# King RR R3 Neg vs Ayala AM

# 1NC

### 1

#### Interp: if the aff defends that appropriation of lunar heritage site by private entities is unjust, they must define what a lunar heritage site is and list all defended sites in a delineated text in the 1AC

#### Vote neg for stable ground — there is no global definition of lunar heritage site since UNESCO is yet to recognize any heritage sites on the moon, the US’s definition is not predictable on a global topic and nebulous - for example, the NASA website excludes chinese landing sites but their aff ev refers to heritage sites as past landing sites - that decks predictable neg ground because they can delink from DA by redefining the aff - for example, they could adopt a narrow definition of heritage sites to delink from DAs like mining or innovation, or pivot to a broad definition if they’re behind on solvency

#### Independently, vote neg on presumption - private entities will just interpret heritage sites narrowly as possible eg UNESCO heritage sites which don’t exist on the moon

#### The “nasa list” does not meet – it is a blurry screenshot that does not define where cites begin and end or what part of the moon they are in

Diagram

Description automatically generated

#### Drop the debater – a) they have a 7-6 rebuttal advantage and the 2ar to make args I can’t respond to, b) it deters future abuse and sets a positive norm.

#### No RVIs – baiting – incentivizes good debaters to be abusive, bait theory, then collapse to the 1AR RVI

### 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.

#### 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.

### Case

#### 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

#### 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.

#### Proliferation dampens conflict --- only our evidence does a statistical, controlled study – every impact they read is theorizing

Akisato Suzuki, June 2015. Akisato, Researcher at the Institute for International Conflict Resolution and Reconstruction, School of Law and Government, Dublin City University, MA in Violence, Terrorism and Security at Queen's University, “Is more better or worse? New empirics on nuclear proliferation and interstate conflict by Random Forests,” Research and Politics, SagePub

Given these conflict-reducing/provoking effects of nuclear proliferation, what overall effect would nuclear proliferation have on a systemic propensity for conflict? This is difficult to answer, not only due to the controversy over whether nuclear states are more or less prone to conflict, but also because the existing theories do not explain whether those conflict-reducing/provoking effects are large enough to influence a systemic propensity for interstate conflict, given the ratio of nuclear states to non-nuclear states in the system. This challenge motivates the empirical examination of the relationship between nuclear proliferation and a systemic propensity for conflict.

Empirical investigation by Random Forests

The interstate–systemic year data are used here to investigate the relationship between nuclear proliferation and a systemic propensity for interstate conflict. The dependent variable is the number of militarized interstate dispute onsets (Palmer et al., 2015; version 4.01 is used) per systemic-year, standardized as the ratio to the number of states in the interstate system (Correlates of War Project, 2011) – hereafter, the ‘dispute–state ratio’. Observations one year ahead (t+1) are used to make sure that causal effects precede a variation in the dispute–state ratio.2

Two regressors are used to examine the effect of nuclear proliferation: the number of nuclear states in the interstate system; and a count of the years since the number of nuclear states changes (hereafter ‘nuclear year counter’), measuring the effect of new nuclear states (Horowitz, 2009). The data about nuclear states are from Gartzke and Kroenig (2009); additionally, the current paper codes North Korea as a nuclear state since 2009 (Table 1).3

The model also includes the number of democratic states (Polity2 score ⩾ 6 in Marshall, 2013) in the interstate system, the gross world product (Earth Policy Institute, 2012), and the binary variable of unipolarity (coded zero until 1989 and one from 1990; see Monteiro, 2011/2012); these three variables control for democratic peace (Russett and Oneal, 2001), capitalist peace (Gartzke, 2007), and polarity (Monteiro, 2011/2012) respectively. The number of nuclear states and these control variables suffer from multicollinearity (see Table A-9 in the online appendix), and this paer later explains how to resolve this problem. A lagged dependent variable is also included to address the temporal dependence of time-series data. The temporal scope is 1950–2009 (i.e. N=59) due to the data availability and the use of the dependent variable at t+1. The descriptive statistics of all variables are displayed in Table 2.4.

