# Cal Semis Neg vs Ayala AM

# 1NC

### 1

#### CP: States ought to place antineutrino detectors, streaming live data to and monitored by the International Atomic Energy Agency, within 10 meters of all nuclear reactors.

#### Solves Neutrinos – the technology already exists, it just needs to be implemented

Scoles 20, Sarah. “Neutrino Detectors Could Be Used to Spot Nuclear Rogues” Wired, Oct 6, 2020, <https://www.wired.com/story/neutrino-detectors-could-be-used-to-spot-nuclear-rogues/> TG

These days, Svoboda and a growing number of colleagues are interested in using signals from neutrinos that burst from reactors for nuclear security: to perhaps detect undeclared devices and to ensure that known reactors are not being used to amass material for weapons. The neutrino signature that slams straight through a reactor’s walls changes with what’s going on inside, providing a window into how much plutonium is in there, and whether it matches what’s expected. If not, it’s a clue that some of it may have been diverted toward weapons programs. It’s a real-time measurement that could augment the inspections and measurements that officials from the International Atomic Energy Agency currently do.

Those “safeguards” measures take many forms: first, declarations from facilities about what they’re up to. And second, monitoring. That involves inspections both routine and ad hoc, satellite imagery, open-source analysis, camera surveillance, collection and analysis of sample nuclear material, and environmental analysis. But neutrinos never lie, can’t hide, and tell the truth as it unfolds.

The tech isn’t quite ready for prime time, but some scientists think neutrino monitoring might be practical, and they’re taking (small) steps toward making that happen: The Department of Energy recently commissioned a study on nuclear security applications for neutrino detectors, and this summer it spooled up a group that aims to determine where the technology might be useful to policy types. A project with the creepy name Watchman, which Svoboda works on, is also developing detectors and methods that officials could use to pick up neutrino signals from a reactor dozens of miles away, revealing its activities without being right next door.

#### That solves prolif detection and is a sufficient distance – we’ve inserted lines they highlighted in 1AC Lee – it also concedes squo solves cuz the existence of the tech is a deterrent which is a reason to negate on presumption

* The neutrino detection technology could offer a solution.
* Optimizing reactor power levels to produce plutonium, a telltale sign that a country is trying to build a bomb, will change the rate and energy spectrum of antineutrinos that a device parked outside of the reactor can detect. And since these particles can pass through matter, the operator can’t shield the reactor’s release of antineutrinos the same way lead blocks X-rays.
* For now, a detector must stay within tens of meters of the reactor to be effective.
* And in any case, the mere knowledge that such technology has become a reality could prove to be a powerful deterrent to nuclear proliferation in itself.

#### 1AR theory is skewed towards the aff – a) the 2NR must cover substance and over-cover theory, since they get the collapse and persuasive spin advantage of the 3min 2AR, b) their responses to my counter interp will be new, which means 1AR theory necessitates intervention. Implications – a) reject 1AR theory since it can’t be a legitimate check for abuse, b) drop the arg to minimize the chance the round is decided unfairly, c) use reasonability with a bar of defense or the aff always wins since the 2AR can line by line the whole 2NR without winning real abuse

### 2

#### CP: Private entities ought not appropriate lunar heritage sites, except for the appropriation of lunar heritage sites in the Sea of Tranquility by helium-3 mining. States ought to clarify that the lunar mining of helium-3 is permissible under the Outer Space Treaty.

#### It competes and there’s no alt causes to the NB –

#### 1] It’s a heritage site – 1AC Fessl ev talks specifically about the Tranquility base and lunar landing sites as protected sites

Villanueva 10 “Sea of Tranquility” JANUARY 14, 2010, JOHN CARL VILLANUEVA <https://www.universetoday.com/50525/sea-of-tranquility/> SM

The Sea of Tranquility is the landing site of Apollo 11, the mission that gave mankind its first ever walk on the Moon.

Walk? Yes, that’s right. The Sea of Tranquility is not actually a sea, so Neil Armstrong didn’t have to walk on water. In fact, there isn’t a single sea on the lunar surface. The Sea of Tranquility is actually a lunar mare. Now, although the plural of ‘mare’, ‘maria’, is a Latin word that means ‘seas’, these maria don’t have water in them.

#### Their ev says the NASA list enshrines sites of Apollo missions

AC Harrington 19, Andrea J. "Preserving Humanity's Heritage in Space: Fifty Years after Apollo 11 and beyond." J. Air L. & Com. 84 (2019): 299. (Associate Professor and Director of the Schriever Space Scholars at USAF Air Command and Staff College)//Elmer

The issue of humanity’s cultural heritage in space has arisen as one of many unanswered questions in space law, with no international agreements specifically addressing it. With the beginning of the space age fifty-six years ago and a series of remarkable achievements in space exploration behind us, it is necessary to determine what should be done regarding the “artifacts” of this exploration. NASA has promulgated their recommendations for spacefaring entities with the goal of protecting the lunar artifacts left behind by the Apollo missions.8 These recommendations establish “keep-out zones” of up to a four kilometer diameter with the aim of protecting the artifacts, particularly from dangerous, fastmoving particles that arise as a result of craft landings.9

#### 2] Uncertainty kills investment in He-3 mining.

Bilder 09 “A Legal Regime for the Mining of Helium-3 on the Moon: U.S. Policy Options” Richard B. Bilder [Foley & Lardner-Bascom Emeritus Professor of Law, University of Wisconsin Law School.] 10/8/2009 <https://media.law.wisc.edu/m/wndnj/bilder1489273mining_helium-3ftns.pdf> SM

B. Should the U.S. Attempt to Establish an International Lunar Resource Regime Outside of the Framework of the Present Moon Agreement? While I have suggested that there are now good arguments for the U.S. – preferably, collectively with other space powers – to ratify and accede to the Moon Agreement under arrangements which would ensure that the legal regime established pursuant to Article 11 fully met U.S. requirements, the fact remains that such ratification by the U.S. may not currently be politically attainable. As was the case when the Agreement was first presented to the Senate subcommittee in 1980, influential and respected individuals and groups in the U.S. continue to strongly oppose U.S. ratification, remaining convinced that the Agreement’s fundamental cast – especially, its provisions characterizing lunar resources as the “common heritage of mankind” and mandating the establishment of an “international regime” – will in practice inhibit the productive development and exploitation of He-3 and other lunar resources, and, in particular, create such uncertainty for private enterprise as to effectively discourage, if not prevent, private investment and industry from playing any meaningful role in the exploitation of such resources – a role they believe essential to the successful commercial development of such resources.61 It may be argued that, given the risks and uncertainty necessarily involved in the development of lunar He-3-based fusion energy, the enormous investment certainly required, and the likely very long time horizon before any financial return can hope to be achieved, the prospect of private enterprises choosing to play a leading role in He-3 or other lunar resource development – at least without substantial government assistance – is open to question.62 However, the 1980 Senate Hearings and subsequent lack of administration interest in the Agreement suggest that, if such opposition persists, the prospect for Senate ratification of the Agreement at any time soon may remain uncertain.

#### Mining on heritage sites lets us skip in the research project with human-obtained samples – that’s preferable to generic sites.

Glass 92 “Lunar Site Characterization and Mining” Charles E. Glass [registered professional geological engineer in the State of Arizona, this is from a NASA edited paper] 1992 <https://space.nss.org/settlement/nasa/spaceresvol3/lscam1.htm> SM

Before resources are committed to lunar mining, a significant amount of information will be needed. I hope that our workshop group will illuminate some of the more obscure areas, such as the specific requirements of an ore processing facility. Other important information can be acquired only through onsite exploration and testing.

Potential lunar mining sites can be divided into two general groups- generic sites and Apollo sites. Geologic data for both types of site are sparse and of poor spatial resolution

Generic sites have not been visited. They are potential mine sites only because they are in lunar regions with mineralogic properties that are generally understood by comparison of remotely sensed data with data from analysis of Apollo site samples; e.g., mare sites, highland sites, or transition sites. See figure 15. Generic sites will require exploration at a variety of scales.

Initial exploration using a satellite in lunar orbit will allow regional exploration of many generic sites. Polar sites, if suitable ones can be identified, have several advantages for a mining operation. First, the continuous solar radiation at the poles would enable continuous mining o perations under stable temperature and lighting conditions. (See figure 16.) Such an environment would eliminate the stress on mining equipment and personnel caused by the alternation of 2-week lunar nights and days at other sites. Second, the high thermal gradients encountered at the poles due to low Sun angles could help provide cryogenic storage for processing gases and product gases. Third, the potential occurrence of water frozen in the perpetually shadowed areas of the poles is an incentive for exploring polar sites.

Exploration of generic sites at intermediate scales is required to bridge the gap between the low- resolution remote sensing data and the more intensive measurements made by human beings. This intermediate-scale exploration could be done by automated rovers, which should be able to cover relatively large areas rather rapidly.

The automated nature of lunar exploration will demand advances in high-resolution sensing and in computer processing and integration of data acquired by different instruments on the same roving vehicle. Knowledge gained from terrestrial mineral exploration can be used for preliminary training of automated interpretation systems, but the unique conditions of the lunar environment will likely require an intelligent computer- vision system capable of "learning" and adjusting as new data become available.

[Images omitted]

Completion of these exploration programs should bring our knowledge of generic sites up to that of the Apollo sites, the second general category. Regional exploration is not deemed necessary for the Apollo sites because of the relatively extensive body of knowledge already assembled. However, detailed site investigations to obtain specific parameters for mine design will be required for the first mining attempt.

In outlining these exploration requirements, our workshop group made several assumptions. First, we assumed that the prototype lunar mining venture should be an unqualified success. Second, we assumed that the startup product would be liquid oxygen, with the subsequent addition of such byproducts as metals for structural use, ceramics, and bulk materials for shielding. Third, we assumed that the mining operation wou[a excavate lunar regolith and deliver a well-graded feedstock to the processing facility. (No crushing is required, with oversized material being removed mechanically.)

