# Lunar Heritage

## 1AC – Plan

#### Plan – States ought to regulate the appropriation of lunar heritage sites by private entities

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

The issue of humanity’s cultural heritage in space has arisen as one of many unanswered questions in space law, with no international agreements specifically addressing it. With the beginning of the space age fifty-six years ago and a series of remarkable achievements in space exploration behind us, it is necessary to determine what should be done regarding the “artifacts” of this exploration. NASA has promulgated their recommendations for spacefaring entities with the goal of protecting the lunar artifacts left behind by the Apollo missions.8 These recommendations establish “keep-out zones” of up to a four kilometer diameter with the aim of protecting the artifacts, particularly from dangerous, fastmoving particles that arise as a result of craft landings.9 Experience has shown that even artifacts that are sheltered by craters can be significantly sandblasted and pitted as a result of the moving particles.10 These recommendations, supposedly drafted in conformity with the Outer Space Treaty, however, are completely nonbinding.11 Legislation that has passed the U.S. Senate and is under consideration by the House of Representatives as of July 2019 would make these recommendations binding on U.S. entities seeking to land on the Moon.12 Accidental damage from unrelated missions, however, is only one of many threats to space artifacts. With the impending return to the Moon, it is likely that individuals and corporations will be looking to turn a profit from space heritage, without concern for the protection of such heritage. Tourists may disrupt sites with careless expeditions and landing sites may be desecrated so that the items can be sold. A Russian Lunakhod lunar rover has already been sold at auction to a private party, though it has not yet been moved from its original position on the Moon.13 While national heritage legislation can protect space artifacts from citizens of their own countries, there is currently no effective means in the present space law regime by which a country can protect id heritage from other countries.14 Both California and New Mexico have added Tranquility Base to their list of protected heritage sites.15 However, this solution, and those proposed in the bill put forth to the U.S. House of Representatives, only serve to restrict the activities of a small subset of the potential visitors to the Moon. Though the Senate bill calls for the President to initiate negotiations for a binding international agreement, there is still a long road from this bill to a potential agreement.16 A solution is needed to prevent the damage, destruction, loss, or private appropriation of our cultural heritage in space.

#### We defend NASA’s list of lunar heritage sites – insert map below.

JPL 13 12-13-2013 "Lunar Heritage Sites" <https://moon.nasa.gov/resources/53/lunar-heritage-sites/> (Jet Propulsion Laboratory at CalTech)//Elmer

A picture containing dome

Description automatically generated

## 1AC - Advantage

#### The advantage is lunar heritage:

#### Global moon rush by private actors is coming now.

Sample 19 Ian Sample 7-19-2019 “Apollo 11 site should be granted heritage status, says space agency boss” <https://www.theguardian.com/science/2019/jul/19/apollo-11-site-heritage-status-space-agency-moon> (PhD at Queens Mary College)//Elmer Recut Ethan Yang

But protecting lunar heritage may not be straightforward. On Earth, the United Nations Educational, Scientific and Cultural Organisation (Unesco) decides what deserves world heritage status from nominations sent by countries that claim ownership of the sites. Different rules apply in space. The UN’s outer space treaty, a keystone of space law, states that all countries are free to explore and use space, but warns it “is not subject to national appropriation by claim of sovereignty”. In other words, space is for all and owned by none. Wörner is not put off and sees no need for troublesome regulations. “My hope is that humanity is smart enough not to go back to this type of earthly protection. Just protect it. That’s enough. Just protect it and have everybody agree,” he said. A no-go zone of 50 metres around Tranquility base should do the job, he added. Martin Rees, the Cambridge cosmologist and astronomer royal, said there was a case for designating the sites so future generations and explorers were aware of their importance. “If there are any artefacts there, they shouldn’t be purloined,” he said. “Probably orbiting spacecraft will provide routine CCTV-style coverage which would prevent this from being done clandestinely.” Beyond the dust-covered hardware that stands motionless on the moon, Lord Rees suspects future activity could drive calls for broader lunar protection. The Apollo 17 astronaut and geologist Harrison Schmidt has advocated strip mining the moon for helium-3, a potential source of energy. The proposal, which Rees suggests has raised eyebrows in the community, could potentially provoke a backlash. “There might be pressure to preserve the more attractive moonscapes against such despoilation, and to try to enforce regulations as in the Antarctic,” he said. Fifty years on from Apollo 11, the moon is still a place to make statements. In January, the Chinese space agency became the first to land a probe on the far side. On Monday, India hopes to launch a robotic probe, the delayed Chandrayaan-2 lander that is bound for the unchartered lunar south pole. Far more is on the cards. Major space agencies, including ESA and Nasa, plan a “lunar gateway”, described by Wörner as a “bus stop to the moon and beyond”. His vision is for a “moon village”, but rather than a sprawl of domes, shops and a cosy pub, it is more an agreement between nations and industry to cooperate on lunar projects. The private sector is eager to be involved. Between now and 2024, at least five companies aim to launch lunar landers. In May, Nasa selected three companies to design, build and operate spacecraft that will ferry scientific experiments and technology packages to the moon. The coming flurry of activity may make protection more urgent. Michelle Hanlon, a space lawyer at the University of Mississippi, co-founded the non-profit organisation For all Moonkind to protect, preserve and memorialise human heritage on the moon. While she conceded that not all of the sites that bear evidence of human activity needed protection, she said many held invaluable scientific and archaeological data that we could not afford to lose. “These sites need to be protected from disruption if only for that reason,” she added. The protection should be far wider, and more formal, than Wörner calls for, Hanlon argues. “It is astounding to me that we wouldn’t protect the site of Luna 2, the very first object humans crashed on to another celestial body, and Luna 9, the very first object humans soft-landed on another celestial body,” she said. The Soviet Luna programme sent robotic craft to the moon between 1959 and 1976. “The director general has a much more optimistic view of human nature than I do,” Hanlon said. “I completely agree that the entities and nations headed back to the moon in the near future will take a commonsense approach and give due regard to the sites and artefacts. However, that is the near future. We have to be prepared for the company or nation that doesn’t care. Or worse, that seeks to pillage for artefacts that will undoubtedly sell for tremendous amounts of money here on Earth.”

#### Destroys scientifically rich artifacts.

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 Recut Ethan Yang

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.

#### Private entities are a unique threat – universal rules key.

Hertzfeld and Pace 13 (, H. and Pace, S., 2013. International Cooperation on Human Lunar Heritage. [online] Cpb-us-e1.wpmucdn.com. Available at: <https://cpb-us-e1.wpmucdn.com/blogs.gwu.edu/dist/7/314/files/2018/10/Hertzfeld-and-Pace-International-Cooperation-on-Human-Lunar-Heritage-t984sx.pdf> [Accessed 18 January 2022] Dr. Hertzfeld is an expert in the economic, legal, and policy issues of space and advanced technological development. Dr. Hertzfeld holds a B.A. from the University of Pennsylvania, an M.A. from Washington University, and a Ph.D. degree in economics from Temple University. He also holds a J.D. degree from the George Washington University and is a member of the Bar in Pennsylvania and the District of Columbia. Dr. Hertzfeld joined the Space Policy Institute in 1992. His research projects have included studies on the privatization of the Space Shuttle, the economic benefits of NASA R&D expenditures, and the socioeconomic impacts of earth observation technologies. He teaches a course in Space Law and a course in microeconomics through the Economics Department at G.W. Dr. Hertzfeld has served as a Senior Economist and Policy Analyst at both NASA and the National Science Foundation, and has been a consultant to many U.S. and international organizations, including a recent project on space applications with the OECD. He is the co-editor of Space Economics (AIAA 1992). Selected other publications include a study of the issues for privatizing the Space Shuttle (2000), an analysis of the value of information from better weather forecasts, an analysis of sovereignty and property rights published in the Journal of International Law (University of Chicago, 2005), and an economic analysis of the space launch vehicle industry (2005). Dr. Hertzfeld has also edited and prepared a new edition of the Study Guide and Case Book for Managerial Economics (Sixth Edition, W.W. Norton & Co.). Dr. Scott N. Pace is the Deputy Assistant to the President and Executive Secretary of the National Space Council (NSpC). He joined the NSpC in August 2017. From 2008-2017, he was the Director of the Space Policy Institute and a Professor of the Practice of International Affairs at George Washington University’s Elliott School of International Affairs. From 2005-2008, he served as the Associate Administrator for Program Analysis and Evaluation at NASA. Prior to NASA, he was the Assistant Director for Space and Aeronautics in the White House Office of Science and Technology Policy. From 1993-2000, he worked for the RAND Corporation’s Science and Technology Policy Institute, and from 1990-1993, he served as the Deputy Director and Acting Director of the Office of Space Commerce, in the Office of the Deputy Secretary of the Department of Commerce. In 1980, he received a Bachelor of Science degree in Physics from Harvey Mudd College; in 1982, Masters degrees in Aeronautics & Astronautics and Technology & Policy from the Massachusetts Institute of Technology; and in 1989, a Doctorate in Policy Analysis from the RAND Graduate School.)-rahulpenu