As mentioned in the introduction, this paper uses the machine learning, non-parametric method Random Forests for the empirical investigation.5 Although it is unfamiliar to most political science and international relations analysts, Random Forests has been widely used in numerous scientific studies (Strobl et al., 2009: 324; Strobl et al., 2008). The popularity of the method is also apparent from the fact that Breiman’s (2001) original paper has been cited 12,721 times in the literature.6

Random Forests generates two useful analytics: first, ‘conditional variable importance’ measures how ‘important’ each regressor is, conditional on the remaining regressors (Hothorn et al., 2006; Strobl et al., 2007, 2008). This is analogous to statistical significance in conventional regression models. The significance threshold proposed by Strobl et al. (2009: 343) is whether the importance score of a regressor is negative, zero, or lower than the absolute value of the lowest negative score. If none applies, the regressor is considered as important; and the second relevant analytic is a partial dependence plot (Friedman, 2001). This estimates the marginal effect of each regressor on the dependent variable while taking the remaining regressors into consideration.

Random Forests has three attractive and distinctive characteristics for the purposes of this paper: first, the estimation of conditional variable importance and partial dependence plots enable conventional applied researchers to interpret non-parametric analysis in an intuitive way; second, Random Forests can examine non-linearity (Strobl et al., 2009: 339–341), which is desirable because, as already noted, some theories expect non-linearity between nuclear proliferation and a systemic propensity for conflict; and finally, it can cope with potential interactions and multicollinearity between regressors (Strobl et al., 2009: 339–341; Strobl et al., 2008). As noted before, most of the regressors here are highly correlated, and also it is plausible to anticipate some interaction effect between them (e.g. the number of democratic states and the gross world product). The specific capabilities of Random Forests are therefore essential.

The estimation of conditional variable importance shows that the nuclear year counter has a negative importance score.7 Thus, the nuclear year counter is not important in explaining the dispute–state ratio. This suggests that the optimist theory is supported. The remaining regressors have an importance score higher than the absolute value of the importance score of the nuclear year counter, meaning that they are all important. Controlling for democratic peace, capitalist peace, and polarity, the number of nuclear states is still a significant predictor in explaining a systemic propensity for interstate conflict.

Figure 1 presents the partial dependence plots of the model.8 First, on average, a larger number of nuclear states is associated with a lower dispute–state ratio, although the changes from two nuclear states to three and from six to seven increase the ratio instead. Thus, the relationship is empirically non-linear, as Bueno de Mesquita and Riker (1982) and Intriligator and Brito (1981) expected in part. Overall, however, the optimist theory is supported, and the change from two nuclear states to nine nuclear states decreases the dispute–state ratio approximately from 0.228 to 0.18. This means that, if there are 194 states in the system (as there were in 2009), the number of militarized interstate dispute onsets per system-year decreases approximately from 44 to 35. This is a substantively significant decline.

Second, the nuclear year counter shows a concave relationship with the dispute–state ratio, suggesting that new nuclear states are less prone to conflict than middle-aged nuclear states. Thus, the pessimist theory finds no support from either the variable importance estimation or the partial dependence plot.

Finally, as for the control variables, the number of democratic states and the gross world product have a complex non-linear relationship with the dispute–state ratio, but if the number of democratic states and the gross world product are sufficiently large, they tend to decrease the dispute–state ratio. Their substantive effects are also significant, though not as much as the number of nuclear states. When comparing the effect of their lowest and highest values (23 and 94 in the number of democratic states and 7 and 71.2 in the gross world product), the number of democratic states decreases the number of militarized interstate dispute onsets per system-year approximately from 40 to 37, and the gross world product from 44 to 37. Unipolarity is also associated with a decline in the dispute–state ratio, suggesting that unipolarity is better than bipolarity in terms of a systemic propensity for interstate conflict; however, its effect is negligible, as it reduces the number of militarized interstate dispute onsets per system-year from 39 to 38. One caveat is, as explained in the online appendix, that the results of the number of democratic states and unipolarity are significantly sensitive to a parameter setting. Thus, these predictors are less robust, and the aforementioned points about them should be treated with caution.

