## A. Text

#### [Trapp 1] Instead of adding an optional protocol under Article II of the OST, states should set up a cap-and-trade system. This entails:

**A] imposing a global limit on allowable space debris;**

**B] regularly recalculating that limit; and**

**C] creating a database to track all space objects.**

**Trapp 1:** Trapp, Timothy Justin. [J.D., University of Illinois Urbana-Champaign School of Law; tax associate] “Taking Up Space By Any Other Means: Coming to Terms with the Nonappropriation Article of the Outer Space Treaty.” *University of Illinois Law Review*, Vol. 2013, No. 4, August 2013. https://www.illinoislawreview.org/wp-content/ilr-content/articles/2013/4/Trapp.pdf JP/CH

**To effectively combat** the **space debris** problem**, a cap-and-trade system should be set up** that will both be effective and withstand scrutiny under the nonappropriation article of the Outer Space Treaty**. As such, an international regulatory agency should be created to serve two functions: first,** the agency should **impose an international limit to** the addition of **debris and** should then **apportion** these **allowances to nations based on their current use of space. The total allowable debris addition should be recalculated yearly based on the state of the space environment**, and individual allowances should also be recalculated annually to account for changes in the abilities and needs of different nations**.** Second, the agency should allot specific LEO area orbital trajectories, such as the ITU allots GEO orbital slots.294 Though this will be more difficult than allocating GEO slots, since those slots appear stationary while LEO orbital paths are constantly in motion, it can be done. **First, an international electronic database should be produced which tracks** the current location of **all space objects registered in the Space Object Registry, which should include all spacecraft** launched into space. It should also record, to the greatest extent possible, the location and trajectory of any debris. **This database should be updated daily** to represent the most accurate portrayal of the location and trajectory of space objects by the nations responsible for those space objects. Second, this database should be used to calculate predictions of where spacecraft will be in the future, and LEO orbital slots should be defined both in time and space, as opposed to being defined purely by location. This may seem difficult, but it is actually made quite simple by the use of computers. Though these calculations will become less accurate over longer periods of time, the constant updating of the database will allow these predictions to be constantly updated as well, so that they will be accurate for at least the immediate future. When a nation applies for a trajectory slot, the agency should only allocate that slot if it can be entered into and sustained for a certain amount of time without requiring a trajectory modification of any other spacecraft. **With a workable allocation system in place, the agency should be in conformity with the nonappropriation article of the Outer Space Treaty.** To ensure this, it is important that, in allocating slots, both the interests of current space-faring nations, as well as those without the capability to get into space, are provided for. To do so, the agency should only allow actual physical entry into trajectory slots to those who comport with the cap-and-trade regime, while allowing claims to such slots to all nations, on bases similar to those of the ITU.299 This will ensure that this agency will not run into some of the problems that the ITU did when it began.300 In doing this, the agency will be comporting to the ideal that space be preserved for all mankind. **Furthermore, since the purpose of the agency would be to mitigate the debris problem, its purpose would be ensuring future access to space**. This, in connection to the fact that this is an international agency responding proportionately to an international problem,301 will allow the agency to withstand scrutiny under the nonappropriation article of the Outer Space Treaty.302

## B. Competition

#### [Competition] It’s mutually exclusive – private entities can still appropriate outer space under the CP, but can’t under the aff – makes perms impossible.

## C. Solvency

#### [Trapp 2] WE SOLVE some of the harms OF THE AFF, including climate change and debris – the CP follows the Outer Space Treaty’s ban on state appropriation, but doesn’t let private entities pollute.

**Trapp 2:** Trapp, Timothy Justin. [J.D., University of Illinois Urbana-Champaign School of Law; tax associate] “Taking Up Space By Any Other Means: Coming to Terms with the Nonappropriation Article of the Outer Space Treaty.” *University of Illinois Law Review*, Vol. 2013, No. 4, August 2013. https://www.illinoislawreview.org/wp-content/ilr-content/articles/2013/4/Trapp.pdf JP/CH