Specific Parameters for Mine Design

The final stage of the exploration program-to acquire specific parameters for mine design-will begin only after a chosen site has been as thoroughly explored as an Apollo site. Even for the Apollo sites, information is insufficient to assure the success of our first lunar mine. Factors that affect mining include mineralogy, grain size distribution, abrasiveness, depth of loosely compacted regolith, and surface topography. How these factors vary from place to place is not well understood. The Apollo missions were never intended to be resource appraisals. Nevertheless, a restudy of Apollo samples and survey data with an eye toward resource appraisal would be a promising first step toward obtaining the needed site detail.

#### Tranquility mining is key – it has the highest known density of He-3.

O’Reilly 16 LUNAR EXPLORATION FOR HE-3 Bryan O’Reilly The Ohio State University 2016 <https://core.ac.uk/download/pdf/159567253.pdf> SM

* Mare Tranquillitatis = science word for Sea of Tranquility

Schmitt (2006) summarized initial research on the exploration for lunar He-3 that identified potential areas of high He-3 concentration. Mare Tranquillitatis, for example, is considered a particularly attractive site for a manned lunar base and the mining of lunar He-3. This site also holds Fe, Ti, and other minerals important for cost-effective, on-site production of construction materials and O2 from mineralized oxygen. In siting a manned lunar base, water may be extracted atomically bound OH- and lunar ice, and other issues that need to be addressed in choosing a manned lunar base.

The present research study further tests the recommended locations (e.g. Mare Tranquillitatis) of high He-3 concentrations. In particular, the utility of satellite-based Gamma Ray Spectrometers (GRS) is investigated to indirectly map He-3 abundances in terms of the surficial abundances of gamma-radiating elements like titanium, oxygen and iron that reflect distributions of lunar ilmenite (e.g., Hasebe et al., 2008). In addition, satellite microwave measurements may be used to estimate regolith thickness, maturity, and dielectric constants to help map out He-3 concentrations and other lunar mineral deposits (Wang, 2010).

Satellite remote sensing data from past lunar missions are used to estimate TiO2 and hydrogen concentrations, and the solar wind flux over the crust to identify lunar He-3 prospects. These results may help constrain the fiscal and technological viability of mining lunar He-3.

Current uses of helium-3 far outpace its supply and production on Earth. This shortage is detrimental to areas ranging from national security to important physics and medical research. The growing decrease of He-3 stores also drastically limits efforts to make He-3-D fusion a realistic energy source. However, the growing demand may well be satisfied with the He-3 concentrations hosted within the regolith of our closest celestial neighbor, the Moon. Indeed, the mining of He-3 on the Moon is an imminent, if not the next, giant leap for space exploration (Schmitt, 2006).

Elements of this research were presented at the fall’15 Undergraduate Student Poster Forum and the spring’16 Denman Undergraduate Research Forum of The Ohio State University. Further aspects of this research were presented at the annual conferences of the Geologic Society of America (O’Reilly and von Frese, 2015) and NASA’s Lunar and Planetary Institute (O’Reilly and von Frese, 2016).

METHODS

National Aeronautics and Space Administration (NASA) data collection

The elemental abundance data for this research were collected from NASA’s publicly available Planetary Data System (PDS) Geoscience Node. Specifically, the data were observed by the Lunar Prospector (LP) mission’s gamma ray and neutron spectrometer tools and processed by the LP Spectrometer Team as part of a NASA Lunar Data Analysis Program. Elemental abundances of Ti were derived from LP gamma ray spectrometer (Feldman et al., 1999) observations acquired during the high-altitude portion of the LP mission. For the Ti distribution, the data are given in units of elemental weight percent (Prettyman et al., 2002). The half-degree hydrogen abundances came from the LP neutron spectrometer epithermal neutron data that had been corrected by the thermal neutron data (Feldman et al., 2001). Equations 3 and 4 of Feldman et al. (2001) show how the corrected epithermal data were converted into hydrogen abundances as parts per million (ppm). Note, however, that these abundances can be unreliable in regions of high thorium and rare-Earth element abundances (Maurice et al., 2004).

In general, using the above method yields an average ±1.7 wt% uncertainty in the TiO2 estimates (Elphic et al., 2002). Estimates from areas with higher levels of TiO2 are considered to be more reliable than those from lower TiO2 areas. Uncertainties in H estimates are typically less than 1% over latitudes ±70° and increase significantly towards the poles (Feldman et al., 2001). Estimates of H taken from large lunar craters in the South Pole showed uncertainties averaging around 50% (Feldman et al., 2001).

Modeling

The raw elemental abundance data were converted from the original ASCII files to Microsoft Excel through the “paste special” tool for import into MATLAB. Once imported, the data were processed by the scripts in Appendix A to produce various lunar abundance maps. The script in Figure A1 produces contour maps of the elemental data on the lunar near and far sides using the M\_Map MATLAB mapping package (Pawlowicz 2014). This script uses the sinusoidal map projection to produce equal-area representations of the abundance data.

The script in Figure A2 produces stereographic projections of abundances in the lunar polar regions. Equation 1 (Fa and Ya-Qiu, 2007) was used to estimate crustal exposure to solar wind flux as a percentage in terms of lunar longitude (θ) and latitude (Φ) in degrees, and the constant flux (F0) at a subsolar point. Here, f represents the amount of time the lunar surface is fully shielded from solar winds by Earth’s magnetotail in the span of 28 days (one orbital period). To produce the normalized solar wind flux, the model assumed F0 = 0.5, and f = 0.25 based on the amount of time the moon is in the magnetotail. Equation 1 was implemented by the MATLAB script in Figure A3 to produce a contour map (Figure 2) of the lunar near and far side exposures in percent of the maximum solar wind flux over a single lunar orbital period. These maps in the sinusoidal map projection were obtained using the previously cited M\_map mapping package.

𝟐 + 𝒔𝒊𝒏(𝜽 − 𝒇𝝅) − 𝒔𝒊𝒏(𝜽 + 𝒇𝝅), |𝜽| ≤ 𝝅(. 𝟓 − 𝒇) 1) 𝑭(𝜱,𝜽)=𝑭𝟎𝒄𝒐𝒔(𝜱)∗{𝟏+𝒔𝒊𝒏(|𝜽|−𝒇𝝅),𝝅(𝟎.𝟓−𝒇)≤|𝜽|≤𝝅(.𝟓+𝒇)

𝟐, 𝝅(. 𝟓 + 𝒇) ≤ |𝜽| ≤ 𝝅

RESULTS

Solar Flux

Figure 2 shows that the Moon’s orbit around Earth largely affects the intensity of solar exposure on its surface, with the near side receiving significantly lower exposure than the far side. This is due to Earth’s magnetosphere which, during a full Moon when the near side is facing the Sun, rests within Earth’s magnetotail shielded from solar radiation.

[Figure omitted] Figure 2. Solar flux as a percent of solar wind flux exposure per lunar cycle for the near (top) and far (bottom) sides of the lunar surface between 65°S - 65°N.

Titanium Distribution

The distribution of Ti correlates with large impact events (Schmitt, 2006), and thus the highest Ti concentrations are within the maria of the lunar near side (Figure 3). Mare Tranquillitatis, in particular, appears to have the highest overall concentration. On the moon, Ti occurs as the mineral ilmenite (FeTiO3) with the crystal structure that locks in the small He-3 atoms. The blank strip surrounding 180°E in Figure 3 reflects a no-data area due to lack of orbital coverage by the satellite (Feldman et al., 1999).

Diurnal Heating

Areas within ±60 ̊ latitudes experience large average daily temperature shifts. The Apollo 15 site (26.13224 N, 3.63400 E), for example, underwent a shift from 374 ̊K to 92 ̊K (Heiken et al., 1991). The areas around the poles typically stay within 10 ̊ of 115 ̊K with even smaller variations in permanently shadowed craters (Vasavada et al., 1999). Volatiles are essentially baked out of the regolith when subjected to these extreme temperature changes (Cocks, 2010).

Polar Migration

After volatiles are released from the lunar regolith, they are either redeposited on the lunar surface or released into space (Cocks 2010). Figure 4 shows the increase of hydrogen around the poles compared to lower longitudes. This measurable increase is attributed to permanently shadowed craters, which prevent massive temperature fluctuations and provide shielding from micrometeoroids. The blank strips surrounding 180°E in Figure 4 reflect areas with no data due to lack of orbital coverage by the satellite (Feldman et al., 1999).

Wt. %

AR = (5.6, 0) ASD = 0.8929 AM = 0.6560 CI = 0.5

[Figure omitted] Figure 3. Weight percent Ti distribution for the near (top) and far (bottom) sides of the lunar surface from 65°S - 65°N. Mare Tranquillitatis is highlighted (8.5°N, 31.4°E) as an area of high Ti. Map statistics include the amplitude range (AR) of (max, min) values, amplitude standard deviation (ASD), amplitude mean (AM), and contour interval (CI) in weight %.

AR = (169.01, 0.0215) ASD = 23.04

AM = 57.06

CI = 20

ppm

[Figure omitted] Figure 4. Volatile hydrogen concentrations in ppm for the lunar north pole (top left) from 90°N - 65°N, south pole (top right) from 90°S - 65°S, and the far side (bottom) from 90°W - 90°E and from 65°S - 65°N of the lunar surface. Map statistics include amplitude range (AR) of (max, min) values, amplitude standard deviation (ASD), amplitude mean (AM), and contour interval (CI) in ppm.

DISCUSSION

The data above contain implications for the search for large concentrations of He-3. The only method for deposition of He-3 is through exposure of the regolith to solar radiation carrying the isotope. Figure 5 shows the geometry of the Moon’s exposure to solar radiation over a single orbital period (28 days). Accordingly, most of this exposure occurs on the far side of the Moon when it is between the Sun and Earth outside the magnetosphere.