Discussion and concluding remarks

The main findings reveal that the optimist expectation of the relationship between nuclear proliferation and interstate conflict is empirically supported:9 first, a larger number of nuclear states on average decreases the systemic propensity for interstate conflict; and second, there is no clear evidence that the emergence of new nuclear states increases the systemic propensity for interstate conflict. Gartzke and Jo (2009) argue that nuclear weapons themselves have no exogenous effect on the probability of conflict, because when a state is engaged in or expects to engage in conflict, it may develop nuclear weapons to keep fighting, or to prepare for, that conflict. If this selection effect existed, the analysis should overestimate the conflict-provoking effect of nuclear proliferation in the above model. Still, the results indicate that a larger number of nuclear states are associated with fewer disputes in the system.

This conclusion, however, raises questions about how to reconcile this study’s findings with those of a recent quantitative dyadic-level study (Bell and Miller, 2015). The current paper finds that nuclear proliferation decreases the systemic propensity for interstate conflict, while Bell and Miller (2015) find that nuclear symmetry has no significant effect on dyadic conflict, but that nuclear asymmetry is associated with a higher probability of dyadic conflict. It is possible that nuclear proliferation decreases conflict through the conflict-mitigating effects of extended nuclear deterrence and/or fear of nuclear states’ intervention, to the extent that these effects overwhelm the conflict-provoking effect of nuclear–asymmetrical dyads. Thus, dyadic-level empirics cannot solely be relied on to infer causal links between nuclear proliferation and a systemic propensity for conflict. The systemic-level empirics deserve attention.

#### 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.

#### Conventional conflict escalates because of non-nuclear emerging technologies—causes nuclear war and independent pathways to extinction

Klare 18—Michael T. Klare, professor emeritus of peace and world security studies at Hampshire College and senior visiting fellow at the Arms Control Association (“The Challenges of Emerging Technologies,” *Arms Control Association*, December 2018, https://www.armscontrol.org/act/2018-12/features/challenges-emerging-technologies)

Today, a whole new array of technologies—artificial intelligence (AI), robotics, hypersonics, and cybertechnology, among others—is being applied to military use, with potentially far-ranging consequences. Although the risks and ramifications of these weapons are not yet widely recognized, policymakers will be compelled to address the dangers posed by innovative weapons technologies and to devise international arrangements to regulate or curb their use. Although some early efforts have been undertaken in this direction, most notably, in attempting to prohibit the deployment of fully autonomous weapons systems, far more work is needed to gauge the impacts of these technologies and to forge new or revised control mechanisms as deemed appropriate.

Tackling the arms control implications of emerging technologies now is becoming a matter of ever-increasing urgency as the pace of their development is accelerating and their potential applications to warfare are multiplying. Many analysts believe that the utilization of AI and robotics will utterly revolutionize warfare, much as the introduction of tanks, airplanes, and nuclear weapons transformed the battlefields of each world war. “We are in the midst of an ever accelerating and expanding global revolution in [AI] and machine learning, with enormous implications for future economic and military competitiveness,” declared former U.S. Deputy Secretary of Defense Robert Work, a prominent advocate for Pentagon utilization of the new technologies.1

The Department of Defense is spending billions of dollars on AI, robotics, and other cutting-edge technologies, contending that the United States must maintain leadership in the development and utilization of those technologies lest its rivals use them to secure a future military advantage. China and Russia are assumed to be spending equivalent sums, indicating the initiation of a vigorous arms race in emerging technologies. “Our adversaries are presenting us today with a renewed challenge of a sophisticated, evolving threat,” Michael Griffin, U.S. undersecretary of defense for research and engineering, told Congress in April. “We are in turn preparing to meet that challenge and to restore the technical overmatch of the United States armed forces that we have traditionally held.”2