Space debris poses a threat to future open access to the space environment. Without some sort of action, the problem will continue to escalate, putting at risk the sustainability of the space around our planet. **An international regulatory authority that operated under the U.N. to institute a cap-and-trade regulation system and to allocate LEO orbital trajectories is the best way to curb** the **space debris** problem **while staying within the** mandate of the **nonappropriation article of the O**uter **S**pace **T**reaty**. The allotment of trajectories would ensure that everyone has fair access to the resource, as well as facilitate the reduction of** space **debris caused by** collision.3 A cap-and-trade system would make sure that the proliferation of further debris is curbed, as well as incentivize actors to contribute to cleaning up the space resource. Since **such an agency would operate under** the authority of **the U.N.,** it would be of an international character, similar to the ITU. Moreover, since the purpose of the regulation would be to curb the space debris problem, it would fall directly in line with the principle of ensuring continued access to the space resource for all mankind.308 Final**ly, since the regulation would benefit** those **nations currently acting in space as well as those who will explore space in the future, without unduly favoring one or the other as some have claimed the ITU allocation procedures have done, it** i**s a proportional response to an international** concern. Thus, the suggested system represents the best way to handle the debris problem without effecting a prohibited appropriation of space.

### 2

#### The appropriation of lunar heritage sites in the Sea of Tranquility by helium-3 mining is necessary for the economy. Adding an optional protocol under Article II of the OST stops the clarification that the lunar mining of helium-3 is permissible under the Outer Space Treaty. Banning lunar mining stops this.

#### 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).

#### Lunar 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.

They link to the DA by limiting Moon mining.

#### 1] 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.

#### 2) 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.

## A. Link

#### [Weinzier and Sarang] The private sector is expanding which propels personal interest.

Weinzier and Sarang: Weinzier Matt [Professor of Business Administration in the Business, Government, and the International Economy Unit Harvard Business School] Sarang Mehak [ Space Exploration Initiative- MIT] “The Commercial Space Age Is Here Private space travel is just the beginning.” Harvard Business Review, 2021. MB/AC

In contrast to governments, the private sector is eager to put people in space to pursue their own personal interests, not the state’s — and then supply the demand they create. This is the vision driving SpaceX, which in its first twenty years has entirely upended the rocket launch industry, securing 60% of the global commercial launch market and building ever-larger spacecraft designed to ferry passengers not just to the International Space Station (ISS), but also to its own promised [settlement on Mars](https://www.spacex.com/media/making_life_multiplanetary_transcript_2017.pdf). Today, the space-for-space market is limited to supplying the people who are already in space: that is, the handful of astronauts employed by NASA and other government programs. While SpaceX has grand visions of supporting large numbers of private space travelers, their current space-for-space activities have all been in response to demand from government customers (i.e., NASA). But as decreasing launch costs enable companies like SpaceX to leverage economies of scale and put more people into space, growing private sector demand (that is, tourists and settlers, rather than government employees) could turn these proof-of-concept initiatives into a sustainable, large-scale industry. This model — of selling to NASA with the hopes of eventually creating and expanding into a larger private market — is exemplified by SpaceX, but the company is by no means the only player taking this approach. For instance, while SpaceX is focused on space-for-space transportation, another key component of this burgeoning industry will be manufacturing.

Link: They stop all appropriation which is bad.

### B. Impacts

#### [Weinzier and Sarang] Private companies increase collaboration.

Weinzier and Sarang: Weinzier Matt [Professor of Business Administration in the Business, Government, and the International Economy Unit Harvard Business School] Sarang Mehak [ Space Exploration Initiative- MIT] “The Commercial Space Age Is Here Private space travel is just the beginning.” Harvard Business Review, 2021. MB/AC

Finally, the development of the space-for-space economy must not be undermined by earthly geopolitical rivalries, such as that between the United States and China. These conflicts will unavoidably extend into space at least to some extent, and military demand has long been an important source of funding for aerospace companies. But if not kept in check, such rivalries will not only distract attention and resources from borderless commercial pursuits but also create barriers and risks that hamper private investment. On earth, private economic activity has long tied together people whose states are at odds. The growing space-for-space economy offers exceptional potential to be such a force for unity — but it’s the job of the world’s governments [not to get in the way](https://www.theatlantic.com/technology/archive/2020/07/space-warfare-unregulated/614059/). A collaborative, international approach to establishing — and enforcing — the rule of law in space will be essential to encouraging a healthy space-for-space economy. Visions of a space-for-space economy have been around since the dawn of the Space Age in the 1960s. Thus far, those hopes have gone largely unmet — but this moment is different. For the first time in history, the private sector’s capital, risk tolerance, and profit motive are being channeled into putting people in space. If we seize this opportunity, we will look back on 2020 as the year when we started the truly transformational project of building an economy and a society in space, for space.

