazing, whether under their own flags or customers’. That globe-centric system will at least make the companies money, which means they may be able to survive long enough to figure out how to do what they really want to do.

#### Asteroid mining is totally infeasible

Amanda Jane Hughes 18. Post-Doctoral Researcher of Astrophysics, Liverpool John Moores University. “Mining Asteroids Could Unlock Untold Wealth – Here’s How To Get Started.” The Conversation. 5/2/2018, http://theconversation.com/mining-asteroids-could-unlock-untold-wealth-heres-how-to-get-started-95675

According to Professor Martin Elvis, an astrophysicist at Harvard University, an asteroid worth mining needs to have a market value of $1 billion. In order to satisfy this requirement, the asteroid must be more than 1km in diameter, contain more than 10 parts per million of platinum and have a velocity relative to the speed of the Earth of less than 4.5 kilometres per second. There are more than 17,000 near-Earth asteroids, but how many of them fit the bill? Professor Elvis made a theoretical estimation based on probabilities and assumptions. For instance, of all the meteorites that have fallen to Earth, approximately 4% were metallic. So we can assume that 4% of near-Earth asteroids are also metallic. Taking into account this and other probabilities, we are left with only 10 asteroids that are – theoretically – economically worthwhile and practically feasible to mine. As the targets have not yet been directly identified, the task now is to find these needles in the haystack. The initial design phase for a prospecting satellite is underway, and the Asteroid Mining Corporation is aiming to launch it by 2020. This would go into low-Earth orbit and would survey the skies for near-Earth asteroids, gathering spectral data and determining their composition in order to identify specific targets. As part of my report I will identify the range and resolution of the spectrograph needed to determine composition. I will also work out a preliminary telescope design. The next objective would be to launch a probe, collect samples for detailed chemical analysis and photograph the surface of the target to identify a potential landing place. The eventual aim would be to land a mining craft on the surface of the target and extract precious metals in situ. Many different techniques have been proposed. However, this would be an incredibly ambitious feat of engineering that cannot be underestimated, with many unanswered questions and unknown timescales at this early stage. There are not just technical challenges to overcome. There is currently concern over the legal ramifications of this burgeoning industry, given the lack of laws and regulations to govern the international nature of space exploration. The United Nations oversees the Outer Space Treaty, signed by 106 countries. This provides a framework for the governance of space-based activities, but it does not provide the detailed legislation needed. There are concerns that the situation could become the new Wild West, with a lack of laws leading to disputes over who has the rights to mine a particular asteroid. There is no mechanism currently in place to adjudicate such claims, and the legal landscape is complex.

#### Centuries of empirics prove strong property rights are the key driver of investment – specifically true for the space economy

CEA 21 [Council of Economic Advisers, executive agency advising the president on economic policy, 2021, “Exploring New Frontiers in Space Policy and Property Rights,” Economic Report of the President, https://www.govinfo.gov/content/pkg/ERP-2021/pdf/ERP-2021-chapter8.pdf]/Kankee

Historical Examples of Property Rights Evolution Historical examples of the development of property rights establish that without these extra sticks in the property rights bundle, we should expect to see higher costs and lower benefits from investments in the space economy, potentially hindering future developments in outer space. The early history of oil drilling provides an example of how resources are likely to be wasted if property rights are not established in a timely manner. Until the early 20th century, oil was not considered property until it was extracted. This led to what Libecap and Smith (2002) call extractive anarchy. Companies drilled wells without concern for maximizing the amount of oil produced from a well, but instead sought to be the first to extract and claim ownership of the oil. Oil flows from a well because of the pressure inside the reservoir; if too many wells are drilled into one reservoir, then the pressure escapes too quickly to push the oil in the reservoir up the well. As a result, less oil is extracted. By 1914, the director of the Federal Bureau of Mines estimated that a quarter of the value of all petroleum production was being wasted due to the race to extract oil. Further, due to oil and natural gas being found together in a reservoir, the lower-valued natural gas was often vented into the atmosphere to ensure that the oil was extracted and thus ownership was secured. As time went on, the structure of property rights for oil and gas has changed to allow for increased value to be created from investments in resource extraction. Without clear in situ property rights for subsurface resources, space could see a repeat of this behavior for its natural resources. Many elements that are common in space are frequently used in important technologies. Iron, aluminum, and titanium are elements critical to the production of electrical components. Silicon is a raw material for solar panels and computers. Extracted water can be broken down into hydrogen and oxygen to meet a variety of needs—oxygen is breathable, recombining hydrogen and oxygen generates electrical power, and liquid hydrogen and liquid oxygen can serve as propellants (Butow et al. 2020). Though it may sound futuristic, we can imagine a situation where mining expeditions recklessly extract resources from various celestial bodies, severely depleting the deposit of resources and diminishing the returns on future investment in mining. Therefore, defining property rights now to ensure the responsible use of resources in space could lead to future higher levels of demand and investment in exploration and a more sustainable space economy. A similar story emerges for mineral rights in Nevada during the 19th century (Libecap 1978). As new deposits of minerals were found, especially those deposits further underground requiring increased investment for extraction, the specification and enforcement of property rights increased. One of the largest deposits in Nevada, the Comstock Lode, was discovered while Nevada was still a Federal territory. Property rights for discoveries on Federal lands were lacking at the time, so citizens created a series of local laws and eventually founded the State of Nevada to ensure these property rights. Libecap (1978) shows that as deposits increased in value, local property rights specification also increased. It may seem difficult to imagine how local property rights would be formed in space as in territorial Nevada, given the lack of settlements in space. However, this history implies that it is important to set these rules as economic actors spend extended time in space in order to maximize the future investment in the space economy.