In general, the areas of high solar exposure are also subject to extreme diurnal

[Figure omitted] Figure 5. A 2-D geometric rendering of the relationship between the Sun (orange), Earth (large circle), and the moon (small circle) throughout a lunar orbital period. The moon is positioned outside the magnetosphere (green dashed line) during a new moon exposing the far side (light blue). The moon is positioned inside the protective magnetotail (red dashed line) during a full moon preventing exposure of the near side (dark blue).

temperature fluctuations. During the lunar orbital period, these drastic temperature changes will occur due to the prolonged exposure or protection from solar radiation causing the deposited volatiles to leave the regolith and possibly be re-ionized and –deposited onto the lunar surface (Cocks, 2010). This implies that many of the volatiles initially deposited by solar wind exposure do not remain stably in place. The distribution of hydrogen measured in Figure 4 suggests that the volatiles in general may be concentrated around the poles.

Much like hydrogen, He-3 is also deposited in the regolith through solar wind. However, exposing these elements to extreme temperature shifts causes them to vaporize and leave the lunar surface. Some of these volatiles are re-ionized due to subsequent solar wind exposure and possibly deposited again near the poles where they are better protected from temperature changes (Cocks, 2010). This mechanism could help explain the larger polar accumulations of volatiles.

The lunar polar regions offer protection from extreme temperature variations, which also may be provided by the presence of permanently shadowed craters. These craters not only protect volatiles from vaporizing out of the regolith, but they also shield the regolith from micrometeorite impacts that disturb the surface encouraging the further release of volatiles. These polar regions are estimated by the Lunar Prospector team (Schmitt, 2000) to contain roughly 5 to 15 times more hydrogen. Figure 6 shows an example of the permanently shadowed Shackleton crater.

[Figure omitted] Figure 6. The Shackleton crater located near the South Pole, where the colors indicate the percentage of time illuminated during a single lunar orbital period. The rim of the crater contains zero (white) and near zero illumination values which identify it as a permanently shadowed crater (Zuber et al., 2012).

Another important aspect to consider is the relationship between titanium (Ti) and He-3. The majority of Ti on the Moon appears in the form of ilmenite (FeTiO3). Tests done on lunar ilmenite, olivine, pyroxene, and plagioclase show that for grains in the same size range from the same soil, ilmenite (FeTiO3) contains 10 to 100 more times as much He-3 (Fa and Ya-Qiu, 2007). The structure of ilmenite, seen in Figure 7, is better able to hold onto the small He-3 ions when subjected to extreme conditions. This suggests that He-3 is more protected from the effects of massive temperature shifts than other volatiles when high concentrations of Ti are present. Figure 3 shows that most of the Ti on the Moon appears in the large impact craters of the nearside.

[Figure omitted] Figure 7. The crystal structure of Ilmenite. The alternating layers of Fe and Ti along with the rhombohedral shape shown above allow for tighter confinement of loose He-3 ions (Ribeiro and Lazaro, 2014).

With all of these factors considered, two areas of particular interest are suggested for holding large concentrations of He-3. They include Mare Tranquillitatis (8.5 ̊N 31.4 ̊E) that has the highest concentration of Ti on the lunar surface, and thus also possible large He-3 stores. The second area of interest is the South Pole Aitken basin with large permanently shadowed craters that enhance its ability to hold volatiles like He-3 through diurnal heating shifts over the lunar orbital period. These permanently shadowed craters would protect the volatiles from temperature shifts and the regolith from being disturbed by micrometeorite impacts.

CONCLUSIONS

Lunar resource development is an extensive and expensive effort, however, this study seeks to introduce the need to explore for these resources. This study examined the shortage of available He-3 and the affected industries. Hopes in the distant future for clean fusion energy also rest on access to this valuable resource. As U.S. stockpiles diminish and demand continues, the economic incentive for the acquisition of He-3 deposits on the moon becomes an increasingly attractive option.

The objective of this study was to use available satellite data to estimate possible locations of large lunar He-3 deposits. From the analysis of NASA’s satellite gamma ray data, two areas were targeted for possibly holding large concentrations of He-3. Specifically, Mare Tranquillitatis was identified as holding enhanced ilmenite concentrations and other elements that would be essential in any mining mission. The South Pole Aitken basin was also targeted due to its large permanently shadowed areas that enhance its ability to hold volatiles and prevent their migration due to diurnal heating. In general, these results are also consistent with previous lunar site recommendations for locating large He-3 concentrations (e.g. Schmitt, 2006).

#### Only mining at Tranquility sites is economically feasible and profitable – it’s the only location with enough data to be categorized as a measured resource.

Schmidt 06 “Return to the Moon exploration, enterprise, and energy in the human settlement of space” Harrison Schmidt [an American geologist, retired NASA astronaut, university professor, former U.S. senator from New Mexico, and the most recent person living, and only civilian to have walked on the Moon. Schmitt is the last surviving crew member of Apollo 17] <https://www.amazon.com/Return-Moon-Exploration-Enterprise-Settlement/dp/0387242856> SM

Economic geologists — who study the value, quantity, and origin of mineral deposits — use the terms "measured," "indicated," and "inferred" to distinguish resources that are at decreasing levels of certainty in terms of available tonnage at a specified value (see Figure 6.4).87 Exploration, drilling, and sample analysis, or other direct means, have delineated "measured reserves" to the extent that further investments of capital for actual production are warranted. Of course, such investments only will be made if the value and tonnage, or volume, make economic sense in the time frame that the resource can be sold in a forecasted market. "Indicated resources" have enough geological definition to be included in long-term mine planning but will require additional investment in quantitative exploration before they can become defined as measured resources ready for production. "Inferred resources" are based on geological inference but are too speculative to be included in planning until further exploration takes place.

The current economic and geological position of lunar helium-3 in the titanium-rich portions of Mare Tranquillitatis is shown in Figure 6.4. Relative to the figure, upward, positive economic change in lunar helium-3 will be determined by increases in the cost of alternative sources of terrestrial energy, particularly coal. Downward, negative economic change would be caused by higher than anticipated lunar development costs. Increases in geological certainty could arise from direct sensing of helium-3 from orbital spacecraft; however, it definitely will come from detailed mapping and the fusion of all pertinent geochemical and geotechnical data prior to mining.

The first consideration an economic geologist makes relative to a potential resource must involve its estimated value, against which the costs of production can be weighed. What is the likely price per unit that can be realized in the marketplace at the point in the future when the production operations begin? The value of lunar helium-3 for fusion electrical power plants on Earth will be a function of the demand and supply of competitive energy sources. As already discussed in the previous chapter (Section 5.3), helium-3 will be in direct future competition with steam coal for power generation. Forecasting coal prices in the 2010-2015 time frame will be important to evaluating the competitive value of lunar helium-3. Prices for thermal or steam coal in Asia (4% of world demand, rising at 10% annually) have begun to rise rapidly, up 70-80% in 2004.88 In fact, some analysts expect steam coal to reach and hold over $2.50/million BTU in 2005.89 Spot prices have approached $2.00 in the United States for the eastern stoker coal in 2004.9° Therefore, forecasting coal prices of at least $2.50/million BTU, appears to be a reasonable planning assumption for 2010-2015.9' This gives a conservative estimate that the energy equivalent value of 100 kg of helium-3 in 2010-2015 would be about $140 million.

6.3.2 Mining analysis With this value of $140 million 100 kg in mind, how much helium-3 is reasonably available in the richest (highest grade or concentration) known portions of the lunar regolith? Working with the Wisconsin Fusion Technology Institute team in the 1980s, the late Professor Eugene Cameron,92 one of the world's foremost economic geologists, made the

[Figure omitted] FIGURE 6.4 Current position of lunar helium-3 in titanium-rich portions of Mare Tranquillitatis relative to demonstrated economic potential. (Graphic background courtesy of P. J. Brown, University of Wisconsin—Madison)

first estimates of the quantities of helium-3 expected to be present in titanium-rich regolith on the Moon. Cameron, using available spectro-scopic data on titanium concentration as discussed in Section 6.2.3, determined that the highest grade area for helium-3 totaled about 84,000 km2 and another 195,000 km2 of medium grade concentrations all within Mare Tranquillitatis. By geological inference, using photogeological mapping and remotely-sensed titanium concentrations, this is the region to which Apollo 11 samples apply, as well as those provided by Apollo 17. Cameron also studied the distribution of craters and estimated that about 50% of the 84,000 km2 would be minable by the Wisconsin Mark II miner (see Section 7.2.2). If mined to a depth of 3 meters with a helium-3 concentration of 20 wppb (Section 5.2), this highest grade area would yield about 2500 tonnes of helium-3. In 2010-2015, with coal at $2.50/ million BTU, this amount of helium-3 will probably have an energy equivalent value of about $3.5 trillion! Even at 2003's contract coal prices, the value would be about $1.75 trillion. This economic potential, and the policy and environmental advantages of helium-3 fusion, have been exciting enough to keep the interest of the Wisconsin group and the author since the late 1980s.

Since Cameron's initial work, as discussed above, the helium-3 resources in Mare Tranquillitatis have moved close enough to being "measured resources" to warrant investment in the integrated analysis of all available sample and remote-sensing data. Cameron based his analysis on Apollo 11 sample data, the available spectroscopic definition of titanium distribution, and 1960s Lunar Orbiter photography.93 Apollos 15, 16, and 17 metric and panametric cameras, operating from orbit, gathered additional high-resolution and stereophotography of the area of interest in Mare Tranquillitatis. Subsequently, two additional data sets obtained by the Department of Defense and NASA promise to further refine our knowledge of the distribution of titanium in that region's regolith. Respectively, these data came from optical spectrometers aboard the Clementine mission in 199494 and from the neutron and gamma-ray spectrometers of the Lunar Prospector mission in 1998-1999.95 Further, improved optical specrometric data from Earth have been collected.96 As discussed above, nanophase native iron accumulates in the regolith as a function of exposure to micrometeor impact, so remotely-sensed concentrations of such iron measure the length of exposure to solar wind and, in turn, indirectly measure relative helium-3 concentrations. This accounts for the strong correlation between both titanium oxide concentration and regolith maturity.97

It may be possible, as well as desirable to potential investors, to directly map helium-3 distribution in the regolith. This could be done on a global scale by developing an advanced gamma-ray spectrometer for a special-purpose, low-cost lunar orbiter, mapping the 20.6 (and higher) MeV gamma-rays released when a helium-3 nucleus captures a solar cosmic-ray-induced neutron.98 (Significant in-situ understanding of neutron flux at the lunar surface was gained by the lunar neutron probe experiment deployed on Apollo 17.99) Telerobotic rovers could accomplish more specific and higher resolution mapping of a targeted mining site, albeit at significantly higher cost than an orbital sensor. The cost, however, of either an orbiter or surface rovers should not be incurred until the existing data sets are fully exploited and the need for one or the other becomes clear.