International Cooperation on Human Lunar Heritage The U.S. Apollo Space Program was a premier technological accomplishment of the 20th century. Preserving the six historic landing sites of the manned Apollo missions, as well as the mementos and equipment still on the Moon from those and other U.S. (e.g., Ranger and Surveyor) and Soviet Union (e.g., Luna) missions is important. Some of the instruments on the lunar surface are still active, monitored, and provide valuable scientifi c information. But recent government and **private**-**sector** **plans** to explore and potentially use lunar resources for commercial activity raise questions about the use of the Moon and potential accidental or purposeful threats to the historic sites and scientific equipment there. Although some steps to protect these sites have been proposed, we suggest a better way, drawing on international, not U.S. unilateral, recognition for the sites. Less than 2 years before the fi rst footsteps on the lunar surface on 20 July 1969 (see the image) , the United Nations Outer Space Treaty (OST) was drafted, ratifi ed, and came into force ( 1). Article II of the OST reinforced and formalized the international standard that outer space, the Moon, and other celestial bodies would not be subject to claims of sovereignty from any nation by any means, including appropriation. The OST prohibits ownership of territory or its appropriation by any state party to the treaty, which includes the United States, Russia, and 126 other nations. It does not prohibit the use of the Moon and its resources. In fact, the treaty emphasizes the importance of freedom of access to space for any nation and the importance of international cooperation in space exploration. These principles of the space treaties have enabled gains in science and technology and have contributed to international stability in space. New attention is being focused on the lunar surface. China has an active Moon exploration program and is considering sending astronauts (taikonauts) to the Moon. **Private** **firms** are contemplating robotic **missions** that could land in the vicinity of the historical sites of Apollo and other missions. Although we might assume the best of intentions for such missions, they could **irreparably** **disturb** the **traces** **of** the first **human** **visits** to another world. NASA has taken **steps** **to** **protect** the lunar landing **sites** and equipment and to initiate a process to create recognized norms of behavior. In July 2011, guidelines were issued for private companies competing in the Google Lunar X Prize that established detailed requirements for avoiding damage to U.S. government property on the Moon ( 2). H.R. 2617, The Apollo Lunar Landing Legacy Act, was introduced into the U.S. Congress on 8 July 2013 ( 3). In essence, it proposes to designate the Apollo landing sites and U.S. equipment on the Moon as a U.S. National Park with jurisdiction under the auspices of the U.S. Department of the Interior. Although the bill acknowledges treaty obligations of the United States, it would create, in effect, a unilateral U.S. action to control parts of the Moon. This would **create** a **direct** **conflict** **with** **i**nternational **law** and could be viewed as a **violation** **of** U.S. commitments under the **OST**. It would be an ineffective way of protecting historical U.S. sites, and it fails to address interests of other states that have visited and will likely visit the Moon. It is **legally** **flawed**, **unenforceable**, and **contradictory** **to** our national **space** **policy** and our international relations in space ( 4). There is a better way for the United States to protect its historic artifacts and equipment on the Moon. The fi rst step is to clearly distinguish between U.S. artifacts left on the Moon, such as fl ags and scientifi c equipment, and the territory they occupy. The second is to gain international, not unilateral, recognition for the sites upon which they rest. Aside from debris from crash landings (by Japan, India, China, and the European Space Agency), there are only two nations with “soft-landed” equipment on the lunar surface: the United States and Russia. China has plans to soft-land Chang’e 3 on the Moon in December 2013. All three nations (and any others wishing to participate) have much to gain and little or **nothing** **to** **lose** **from** a **multinational** **agreement** based on mutual respect and mutual protection of each other’s historical sites and equipment. Legal Issues Although ownership of planets, the Moon, and celestial bodies is prohibited, ownership of equipment launched into space remains with the nation or entity that launched the equipment, wherever that equipment is in the solar system. Under the OST, that nation is both responsible and liable for any harmful acts that equipment may create in space. There are no prescribed limits on time or the amount of damage a nation may have to pay. The U.S. government therefore still owns equipment it placed on the Moon. Ownership has the associated right of protecting the equipment, subject to using necessary and proportional means for protection. But, because no nation can claim ownership of the territory on which equipment rests, there is an open issue of how to control the spots on the Moon underneath that equipment, because the site is **integral** **to** the **historical** **signifi** **-** **cance**. In H.R. 2617, establishment of Apollo sites as a unit of the U.S. National Park System could be interpreted as a declaration of territorial sovereignty on the Moon, even though ensuing paragraphs specify the Park’s components as the “artifacts on the surface of the Moon” at those sites. This problem needs international legal clarifi cation, achievable via a formal agreement among those nations that have the technological ability to directly access the Moon ( 5). Section 6(a) raises another legal issue. The bill proposes that the Secretary of the Interior shall administer the park in accordance with laws generally applicable to U.S. National Parks. It also requires the Secretary to act in accordance with applicable international law and treaties. The U.S. National Park System Act states that the Parks are “managed for the benefi t and inspiration of all the people of the United States” ( 6). The OST clearly emphasizes that the exploration and use of space by nations is to benefi t all peoples. The laws and space policies of the United States have always emphasized peaceful uses of space and the benefi ts of space for humankind. It may not be possible to implement and execute provisions of this Bill without raising important and fundamental questions about these contradictions between the language of the treaty and the mandates of our National Park Service. A third legal issue is raised in section (6) (c)(2) that allows private donations and cooperative agreements to “provide visitors centers and administrative facilities within reasonable proximity to the Historical Park.” This **implies** **future** **private** **use** of the Moon **under** **rights** **granted** **by** the **U.S.** government. **Unilateral** **granting** **of** lunar territorial **rights** to private individuals and implicit sovereign protection of that territory **violates** the **OST**. Finally, section 8 of the bill requires the Secretary of the Interior to submit the Apollo 11 lunar landing site to the United Nations Educational, Scientifi c, and Cultural Organization (UNESCO) for designation as a World Heritage Site. This violates Article II of the OST. All current World Heritage Sites are located on sovereign territory of nations. The only exception is a separate treaty that allows UNESCO to designate underwater sites (such as sunken ships) as protected cultural sites ( 7). These designations are very limited, and although the convention has been ratifi ed by 43 nations, the United States, Russia, and China are not among them. Thus, any new treaty of this type specifi cally for outer space would have little chance of being ratifi ed by the major space-faring nations. A Proposal to Protect Lunar Sites Although a new U.N. treaty for space artifacts of signifi cant cultural and historic importance may be reasonable someday, this would start a very long process with unknown outcomes. Such a treaty could be delayed to a point beyond the time when nations and/or companies may be active on the Moon ( 8). Our suggested alternative is to create a bilateral agreement between the United States and Russia, offered as a multilateral agreement to other nations with artifacts on the Moon. This would be more legally expedient, politically sustainable, and would more likely meet and exceed the stated goals of the bill. It would also emphasize the important role of national laws to implement and enforce these international space agreements. **Any** **nation** **with** **assets** on the lunar surface will **endeavor** **to** **protect** those assets. This creates a situation where those nations have a **timely**, **current**, and **common** **interest** incorporating important implications for peaceful uses of outer space; **scientific** **research** and the advancement of **knowledge**; and **cultural** **and** **heritage** **value**, either presently or in the foreseeable future. The United States, Russia, and China all engage in multilateral cooperative space programs. They share many economic and trade dependencies adding to the international importance of promoting cooperation in space and commerce. In spite of today’s charged political environment, an **agreement** of the type we propose may still be possible to negotiate because it **focuses** **on** the **culture** **of** **space**, the use of space to benefit humankind, and the **archaeological** **record** of our civilization. It specifi cally would not touch sensitive issues of real property rights, export controls, human rights, or the weaponization of outer space. **Cooperation** on recognizing and protecting each other’s interests in historical sites and on equipment and artifacts also has no signifi cant security, prestige, or technological impediments. It reinforces the basic principles of the existing space treaties, avoids declarations of sovereignity on the Moon, and encourages multilateral cooperation resulting in a more stable and predictable environment for private activities on the Moon. The best mechanism for implementing a new agreement would be direct negotiations at highest levels of government in the United States, Russia, and China, with priority to include Russian sites in a proposal that protects U.S. sites. It could be included in meetings of heads of state of those nations, either jointly or sequentially among the three nations. Such an agreement could be executed in a relatively short period of time, setting precedents for peaceful and coordinated research, exploration, and exploitation of the Moon ( 9). An international agreement on lunar artifacts among the United States, Russia, and China would be a far superior and long-lasting solution than the unilateral U.S. proclamation in H.R. 2617. Enforcement of the agreement would be through each nation’s national laws, applying to those entities subject to the jurisdiction or control of the agreement members. Each nation’s property would be protected and preserved. Other nations should be free to join the agreement, and particularly encouraged to do so if they have the ability to access the Moon. An important result would be to develop a new level of trust among nations that could then lead to more **comprehensive** **future** cooperative agreements on **space**, **science**, **exploration**, **commerce**, **and** the use of the Moon and **other** **celestial** **bodies**.

#### Heritage Sites are critical for science research around dust.

OSTP 18 Office of Science and Technology Policy March 2018 “PROTECTING & PRESERVING APOLLO PROGRAM LUNAR LANDING SITES & ARTIFACTS” (The Office of Science and Technology Policy is a department of the United States government, part of the Executive Office of the President, established by United States Congress on May 11, 1976, with a broad mandate to advise the President on the effects of science and technology on domestic and international affairs.)//Elmer Recut Ethan Yang

The Moon continues to hold great significance around the world. The successes of the Apollo missions still represent a profound human technological achievement almost 50 years later and continue to symbolize the pride of the only nation to send humans to an extraterrestrial body. The Apollo missions reflect the depth and scope of human imagination and the desire to push the boundaries of humankind’s existence. The Apollo landing sites and the accomplishments of our early space explorers energized our Nation's technological prowess, inspired generations of students, and greatly contributed to the worldwide scientific understanding of the Moon and our Solar System. Additionally, other countries have placed hardware on the Moon which undoubtedly has similar historic, cultural, and scientific value to their country and to humanity. Three Apollo sites remain scientifically active and all the landing sites provide the opportunity to learn about the changes associated with long-term exposure of human-created systems in the harsh lunar environment. These sites offer rich opportunities for biological, physical, and material sciences. Future visits to the Moon’s surface offer opportunities to study the effects of long-term exposure to the lunar environment on materials and articles, including food left behind, paint, nylon, rubber, and metals. Currently, very little data exist that describe what effect temperature extremes, lunar dust, micrometeoroids, solar radiation, etc. have on such man-made material, and no data exist for time frames approaching the five decades that have elapsed since the Apollo missions. While some of the hardware on the Moon was designed to remain operational for extended periods and successfully telemetered scientific data back to the Earth, much of what is there was designed only for use during the Apollo mission and then abandoned with no expectation of further survivability. How these artifacts and their constituent materials have survived and been altered while on the lunar surface is of great interest to engineers and scientists. The Apollo artifacts and the impact sites have the potential to provide unprecedented data if lunar missions to gather and not corrupt the data are developed. These data will be invaluable for helping to design future long-duration systems for operation on the lunar surface. NASA has formally evaluated the possible effects of the lunar environment and identified potential science opportunities. For example, using Apollo 15 as a representative landing site, the crew left 189 individually cataloged items on the lunar surface, including the descent stage of the Lunar Module, the Lunar Roving Vehicle, the Apollo Lunar Surface Experiments Package, and a wide variety of miscellaneous items that were offloaded by the astronauts to save weight prior to departure. The locations of many of these items are well documented, and numerous photographs are available to establish their appearance and condition at the time they were left behind.