Investment Responses to Property Right Enhancement All the space policy developments discussed above have improved the ability of investors to set expectations for the manner in which benefits flow from investments in space. The historical examples given argue that further specifying property rights will bolster investment in the space economy. Increased investments in the space economy will lead to advances in space technology. In this subsection, we discuss the economics literature that addresses the effects of setting and strengthening property rights on both investment and economic growth. The research presented here aims to convey that the benefits for economic activity from improved setting of expectations that clarifies property rights is universal and not just due to specific circumstances of time and/or place. Losses from short-term decisionmaking. A growing concern for future space exploration activities arises from a lack of property rights security leading to short-term decisionmaking, which may inhibit long-term human activity. Many empirical studies show that insecure property rights lead to investment decisions with lower values. Many of these studies have come from analyses of water rights in the western United States. In what is known as the Prior Appropriation Doctrine, water rights are handed out based on a “first in time, first in right” principle. Given that the amount of water available changes each year due to precipitation patterns, water rights holders that were, earlier in time, known as senior rights holders are more likely to receive their water allocation each year than those that were later in time, known as junior rights holders. Leonard and Libecap (2019) argue that the Prior Appropriation Doctrine, with its clear rights for senior rights holders, allowed for investment in irrigation technologies. Given the climate of the western United States, large-scale investment in irrigation is required to maximize the productivity of large swaths of land. Leonard and Libecap estimate that 16 percent of western States’ income in 1930 is attributable to investments made in irrigation that would not have occurred without secure property rights. Another concern with insecure property rights is that owners of natural resources rush to extract them to ensure that they accrue the benefits of their investments. This rush to extract resources has a detrimental effect on the value obtained from those resources and other negative spillover effects on society. One example is the increase in the rate of deforestation that occurs when property rights for the land are insecure (Bohn and Deacon 2000). Ferreira (2004) finds that those countries with clearly defined property rights experience less deforestation than those with weaker protections. Kemal and Lange (2018) find that a reduced chance of oil well expropriation in Indonesia lowered the rate of extraction by up to 40 percent. If short-term decisionmaking prevails in the initial incursions into space, the future of the space economy could be seriously harmed. Depleting the resources necessary to sustain life in space would mean having to transport these resources from Earth at a prohibitive cost and complexity. Therefore, protecting and responsibly using the resources available in space is more efficient in the long term. If done prudently, establishing property rights in space could diminish the risk of short-term decisionmaking and strengthen the ability of humans to receive benefits from space.