In accordance with this dynamic, the United States and its rivals are pursuing multiple weapons systems employing various combinations of AI, autonomy, and other emerging technologies. These include, for example, unmanned aerial vehicles (UAVs) and unmanned surface and subsurface naval vessels capable of being assembled in swarms, or “wolfpacks,” to locate enemy assets such as tanks, missile launchers, submarines and, if communications are lost with their human operators, decide to strike them on their own. The Defense Department also has funded the development of two advanced weapons systems employing hypersonic technology: a hypersonic air-launched cruise missile and the Tactical Boost Glide (TBG) system, encompassing a hypersonic rocket for initial momentum and an unpowered payload that glides to its destination. In the cyberspace realm, a variety of offensive and retaliatory cyberweapons are being developed by the U.S. Cyber Command for use against hostile states found to be using cyberspace to endanger U.S. national security.

The introduction of these and other such weapons on future battlefields will transform every aspect of combat and raise a host of challenges for advocates of responsible arms control. The use of fully autonomous weapons in combat, for example, automatically raises questions about the military’s ability to comply with the laws of war and international humanitarian law, which require belligerents to distinguish between enemy combatants and civilian bystanders. It is on this basis that opponents of such systems are seeking to negotiate a binding international ban on their deployment.

Even more worrisome, some of the weapons now in development, such as unmanned anti-submarine wolfpacks and the TBG system, could theoretically endanger the current equilibrium in nuclear relations among the major powers, which rests on the threat of assured retaliation by invulnerable second-strike forces, by opening or seeming to open various first-strike options. Warfare in cyberspace could also threaten nuclear stability by exposing critical early-warning and communications systems to paralyzing attacks and prompting anxious leaders to authorize the early launch of nuclear weapons.

These are only some of the challenges to global security and arms control that are likely to be posed by the weaponization of new technologies. Observers of these developments, including many who have studied them closely, warn that the development and weaponization of AI and other emerging technologies is occurring faster than efforts to understand their impacts or devise appropriate safeguards. “Unfortunately,” said former U.S. Secretary of the Navy Richard Danzig, “the uncertainties surrounding the use and interaction of new military technologies are not subject to confident calculation or control.”3 Given the enormity of the risks involved, this lack of attention and oversight must be overcome.

Mapping out the implications of the new technologies for warfare and arms control and devising effective mechanisms for their control are a mammoth undertaking that requires the efforts of many analysts and policymakers around the world. This piece, an overview of the issues, is the first in a series for Arms Control Today (ACT) that will assess some of the most disruptive emerging technologies and their war-fighting and arms control implications. Future installments will look in greater depth at four especially problematic technologies: AI, autonomous weaponry, hypersonics, and cyberwarfare. These four have been chosen for close examination because, at this time, they appear to be the furthest along in terms of conversion into military systems and pose immediate challenges for international peace and stability.

Artificial Intelligence

AI is a generic term used to describe a variety of techniques for investing machines with an ability to monitor their surroundings in the physical world or cyberspace and to take independent action in response to various stimuli. To invest machines with these capacities, engineers have developed complex algorithms, or computer-based sets of rules, to govern their operations. An AI-equipped aerial drone, for example, could be equipped with sensors to distinguish enemy tanks from other vehicles on a crowded battlefield and, when some are spotted, choose on its own to fire at them with its onboard missiles. AI can also be employed in cyberspace, for example to watch for enemy cyberattacks and counter them with a barrage of counterstrikes. In the future, AI-invested machines may be empowered to determine if a nuclear attack is underway and, if so, initiate a retaliatory strike.4 In this sense, AI is an “omni-use” technology, with multiple implications for war-fighting and arms control.5

Many analysts believe that AI will revolutionize warfare by allowing military commanders to bolster or, in some cases, replace their personnel with a wide variety of “smart” machines. Intelligent systems are prized for the speed with which they can detect a potential threat and their ability to calculate the best course of action to neutralize that peril. As warfare among the major powers grows increasingly rapid and multidimensional, including in the cyberspace and outer space domains, commanders may choose to place ever-greater reliance on intelligent machines for monitoring enemy actions and initiating appropriate countermeasures. This could provide an advantage on the battlefield, where rapid and informed action could prove the key to success, but also raises numerous concerns, especially regarding nuclear “crisis stability.”