#### Moon dust research key to moon bases.

Smith 19 Belinda Smith 7-18-2019 “Who protects Apollo sites when no-one owns the Moon?” <https://www.abc.net.au/news/science/2019-07-19/apollo-11-moon-landing-heritage-preservation-outer-space-treaty/11055458> (Strategic Communications Advisor at Department of Education and Training at University of Victoria)//Elmer Recut Ethan Yang

It's not just about history Alongside heritage value, the bits and pieces left on the Moon have enormous scientific significance. Take moon dust. It's a real problem for moon-bound equipment because it's made of fine, super sticky and highly abrasive grains, which have a habit of clogging instruments and spacesuits. But as Armstrong and Aldrin trotted across the surface, the footprints they left behind gave us valuable information into the properties of moon dust, Flinders University space archaeologist Alice Gorman said. "The ridges on the boots were meant to measure how far they sank into the dust. "Then they used the light contrast between the ridges to measure the reflectance properties of the dust." A boot print in grey dust. This iconic photo of Buzz Aldrin's footprint is also a science experiment. (Supplied: NASA) It's data like this that will help if we want a long-term base on the Moon — we need to know how our gear will stand up to lunar conditions. Apart from the sticky, gritty dust, the lunar surface is also peppered with meteorites and cosmic rays. So, Dr Gorman said, one of the very few reasons to revisit a moon site is to collect some of the equipment left behind and see how it fared. "What has happened to this material in 50 years of sitting on the lunar surface? "This is going to be really interesting scientific information because it will help planning for future missions and get an understanding of long-term conditions." And NASA has already done this. The Apollo 12 mission, which landed on the Moon four months after Apollo 11, collected parts from the 1967 Surveyor probe and brought them back to Earth. An astronaut standing next to a piece of equipment on the lunar surface Along with rocks and soil samples, Apollo 12 astronauts collected pieces of the Surveyor 3 probe for analysis back on Earth. (Supplied: NASA) Another reason to preserve the equipment left on the Moon is to prove we really went there, Professor Capelotti said. "There's a lot of people out there who still don't believe it happened. "The stuff on the Moon is a testament to what we did and when we did it."

#### Scenario 1 is warming

#### Lunar observatory solves warming adaptation.

Ding et al. 17 (, Y., Liu, G. and Guo, H., 2017. Moon-based Earth observation: scientific concept and potential applications. [online] Volume 11, 2018. Available at: <https://www.tandfonline.com/doi/full/10.1080/17538947.2017.1356879> [Accessed 22 January 2022] Yixing Ding - Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences, Beijing, People’s Republic of China Guang Liu - Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences, Beijing, People’s Republic of China Huadong Guo - Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences, Beijing, People’s Republic of China.)-rahulpenu

4. Scientific goal of moon-based earth observation A basic question for moon-based Earth observation is, ‘What to see?’ According to the characteristics of moon-based Earth observation, the phenomena suitable for Moon-based Earth observation may have at least one of the following features: long-lasting, related to Sun–Earth–Moon motion, requires stable baseline observation, large-scale and describes multiple parameters. In the following sections, we will present several observation objectives to discuss in detail. 4.1. Solid earth dynamics Solid Earth tides, continental plate movement and glacier isostatic adjustment (GIA) are three typical large-scale solid Earth movements (Jiang et al. 2016), the measurement of which is a basic task of geodesy. For a uniform layered Earth, accurately predicting tidal movement can be done theoretically, but complex ocean tides and the inelasticity and heterogeneity of Earth’s interior material make the solid tide of the real Earth difficult to research theoretically. For GIA studies, prior knowledge about ancient ice cover evolution and a large amount of observational data are needed. Plate tectonics theory is a quantitative description of Earth plate movement (Ni et al. 2016). It may well explain the movement of most oceanic plates, but still have some problems to explain the mechanism of strong continental earthquakes, large-scale continental deformation, as well as the movements of other oceanic plates (Bird 2003). Accurately **measuring** solid **Earth** **dynamics** is **beneficial** **to** **understanding** solid Earth **tides**, **continental** **plate** **movement** and **GIA**, and provides further support for geodynamics and seismology. Devices such as a superconducting gravimeter and global navigation satellite system are currently used to measure small deformations of solid Earth, but these point-by-point methods are spatially limited to certain regions. Spaceborne InSAR measures deformation continuously, but the swath is not wide enough for mapping large-scale solid Earth movement. The Moon is a vast and stable platform that can provide sufficiently long and stable baseline interferometry. Its movement is easier to predict and the time interval of repeat-pass interferometry could be reduced to one day (Fornaro et al. 2010). In addition, the Moon is one of the main sources of tides on the Earth; so if we compare two measurements at different times, the lunar tide portion can be subtracted, leaving only the solar tide portion. After proper processing, it may help us learn more about the interior structure of Earth’s crust. To measure the large-scale deformation, a Moon-based repeat-pass InSAR system needs to be carefully designed. Except for the general SAR parameters, the critical baseline is a key factor that impacts its performance. The critical baseline Bc leading to a complete spatial decorrelation is given by Bc = BlDem tan ui c . (7) In this equation, the incidence angle ui is related to the observational geometry, while l and B are optional. When the bandwidth is 100 MHz and the incidence angle is 25°, the critical baselines are 14,000, 3300 and 1770 km at the L-band, C-band and X-band, respectively. In order to keep the correlation between two repeat passes, a practical baseline must be smaller than Bc. Therefore, from a practical point of view, the L-band is better than the C-band or X-band. Figure 4 shows the simulation results of one-day interval interferometry, but the side-looking constraints are not involved. In this case, the temporal decorrelation is highly reduced. It is obvious that the interferometric area is larger in the L-band than in X-band. Meanwhile, when the declination of the Moon is near the extremes, the interferometric area becomes larger. When the declination of the Moon is near the equatorial plane, one-day interval repeat-pass interferometry is not feasible, but a half month or one month interval repeat-pass interferometry is available. The magnitude of the solid Earth motion is not large. For example, the typical solid Earth tide amplitude is dozens of centimetres in one day. A resolution of hundreds of metres or even coarser will be enough if the wave is stably scattered. 4.2. Energy budget of earth Fundamentally, **climate** **change** **depends** **on** Earth’s **radiation** **balance**. **Observation** **of** both the solar **radiation** **and** Earth’s **reflection** and emission will **depend** **on** **accurate** **measurement** with space technology. Since the late 1970s, the United States and Europe have launched a number of missions to measure solar and terrestrial radiation, such as NASA’s Active Cavity Radiometer Irradiance Monitor Series programme (ACRIM1, 1980–1989; ACRIM2, 1991–2001; ACRIM3, 2000–present), Earth Radiation Budget Experiment (ERBE, 1984–1994), Clouds and Earth’s Radiant Energy System (CERES, 1997–present), Solar Radiation and Climate Experiment (SORCE, 2003–present) and the French Megha-Tropiques satellite on the Scanner for Radiation Budget (ScaRaB, 2011–present). These missions have greatly improved our understanding of Earth’s energy system. The Deep Space Climate Observatory (DSCOVR), placed at the earth–Sun first Lagrangian point, has been designed to measure the outgoing radiation of the sunlit Earth disk with a constant look angle. But in the outgoing radiation, the reflected shortwave **radiation** is **highly** **affected** **by** **albedo** **and** **atmospheric** **conditions**, showing obvious anisotropy. **Lack** **of** **sampling** in space and time is **vulnerable** **to** **uncertainties**. The **lunar** **observatory** **provides** **large**-**scale** **observation** **with** continuously **changing** **angles**, enabling it to calibrate the **data** of satellites in different orbits at different times. Its most important property is that it can provide a **very** **long**-**term** time series from a single orbit platform. In a year, the time series covers all local times, all seasons (different weather pattern) and all Earth phases for all underlying surfaces (Pallé and Goode 2009; Karalidi et al. 2012). The diversity of the **surface**-**weatherphase** combination is beneficial to improving the quality of global energy budget data and to the study of regional energy redistribution and its multi-layer coupling effects. The Moon-based data will also provide a direct connection between the data from space technology and the data from ground-based earthshine measurement series, which span almost one hundred years. The system design can consult the DSCOVR satellite, a radiometer measuring irradiance of the Earth phase and an imaging camera taking images of the Earth phase for various Earth sciences purposes. In order to take into account the needs of observing the Earth’s environmental elements, 1 km spatial resolution and 20–30 channels of the camera are suggested. 4.3. Earth’s environmental elements Vegetation is an important part of the global carbon pool and a key element of global carbon cycle. Most vegetation is distributed in middle- and low-latitude regions. A Moon-based optical camera can image global **vegetation** almost every day. SAR maps not only the horizontal distribution of vegetation, but also extracts forest morphological structure through tomography. The Moon provides multi-baseline **accessibility** within a single pass to eliminate the tomographic temporal decorrelation, but the imaging temporal decorrelation within a long synthetic aperture time hampers the focusing of forest. Therefore, to validate the feasibility of Moon-based **3D** **mapping** of forest, more imaging methods for unstable scatterer, for example, the time reversal imaging method (Jin and Moura 2007), need to be tested and new methods are also expected. Glaciers are sensitive variables of climate change. The monitoring of glacier area, surface velocity and mass balance plays an important role in understanding the status of glaciers and their response to global change. Remote sensing techniques, such as optical sensors, SAR and altimeter data, provide regular observations of key glacial parameters. A lunar platform would provide continuous three- or four-day temporal coverage per month at the polar regions, but the observation incidence angle would typically be larger than 40° (see Figure 5) due to the relatively small inclination angle of the lunar orbit. For the High Asia area, the average coverage is about 4 h per day with proper incidence angle. The challenges may be the cost of high-resolution mapping for the optical sensor, and the layover problem (Tilley and Bonwit 1989) in heavy gradient area for SAR. Moon-based altimetry faces the same problems as LiDAR mentioned before, and is not recommended. An **atmospheric** **observatory** on the Moon can be used to evaluate the cloud fraction in an unambiguous manner, **determine** the **composition** in terms **of** the major **trace** **gas** and aerosols (Hamill 2016), and shed light on the relationship between lunar phases and **cloudiness** or **precipitation**. Particularly, the Moon offers a good place for **occultation** observation, which means observing the light or microwave changes emitted by stars or satellites when they are obstructed by atmosphere around the Earth. The Global Ozone Monitoring by Occultation of Stars (GOMOS) instrument on board the Envisat satellite is a typical system using the stellar occultation measurement principle in monitoring ozone and other trace gases in Earth’s stratosphere (Kyrola et al. 2004). Moon-based occultation was proposed in Link (1969), and was considered promising in Moon-based Earth atmosphere monitoring (Hamill 2007, 2016; Guo et al. 2014). The advantage of Moon-based occultation is that a star descends several times slower through the atmosphere than when viewed from a LEO satellite. This helps by increasing the SNR and resolution to some extent, but the practical performance also relies on the system design and the probability of finding an appropriate occultation geometry. 4.4. Earth-space environment Observing the environment of outer space surrounding Earth requires much larger FOV than only observing the solid Earth. The Moon is an ideal place to monitor the interaction between the solar wind and the magnetosphere. Moon-based observation combined with high near-polar Earth orbit or Molniya orbit observations can help us construct the three-dimensional structure of the magnetosphere by X-ray and EUV remote imaging. Images in all meridian planes of the whole plasma layer have already been captured by the EUV camera on the Chang’e 3 lander. Some initial results reflect the basic features of the plasmasphere, and also verified the accessibility of high-quality data of magnetosphere from the Moon (Feng et al. 2014). 5. Conclusion In this paper, we propose the Moon as a platform for Earth observation with long-term, dynamic capabilities, mainly focusing on large-scale geoscience phenomena. The characteristics of a lunar platform, the sensors and the scientific objectives of Moon-based Earth observation are discussed in detail. A lunar platform could observe Earth in quite a different way, and give a long-lasting disk view, a stable baseline and a unique perspective. The proposed sensors include some optical sensors and SAR. LiDAR, altimeters and scatterometers may not be functional on the lunar surface mainly because of the long viewing distance, and Moon-based radiometers may not be necessary if spaceborne radiometers are effective enough. Though the cost is not discussed in this paper, a Moon-based SAR would be extremely expensive and face too many specific technical difficulties to be implemented at the present time. On the contrary, passive optical sensors, such as spectrographs and panchromatic cameras, are much easier to realize. The scientific objectives of Moon-based Earth observation include measuring solid Earth dynamics and the global energy budget, and monitoring Earth’s environment and the surrounding environment of outer space. Moon-based Earth observation will be effective in measuring solid Earth tides, detecting outgoing radiation, and monitoring the magnetosphere and some of Earth’s environmental elements. Finally, we suggest that numerical simulations are indispensable to validate the proposals and to address specific problems.