Enhanced investment and asset value. Frameworks such as the U.S. Commercial Space Launch Competitiveness Act and the Artemis Accords enhance property rights by providing clear expectations of the benefits one can receive from their investment and providing a list of principles that partner nations will follow as a way to encourage economic activity in space. One branch of the economics literature uses legal or legislative decisions that enhance or diminish property rights to determine how investment and asset values respond to a change in property rights specification. We discuss this literature here. Later in the chapter, we apply the conclusions of these studies to estimate the value of enhancing property rights in space. Alston and Smith (2020) measure the effect of uncertain property rights resulting from the manner in which Northern Pacific Railroad’s land grants were structured. The Federal Government provided generous land grants to railroad companies in hopes of ensuring the quick buildout of rail infrastructure. Northern Pacific was granted almost 16 percent of the land area in Montana, a State that requires coordination among its farmers and ranchers to irrigate any tract of land for productive use. Delays in the completion of the rail line in the 1870s led to uncertainty as to whether Northern Pacific owned (and could sell) land in its land grant or whether the land was the property of the Federal Government. As a result of this uncertainty, completed irrigation projects averaged delays of four years, while investment in irrigation projects decreased by 28 percent. Insecure property rights affected the landowners whose rights were secure, because irrigation projects often require coordination among many parcels due to their high capital costs. The delay in undertaking irrigation investments led to these landowners being more junior water rights holders and, subsequently, holding less secure water rights. In total, Montana’s economic activity was 6 percent lower in 1930 as a result of these insecure property rights. Grainger and Costello (2014) compare the value of more secure property rights for fisheries in the United States, Canada, and New Zealand. New Zealand’s regulations on quotas to operate in a given fishery explicitly state that these quotas are a property right, yet similar quota systems in the United States and Canada have regulations that explicitly state that the quotas are not property rights. The fact that the United States’ and Canada’s fishery quotas are not as secure as New Zealand’s quotas leads to a lower perpetuity value of the quotas relative to their current annual value. Because U.S. and Canadian firms have the potential for their quotas to be taken away without recourse, their assets have lower values relative to New Zealand’s firms. In an additional analysis, Grainger and Costello (2014) show that the increased security of property rights with the settling of an ownership dispute between native New Zealanders, known as the Maori, and New Zealanders of European descent improved the perpetuity value of fishing quotas by 50 percent. Ensuring that property rights will be honored is very important for market participants in understanding the value of their asset. Galiani and Schargodsky (2010) use a court case in Argentina to estimate the effect of secure property rights for one’s home on household decisions. Their results show that households that gained secure property rights increased their investments in the home structure. Investment in walls and roofs increased by 40 percent and 47 percent, respectively, as a result of households being granted title to the home. Though not directly related to space assets, the available evidence demonstrates that more secure property rights lead to other spillover benefits that are not directly related to the assets on which a property rights are granted. Galiani and Schargodsky (2010) find that when households had increased property rights security, they increased investment in their children’s education. Children in households who obtained the secure property rights on their land achieved an extra 0.7 year of schooling on average. This is an important spillover effect given the large individual and societal benefits of extra years of education (see chapter 7 of this Report). Telecommunications satellites orbiting Earth provide an example of positive spillovers from ensuring secure property rights in space. The International Telecommunication Union (ITU) is an organization that standardizes rules and regulations for a wide range of communications. Through the ITU, the United States was able to operate satellites that used specific frequencies to transmit information to Earth, thereby allowing companies to invest in utilizing those signals for commercial purposes. Communications satellites in geosynchronous orbit rely on the ITU to secure access to specific orbital slots as well as specific frequencies.