Leads to their impacts because lack of collaboration is war.

CASE

THEY DON’T SOLVE

#### [Trapp] STATE-LED APPROPRIATION IS INFINITELY WORSE THAN PRIVATE APPROPRIATION – MASSIVELY INCREASES VIOLENCE.

**Trapp:** Trapp, Timothy Justin. [J.D., University of Illinois Urbana-Champaign School of Law; tax associate] “Taking Up Space By Any Other Means: Coming to Terms with the Nonappropriation Article of the Outer Space Treaty.” *University of Illinois Law Review*, Vol. 2013, No. 4, August 2013. https://www.illinoislawreview.org/wp-content/ilr-content/articles/2013/4/Trapp.pdf JP/CH

In general, nations have appropriated areas by some sort of physical ceremony, such as establishing colonies or planting a flag.167 There have been no decent standards set up, however, for determining whose claim was superior in instances in which claims competed.168 Instead, these claims would only survive if they were backed up by military power, and the superior claim would belong to the victor of the struggle over the disputed territory.169 From this, it is clear that any nation which tried to exclude other nations from any portion of space through use of force would be considered to have appropriated, or at least attempted to appropriate, that portion of space, and it would be prohibited from doing so.170 In fact, there is a good chance that the possibility of such a scenario, multiplied by the number of interested parties in space, helped to inspire the drafters of the Outer Space Treaty to include the nonappropriation article.171 Also, the classical version of property law gives dominion to the owner of an article of land from the center of the earth to the reaches of the heavens.172 While this presents obvious problems for objects in LEO, which move over large amounts of landspace very quickly and thus would go through many different parcels of property,173 it seems like it could be applied to objects in geostationary orbit, since they stay over one piece of land indefinitely.174 If this were the case, would countries that lie under the orbit of a geostationary satellite already have claim to that area that predated the Outer Space Treaty, or would they be subject to having satellites hanging over them against their wills?

#### No non state acquisition from new nuclear states

\* fear of backlash from supporters, internal division, and international retaliation = deterrence

McIntosh & Storey 18 (Christopher McIntosh is visiting assistant professor of political studies at Bard College, Ph.D. in 2013 from The University of Chicago, specializing in international relations and has an M.A. in Security Studies from Georgetown & Ian Storey is a fellow at the Hannah Arendt Center for Politics and Humanities at Bard College, Ph.D. in Political Science from the University of Chicago; Between Acquisition and Use: Assessing the Likelihood of Nuclear Terrorism, *International Studies Quarterly*, 19 April 2018, sqx087, https://doi.org/10.1093/isq/sqx087)

Our approach offers a point of departure for strategically assessing the options, likely responses, and potential outcomes that could arise from the different paths available to a nuclear-armed non-state group. Too often analysts treat the decision by such groups to use nuclear weapons as if it occurs in a vacuum. In practice, terrorist groups face many short-term and long-term considerations. They are influenced by factors both external and internal to their organization. These include the potential for backlash among supporters, internal factionalization over nuclear strategy and doctrine, and an overwhelming response by the target state and the international community.

Moreover, we suggest a way to bring the recursivity of strategic choice into the account of terrorist organizational decision-making. These organizations must consider the long-term effects of a nuclear attack. An attack occurs in the context of an ongoing campaign by a well-established organization. Opportunity costs exist because escalating to nuclear attack forecloses future options. As well, conducting an attack may not only preclude other strategies, but the continued existence of the group itself. This changes the game significantly. In most cases, a nuclear attack must present not just an effective option for the moment, but the only strategic option worth pursuing going forward.

Once we take these considerations into account, the detonation of a nuclear weapon generally appears the least strategically advantageous option for non-state groups. Indeed, the factors presented here are analytically independent, adaptable, and scalable to particular threat contexts. We can therefore use our framework to study the opportunities and constraints faced by specific future groups. It should therefore assist in the process of planning responses to potential nuclear acquisition by terrorist groups.