#### Only moon bases solve

Ding et al. 17 (, Y., Liu, G. and Guo, H., 2017. Moon-based Earth observation: scientific concept and potential applications. [online] Volume 11, 2018. Available at: <https://www.tandfonline.com/doi/full/10.1080/17538947.2017.1356879> [Accessed 22 January 2022] Yixing Ding - Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences, Beijing, People’s Republic of China Guang Liu - Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences, Beijing, People’s Republic of China Huadong Guo - Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences, Beijing, People’s Republic of China.) Recut Ethan Yang

There are several characteristics of Moon-based Earth observation as listed below. (1) Longevity The life cycle of artificial satellites is generally several years, while the Moon has already existed for billions of years, and will not go extinct in the foreseeable future. It is a longstanding, essentially permanent platform. The revisit cycle is quite different from LEO satellite. Except for the polar regions, the revisit period is one day, the same as Earth’s rotation period. The revisit period in the same geometric condition is one month, the same as the moon’s revolution period. The temporal sampling of the lunar platform is not systematically biased. It covers all local times in a month and all seasons in a year. This will be very useful for long-term time series analysis in climate change research. Furthermore, the lunar platform can also provide time series data to calibrate the remote sensing data from other platforms. (2) Integrity The whole Earth disk facing the Moon, both the sunlit portion and dark portion, is always observable from the near side of the Moon, with a field angle of only about 2°. This allows an observer on the Moon to view the whole Earth disk at any given time and Earth’s entire surface in a day, both in dark and sunlit conditions. (3) Stability Studies show that the lunar crust lacks plate tectonics; so the quantity and degree of moonquake activities are much less than earthquakes (Jaumann et al. 2012). Compared to satellite platforms, the Moon has vast spaces on which to install a set of sensors to form a long, stable baseline of large observational networks for precise measurement. Moon also moves stably, which enables repeat-pass interferometry. (4) Uniqueness Moon exerts influences on precipitation, ice nuclei concentrations, diurnal pressure changes, hurricanes, cloudiness, thunderstorm and surface temperature (Balling and Cerveny 1995). The tidal force of the Moon is also considered as a trigger of earthquakes (Cochran et al. 2004) and a resource generating internal waves (Simmons et al. 2004). For those Moon-related terrestrial phenomena, the lunar platform provides such a unique perspective that any place on the Earth can be continuously monitored at different Moon–Earth phase angles each day. A Moon-based sensor can dynamically trace the whole process covering their occurrence, development and dissipation. It will help the understanding of the relationship between the tidal phases and the evolution of the phenomena. 3. Sensors for moon-based earth observation For most of the history of lunar exploration, the United States, China and Japan have been taking a few pictures of Earth with cameras both on the lunar surface and in lunar orbit. This proved that it is possible to observe Earth utilizing Moon-based optical sensors. However, except for observing Earth’s magnetosphere, these photos had no specific scientific objective. Few works about the sensors for Moon-based Earth observation have been published by previous missions. So, in this section we discuss the feasibility and the key parameters of various traditional remote sensors, including both the optical sensors and the microwave sensors. 3.1. Optical sensors for moon-based earth observation One important parameter of most remote sensing systems is the spatial resolution. The detection range of Moon-based optical sensors is much further than spaceborne sensors. The diffraction limited resolution of optical sensors r is given by = 1.22lR/d, (1) where l is the wavelength, d the telescopic aperture and R the distance from the sensor to the target. In the visible band, the limiting resolution is 0.17–0.36 km, when d is 1 m. In short, if the telescopic aperture is 0.5 m, the spatial resolution can be less than 1 km in the visible band and several kilometres in the near-infrared and thermal infrared bands, which satisfies the needs of climatologic models and global mapping for oceans, clouds and land use (Ding, Guo and Liu 2014). LiDAR is an example of an active sensor. To place a LiDAR on the Moon, many technological challenges must be taken into consideration, such as the echo power, the size of the laser beam on earth’s surface and the coverage performance. If the scattering solid angle of a homogeneous scatterer is p, the received power of this system falls within the square of the distance from LiDAR to scatterer R (Wagner et al. 2006): Pr = PtrD2 r 4R2 , (2) where the received power and transmitted power is Pr and Pt, Dr the receiving aperture and r the reflectivity. The power needed for Moon-based LiDAR would be a hundred thousand times greater than that of satellite-based LiDAR, which is at the megawatt level. The footprint of the laser beam on Earth’s surface is proportional to the laser divergence angle. Under a divergence of 0.1 m/rad, the beam of Moon-based LiDAR would be 36–40 km, two orders of magnitude larger than the beam width of spaceborne LiDAR. Such a large beam would stretch the length of the echo signal and complicate its waveform, and will lead to a difficulty to determine the exact echo position of the target in measuring the altitude of sea surface and the thickness of vegetation.