Analysts worry that machines will accelerate the pace of fighting beyond human comprehension and possibly take actions that result in the unintended escalation of hostilities, even leading to use of nuclear weapons. Not only are AI-equipped machines vulnerable to error and sabotage, they lack an ability to assess the context of events and may initiate inappropriate or unjustified escalatory steps that occur too rapidly for humans to correct. “Even if everything functioned properly, policymakers could nevertheless effectively lose the ability to control escalation as the speed of action on the battlefield begins to eclipse their speed of decision-making,” writes Paul Scharre, who is director of the technology and national security program at the Center for a New American Security.6

As AI-equipped machines assume an ever-growing number and range of military functions, policymakers will have to determine what safeguards are needed to prevent unintended, possibly catastrophic consequences of the sort suggested by Scharre and many others. Conceivably, AI could bolster nuclear stability by providing enhanced intelligence about enemy intentions and reducing the risk of misperception and miscalculation; such options also deserve attention. In the near term, however, control efforts will largely be focused on one particular application of AI: fully autonomous weapons systems.

Autonomous Weapons Systems

Autonomous weapons systems, sometimes called lethal autonomous weapons systems, or “killer robots,” combine AI and drone technology in machines equipped to identify, track, and attack enemy assets on their own. As defined by the U.S. Defense Department, such a device is “a weapons system that, once activated, can select and engage targets without further intervention by a human operator.”7

Some such systems have already been put to military use. The Navy’s Aegis air defense system, for example, is empowered to track enemy planes and missiles within a certain radius of a ship at sea and, if it identifies an imminent threat, to fire missiles against it. Similarly, Israel’s Harpy UAV can search for enemy radar systems over a designated area and, when it locates one, strike it on its own. Many other such munitions are now in development, including undersea drones intended for anti-submarine warfare and entire fleets of UAVs designed for use in “swarms,” or flocks of armed drones that twist and turn above the battlefield in coordinated maneuvers that are difficult to follow.8

The deployment of fully autonomous weapons systems poses numerous challenges to international security and arms control, beginning with a potentially insuperable threat to the laws of war and international humanitarian law. Under these norms, armed belligerents are obligated to distinguish between enemy combatants and civilians on the battlefield and to avoid unnecessary harm to the latter. In addition, any civilian casualties that do occur in battle should not be disproportionate to the military necessity of attacking that position. Opponents of lethal autonomous weapons systems argue that only humans possess the necessary judgment to make such fine distinctions in the heat of battle and that machines will never be made intelligent enough to do so and thus should be banned from deployment.9

At this point, some 25 countries have endorsed steps to enact such a ban in the form of a protocol to the Convention on Certain Conventional Weapons (CCW). Several other nations, including the United States and Russia, oppose a ban on lethal autonomous weapons systems, saying they can be made compliant with international humanitarian law.10

Looking further into the future, autonomous weapons systems could pose a potential threat to nuclear stability by investing their owners with a capacity to detect, track, and destroy enemy submarines and mobile missile launchers. Today’s stability, which can be seen as an uneasy nuclear balance of terror, rests on the belief that each major power possesses at least some devastating second-strike, or retaliatory, capability, whether mobile launchers for intercontinental ballistic missiles (ICBMs), submarine-launched ballistic missiles (SLBMs), or both, that are immune to real-time detection and safe from a first strike. Yet, a nuclear-armed belligerent might someday undermine the deterrence equation by employing undersea drones to pursue and destroy enemy ballistic missile submarines along with swarms of UAVs to hunt and attack enemy mobile ICBM launchers.