Protection against expropriation. A number of nongovernmental organizations produce indices that measure property rights protections or general institutional quality. The indices attempt to quantify the relative level of property rights characteristics, such as the rule of law or protection against expropriation risk, that are consistent across countries and time. A large body of economics literature uses these country-level indices of institutional quality to determine the extent to which improvements in property rights enforcement affect economic outcomes. Policies initiated under the Trump Administration would likely alter these indices in a measurable way if there were a property rights index for space. Seminal work by Acemoglu, Johnson, and Robinson (2001) shows that improving the enforcement of property rights, in this case property rights that protect against expropriation risk, has large effects on gross domestic product (GDP). In their analysis, the authors show that a one-unit improvement in the protection against expropriation risk would lead to more than doubling GDP per capita 10 years later. Similar results are found when researchers examine specific industries. For example, Cust and Harding (2020) show that firms drill for oil twice as often in countries with stronger property rights enforcement relative to their neighbors with weaker property rights. They also show that the effect of the enforcement of rights is most important for private international oil companies relative to national oil companies, highlighting the important role of stronger rights for harnessing private investment. Bohn and Deacon (2000) find a similar pattern for the effect on oil drilling as property rights security improves, with a 30 percent increase in security leading to a 60 percent increase in drilling per year. Some changes in property rights enforcement come through improvements in technology. Hornbeck (2010) uses the invention and widespread use of barbed wire as a technology advancement that reduced the costs of enforcing property rights in agriculture. Importantly, Hornbeck compares areas that had access to timber for wooden fences with those that did not and finds a 23 percent relative improvement in crop productivity when barbed wire came into use, as barbed wire lowered the relative cost of fencing. Most of the gain came from farmers altering the type of crop that they planted once they were confident that livestock would not destroy the crop. This increased ability to effectively enforce property rights led to investments that increased the total area of farmland that had been improved by 19 percentage points, while also increasing land values. In many ways, this example of marking off territory is similar to the Artemis Accords’ “Deconfliction of Activities” Principle. This principle prescribes setting “safety zones” to limit harmful interference and keep the probability of accidental loss to a minimum. The Effects of Policies on Investment in Space Industries The previous section detailed the expansive literature showing that more secure property rights increase both investment and economic activity. The examples discussed varied across time and space, leaving little doubt that the results are not driven by random chance; the studies as a whole reveal that the findings hold outside specific examples. Because the examples are numerous and varied, determining an average effect of more secure property rights on investment is difficult. Each study concerns a particular improvement in the security of property rights that is difficult to quantify. However, it is still a goal of this chapter to estimate the effect of the last year’s space policy developments on future investment, given the available evidence. Table 8-2 summarizes the effects of most of the studies discussed in the previous section. All these effects are large in magnitude. Another data point is the increase of investment in the space economy in the United States with the passage of the U.S. Commercial Space Launch Competitiveness Act in 2015 relative to investments in other countries. Using the Space Capital data discussed in the second section, and the historical examples given above, the CEA estimates the increase in investment in the United States due to the improved property rights specification in 2015. Controlling for country and time period effects, the data show a statistically significant increase in investment of 92 percent—or roughly double—in the United States since passage of the U.S. Commercial Space Launch Competitiveness Act relative to countries that did not improve property specification. Together, these small improvements in the security of property rights have the potential to lead to large increases in investment. As an approximation, the CEA assumes that these improvements in property rights security will double the amount of investment in space. This number is in line with the evidence that has been discussed here. To project the effect of the enhancements of property rights security that the Trump Administration’s policies have achieved, the CEA starts with data from Space Capital on total private investment in space activities. Figure 8-4 illustrates the increasing rate of private investment in space activities. The review of the literature discussed above shows that further property rights specification leads to increased investment and further economic activity. In figure 8-4, the diverging lines from 2020 to 2028 project the expected path of private investment as a result of policy developments in 2020. The Space Capital data suggest that a linear projection of private investment in space would reach $23 billion in 2028, which is illustrated by the blue dashed line in figure 8-4. However, this does not take into account property rights enhancements that occurred in 2020 or will be occurring in the future. Therefore, the CEA projects that private investment in space will reach $46 billion by 2028. This projection is based on a doubling of investment over the eight-year period, which is in line with empirical estimates in the academic literature discussed above. Establishing rights to distant resources with the goals of incentivizing economic development and investment has not always produced the desired results. The above-mentioned examples demonstrate how property rights specification and security can lead to increased investment. However, aligning incentives is a necessary but not sufficient condition in the short term. For example, the leading asteroid mining companies that were supporting the space resources language in the Commercial Space Launch Amendments Act of 2004 have both failed, despite the benefit of positive Federal legislation. In addition, the Deep Seabed Hard Mineral Resources Act, which was passed in 1980, established a legal system for extracting resources from the deep seabed with hopes of achieving economic viability before 2000. Forty years after the law’s passage, the deep seabed mineral extraction industry still lacks the technology for economical extraction and does not bolster the argument that enhanced property rights typically unlock commercial value. Certain similarities do exist with the space industry, such as the need for technological innovation, the considerable distance to the resources, and some uncertainty about the types of resources for extraction. Moreover, the space resource extraction industry currently lacks a customer base other than national governments, and even government demand will not become substantive until robust human and robotic operations on the lunar surface and elsewhere can be established. However, several key differences would support a space resource extraction industry. First, the commercial space industry benefits from public investment in civil space exploration, which might result in a decreased amount of investment necessary for the development of basic technologies. In addition, space exploration and research remain a national priority for many countries, which may drive further development of the industrial base. Moreover, space resource extraction potentially offers more valuable resources than deep sea mining (Barton and Recht 2018). Looking Ahead