#### Adaptation solves warming impacts – it’s the silver bullet.

Rood and Gibbons 21 Richard B. Rood and Elizabeth Gibbons 9-11-2021 "After a summer of weather horrors, adapting to climate change is an imperative" <https://archive.is/VKac8#selection-391.0-413.1> (Richard B. (Ricky) Rood is a professor of climate and space sciences and engineering at the University of Michigan. Elizabeth (Beth) Gibbons is executive director of the American Society of Adaptation Professionals.)//Elmer Recut Ethan Yang

This summer, the extraordinary heat in the Pacific Northwest, floods across the Northern Hemisphere and Hurricane Ida’s swath across the country have awakened more people to the dangers of climate change. As professionals working on climate change, we receive many requests for comments and interviews. More telling, perhaps, have been panic-tinged personal letters from family and friends as well as colleagues working in the field awakening to the real-world consequences of our warming climate. Public messaging on climate change is dominated by the discussion of reducing carbon dioxide emissions to limit the warming and to stop the “worst effects” of climate change. This is the mitigation of global warming. Headlines range from declarations of climate despair to the measured voices of those who insist that there is still the time and wherewithal to limit warming to the goals aspired to by the United Nations. Amid this cacophony of mitigation panic and sought-after patience is another discussion that has been going on for more than a decade. Namely, that we are not likely to meet emission-reduction goals such as those of the Paris agreement. This is complemented by the fact that we live in a rapidly changing climate, rapid change will continue, and we are not going back to the climate of our childhoods. When we consider how we will address our climate future, it is worth considering our past behavior and choices. We have had the ability and the roadmap to make major strides in reducing carbon dioxide emissions and mitigating climate change for many years. In many cases, these mitigation tactics are “no regrets,” with very quick monetary payback for expenditures — the insulation of houses and choosing fuel-efficient vehicles, for example. Yet we have not taken these steps at the scales that are required for effective intervention. Mitigation is one response, but adaptation can be framed as the other response. Adaptation is responding to the effects of warming or perhaps coping with the consequences of the warming Earth. With the public conversation focusing overwhelmingly on mitigation, adaptation has been a neglected topic. Compared with mitigation, adaptation is relatively easy. Effective mitigation requires changing human behavior, ingrained geopolitical and economic power structures, and built infrastructure on a global scale. It requires convincing people to invest for the common good of other people, often decades into the future. At its simplest, adaptation can be carried out by an individual. You can sell the house next to the ocean and move to northern Michigan. You can reinforce your roof and put your oceanside house on stilts. There is a concrete value proposition. Although adaptation can be carried out by individuals, it is better and certainly more equitable to plan on the larger scales of a community, a city or a region. As the geographical scale increases and more individuals, organizations and local governments are involved, it does get more difficult. However, the threats to life, property and the local environment often serve as motivation to challenge the barriers of cooperation and shared beneficial outcomes. For example, a region threatened by rising seas is motivated to come together to find solution strategies. Indeed such efforts are underway, for example, in the Southeast Florida climate compact, the Puget Sound climate collaborative, and efforts across Southeast Virginia’s Hampton Roads region. When a region successfully implements adaptation plans, communities are likely to have wins when the next storm is not as destructive and costly. These wins help people cope with global warming and realize some ability to take control of what has been often stated as an existential threat. There have been those calling for adaptation policy for many years. However, it has been difficult to get adaptation on the policy agenda. This is ascribed to many reasons, including the persistent, spurious argument that if we talk of adaptation, then we will decide that we do not need to mitigate our emissions. However, we are at the point that, even if we were to meet all of the emission reduction goals of the United Nations’ Paris agreement, adaptation will still be required. In the end, the most important aspect of adaptation is fundamentally human. If individuals and communities can see adaptation as a way of sustaining their well-being in the face of rapidly changing weather, then it is a step of moving past the narrative that we must, between now and 2030, solve an existential threat to our survival. We can see successful adaptation strategies spreading, scaling, and bringing planetary warming into the mind-set and the behavior of more and more people. We must entrain dealing with the weather of a warming Earth into all that we do. And that, we assert, will make the need for mitigation more real and urgent.

#### Warming causes extinction.

Dr. Peter Kareiva 18 – Ph.D. in Ecology and Applied Mathematics from Cornell University, Director of the Institute of the Environment and Sustainability at UCLA, Pritzker Distinguished Professor in Environment & Sustainability at UCLA, et al., September 2018, “Existential Risk Due To Ecosystem Collapse: Nature Strikes Back”, Futures, Volume 102, p. 39-50

In summary, six of the nine proposed planetary boundaries (phosphorous, nitrogen, biodiversity, land use, atmospheric aerosol loading, and chemical pollution) are unlikely to be associated with existential risks. They all correspond to a degraded environment, but in our assessment do not represent existential risks. However, the three remaining boundaries (climate change, global freshwater cycle, and ocean acidification) do pose existential risks. This is because of intrinsic positive feedback loops, substantial lag times between system change and experiencing the consequences of that change, and the fact these different boundaries interact with one another in ways that yield surprises. In addition, climate, freshwater, and ocean acidification are all directly connected to the provision of food and water, and shortages of food and water can create conflict and social unrest.

Climate change has a long history of disrupting civilizations and sometimes precipitating the collapse of cultures or mass emigrations (McMichael, 2017). For example, the 12th century drought in the North American Southwest is held responsible for the collapse of the Anasazi pueblo culture. More recently, the infamous potato famine of 1846–1849 and the large migration of Irish to the U.S. can be traced to a combination of factors, one of which was climate. Specifically, 1846 was an unusually warm and moist year in Ireland, providing the climatic conditions favorable to the fungus that caused the potato blight. As is so often the case, poor government had a role as well—as the British government forbade the import of grains from outside Britain (imports that could have helped to redress the ravaged potato yields).

Climate change intersects with freshwater resources because it is expected to exacerbate drought and water scarcity, as well as flooding. Climate change can even impair water quality because it is associated with heavy rains that overwhelm sewage treatment facilities, or because it results in higher concentrations of pollutants in groundwater as a result of enhanced evaporation and reduced groundwater recharge. Ample clean water is not a luxury—it is essential for human survival. Consequently, cities, regions and nations that lack clean freshwater are vulnerable to social disruption and disease.

Finally, ocean acidification is linked to climate change because it is driven by CO2 emissions just as global warming is. With close to 20% of the world’s protein coming from oceans (FAO, 2016), the potential for severe impacts due to acidification is obvious. Less obvious, but perhaps more insidious, is the interaction between climate change and the loss of oyster and coral reefs due to acidification. Acidification is known to interfere with oyster reef building and coral reefs. Climate change also increases storm frequency and severity. Coral reefs and oyster reefs provide protection from storm surge because they reduce wave energy (Spalding et al., 2014). If these reefs are lost due to acidification at the same time as storms become more severe and sea level rises, coastal communities will be exposed to unprecedented storm surge—and may be ravaged by recurrent storms.

A key feature of the risk associated with climate change is that mean annual temperature and mean annual rainfall are not the variables of interest. Rather it is extreme episodic events that place nations and entire regions of the world at risk. These extreme events are by definition “rare” (once every hundred years), and changes in their likelihood are challenging to detect because of their rarity, but are exactly the manifestations of climate change that we must get better at anticipating (Diffenbaugh et al., 2017). Society will have a hard time responding to shorter intervals between rare extreme events because in the lifespan of an individual human, a person might experience as few as two or three extreme events. How likely is it that you would notice a change in the interval between events that are separated by decades, especially given that the interval is not regular but varies stochastically? A concrete example of this dilemma can be found in the past and expected future changes in storm-related flooding of New York City. The highly disruptive flooding of New York City associated with Hurricane Sandy represented a flood height that occurred once every 500 years in the 18th century, and that occurs now once every 25 years, but is expected to occur once every 5 years by 2050 (Garner et al., 2017). This change in frequency of extreme floods has profound implications for the measures New York City should take to protect its infrastructure and its population, yet because of the stochastic nature of such events, this shift in flood frequency is an elevated risk that will go unnoticed by most people.

4. The combination of positive feedback loops and societal inertia is fertile ground for global environmental catastrophes.

Humans are remarkably ingenious, and have adapted to crises throughout their history. Our doom has been repeatedly predicted, only to be averted by innovation (Ridley, 2011). However, the many stories of human ingenuity successfully addressing existential risks such as global famine or extreme air pollution represent environmental challenges that are largely linear, have immediate consequences, and operate without positive feedbacks. For example, the fact that food is in short supply does not increase the rate at which humans consume food—thereby increasing the shortage. Similarly, massive air pollution episodes such as the London fog of 1952 that killed 12,000 people did not make future air pollution events more likely. In fact it was just the opposite—the London fog sent such a clear message that Britain quickly enacted pollution control measures (Stradling, 2016). Food shortages, air pollution, water pollution, etc. send immediate signals to society of harm, which then trigger a negative feedback of society seeking to reduce the harm.

In contrast, today’s great environmental crisis of climate change may cause some harm but there are generally long time delays between rising CO2 concentrations and damage to humans. The consequence of these delays are an absence of urgency; thus although 70% of Americans believe global warming is happening, only 40% think it will harm them (http://climatecommunication.yale.edu/visualizations-data/ycom-us-2016/). Secondly, unlike past environmental challenges, the Earth’s climate system is rife with positive feedback loops. In particular, as CO2 increases and the climate warms, that very warming can cause more CO2 release which further increases global warming, and then more CO2, and so on. Table 2 summarizes the best documented positive feedback loops for the Earth’s climate system. These feedbacks can be neatly categorized into carbon cycle, biogeochemical, biogeophysical, cloud, ice-albedo, and water vapor feedbacks. As important as it is to understand these feedbacks individually, it is even more essential to study the interactive nature of these feedbacks. Modeling studies show that when interactions among feedback loops are included, uncertainty increases dramatically and there is a heightened potential for perturbations to be magnified (e.g., Cox, Betts, Jones, Spall, & Totterdell, 2000; Hajima, Tachiiri, Ito, & Kawamiya, 2014; Knutti & Rugenstein, 2015; Rosenfeld, Sherwood, Wood, & Donner, 2014). This produces a wide range of future scenarios.