Successive governments have now identified nuclear terrorism as a critical concern in the formulation of security policy. This line of thinking systematically underspecifies, or simply misunderstands, key considerations that terrorist organizations take into account. These include the group's organizational survival, opportunity costs, and the conflation of victory with the end of hostilities. Each factor presents strong disincentives to immediate nuclear attack. A nuclear-armed terrorist group is exceedingly dangerous, but for different reasons than normally assumed. The options available to the group that fall short of detonation or attack remain considerable, albeit less spectacular and immediate.

Just as scholars like Bunn et al. (2015) are careful to do, political actors and analysts should resist uncritically deploying the term “nuclear terrorism” in an umbrella fashion. This point goes beyond even the attempts at disaggregating “use” presented here. The threat of an attack involving an improvised nuclear device is vastly different than that of a “dirty bomb,” and both have little in common with the threat posed by an attack on a nuclear facility. Each deserves separate consideration when formulating policy, even if measures taken to address these concerns, such as controlling nuclear leakage, ultimately overlap. If any of the acquisition or threat scenarios we explore come to fruition, then potential target states will need strategies that potentially employ positive, as well as negative, incentives to lessen the attractiveness of nuclear attack. As we argue, a crisis involving a nuclear-armed terrorist group will be a negotiation—regardless of what the target state chooses to label it. Far from demonstrating weakness, employing threats while dangling the possibility of political concessions can widen internal divisions, heightening the overall organizational costs of escalating violence (Toros 2008; Cronin 2009).

Finally, efforts designed to improve intelligence capabilities both prior to and post-attack remain vital. Signature analysis as a forensic measure has shown promise as a way of identifying the origin of nuclear material—in some cases it can identify whether or not it was provided by a state (Kristo and Tumey 2013). These efforts would be improved with a more widespread international commitment via the IAEA to placing signature markers in weapons and weaponizable material (Korbatov et al. 2015, 70; Findlay 2014, 6).

Ultimately, when it comes to the threat of a nuclear attack by a terrorist, presumption should lie squarely on the side of skepticism rather than inevitability. While some terrorist organizations have some incentives for nuclear acquisition, paradoxically and thankfully, the most strategic uses of a nuclear weapon fall well short of actual nuclear attack. From a scholarly perspective, as well as a political one, we need to start to think through how states would act in a world with nuclear-armed non-state actors. In doing so, we should avoid assumptions that fit neither with known nuclear strategy nor the empirical behavior of non-state organizations. Like most clichés, the post–Cold War trope that the threat of attack is higher now than it was during the US-USSR arms race (Litwak 2016) obscures much more than it reveals.

#### Prolif doesn’t cause accidental war or pre-emptive strikes—pessimists are methodologically biased. Strategic uncertainty from small, new arsenals moderates crisis which flips their 2nd gen bad framing – emprics disprove 2nd gen use it or lose it

Cohen 17 (Michael, Ph.D. at the University of British Columbia in April 2012 Assistant Professor in the Department of Political Science and Public Management at the University of Southern Denmark "How nuclear proliferation causes conflict: the case for optimistic pessimism" The Nonproliferation Review Volume 23, 2016 - Issue 3-4: Twenty years of the Comprehensive Nuclear-Test-Ban Treaty)

The claim that the spread of nuclear weapons leads to interstate conflict and nuclear war has become very influential. However, proliferation pessimists have failed to specify how and when nuclear proliferation precipitates conflict. I make four arguments for an optimistic pessimism. (1) The few preventive strikes against nuclear facilities that have occurred would have occurred absent of the target's nuclear program, and these rare strikes did not lead to conflict escalation. (2) The problem of nonsurvivable arsenals is, properly understood, a problem of preventive-war motivations where subjective uncertainty reduces the dangers of arsenal survivability. (3) Claims that bias within nuclear organizations may lead to accidental nuclear detonations suffer from omitted variable bias: leaders' decisions to revise the status quo after developing nuclear weapons tend to give rise to the most dangerous nuclear accidents. Accidents that have not occurred during a nuclear crisis pose substantially less risk of nuclear escalation. (4) Leaders of nuclear states have tended to engage in conventional aggression, but experience with nuclear weapons moderates their conflict propensity. Ultimately, I argue that while nuclear weapons have led to conflict through one causal mechanism and for a limited time, the dangers are substantially weaker than usually assumed.