Although a major project that fuses all the available data sets is clearly necessary, there can be little doubt that very interesting concentrations (grades) of helium-3 are present in the upper 3 to 6 meters of Mare Tranquillitatis regolith. Based on analyses of Apollo samples to date, the average, undisturbed concentration of helium-3 in major portions of Mare Tranquillitatis appears to be at least 20 wppb, and conceivably higher. Analysis of drill cores from Apollo 15, 16, and 17, even though they have been depleted in volatiles by agitation and are highly variable from one buried ejecta blanket to another, indicates that this average grade will continue to a depth of at least 3 meters and probably to the base of the regolith.10°

#### Helium-3 fusion possible now—Solves warming and energy infrastructure reliability

**Whittington 21** (Mark, contributor to the Hill. “Solving the climate and energy crises: Mine the Moon's helium-3?”<https://thehill.com/opinion/technology/540856-solving-the-climate-and-energy-crises-mine-the-moons-helium-3> February 28, 2021)DR 22

Solar System Resources has agreed to provide 500 kilograms of helium-3 mined from the Moon to U.S. Nuclear Corp. in the 2028-2032 timeframe.

According to [a paper](https://mdcampbell.com/Helium-3version2.pdf) published by Jeff Bonde and Anthony Tortorello, helium-3 is an isotope that has been deposited in lunar soil over billions of years by solar wind. Roughly 1.1 million metric tons of the isotope exists on the Moon down to a depth of several meters. Twenty-five metric tons of helium-3, about a quarter of the cargo capacity of a SpaceX Starship, would suffice to fuel all the power needs of the United States for a year.

The announcement does not reveal how Solar System Resource proposes to mine the helium-3. The company’s website is very heavy on breathtakingly inspirational verbiage and light on how it intends to raise the money and develop the technology to mine the solar system’s resources. However, the paper suggests that a rover could scoop up lunar regolith, separate helium-3 along with oxygen and hydrogen, store them and eject the processed lunar soil. The gasses would be taken back to a lunar base where the oxygen and hydrogen would be put to good use and the helium-3 stored for later export to Earth.

The announcement also does not reveal what U.S. Nuclear Corp. intends to do with the helium-3 once it takes delivery. The company, which builds radiation detection devices, has a subsidiary, [Magneto-Inertial Fusion Technology, Inc.,](https://www.usnuclearcorp.com/magneto-inertial-fusion-technologies/) that is researching a fusion technology called [staged Z-pinch.](https://arpa-e.energy.gov/sites/default/files/04_WESSEL.pdf) This would create a fusion reaction long enough and sustained enough to become a power source. Presumably, an abundant store of helium-3 could be an asset for those experiments.

Fusion using helium-3 has advantages and disadvantages over using deuterium, an isotope of hydrogen and tritium, another isotope of hydrogen.

Deuterium and tritium fusion releases radioactive neutrons that will damage and weaken the containment vessel. Periodically, a fusion reactor using this method would have to be taken offline for decontamination. Tritium is also radioactive, making its handling difficult and dangerous. A deuterium and helium-3 fusion creates helium and charged protons as byproducts and few or no radioactive particles.

The main disadvantage of fusion using helium-3 is that it would take a far greater amount of energy to achieve it than the conventional deuterium and tritium variety. According to [Open Mind,](https://www.bbvaopenmind.com/en/science/physics/helium-3-lunar-gold-fever/#:~:text=In%201986%2C%20scientists%20at%20the,produce%20energy%20by%20nuclear%20fusion.) Frank Close, a physicist at the University of Oxford, regards fusion using helium-3 as “moonshine.” Close suggests that a deuterium and helium-3 fusion will still produce some radioactive neutrons.

Gerald Kulcinski, director of the [Fusion Technology Institute](https://fti.neep.wisc.edu/fti.neep.wisc.edu/index.html) at the University of Wisconsin at Madison, disagrees. Close’s objection is based on using conventional fusion technology. The Fusion Technology Institute has achieved some progress in minimizing radioactive neutron production using different technology.

Helium-3 fusion is an even more promising technology, albeit a more difficult and complicated one to develop. The consensus seems to be that such reactors will not be achieved for some decades, say mid-century.

No one can guarantee that enough helium-3 will be mined from the Moon to jump-start serious development of technology using the isotope as a fusion fuel in the foreseeable future. There is no guarantee that such a development will see practical results anytime soon. However, the effort would be well worth pursuing, with substantial money and effort deployed behind it. If not the two aforementioned companies, someone should undertake the effort. Fusion using helium-3 as fuel would change the world in profoundly beneficial ways.

The great problem civilization faces is access to clean, affordable and reliable energy. Recent [events](https://www.nbcnews.com/news/weather/knocked-out-texas-millions-face-record-lows-without-power-new-n1257964) in Texas prove that not having energy, even for a few days, can be catastrophic. At the same time, humankind needs sources of energy that do not harm the environment, especially by emitting greenhouse gasses.

It appears that humankind is returning to the Moon, at long last. [President Trump](https://thehill.com/people/donald-trump) [started](https://thehill.com/opinion/technology/482265-trump-goes-all-in-for-nasas-artemis-return-to-the-moon-program) the Artemis Project. [President Biden](https://thehill.com/people/joe-biden) has thrown his support behind the effort. There are many reasons to return to the Moon, from science, to commerce, to soft political power. Solving the decades-long energy crisis could be the singular benefit for expanding human activity to Earth’s nearest neighbor.

#### Extinction from energy collapse

Greene 19 [Sherrell R. Greene Mr. Greene received his B.S. and M.S. degrees in Nuclear Engineering from the University of Tennessee. He is a recognized subject matter expert in nuclear reactor safety, nuclear fuel cycle technologies, and advanced reactor concept development. Mr. Greene is widely acclaimed for his systems analysis, team building, innovation, knowledge organization, presentation, and technical communication skills. Mr. Greene worked at the Oak Ridge National Laboratory (ORNL) for over three decades. During his career at ORNL, he served as Director of Research Reactor Development Programs and Director of Nuclear Technology Programs. . "Enhancing Electric Grid, Critical Infrastructure, and Societal Resilience with Resilient Nuclear Power Plants (rNPPs)." <https://ans.tandfonline.com/doi/pdf/10.1080/00295450.2018.1505357?needAccess=true> edited for ableist language in brackets[]]

Societies and nations are examples of large-scale, complex social-physical systems. Thus, societal resilience can be defined as the ability of a nation, population, or society to anticipate and prepare for major stressors or calamities and then to absorb, adapt to, recover from, and restore normal functions in the wake of such events when they occur. A nation’s dependence on its Critical Infrastructure systems, and the resilience of those systems, are therefore major components of national and societal resilience.

There are a variety of events that could deal ~~crippling~~ [Incapacitating] blows to a nation’s Grid, Critical Infrastructure, and social fabric. The types of catastrophes under consideration here are “very bad day” scenarios that might result from severe GMDs induced by solar CMEs, HEMP attacks, cyber attacks, etc.5

As briefly discussed in Sec. III.C, the probability of a GMD of the magnitude of the 1859 Carrington Event is now believed to be on the order of 1%/year. The Earth narrowly missed (by only several days) intercepting a CME stream in July 2012 that would have created a GMD equal to or larger than the Carrington Event.41 Lloyd’s, in its 2013 report, “Solar Storm Risk to the North American Electric Grid,” 42 stated the following: “A Carrington-level, extreme geomagnetic storm is almost inevitable in the future…The total U.S. population at risk of extended power outage from a Carrington-level storm is between 20-40 million, with durations of 16 days to 1-2 years…The total economic cost for such a scenario is estimated at $0.6-2.6 trillion USD.” Analyses conducted subsequent to the Lloyd’s assessment indicated the geographical area impacted by the CME would be larger than that estimated in Lloyd’s analysis (extending farther northward along the New England coast of the United States and in the state of Minnesota),43 and that the actual consequences of such an event could actually be greater than estimated by Lloyd’s.

Based on “Report of the Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack: Critical National Infrastructures” to Congress in 2008 (Ref. 39), a HEMP attack over the Central U.S. could impact virtually the entire North American continent. The consequences of such an event are difficult to quantify with confidence. Experts affiliated with the aforementioned Commission and others familiar with the details of the Commission’s work have stated in Congressional testimony that such an event could “kill up to 90 percent of the national population through starvation, disease, and societal collapse.” 44,45 Most of these consequences are either direct or indirect impacts of the predicted collapse of virtually the entire U.S. Critical Infrastructure system in the wake of the attack.

Last, recent analyses by both the U.S. Department of Energy46 and the U.S. National Academies of Sciences, Engineering, and Medicine47 have concluded that cyber threats to the U.S. Grid from both state-level and substatelevel entities are likely to grow in number and sophistication in the coming years, posing a growing threat to the U.S. Grid.

These three “very bad day” scenarios are not creations of overzealous science fiction writers. A variety of mitigating actions to reduce both the vulnerability and the consequences of these events has been identified, and some are being implemented. However, the fact remains that events such as those described here have the potential to change life as we know it in the United States and other developed nations in the 21st century, whether the events occur individually, or simultaneously, and with or without coordinated physical attacks on Critical Infrastructure assets.