Positive feedbacks in the carbon cycle involves the enhancement of future carbon contributions to the atmosphere due to some initial increase in atmospheric CO2. This happens because as CO2 accumulates, it reduces the efficiency in which oceans and terrestrial ecosystems sequester carbon, which in return feeds back to exacerbate climate change (Friedlingstein et al., 2001). Warming can also increase the rate at which organic matter decays and carbon is released into the atmosphere, thereby causing more warming (Melillo et al., 2017). Increases in food shortages and lack of water is also of major concern when biogeophysical feedback mechanisms perpetuate drought conditions. The underlying mechanism here is that losses in vegetation increases the surface albedo, which suppresses rainfall, and thus enhances future vegetation loss and more suppression of rainfall—thereby initiating or prolonging a drought (Chamey, Stone, & Quirk, 1975). To top it off, overgrazing depletes the soil, leading to augmented vegetation loss (Anderies, Janssen, & Walker, 2002).

Climate change often also increases the risk of forest fires, as a result of higher temperatures and persistent drought conditions. The expectation is that forest fires will become more frequent and severe with climate warming and drought (Scholze, Knorr, Arnell, & Prentice, 2006), a trend for which we have already seen evidence (Allen et al., 2010). Tragically, the increased severity and risk of Southern California wildfires recently predicted by climate scientists (Jin et al., 2015), was realized in December 2017, with the largest fire in the history of California (the “Thomas fire” that burned 282,000 acres, https://www.vox.com/2017/12/27/16822180/thomas-fire-california-largest-wildfire). This catastrophic fire embodies the sorts of positive feedbacks and interacting factors that could catch humanity off-guard and produce a true apocalyptic event. Record-breaking rains produced an extraordinary flush of new vegetation, that then dried out as record heat waves and dry conditions took hold, coupled with stronger than normal winds, and ignition. Of course the record-fire released CO2 into the atmosphere, thereby contributing to future warming.

Out of all types of feedbacks, water vapor and the ice-albedo feedbacks are the most clearly understood mechanisms. Losses in reflective snow and ice cover drive up surface temperatures, leading to even more melting of snow and ice cover—this is known as the ice-albedo feedback (Curry, Schramm, & Ebert, 1995). As snow and ice continue to melt at a more rapid pace, millions of people may be displaced by flooding risks as a consequence of sea level rise near coastal communities (Biermann & Boas, 2010; Myers, 2002; Nicholls et al., 2011). The water vapor feedback operates when warmer atmospheric conditions strengthen the saturation vapor pressure, which creates a warming effect given water vapor’s strong greenhouse gas properties (Manabe & Wetherald, 1967).

Global warming tends to increase cloud formation because warmer temperatures lead to more evaporation of water into the atmosphere, and warmer temperature also allows the atmosphere to hold more water. The key question is whether this increase in clouds associated with global warming will result in a positive feedback loop (more warming) or a negative feedback loop (less warming). For decades, scientists have sought to answer this question and understand the net role clouds play in future climate projections (Schneider et al., 2017). Clouds are complex because they both have a cooling (reflecting incoming solar radiation) and warming (absorbing incoming solar radiation) effect (Lashof, DeAngelo, Saleska, & Harte, 1997). The type of cloud, altitude, and optical properties combine to determine how these countervailing effects balance out. Although still under debate, it appears that in most circumstances the cloud feedback is likely positive (Boucher et al., 2013). For example, models and observations show that increasing greenhouse gas concentrations reduces the low-level cloud fraction in the Northeast Pacific at decadal time scales. This then has a positive feedback effect and enhances climate warming since less solar radiation is reflected by the atmosphere (Clement, Burgman, & Norris, 2009).

The key lesson from the long list of potentially positive feedbacks and their interactions is that runaway climate change, and runaway perturbations have to be taken as a serious possibility. Table 2 is just a snapshot of the type of feedbacks that have been identified (see Supplementary material for a more thorough explanation of positive feedback loops). However, this list is not exhaustive and the possibility of undiscovered positive feedbacks portends even greater existential risks. The many environmental crises humankind has previously averted (famine, ozone depletion, London fog, water pollution, etc.) were averted because of political will based on solid scientific understanding. We cannot count on complete scientific understanding when it comes to positive feedback loops and climate change.

#### Scenario 2 is neutrino research

#### Earth’s atmosphere limits neutrino research – only a moon base solves.

Crawford 12, I. A., et al. "Back to the Moon: The scientific rationale for resuming lunar surface exploration." Planetary and Space Science 74.1 (2012): 3-14. (Department of Earth and Planetary Sciences, Birkbeck College)//Elmer Recut Ethan Yang

A natural area to use the Moon as a platform for performing scientific experiments is astronomy (for summaries see, e.g., Burns et al., 1990; Livio, 2006; Crawford and Zarnecki, 2008; Jester and Falcke, 2009). Almost the entire electromagnetic spectrum is currently being used to study the universe from radio to high-energy gamma ray emission. Different frequencies typically relate to different physical processes, and consequently the universe looks markedly different in optical, infrared, or radio wavelengths. Hence, during the last century modern telescopes have diversified and evolved enormously, fundamentally changing our view of the universe and our place therein. Due to their ever increasing sensitivity, which allows one to peer deeper and deeper into the earliest phases of the cosmos, the requirements for telescope sites have become more and more extreme: one simply needs the best possible observing conditions. The most important factors here are light pollution (at the relevant frequencies) and distortions due to the atmosphere. Light pollution is generally caused by any form of civilization, thereby pushing observatories to more and more remote locations. Detrimental effects of the atmosphere include: • temporary effects such as clouds and water vapour, which temporarily absorb and disturb optical or high-frequency radio radiation, • turbulence in the ionosphere or troposphere, which distorts radio or optical wave fronts, thereby severely degrading the image quality, • air glow, which can overpower sensitive infrared observations, • total absorption of radiation, e.g., of very low-frequency radio, infrared, X-ray, and gamma-ray radiation. The best – and in many cases only – remedy is to observe from dry deserts, high mountains, or from space. Two of the most remote, but also most exquisite, astronomical sites on Earth are the Atacama desert and Antarctica. The former currently hosts some of the world’s largest telescopes, including ESO’s 8m-class Very Large Telescopes (VLT), the ALMA sub-mm-wave radio telescope, and in the future probably also the ~40 m diameter European Extremely Large Telescope (E-ELT; see http:// www.eso.org). A century after its initial exploration, Antarctica now also hosts a number of somewhat smaller telescopes (e.g., the South Pole Telescope, Carlstrom et al., 2011) as well as the giant IceCube detector. IceCube is the world’s largest neutrino observatory, using the ice itself as detector material (e.g., Abbasi et al., 2011). The Moon would be a logical next step in the quest for the most suitable sites to be used for astronomy. An important secondary important factor in selecting a site, however, is the available infrastructure: How accessible is the site for people and material? How does one obtain power and how good is the data connection? Already for Antarctica this poses serious constraints, and it took a long time until this continent became useful for scientific exploitation. It is needless to say that the Moon is even more difficult to reach. Hence, like Antarctica, any significant exploitation of the Moon requires a developed infrastructure – something that would likely become available only in conjunction with human exploration of the Moon. Even then one has to assess how unique and useful the Moon is for astronomy in the first place. After all, the International Space Station (ISS), while having a well-developed infrastructure available, is not used for telescopes; its small, relatively unstable platform in low Earth orbit (LEO) is simply too poor a telescope site to be competitive. Hence, the vast majority of space-based telescopes have been associated with free-flying satellites. Of course, some of these satellites, most notably the Hubble Space Telescope (HST), benefited from the heavy lift capabilities of the Space Shuttle and the servicing possibilities the human space flight program offered (NRC, 2005). Indeed, it is interesting to note that the one human-serviced space telescope, HST, is in fact the most productive of all astronomy space missions even many years after its launch (see Tables 4 and 6 in Trimble and Ceja, 2008; HST produced 1063 papers in the time frame 2001-2003, compared to 724 for Chandra, the next most productive). So, the question to ask is: Which type of telescopes would uniquely benefit from a lunar surface location? This question has been addressed in a couple of workshops and scientific roadmaps in recent years (Falcke et al., 2006; Livio, 2006; NRC, 2007; Crawford and Zarnecki, 2008; Worms et al., 2009). In the following section we try to synthesize these findings. 4.2 Which astronomy? There is a wide consensus that a low-frequency radio telescope (i.e. a radio telescope operating at frequencies below 30-100 MHz) would be the highest priority (e.g., Jester and Falcke, 2009; Burns et al., 2009). Radio waves at these frequencies are seriously distorted by the Earth’s ionosphere and completely absorbed or reflected at frequencies below 10-30 MHz. Hence, the low-frequency universe is the last uncharted part of the electromagnetic spectrum, and a lunar infrastructure would greatly benefit its exploration. Of particular relevance for science here is the investigation of the “dark ages” of the universe. This is the epoch several hundred million years after the big bang, but before the formation of the first stars and black holes, when the cosmos was mainly filled with dark matter and neutral hydrogen. This epoch contains still pristine information of the state of the big bang and can essentially only be observed through radio emission from atomic hydrogen red-shifted to several tens of MHz. The best location to study this treasure trove of cosmology (Loeb and Zaldariaga 2004) would indeed be on the lunar far-side.