Many scholars and policy makers believe that nuclear proliferation increases the likelihood of interstate conflict. The development of nuclear weapons by North Korea and Iran is widely assumed to increase the probability of regional conflict on the Korean peninsula and Persian Gulf. Any potential stabilizing or war-deterring effects of the spread of nuclear weapons are considered outweighed by the increased probability of conventional and nuclear war.1 Director of National Intelligence James Clapper argued in 2014 before the US Congress that the spread of nuclear weapons around the world constitutes one of the greatest threats to US national security.2 Secretary of State Hillary Clinton claimed that a nuclear-armed Iran would be “a direct threat to the lives and the livelihoods and the stability not only of the region but beyond.”3 Scott Sagan claimed that “we should worry that Iranian leaders with nuclear weapons will see them as a shield behind which they can more safely engage in aggression against neighbors and the United States.”4

According to traditional proliferation-pessimist wisdom, nuclear proliferation generates the conditions for conflict in several ways, by inviting preemptive strikes on nascent nuclear states whose nuclear arsenals cannot survive a first strike, increasing the risk of nuclear-weapon accidents, and increasing the likelihood that states will engage in conventional or subconventional aggression.5

Despite the high stakes involved and a lack of clarity over when and how newly or aspiring nuclear states would use nuclear weapons and thus cause conflict, many believe that preventive strikes against nascent nuclear-weapon states represent the best—and in some cases only—option to deal with proliferators.6 However, and notwithstanding more than seventy years of living with nuclear weapons and much evidence that speaks to these mechanisms, we lack an empirical assessment that specifies how and when nuclear weapons have actually caused conflict.7 It is unclear whether the evidence marshaled by proliferation pessimists supports their claims: these scholars have not sufficiently addressed whether nuclear weapons caused the ensuing conflicts. This article argues that, of the mechanisms identified as triggers by which nuclear proliferation may lead to conflict, only one—conventional aggression by nuclear powers—has done so.8 But even here, experience with nuclear weapons moderates the conflict propensity of new nuclear powers. Nuclear proliferation leads to conflict under restrictive conditions and for limited periods of time. A case can therefore be made for “optimistic pessimism” regarding the spread of nuclear weapons: nuclear proliferation poses some dangers under some conditions, but the dangers are much weaker than usually assumed.

This article makes four key arguments. First, preventive strikes to destroy nuclear facilities are rare and do not escalate to war; moreover, they often would have occurred even if the target state did not have a nuclear program. Second, the problem of survivable arsenals is a problem of preventive-war motivations where subjective uncertainty—not arsenal size—reduces the dangers presented by non-survivable arsenals. Third, claims about dangerous bias in the organizations that manage nuclear weapons causing accidental crises and nuclear detonations suffer from omitted variable bias: leaders' decisions to challenge the status quo from “behind a nuclear shield” tends to cause those accidents that pose the greatest risk of nuclear war. Fourth, concerns about leaders using nuclear weapons as shields behind which they can pursue dangerous foreign policies has qualitative and quantitative support, but experience with nuclear weapons moderates the conflict propensity of new nuclear states. Consequently, the dangers that nuclear proliferation, preventive-strike motivations, non-survivable arsenals, and nuclear accidents pose to regional and global stability are much weaker than usually assumed. Nuclear proliferation could lead to conflict by emboldening new nuclear states within their respective regions, but this tends to be a short-term effect that ends after a few years. While North Korean or Iranian nuclear missiles may cause problems in the short term, proliferation-pessimist claims that nuclear proliferation leads to conflict warrant substantial revision. An optimistic pessimism is in order. A nuclear Iran or North Korea will be less dangerous than usually assumed.

This article makes several contributions to our understanding of proliferation pessimism and nuclear-weapon proliferation. First, it proposes a novel argument about how several methodological errors aided the intellectual diffusion of proliferation pessimism, and shows how the destructive potential of nuclear weapons has caused scholars and analysts to overestimate the potential for nuclear weapons to lead to conflict. Second, it confronts core proliferation pessimist claims—mainly by the most influential pessimist, Stanford University's Scott Sagan—head on, and shows that most of their assertions about nuclear weapons and conflict do not survive empirical and methodological scrutiny. Third, this essay specifies how and when nuclear proliferation by Iran and North Korea might lead to conflict and suggests that many proposed strategies to deal with these challenges—such as attacking a potential proliferator—should be discarded. Finally, it argues that extended deterrence policies that strike the balance between deterring and reassuring new nuclear powers are key to reducing the dangers associated with nuclear proliferation.

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