#### Extinction from warming—feedback loops bypass defense

Ng ’19 [Yew-Kwang; May 2019; Professor of Economics at Nanyang Technology University, Fellow of the Academy of Social Sciences in Australia and Member of the Advisory Board at the Global Priorities Institute at Oxford University, Ph.D. in Economics from Sydney University; Global Policy, “Keynote: Global Extinction and Animal Welfare: Two Priorities for Effective Altruism,” vol. 10, no. 2, p. 258-266]

Catastrophic climate change

Though by no means certain, CCC causing global extinction is possible due to interrelated factors of non‐linearity, cascading effects, positive feedbacks, multiplicative factors, critical thresholds and tipping points (e.g. Barnosky and Hadly, [2016](https://onlinelibrary-wiley-com.proxy.lib.umich.edu/doi/full/10.1111/1758-5899.12647#gpol12647-bib-0005); Belaia et al., [2017](https://onlinelibrary-wiley-com.proxy.lib.umich.edu/doi/full/10.1111/1758-5899.12647#gpol12647-bib-0008); Buldyrev et al., [2010](https://onlinelibrary-wiley-com.proxy.lib.umich.edu/doi/full/10.1111/1758-5899.12647#gpol12647-bib-0016); Grainger, [2017](https://onlinelibrary-wiley-com.proxy.lib.umich.edu/doi/full/10.1111/1758-5899.12647#gpol12647-bib-0027); Hansen and Sato, [2012](https://onlinelibrary-wiley-com.proxy.lib.umich.edu/doi/full/10.1111/1758-5899.12647#gpol12647-bib-0029); IPCC [2014](https://onlinelibrary-wiley-com.proxy.lib.umich.edu/doi/full/10.1111/1758-5899.12647#gpol12647-bib-0031); Kareiva and Carranza, [2018](https://onlinelibrary-wiley-com.proxy.lib.umich.edu/doi/full/10.1111/1758-5899.12647#gpol12647-bib-0033); Osmond and Klausmeier, [2017](https://onlinelibrary-wiley-com.proxy.lib.umich.edu/doi/full/10.1111/1758-5899.12647#gpol12647-bib-0056); Rothman, [2017](https://onlinelibrary-wiley-com.proxy.lib.umich.edu/doi/full/10.1111/1758-5899.12647#gpol12647-bib-0066); Schuur et al., [2015](https://onlinelibrary-wiley-com.proxy.lib.umich.edu/doi/full/10.1111/1758-5899.12647#gpol12647-bib-0069); Sims and Finnoff, [2016](https://onlinelibrary-wiley-com.proxy.lib.umich.edu/doi/full/10.1111/1758-5899.12647#gpol12647-bib-0072); Van Aalst, [2006](https://onlinelibrary-wiley-com.proxy.lib.umich.edu/doi/full/10.1111/1758-5899.12647#gpol12647-bib-0079)).[7](https://onlinelibrary-wiley-com.proxy.lib.umich.edu/doi/full/10.1111/1758-5899.12647#gpol12647-note-1009_67)

A possibly imminent tipping point could be in the form of ‘an abrupt ice sheet collapse [that] could cause a rapid sea level rise’ (Baum et al., [2011](https://onlinelibrary-wiley-com.proxy.lib.umich.edu/doi/full/10.1111/1758-5899.12647#gpol12647-bib-0006), p. 399). There are many avenues for positive feedback in global warming, including:

* the replacement of an ice sea by a liquid ocean surface from melting reduces the reflection and increases the absorption of sunlight, leading to faster warming;
* the drying of forests from warming increases forest fires and the release of more carbon; and
* higher ocean temperatures may lead to the release of methane trapped under the ocean floor, producing runaway global warming.

Though there are also avenues for negative feedback, the scientific consensus is for an overall net positive feedback (Roe and Baker, [2007](https://onlinelibrary-wiley-com.proxy.lib.umich.edu/doi/full/10.1111/1758-5899.12647#gpol12647-bib-0065)). Thus, the Global Challenges Foundation ([2017](https://onlinelibrary-wiley-com.proxy.lib.umich.edu/doi/full/10.1111/1758-5899.12647#gpol12647-bib-0026), p. 25) concludes, ‘The world is currently completely unprepared to envisage, and even less deal with, the consequences of CCC’.

The threat of sea‐level rising from global warming is well known, but there are also other likely and more imminent threats to the survivability of mankind and other living things. For example, Sherwood and Huber ([2010](https://onlinelibrary-wiley-com.proxy.lib.umich.edu/doi/full/10.1111/1758-5899.12647#gpol12647-bib-0071)) emphasize the adaptability limit to climate change due to heat stress from high environmental wet‐bulb temperature. They show that ‘even modest global warming could … expose large fractions of the [world] population to unprecedented heat stress’ p. 9552 and that with substantial global warming, ‘the area of land rendered uninhabitable by heat stress would dwarf that affected by rising sea level’ p. 9555, making extinction much more likely and the relatively moderate damages estimated by most integrated assessment models unreliably low.

While imminent extinction is very unlikely and may not come for a long time even under business as usual, the main point is that we cannot rule it out. Annan and Hargreaves ([2011](https://onlinelibrary-wiley-com.proxy.lib.umich.edu/doi/full/10.1111/1758-5899.12647#gpol12647-bib-0004), pp. 434–435) may be right that there is ‘an upper 95 per cent probability limit for S [temperature increase] … to lie close to 4°C, and certainly well below 6°C’. However, probabilities of 5 per cent, 0.5 per cent, 0.05 per cent or even 0.005 per cent of excessive warming and the resulting extinction probabilities cannot be ruled out and are unacceptable. Even if there is only a 1 per cent probability that there is a time bomb in the airplane, you probably want to change your flight. Extinction of the whole world is more important to avoid by literally a trillion times.

### 3

#### CP: The Supreme Court of the United States should request and accept an appeal for the case LAURA MURRAY CICCO, v. NATIONAL AERONAUTICS & SPACE ADMINISTRATION, and rule in favor of Cicco, on the basis of the ban on national appropriation in the Outer Space Treaty and the common law property rights regime. Relevant Courts should uphold this precedent.

#### Except for the appropriation of one vial of moon dust by Laura Murray Cicco, private entities should not appropriate lunar heritage sites.

#### Ruling in favor of Cicco realigns the US with the OST.

Chow 18 “Woman says Neil Armstrong gave her moon dust. She's suing NASA to keep it.” June 14, 2018 Denise Chow <https://www.nbcnews.com/mach/science/woman-says-neil-armstrong-gave-her-moon-dust-she-s-ncna883116> SM

In a case that mixes nostalgia with serious questions about who is allowed to own materials brought back from space, a Tennessee woman is suing NASA to maintain possession of what she says is a vial of moon dust that astronaut Neil Armstrong gave her when she was 10 years old.

In her lawsuit filed in federal court last week, Laura Cicco says Armstrong, the first human to walk on the moon, gave her the vial in the 1970s along with a handwritten note: “To Laura Ann Murray — Best of Luck — Neil Armstrong Apollo 11.”

Moondust

Cicco, then named Laura Murray, claims she received the memento while living with her family in Cincinnati. She maintains that Armstrong, who taught aerospace engineering at the University of Cincinnati at the time, had been a friend of her late father. Armstrong died in 2012.

A handwriting expert authenticated the signature on the note, said Cicco’s lawyer, Christopher McHugh of Kansas City, Missouri. Tests of the vial's contents found that "there is no evidence to rule out a lunar origin," according to the court documents, but terrestrial materials from Earth's crust were also identified in the sample.

Cicco told the Washington Post that she had lost track of the vial until five years ago, when she rediscovered it in her father’s belongings after his death, and that she had filed the suit in an effort to block NASA from trying to seize the moon dust.

The space agency declined a request by MACH to comment on the case, but it has a reputation for aggressiveness in its efforts to take possession of lunar samples held by private citizens. In one highly publicized case from 2011, NASA conducted a sting operation in Lake Elsinore, California, to seize paperweights containing slivers of moon rock that a 74-year-old woman was trying to sell.

“Lunar samples that have been collected by U.S. government missions are considered unique and limited natural resources,” said Michelle Hanlon, co-founder of For All Moonkind, a nonprofit dedicated to preserving the Apollo lunar landing sites. “NASA retains all lunar samples collected through U.S. government missions as NASA property.” Hanlon is not involved in the case.

McHugh said there is no law against private ownership of moon dust. “The law is silent on this — it’s still an open question,” he said. “NASA bases its position on the assumption that no lunar material ever left NASA unless it was stolen, but there is no law that says you can’t own lunar material.”

The outcome of Cicco's case will hinge on whether Armstrong or the government owned the dust at the time it was given, according to Christopher Johnson, a professor of law at Georgetown University in Washington, D.C. and a space law expert. “If it’s the property of the U.S. government, he could not have passed it along to somebody else — he didn’t have the correct chain of custody or title for that,” said Johnson, who is not involved in the case.

McHugh said the handwritten note from Armstrong gives Cicco a strong claim of ownership. “We get past that hurdle because we have proof that Laura was given it directly by Neil Armstrong,” he said. “Unless you call Neil Armstrong a thief,” he added, “he had the authority to own it and give it to people. I don’t think Neil Armstrong was a thief.”

If there are no federal statutes against private ownership of materials from space, other experts say international law may provide some guidance. The Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, signed in 1967 and commonly called the Outer Space Treaty, prohibits governments from claiming territory on the moon and other celestial bodies. It is recognized by 107 countries, including the U.S. and Russia.

“In international law, nobody can appropriate anything in space. That is very clear,” said Ram Jakhu, an associate professor of space law at McGill University in Montreal, Canada. But, he added, “There are some exceptions and tolerance of violations. Countries like the U.S. and Russia have been collecting these moon samples and have been keeping it, so there’s some kind of tolerance of violation of international law.”

#### Lunar basing isn’t prohibited under this interpretation of the OST and isn’t seen as appropriation as long as it doesn’t constitute sovereign control – means credible OST encourages peaceful collaboration for lunar research which turns the aff

OST, "Outer Space Treaty," United Nations Office for Outer Space Affairs, <https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/outerspacetreaty.html> mvp mvp

The exploration and use of outer space, including the moon and other celestial bodies, shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and shall be the province of all mankind.