#### The moon is key for neutrino research – would be involved in any mission

Wilson 92, T. L. "Neutrino Astronomy of the Moon." Lunar and Planetary Science Conference. Vol. 23. 1992. https://www.lpi.usra.edu/meetings/lpsc1992/pdf/1757.pdf (Thomas L. Wilson, NASA Johnson Space CenterISN1)//Elmer Recut Ethan Yang

The notion of conducting neutrino astronomy on the Moon has had a very brief history [I-91. The case has even been presented [7] that the ultimate future of neutrino astronomy in the 21st Century may be on the Moon. A recent NASA workshop at Stanford University [6] clearly demonstrated that the physics community supports a return to the Moon, provided its justification is a strong scientific initiative directed at taking advantage of the lower background ambient magnetic fields than on Earth and the absence of an appreciable atmosphere. Several significant issues in particle physics, such as searches for proton decay and measurement of the neutron's electric dipole moment, are background-limited on Earth. Similarly, the Earth's stratosphere is a source of considerable noise in neutrino astronomy on Earth [6,9]. The Moon, in contrast, ostensibly may offer a viable advantage in both of these cases if its backgrounds are appreciably lower as they appear to be. The proposal for a neutrino detector at a lunar base, then, represents an important shift in emphasis towards fundamental physics research in space, as a part of NASA's initiative to re-establish a permanent presence on the Moon. Such a detector would bolster not only the science of neutrino astronomy and its role in basic astrophysics as a neutrino telescope, but would also enhance our fundamental understanding of the physics of the Universe. It is conceivable that long-baseline neutrino oscillations experiments could be conducted between Earth-based accelerators [10,6] and a lunar base neutrino detector. The first round of scientific experiment candidates for a lunar outpost, in fact, includes a lunar neutrino telescope [ll] although any such strategy is still under study. In this regard, neutrino and antineutrino spectra as might be seen on the Moon's surface have been published [6,1-31. The critical issue of prompt neutrino production by decay of charmed mesons has been studied [3,S], but the branching ratios have changed due to further refinement of Earth-based accelerator experiments and these analyses may require additional work. The charm production issue is particularly important because it background-limits a lunar observatory. Furthermore, this occurs in the 1 MeV portion of the neutrino spectrum, right where grand unification in particle physics has been predicting proton decay. Another analysis [12] of Earth-based neutrino astronomy has attempted to illustrate the full spectrum as might be observed from the surface of the Earth, including the (presently undetectable) relic neutrinos left over from the Big Bang [13,14]. This spectrum is amended and presented here (Figure 1) to include the antineutrino luminosity of the Moon [6,15] produced by its natural radioactivity. Charm [I51 is not presented, and it may have overriding significance. This view of the neutrino Universe from the surface of the Moon is important in the assessment and scientific justification for such a detector at a lunar base. The Earth has many advantages in neutrino astronomy because grand-scale neutrino detectors are already in use there, such as in the ongoing radiochemical studies [16] of solar neutrinos. The Moon, on the other hand, clearly has advantages illustrated in Figure 1 due to the lack of in situ atmospheric neutrinos [6,9] and the absence of nuclear reactor antineutrino fluxes which are beginning to complicate antineutrino astronomy's access on Earth to portions of supernovae spectra in astrophysics. The recent study of active galactic nuclei (AGN) neutrinos [17, 181 as another interesting astrophysical source are not presented.

#### Neutrino research key to nuclear detection that deters proliferation

Lee 20 Thomas Lee "Can tiny, invisible particles help stop the spread of nuclear weapons?" <https://engineering.berkeley.edu/news/2020/03/can-tiny-invisible-particles-help-stop-the-spread-of-nuclear-weapons/> (Associate Adjunct Professor, Research Scientist Operations & IT Management.)//Elmer Recut Ethan Yang

The key to preventing nuclear proliferation may depend on a little bit of ghost hunting. Scientists have long been interested in a device that can detect neutrinos, ghost-like particles that have no electric charge and nearly no mass — and therefore can pass through matter. Now, researchers are closer than ever to deploying technology that can spot those elusive subatomic particles and, in doing so, alert international authorities to the illicit production of plutonium, a key fuel for nuclear bombs. The technology may provide a “way to monitor the plutonium content in a nuclear reactor in real time that we just don’t have right now,” said Bethany Goldblum (M.S.’05, Ph.D.’07 NE), a top researcher with UC Berkeley’s Department of Nuclear Engineering. Goldblum, the executive director of the Berkeley-based Nuclear Science and Security Consortium, co-wrote a study published this week in the Review of Modern Physics that examines the feasibility of neutrino detectors in nuclear nonproliferation efforts. The study’s co-authors include Adam Bernstein and Nathaniel Bowden from Lawrence Livermore National Laboratory, Patrick Huber from Virginia Tech, Igor Jovanovic from the University of Michigan and John Mattingly from North Carolina State University. The study ultimately concludes that such technology deployed outside nuclear reactors could prove effective in ensuring that countries are not making weapons-related material under the guise of peaceful civilian energy production. The report also advances the idea that researchers could one day use the technology to discover or exclude the presence of reactors at distances of a few hundred kilometers. “Over several decades, physicists have conceived many ideas for using ﬁssion neutrinos in nuclear security,” the study says. “Some ideas remain in the realm of pen and paper, constrained by basic physical and practical considerations. For other concepts, demonstrated technology is catching up with real opportunities.” The ghost particle Neutrinos are the most abundant particles in the universe, having been formed by large nuclear explosions like the Big Bang, supernovas and the fusion process that happens inside the sun. They travel near the speed of light, have little mass and carry no electric charge. Because of these attributes, neutrinos can pass through matter and are incredibly difficult to detect, which is why scientists often refer to them as “ghost particles.” For example, if 10 trillion neutrinos struck the Earth, all but one would pass through the planet without having interacted with anything at all. In 1956, Clyde Cowen and Frederick Reins, two scientists at the Los Alamos National Laboratory in New Mexico, confirmed the neutrino’s existence, work that eventually earned the Nobel Prize in Physics. The duo placed two large water tanks near a nuclear reactor, which produces electron antineutrinos in huge quantities, as part of the fission process. As it turns out, neutrinos can collide with protons in the water and produce a neutron and a positron through a process called inverse beta decay. When the positron moves through the water, it produces a flash of light that special sensors can detect. Up to this point, scientists were primarily interested in finding neutrinos because the particles might offer clues to the universe’s origin and the formation of stars and galaxies. But starting around the turn of the 21st century, the idea that neutrino detectors could be used in nuclear nonproliferation efforts started to gain real traction. In 2000, Adam Bernstein, then a postdoctoral fellow at the Sandia National Laboratory in Livermore, California, wrote a paper exploring the idea of using detectors filled with purified water to spot neutrinos produced from nuclear explosions. In many ways, water is a great medium to detect neutrinos because it is easy to purify, cheap and is transparent to light produced by neutrinos colliding with water molecules. The key would be to build detectors big enough to hold enough water to see the neutrino signal above background radiation. However, finding neutrinos in water is still pretty hard. Bernstein found that adding small amounts of gadolinium — a rare earth metal with unusual nuclear properties — to the water could significantly boost the detector’s chances of spotting neutrinos. In gadolinium-doped water, neutrino interactions produce a much stronger signal than neutrinos in water alone. Bernstein eventually abandoned the idea to monitor explosions because the cost and size of such neutrino detectors would make the technology impractical, especially compared to existing, cheaper technologies like seismic detectors, he said. Instead, Bernstein turned his attention to using the gadolinium-doped technology to catch neutrinos from nuclear reactors. “Since we’re still mostly using water, it is possible to build large detectors, up to 100 kilotons in size or more, to spot these reactor neutrinos,” said Bernstein, now a staff physicist at the Lawrence Livermore National Laboratory (LLNL) and director of the lab’s Rare Event Detection group in the Nuclear and Chemical Sciences division. “The neutrino signature would stand out much more readily above background radiation even in a big detector,” he said. LLNL is the lead laboratory for a proposed United States/United Kingdom experiment, called WATCHMAN, to demonstrate remote monitoring of nuclear reactors using a kiloton-scale antineutrino detector. This experiment has already “exceeded my expectations,” Bernstein said. “The idea that the nonproliferation community might one day be able to use this technology that until now has been the exclusive province of fundamental science is an exciting motivation for this work.” Halting the spread of nukes Since 1970, nearly 200 nations signed the landmark Treaty of the Non-Proliferation of Nuclear Weapons (NPT), which seeks to limit the spread of nuclear weapons. Through a combination of remote monitoring and on–the–ground inspections, containment and surveillance, the International Atomic Energy Agency (IAEA) commands plenty of tools to figure out if countries are using nuclear energy for peaceful purposes, Goldblum said. But what happens if the line between civilian and military use of nuclear energy is not so clear? For example, the United States has long accused Iran of trying to make nuclear weapons, but Iran says it wants to develop nuclear capabilities for civilian power generation. The knowledge to construct a nuclear bomb is actually pretty well known. The hard part is getting enough materials — either enriched uranium or plutonium — to fuel the weapon. A country can reprocess the spent fuel from a civilian nuclear reactor and extract plutonium for a weapon. And a nuclear bomb only requires about 10 kilograms of plutonium. The so-called “dual-use” capabilities of nuclear reactors presents a significant challenge to the IAEA. “None of the countries now embarking on civil nuclear power programs say they are planning to acquire reprocessing capabilities,” according to a 2017 report by the Brookings Institute think tank. “But many of them are unwilling to forswear what they consider to be their ‘right’ eventually to have dual-use capabilities.” The neutrino detection technology could offer a solution. In addition to the large systems like WATCHMAN, scientists have constructed much smaller detectors that can be deployed close to reactor cores — provided operators allow such access. Optimizing reactor power levels to produce plutonium, a telltale sign that a country is trying to build a bomb, will change the rate and energy spectrum of antineutrinos that a device parked outside of the reactor can detect. And since these particles can pass through matter, the operator can’t shield the reactor’s release of antineutrinos the same way lead blocks X-rays. So if a country wants to operate a civilian nuclear power program, an antineutrino detector could provide an effective tool to continuously verify the reactor is only producing energy for peaceful purposes. For now, a detector must stay within tens of meters of the reactor to be effective. But in the future, could such technology spot antineutrinos from longer distances and even across borders? For distances 100 kilometers or beyond, the Review of Modern Physics study shows detectors would need to be 10 to 100 times bigger than WATCHMAN. But researchers hope WATCHMAN will demonstrate the basic technology and provide a platform for study of a range of possible enhancements to improve standoff and overall sensitivity. And in any case, the mere knowledge that such technology has become a reality could prove to be a powerful deterrent to nuclear proliferation in itself.