Even the mere existence of such weapons could jeopardize stability by encouraging an opponent in a crisis to launch a nuclear first strike rather than risk losing its deterrent capability to an enemy attack. Such an environment would erode the underlying logic of today’s strategic nuclear arms control measures, that is, the preservation of deterrence and stability with ever-diminishing numbers of warheads and launchers, and would require new or revised approaches to war prevention and disarmament.11

Hypersonic Weapons

Proposed hypersonic weapons, which can travel at a speed of more than five time the speed of sound, or more than 5,000 kilometers per hour, generally fall into two categories: hypersonic glide vehicles and hypersonic cruise missiles, either of which could be armed with nuclear or conventional warheads. With hypersonic glide vehicle systems, a rocket carries the unpowered glide vehicle into space, where it detaches and flies to its target by gliding along the upper atmosphere. Hypersonic cruise missiles are self-powered missiles, utilizing advanced rocket technology to achieve extraordinary speed and maneuverability.

No such munitions currently exist, but China, Russia, and the United States are developing hypersonic weapons of various types. The U.S. Defense Department, for example, is testing the components of a hypersonic glide vehicle system under its Tactical Boost Glide project and recently awarded a $928 million contract to Lockheed Martin Corp. for the full-scale development of a hypersonic air-launched cruise missile, tentatively called the Hypersonic Conventional Strike Weapon.12 Russia, for its part, is developing a hypersonic glide vehicle it calls the Avangard, which it claims will be ready for deployment by the end of 2019, and China in August announced a successful test of the Starry Sky-2 hypersonic glide vehicle described as capable of carrying a nuclear weapon.13

Whether armed with conventional or nuclear warheads, hypersonic weapons pose a variety of challenges to international stability and arms control. At the heart of such concerns is these weapons’ exceptional speed and agility. Anti-missile systems that may work against existing threats might not be able to track and engage hypersonic vehicles, potentially allowing an aggressor to contemplate first-strike disarming attacks on nuclear or conventional forces while impelling vulnerable defenders to adopt a launch-on-warning policy.14 Some analysts warn that the mere acquisition of such weapons could “increase the expectation of a disarming attack.” Such expectations “encourage the threatened nations to take such actions as devolution of command-and-control of strategic forces, wider dispersion of such forces, a launch-on-warning posture, or a policy of preemption during a crisis.” In short, “hypersonic threats encourage hair-trigger tactics that would increase crisis instability.”15

The development of hypersonic weaponry poses a significant threat to the core principle of assured retaliation, on which today’s nuclear strategies and arms control measures largely rest. Overcoming that danger will require commitments on the part of the major powers jointly to consider the risks posed by such weapons and what steps might be necessary to curb their destabilizing effects.

The development of hypersonic munitions also introduces added problems of proliferation. Although the bulk of research on such weapons is now being conducted by China, Russia, and the United States, other nations are exploring the technologies involved and eventually could produce such munitions on their own eventually. In a world of widely disseminated hypersonic weapons, vulnerable states would fear being attacked with little or no warning time, possibly impelling them to conduct pre-emptive strikes on enemy capabilities or to commence hostilities at the earliest indication of an incoming missile. Accordingly, the adoption of fresh nonproliferation measures also belongs on the agenda of major world leaders.16

Cyberattack

Secure operations in cyberspace, the global web of information streams tied to the internet, has become essential for the continued functioning of the international economy and much else besides. An extraordinary tool for many purposes, the internet is also vulnerable to attack by hostile intruders, whether to spread misinformation, disrupt vital infrastructure, or steal valuable data. Most of those malicious activities are conducted by individuals or groups of individuals seeking to enrich themselves or sway public opinion. It is increasingly evident, however, that governmental bodies, often working in conjunction with some of those individuals, are employing cyberweapons to weaken their enemies by sowing distrust or sabotaging key institutions or to bolster their own defenses by stealing militarily relevant technological know-how.

Moreover, in the event of a crisis or approaching hostilities, cyberattacks could be launched on an adversary’s early-warning, communications, and command and control systems, significantly impairing its response capabilities.17 For all these reasons, cybersecurity, or the protection of cyberspace from malicious attack, has become a major national security priority.18