Outer space, including the moon and other celestial bodies, shall be free for exploration and use by all States without discrimination of any kind, on a basis of equality and in accordance with international law, and there shall be free access to all areas of celestial bodies.

There shall be freedom of scientific investigation in outer space, including the moon and other celestial bodies, and States shall facilitate and encourage international co-operation in such investigation.

#### Exemptions from the OST endangers the credibility of the entire treaty.

Hickman and Dolman 2 John Hickman and Everett Dolman Volume 21 Number 1 2002 “Resurrecting the Space Age: A State–Centered Commentary on the Outer Space Regime” (associate professor in the Department of Government and International Studies at Berry College in Mt. Berry)//Elmer

Thus a state party need merely announce its intention to withdraw and then wait one year. Withdrawal of a single state party to the treaty, however, would not necessarily terminate the treaty between the other state parties. Yet, the decision of an important state not to be bound by a regime–creating treaty obviously endangers the entire treaty. The decision of the United States or China to withdraw from the OST would have far greater implications for the survival of the international space regime than the same decision by Bangladesh, Burkina Faso, or Papua New Guinea—the equality of states under international law remains nothing more than a useful fiction. For the OST to remain good international law, it must be accepted as such by the major space faring states of the 21st Century: the United States, Russia, the European Union, Japan, and China. One defection from the regime by a member of this group would no doubt lead to its effective collapse, as the remaining space faring states are unlikely to use the kind of coercion necessary to enforce the regime. A more likely response to such a defection is a scramble to make similar claims to sovereignty, based on historical precedent and effective occupation. Similar rushes to stake claims for territory sovereignty in other celestial bodies might follow.

#### Violations cause credibility spirals.

Jha 17 “US lawmakers seek review of Outer Space Treaty amid competition from India, China” May 26, 2017 Lalit K. Jha <https://www.livemint.com/Science/6uxgbhcNcRfBtbWyq63wTO/US-lawmakers-seek-review-of-Outer-Space-Treaty-amid-competit.html> SM

Outer Space Treaty which entered into force in 1967 forms the basis of international space law. While the treaty has been successful so far, lawmakers said some of the provisions have not been tested. For instance the treaty does not prohibit the placement of conventional weapons in orbit. It also states that the exploration of outer space shall be done to benefit all countries and that space shall be free for exploration and use by all the states.

Matthew Schaefer, co-director, Space, Cyber and Telecommunications Law Programme, University of Nebraska College of Law, said there is going to be some countries that oppose US interpretations of various OST provisions for matters of national interest regardless.

“But I think when we comply with Article 6 the OST, we increase the number of countries that we have credibility to lead towards the US inspired to the commercially friendly inspired interpretations of the treaty," he said.

“And when we don’t comply with Article 6 of the OST, what we do is we send some countries, China and Russia is—though China actually has been noticeably pretty quiet when it comes to asteroid mining and property rights. But as a general matter, we send countries their way and we also have less credibility to insist those countries when, again, a US company is a first mover," Schaefer said.

“If we don’t have as part of our criteria for authorising commercial companies looking at whether we’re doing harmful interference with a pre-existing activity with them, we won’t have the credibility to them, insist on them doing the same for us," Schaefer said.

#### Credible OST solves Space War.

Johnson 17 Christopher Johnson 1-23-2017 “The Outer Space Treaty at 50” , <http://thespacereview.com/article/3155/1> (graduate of Leiden University’s International Institute of Air and Space Law and the International Space University)//Elmer

As mentioned, many of the provisions of the Outer Space Treaty were borrowed from previous UN General Assembly resolutions. But as resolutions alone, these documents were non-binding and did not require states to alter their behavior. And while UN General Assembly resolutions are not normally law-making exercises, they do record the commonly-held expression of intentions by the states in the General Assembly, and make political recommendations to UNGA Members (or to the UN Security Council). UNGA Resolutions can also set priorities and mold opinion for inclusion in subsequent treaties. The prohibition on the placement of nuclear weapons and other weapons of mass destruction in outer space or their installation on celestial bodies was taken from UNGA Resolution 1884 of 1963. The resolution: [s]olemnly calls upon all States… [t]o refrain from placing in orbit around the earth any objects carrying nuclear weapons or any other kinds of weapons of mass destruction, installing such weapons on celestial bodies, or stationing such weapons in outer space in any other manner. This prohibition was transferred to the Outer Space Treaty, and thereby remade into international treaty law. As President Johnson pointed out in his recommendation to Congress to ratify the Outer Space Treaty, “the realms of space should forever remain realms of peace.”5 He continued: We know the gains of cooperation. We know the losses of the failure to cooperate. If we fail now to apply the lessons we have learned, or even if we delay their application, we know that the advances into space may only mean adding a new dimension to warfare. If, however, we proceed along the orderly course of full cooperation we shall, by the very fact of cooperation, make the most substantial contribution toward perfecting peace.6 The agreement contained in Article IV of the Outer Space Treaty reflects an agreement between the US and the USSR, as obligations restricting their freedom of action. Why would a state intentionally place a restriction on itself? Isn’t it better to merely keep outer space as unregulated as possible? Since there were only two states then capable of venturing into outer space, why did either state agree to rules governing its actions? It may seem counterintuitive, but the deeper rationale behind security arrangements like this is that the parties actually benefit in the long-term from placing mutual restrictions on their behavior. Agreeing to restrict your freedom of action has deep links to the usefulness or utility of law itself. Consider driving a car: in order to get a license, you agree to observe certain rules, and the license signals your obligation to obey these rules. However, sometimes adhering to those rules is not only inconvenient (such as stopping at stop signs when there’s nobody else at the intersection), it is also against your short term-interests (you have an appointment or will otherwise suffer from observing the rules.) However, agreeing to operate within a system where your freedoms are sometimes restricted can have the effect of actually increasing your freedom over the long term. Wouldn’t you rather live in a state where traffic laws exist, and other drivers agree to observe them? Isn’t that system preferable to living in a state without traffic rules? Indeed, a system with traffic rules increases not just freedom in general, but overall safety and orderliness. Consequently, because the system with rules is preferable to the system without rules, your willingness to use the roads allows you to travel with greater security and ease. You are better assured of the likelihood that you will get to your intended destination without some other driver crashing into you. Knowing that safe travel is likely, you are more willing to take trips more often, and to farther destinations. Your freedom is actually increased over the long term because you are willing to suffer temporary, short-term restrictions such as inconvenient red lights. Long-term rationality warrants adherence to efficient systems of law. Correctly-balanced rules help increase long-term benefits (like safety and security) that would otherwise be unattainable without a system of rules. It is this rationale that also underpins international treaty-making. Today, the current absence of nuclear weapons or other weapons of mass destruction in outer space attests to the bargain struck in the Outer Space Treaty being a successful one, where security (and the liberty and freedom possible with security) were furthered by the mutual exchange of restrictions that states placed upon themselves. The more than 50 years of peaceful uses of outer space, including cooperation between states who remain rivals elsewhere, are the rich long-term gains resulting from the Outer Space Treaty.

#### Space war goes nuclear.

Johnson-Freese 17 Joan Johnson-Freese, Professor and chair of space science and technology @ Naval War College, 17, Space Warfare in the 21st Century, Routledge, ISBN 978131552917, p 18-20.

Space warfare runs two untenable risks: the creation of destructive debris and escalation to terrestrial, even nuclear, warfare. Kinetic warfare in space creates debris traveling at a speed of more than 17,000 miles per hour, which then in itself becomes a destructive weapon if it hits another object—even potentially triggering the so-called Kessler Syndrome,86 exaggerated for dramatic effect in the movie Gravity. Ironically, both China and the United States learned the negative lessons of debris creation the hard way. In 1985, the United States tested a miniature homing vehicle (MHV) ASAT launched from an F-15 aircraft. The MHV intercepted and destroyed a defunct US satellite at an altitude of approximately 250 miles. It took almost 17 years for the debris resulting from that test to be fully eliminated by conflagration re-entering the Earth’s atmosphere or being consumed by frictional forces, though no fragment had any adverse consequences to another satellite—in particular, no collisions. China irresponsibly tested a direct-ascent ASAT in 2007, destroying one if its defunct satellites. That test was at an altitude almost twice that of the 1985 US test. The debris created by the impact added 25 percent to the debris total in low Earth orbit87 and will dissipate through the low Earth orbit, heavily populated with satellites, for decades, perhaps centuries, to come. Perhaps most ironically, because of superior US debris-tracking capabilities, the United States—even though not required to do so—has on more than one occasion warned China that it needed to maneuver one of its satellites to avoid a collision with debris China itself had likely created.88 In 2013, a piece of Chinese space junk from the 2007 ASAT test collided with a Russian laser ranging nanosatellite called BLITS, creating still more debris.89 The broader point is that all nations have a compelling common interest in avoiding the massive increase in space debris that would be created by a substantial ASAT conflict. Gen. Hyten has said that not creating debris is “the one limiting factor” to space war. “Whatever you do,” he warns, “don’t create debris.”90 While that might appear an obvious “limiting factor,” preparing to fight its way through a debris cloud had been a Pentagon consideration in the past. Now, however, sustaining the space environment has been incorporated into Pentagon space goals. Beyond debris creation, MacDonald points out that as China becomes more militarily capable in space and there is more symmetry between the countries, other risks are created – specifically, escalation. That is, the United States could threaten to attack not just Chinese space assets, but also ground-based assets, including ASAT command-and-control centers and other military capabilities. But such actions, which would involve attacking Chinese soil and likely causing substantial direct casualties, would politically weigh much heavier than the U.S. loss of space hardware, and thus might climb the escalatory ladder to a more damaging war that both sides would probably want to avoid.91 MacDonald isn’t alone in concerns about escalation. Secure World Foundation analyst Victoria Samson has also voiced apprehension regarding US rhetoric that does not distinguish between actions against unclassified and classified US satellites, stating that “things can escalate pretty quickly should we come into a time of hostility.”92 Theresa Hitchens explained the most frightening, but not implausible, risk of space war escalation in a 2012 Time magazine interview. Say you have a crisis between two nuclear-armed, space-faring countries, Nation A and Nation B, which have a long-standing border dispute. Nation A, with its satellite capability, sees that Nation B is mobilizing troops and opening up military depots in a region where things are very tense already, on the tipping point. Nation A thinks: “That’s it, they’re going to attack.” So it might decide to pre-emptively strike the communications satellite used by Nation B to slow down its ability to move toward the border and give itself time to fortify. Say this happens and Nation B has no use of satellites for 12 hours, the time it takes it to get another satellite into position. What does Nation B do? It’s blind, it’s deaf, it’s thinking all this time that it’s about to be overwhelmed by an invasion or even nuked. This is possibly a real crisis escalation situation; something similar has been played out in U.S. Air Force war games, a scenario-planning exercise practiced by the U.S. military. The first game involving anti-satellite weapons stopped in five minutes because it went nuclear – bam. Nation B nuked Nation A. This is not a far-out, “The sky’s falling in!” concern, it is something that has been played out over and over again in the gaming of these things, and I have real fears about it.93 While escalation to a nuclear exchange may seem unthinkable, in war games conducted by the military, nuclear weapons are treated as just another warfighting weapon. Morgan also voiced concerns about escalation generally and nuclear escalation specifically in the 2010 RAND report, stating: The adversary would also likely be deterred from damaging U.S. satellite early-warning system (SEWS) assets to avoid risking inadvertent escalation to the nuclear threshold, but that firebreak would almost certainly collapse with the conclusion that such escalation is inevitable and that it is in the adversary’s interest to launch a preemptive nuclear strike.94

### 4

#### Interpretation: Debaters must disclose all constructive positions on open source with highlighting on the 2021-22 NDCA LD wiki after the round in which they read them and before the next round they debate.

#### Violation – missing cal r3 and all elims as of 11:40am PT – screenshots in the doc

A picture containing graphical user interface

Description automatically generated

Graphical user interface, text, application, chat or text message

Description automatically generated

Graphical user interface, application

Description automatically generated

#### 1] Debate resource inequities—level the playing field for students like novices in under-privileged programs by giving them access to evidence and 1nc constructions – also allows bypassing paywalled articles for access to literature

#### 2] Evidence ethics – open source is the only way to verify pre-round that cards aren’t miscut or highlighted or bracketed unethically. That’s a voter – maintaining ethical ev practices is key to being good academics and we should be able to verify you didn’t cheat

#### 3] Depth of clash – it allows debaters to have nuanced researched objections to their opponents evidence before the round at a much faster rate, which leads to higher quality ev comparison – outweighs cause thinking on your feet is NUQ but the best quality responses come from full access to a case.

### Case

#### 1AC Fessl is an alt cause – they highlighted the line for us and we made it red – it says a tourist’s hand brushing the dust is enough to sweep stuff away – if they have any solvency deficit to the PIC, then they definitively can’t solve the aff

Fessl 19 Sophie Fessl 7-10-2019 “Should the Moon Landing Site Be a National Historic Landmark?” <https://daily.jstor.org/should-the-moon-landing-site-be-a-national-historic-landmark/> (PhD King’s College London, BA Oxford)//Elmer

When Neil Armstrong set foot on the moon on July 20, 1969, the pictures sent to Earth captured a historical moment: It was the first time that any human set foot on another body in our solar system. Fifty years later, experts are debating how to preserve humankind’s first steps beyond Earth. Could a National Park on the moon be the solution to saving Armstrong’s bootprints for future archaeologists? Flags, rovers, laser-reflecting mirrors, footprint—these are just a few of the dozens of artifacts and features that bear witness to our exploration of the moon. Archaeologists argue that these objects are a record to trace the development of humans in space. “Surely, those footprints are as important as those left by hominids at Laetoli, Tanzania, in the story of human development,” the anthropologist P.J. Capelotti wrote in Archaeology. While the oldest then known examples of hominins walking on two feet were cemented in ash 3.6 million years ago, “those at Tranquility Base could be swept away with a casual brush of a space tourist’s hand.” Fragile Traces Just how fragile humankind’s lunar traces are was seen already during Apollo 12. On November 19, 1969, Charles “Pete” Conrad and Alan Bean manually landed their lunar module in the moon’s Ocean of Storms, 200 meters from the unmanned probe Surveyor 3, which was left sitting on the moon’s surface two years earlier, in 1967. The next day, Conrad and Bean hopped to Surveyor 3. As they approached the spacecraft, they were surprised: The spacecraft, originally bright white, had turned light brown. It was covered in a fine layer of moon dust, likely kicked up by their landing. Harsh ultraviolet light has likely bleached the U.S. flag bright white. Without Apollo 12 upsetting the moon dust, Surveyor 3 would likely have remained stark white. Unlike Earth, the moon has no wind that carries away the dust, no rain to corrode materials, and no plate tectonic activity to pull sites on the surface back into the moon. But the moon’s thin atmosphere also means that solar wind particles bombard the lunar surface, and harsh ultraviolet light has likely bleached the U.S. flag bright white. The astronauts’ first bootprints will likely be on the moon for a long time, and will almost certainly still be there when humans next visit—unless, by tragic coincidence, a meteorite hits them first. Had LunaCorp not abandoned the idea in the early 2000s, the company’s plan to send a robot to visit the most famous sites of moon exploration could have done a lot of damage. And with Jeff Bezos’ recent unveiling of a mock-up of the lunar lander Blue Moon, it is only a matter of time before corporate adventurers and space tourists reach the moon. Historians and archaeologists are keen to avoid lunar looting. Roger Launius, senior curator of space history at the National Air and Space Museum in Washington, D.C., warned: “What we don’t want to happen is what happened in Antarctica at Scott’s hut. People took souvenirs, and nothing was done to try to preserve those until fairly late in the game.” On the other hand, there is a legitimate scientific interest in investigating how the equipment that’s on the moon was affected by a decades-long stay there.

#### Tourism isn’t appropriation – they don’t solve

Trapp 13, Timothy Justin. "Taking up Space by Any Other Means: Coming to Terms with Nonappropriation Article of the Outer Space Treaty." U. Ill. L. Rev. (2013): 1681. (JD Candidate at UIUC Law School)//Re-cut by Elmer

The issues presented in relation to the nonappropriation article of the Outer Space Treaty should be clear.214 The ITU has, quite blatantly, created something akin to “property interests in outer space.”215 It allows nations to exclude others from their orbital slots, even when the nation is not currently using that slot.216 This is directly in line with at least one definition of outer-space appropriation.217

[\*\*Start Footnote 217\*\*Id. at 236 (“Appropriation of outer space, therefore, is ‘the exercise of exclusive control or exclusive use’ with a sense of permanence, which limits other nations’ access to it.”) (quoting Milton L. Smith, The Role of the ITU in the Development of Space Law, 17 ANNALS AIR & SPACE L. 157, 165 (1992)). \*\*End Footnote 217\*\*]

The ITU even allows nations with unused slots to devise them to other entities, creating a market for the property rights set up by this regulation.218 In some aspects, this seems to effect exactly what those signatory nations of the Bogotá Declaration were try3ing to accomplish, albeit through different means.219

#### It’s travel over a short duration – neither permanent nor limit other uses by other actors of a particular region of space

Henderson and Tsui 19 Henderson, I. L., and W. H. K. Tsui. "The role of niche aviation operations as tourist attractions." Air transport: A tourism perspective (2019): 233-244. (Massey University School of Aviation, Palmerston North, New Zealand)//Elmer

17.5 Space Tourism Space tourism is another niche segment of the aviation industry that seeks to give tourists the ability to become astronauts and experience space travel for recreational, leisure, or business purposes. Since space tourism is extremely expensive, it is a case of a very small segment of consumers that are able and willing to purchase a space experience. There are several options for space tourists. For example, Crouch et al. (2009) investigate the choice behaviour between four types of space tourism: high altitude jet fighter flights, atmospheric zero-gravity flights, short-duration suborbital flights, and longer duration orbital trips into space. Reddy et al. (2012) find the following motivational factors behind space tourism (in order of importance): vision of earth from space, weightlessness, high speed experience, unusual experience, and scientific contribution. Currently, only high-altitude jet fighter flights and atmospheric zero-gravity flights are commercially available to tourists in the space tourism sector. Accordingly, this section provides an example of each, whilst the potential for suborbital and longer duration orbital trips into space are discussed later in this chapter. Case Study 17.3 Examples of Space Tourism MiG-29 Edge of Space Flight One current option for space tourists is to be taken up into the stratosphere in a supersonic fighter jet (see MiGFlug, 2017a). MiGFlug acts as a sales agent for this unique space tourism activity, which usually involves reaching an altitude of 20–22 km. At such an altitude, the curvature of the earth can be seen, the sky is dark, and it is possible to see into space. As part of this space travel experience, tourists are also given an opportunity to control the aircraft and there are a number of aerobatic manoeuvres that are performed by an experienced pilot. This operation is based out of Russia. The Mikoyan MiG-29 Fulcrum is a Russian military fighter jet that allows for rates of climb of 330 m/s and a top speed of Mach 2.25 (2390 km/h). MiGFlug sells three different services in this aircraft. For €12,500 a passenger can enjoy a 25-min flight featuring a number of aerobatic manoeuvres but without supersonic flight. For €14,500 a passenger can enjoy a 45-min flight that includes higher aerobatics and supersonic flight. The ‘Edge of Space’ flight includes aerobatics, supersonic flight, and the experience of being taken up into the stratosphere and is sold for €17,500.

#### ISS and space stations solve neutrino experimentation – only moon key warrant is lack of atmospheric interference which doesn’t exist on stations

#### Solves radio frequencuy – no stations

#### No impact – their ev says neutrino research has been lacking for decades BUT no second gen proliferators since North Korea – proves monitoring isn’t key and no impact to prolif it causes – every “prolif risk” in their Dalton ev is ALREADY a nuclear state

#### Missing internal link between tech for space aquacultures being developed and that tech being modified, used, and implemented on a large scale to revamp global food supply – ev says quote “tech would be applicable to earth”, not that it would be applied

#### No overfishing impact – fishies are vibing

Mossler 20 [Max Mossler (Max studied environmental perception & policy in grad school. He thinks a lot about how other people think about the planet. He is the managing editor at Sustainable Fisheries UW.), 1-13-2020, "Fish populations around the world are improving," Sustainable Fisheries UW, https://sustainablefisheries-uw.org/fish-populations-are-improving/ || belle]

Let’s enjoy some unequivocal, inarguable good news: a paper published today in PNAS, Hilborn et al. 2020, shows that on average, scientifically-assessed fish populations around the world are healthy or improving. And, for fish populations that are not doing well, there is a clear roadmap to sustainability. With Australia on fire and scares of World War III, the start of 2020 and the new decade has been awful; hopefully Hilborn et al. 2020 can kickstart a decade of ocean optimism.

Hilborn et al. 2020 counters the perception that fish populations around the world are declining and the only solution is closing vast swaths of ocean to fishing. Instead, Hilborn et al. 2020 argues that increasing scientific, management, and enforcement capacity will lead to more abundant and sustainable oceans. The major takeaway of the paper is that fishery management works—when fisheries are managed, they are sustained. The key is following the science-to-management blueprint. Scientific data collection and fishery assessment comes first, then fishing regulation and enforcement of fishing policies. With the blueprint in place, most fisheries around the world are sustainable or improving.

The paper uses updates to the RAM Legacy Stock Assessment Database, a decades-long project to assemble data on fish populations that are scientifically assessed. As of 2019, the database contains data on 882 marine fish populations, representing about half of reported wild-caught seafood. In 2009, the database contained data on only 166, representing a much smaller proportion of global seafood. Researchers have spent the last 10 years adding to the database, and with today’s publication, update the global status of fish stocks. They found that, on average, fish populations are above target levels. Not every stock is doing well, but on average, things are much better than they were 2 decades ago. How nice: an environmental story where things are better now than they were in the past!

The paper describes the global status of fish stocks, but it also tells the story of fishery sustainability from the past 50 years.

A brief history of commercial fishing and fishery science

A very general history of industrial fishing goes like this: before the 1950s, commercial fishing was a niche industry supplying a small proportion of the world’s protein. Then, starting in the 1950s, a global effort to increase food security led governments to invest heavily in fishing—often too heavily. Over the next few decades, it became clear that many fisheries were overcapitalized, meaning there were too many boats, too many fishermen, or some combination of the two. Put simply: fishing pressure was too high and eventually led to unsustainable, depleted fish stocks. In the 1990s, the collapse of several prominent fisheries and many high-profile media stories and scientific publications pressured governments to start taking action to protect their fish stocks. The U.S. in 1996 and the EU in 2002 began mandating their fishery policies to be based on fishery science. Take a look at the last 50 years of fish stocks:

You can see a big increase in fishing pressure and declining abundance through the mid-1990s, then a decrease in fishing pressure and recovery of abundance to the present day.

RAM Database: From Worm et al. 2009 to Hilborn et al. 2020

In 2009, Worm et al. was published. It was the first paper to put together and present global fish abundance data over time. It is now one of the most important and highly-cited fisheries paper in history. The data from that paper eventually became the RAM Legacy Stock Assessment database, where anyone could access information about specific stock assessments from around the world. When the paper was published, it showed a general trend of stabilization in the 166 fish populations it reported on. However, it was criticized for mainly including stocks from North America, Europe, and Oceania, painting a global picture with data from only a few regions. Hilborn et al. 2020 updates that work to 882 populations including a much broader global scope. The added decade of data also shows a more positive, upward trend: 78% of fisheries considered overfished in Worm et al. 2009 are improved in Hilborn et al. 2020.

#### Marine ecosystems are resilient to everything

Nield 17 [David Nield, freelance journalist who has been writing about technology, science, apps, gadgets and the web since 2002. Extensively citing "Impact of the Late Triassic mass extinction on functional diversity and composition of marine ecosystems," written by Alexander M. Dunhill, William J. Foster, James Sciberras, and Richard J. Twitchett. Marine Ecosystems Can Survive The Worst Mass Extinction Events, Study Shows. October 23, 2017. <https://www.sciencealert.com/marine-ecosystems-cling-on-to-life-through-some-of-the-worst-mass-extinction-events>]

Researchers have studied fossil records from the Late Triassic mass extinction, which happened around 201.3 million years ago, and found that marine life did not fundamentally change, even though the vast proportion of species were killed off.

The international team of researchers says that while marine species were still badly affected by the event, enough life survived underwater to keep the ecosystems functioning. The findings could help us understand more about how the changing climate of today could affect the planet.

"While the Late Triassic mass extinction had a big impact on the overall number of marine species, there was still enough diversity among the remaining species that the marine ecosystem was able to function in the same way it had before," says lead researcher Alex Dunhill from the University of Leeds in the UK.

It's thought that huge volcanic eruptions, and the subsequent warming of the planet caused by the greenhouse gases produced, was behind the Late Triassic extinction event.

At least half the species on Earth at that time were wiped out by the rise in temperatures, and in the event's aftermath, dinosaurs came to dominate life on our planet.

The researchers analysed fossils dated between the Middle Triassic to the Middle Jurassic periods, a time span of around 70 million years, covering life before and after the mass extinction event.

Ocean-dwelling animals were classified by how they moved, where they lived, and how they fed, and the study showed that none of these categories of life completely disappeared after the extinction event.

That said, there were major impacts on different regions and the environment as a whole, and some specific marine ecosystems were badly damaged.

"We're not saying nothing happened," says one of the researchers, palaeontologist William Foster from the University of Texas at Austin. "Rather, global oceans in the extinction's aftermath were a bit like a ship manned by a skeleton crew – all stations were operational, but manned by relatively few species."

The idea of a skeleton crew of lifeforms keeping the lights on in an ecosystem was first raised by Foster and his colleague Richard J. Twitchett in 2014, after another study focussed on the Late Permian mass extinction event about 252 million years ago.

The current study found one of the hardest-hit underwater organisms were corals, and the fossil record shows it took some 20 million years before tropical reef ecosystems recovered from the Late Triassic extinction, even though the ecosystem as a whole carried on functioning.

With corals again under threat from rising temperatures in the modern day, the new research could provide a blueprint for the potential damage we're going to see – and perhaps give us some clues for how to prevent it.

On a more positive note, it shows life underwater is incredibly resilient, and capable of surviving through even the worst times of environmental upheaval on our planet.

#### Causes space militarization – cross apply terminal

O’Donnell 19 “The Political Realities behind Establishing a Moon Base” Wes O’Donnell [Managing Editor, Edge] 2/26/2019 <https://amuedge.com/the-political-realities-behind-establishing-a-moon-base/> SM

International Conflicts May Expand to Space

No nation has placed weapons in orbit, but some advanced military nations have become dependent on space-based systems for everything from weapons targeting and navigation to intelligence collection. As nations look to establish a semi-permanent presence on the moon, conflict will become inevitable with the lunar surface having a role in how events on Earth play out. In much the same way as the Wright brothers’ plane evolved into a strategic bomber, earthly conflict will expand to spacecraft and a manned presence on the moon.

It seems far-fetched to think in these terms, but mankind has proven adept at turning many scientific achievements into weapons of war. For example, during the past 30 years, Internet access has become nearly omnipresent. But the Internet also serves as a venue for disinformation campaigns and cyberattacks.

It’s also relevant to point out that the systems that maintain human life in space would work equally well for soldiers. All of these advancements to further scientific research and maintain life aboard the International Space Station can easily be adapted to military purposes. It’s now just a matter of funding to build military space systems based on established technology.

In 1959, the U.S. Army conducted a study called Project Horizon that considered establishing a moon base with construction occurring throughout the 1960s. The formal establishment of NASA in February 1958 shelved the project. However, the study demonstrated the military’s long-held desire for a permanent space presence.

Repairing and Protecting Technological Assets in Space

With space-based systems now ubiquitous, there is a need for platforms in space to protect technological assets and repair them when necessary. That will mean having humans in space to manage these systems.

The U.S., China and Russia have the capability to shoot down satellites. Replacing these satellites would require rocket launches with replacement equipment on board.

With space-based systems, however, those assets could be repaired or replaced faster from orbiting stock or from a lunar base. From a U.S. perspective, this would save time and money. Also, it would lessen the potential impact of losing launch centers at Vandenberg AFB and Cape Canaveral in an international conflict involving missile attacks.

Militarization of the Moon

It is certainly a possibility that the moon will be militarized in some fashion. China’s questioning the limits of national sovereignty in space puts in doubt Beijing’s adherence to the 1967 Outer Space Treaty.

That treaty defines the moon as the “province of all mankind” and reserves it for peaceful purposes. But the speed with which contemporary leaders have forsaken international treaties could throw this status into doubt.

Some Chinese legal scholars, for instance, claim that the space above China, at least that which is in geosynchronous orbit, is sovereign Chinese territory. Clearly, by including anything within that geosynchronous orbit, these scholars are referring to the moon in much the same way that China makes claims to nearby territorial waters.

Currently, there is no treaty that delineates the vertical extent of a nation’s sovereignty into space. However, the Chinese claim suggests that Beijing might ignore existing international norms if they conflict with China’s interests.

The Unspoken Moon Race

The first manned mission to the moon was for the benefit “of all mankind.” Today’s extension of military affairs into space suggests that the once-peaceful endeavor of a lunar landing will eventually take on a combat dimension.

Scientific breakthroughs are currently taking the headlines and attention away from the pressing matter of preventing space-based military moves. The U.S., Russia and China have lunar missions planned into the 2030s. Whether those missions will actually take place largely depends on political will and national budgets.

A conventional conflict involving the U.S., Russia or China would be an impetus for the expansion of space-based military assets. That would make the current ventures to the moon ever more pressing during peacetime.

In essence, the current race to the moon certainly appears peaceful. But the potential to use the lunar body for war is certainly not lost on political or military leaders.