#### Proliferation causes nuclear war

Kroenig 15(Matthew Kroenig; Associate Professor and International Relations Field Chair in the Department of Government and School of Foreign Service at Georgetown University; 2015, “The History of Proliferation Optimism: Does It Have a Future?”; *Journal of Strategic Studies*, Volume 38, Issue 1-2)//Re-cut by Elmer

The spread of nuclear weapons poses at least six severe threats to international peace and security including: nuclear war, nuclear terrorism, global and regional instability, constrained US freedom of action, weakened alliances, and further nuclear proliferation. Each of these threats has received extensive treatment elsewhere and this review is not intended to replicate or even necessarily to improve upon these previous efforts. Rather the goals of this section are more modest: to usefully bring together and recap the many reasons why we should be pessimistic about the likely consequences of nuclear proliferation. Many of these threats will be illuminated with a discussion of a case of much contemporary concern: Iran’s advanced nuclear program. Nuclear War The greatest threat posed by the spread of nuclear weapons is nuclear war. The more states in possession of nuclear weapons, the greater the probability that somewhere, someday, there will be a catastrophic nuclear war. To date, nuclear weapons have only been used in warfare once. In 1945, the United States used nuclear weapons on Hiroshima and Nagasaki, bringing World War II to a close. Many analysts point to the 65-plus-year tradition of nuclear non-use as evidence that nuclear weapons are unusable, but it would be naïve to think that nuclear weapons will never be used again simply because they have not been used for some time. After all, analysts in the 1990s argued that worldwide economic downturns like the Great Depression were a thing of the past, only to be surprised by the dot-com bubble bursting later in the decade and the Great Recession of the late 2000s.48 This author, for one, would be surprised if nuclear weapons are not used again sometime in his lifetime. Before reaching a state of MAD, new nuclear states go through a transition period in which they lack a secure-second strike capability. In this context, one or both states might believe that it has an incentive to use nuclear weapons first. For example, if Iran acquires nuclear weapons, neither Iran, nor its nuclear-armed rival, Israel, will have a secure, second-strike capability. Even though it is believed to have a large arsenal, given its small size and lack of strategic depth, Israel might not be confident that it could absorb a nuclear strike and respond with a devastating counterstrike. Similarly, Iran might eventually be able to build a large and survivable nuclear arsenal, but, when it first crosses the nuclear threshold, Tehran will have a small and vulnerable nuclear force. In these pre-MAD situations, there are at least three ways that nuclear war could occur. First, the state with the nuclear advantage might believe it has a splendid first strike capability. In a crisis, Israel might, therefore, decide to launch a preventive nuclear strike to disarm Iran’s nuclear capabilities. Indeed, this incentive might be further increased by Israel’s aggressive strategic culture that emphasizes preemptive action. Second, the state with a small and vulnerable nuclear arsenal, in this case Iran, might feel use them or lose them pressures. That is, in a crisis, Iran might decide to strike first rather than risk having its entire nuclear arsenal destroyed. Third, as Thomas Schelling has argued, nuclear war could result due to the reciprocal fear of surprise attack.49 If there are advantages to striking first, one state might start a nuclear war in the belief that war is inevitable and that it would be better to go first than to go second. Fortunately, there is no historic evidence of this dynamic occurring in a nuclear context, but it is still possible. In an Israeli–Iranian crisis, for example, Israel and Iran might both prefer to avoid a nuclear war, but decide to strike first rather than suffer a devastating first attack from an opponent. Even in a world of MAD, however, when both sides have secure, second-strike capabilities, there is still a risk of nuclear war. Rational deterrence theory assumes nuclear-armed states are governed by rational leaders who would not intentionally launch a suicidal nuclear war. This assumption appears to have applied to past and current nuclear powers, but there is no guarantee that it will continue to hold in the future. Iran’s theocratic government, despite its inflammatory rhetoric, has followed a fairly pragmatic foreign policy since 1979, but it contains leaders who hold millenarian religious worldviews and could one day ascend to power. We cannot rule out the possibility that, as nuclear weapons continue to spread, some leader somewhere will choose to launch a nuclear war, knowing full well that it could result in self-destruction. One does not need to resort to irrationality, however, to imagine nuclear war under MAD. Nuclear weapons may deter leaders from intentionally launching full-scale wars, but they do not mean the end of international politics. As was discussed above, nuclear-armed states still have conflicts of interest and leaders still seek to coerce nuclear-armed adversaries. Leaders might, therefore, choose to launch a limited nuclear war.50 This strategy might be especially attractive to states in a position of conventional inferiority that might have an incentive to escalate a crisis quickly to the nuclear level. During the Cold War, the United States planned to use nuclear weapons first to stop a Soviet invasion of Western Europe given NATO’s conventional inferiority.51 As Russia’s conventional power has deteriorated since the end of the Cold War, Moscow has come to rely more heavily on nuclear weapons in its military doctrine. Indeed, Russian strategy calls for the use of nuclear weapons early in a conflict (something that most Western strategists would consider to be escalatory) as a way to de-escalate a crisis. Similarly, Pakistan’s military plans for nuclear use in the event of an invasion from conventionally stronger India. And finally, Chinese generals openly talk about the possibility of nuclear use against a US superpower in a possible East Asia contingency. Second, as was also discussed above, leaders can make a ‘threat that leaves something to chance’.52 They can initiate a nuclear crisis. By playing these risky games of nuclear brinkmanship, states can increase the risk of nuclear war in an attempt to force a less resolved adversary to back down. Historical crises have not resulted in nuclear war, but many of them, including the 1962 Cuban Missile Crisis, have come close. And scholars have documented historical incidents when accidents nearly led to war.53 When we think about future nuclear crisis dyads, such as Iran and Israel, with fewer sources of stability than existed during the Cold War, we can see that there is a real risk that a future crisis could result in a devastating nuclear exchange. Nuclear Terrorism The spread of nuclear weapons also increases the risk of nuclear terrorism.54 While September 11th was one of the greatest tragedies in American history, it would have been much worse had Osama Bin Laden possessed nuclear weapons. Bin Laden declared it a ‘religious duty’ for Al- Qa’eda to acquire nuclear weapons and radical clerics have issued fatwas declaring it permissible to use nuclear weapons in Jihad against the West.55 Unlike states, which can be more easily deterred, there is little doubt that if terrorists acquired nuclear weapons, they would use them.56 Indeed, in recent years, many US politicians and security analysts have argued that nuclear terrorism poses the greatest threat to US national security.57 Analysts have pointed out the tremendous hurdles that terrorists would have to overcome in order to acquire nuclear weapons.58 Nevertheless, as nuclear weapons spread, the possibility that they will eventually fall into terrorist hands increases. States could intentionally transfer nuclear weapons, or the fissile material required to build them, to terrorist groups. There are good reasons why a state might be reluctant to transfer nuclear weapons to terrorists, but, as nuclear weapons spread, the probability that a leader might someday purposely arm a terrorist group increases. Some fear, for example, that Iran, with its close ties to Hamas and Hizballah, might be at a heightened risk of transferring nuclear weapons to terrorists. Moreover, even if no state would ever intentionally transfer nuclear capabilities to terrorists, a new nuclear state, with underdeveloped security procedures, might be vulnerable to theft, allowing terrorist groups or corrupt or ideologically-motivated insiders to transfer dangerous material to terrorists. There is evidence, for example, that representatives from Pakistan’s atomic energy establishment met with Al-Qa’eda members to discuss a possible nuclear deal.59 Finally, a nuclear-armed state could collapse, resulting in a breakdown of law and order and a loose nukes problem. US officials are currently very concerned about what would happen to Pakistan’s nuclear weapons if the government were to fall. As nuclear weapons spread, this problem is only further amplified. Iran is a country with a history of revolutions and a government with a tenuous hold on power. The regime change that Washington has long dreamed about in Tehran could actually become a nightmare if a nuclear-armed Iran suffered a breakdown in authority, forcing us to worry about the fate of Iran’s nuclear arsenal. Regional Instability The spread of nuclear weapons also emboldens nuclear powers, contributing to regional instability. States that lack nuclear weapons need to fear direct military attack from other states, but states with nuclear weapons can be confident that they can deter an intentional military attack, giving them an incentive to be more aggressive in the conduct of their foreign policy. In this way, nuclear weapons provide a shield under which states can feel free to engage in lower-level aggression. Indeed, international relations theories about the ‘stability-instability paradox’ maintain that stability at the nuclear level contributes to conventional instability.60 Historically, we have seen that the spread of nuclear weapons has emboldened their possessors and contributed to regional instability. Recent scholarly analyses have demonstrated that, after controlling for other relevant factors, nuclear-weapon states are more likely to engage in conflict than nonnuclear-weapon states and that this aggressiveness is more pronounced in new nuclear states that have less experience with nuclear diplomacy.61 Similarly, research on internal decision-making in Pakistan reveals that Pakistani foreign policymakers may have been emboldened by the acquisition of nuclear weapons, which encouraged them to initiate militarized disputes against India.62 Currently, Iran restrains its foreign policy because it fears major military retaliation from the United States or Israel, but with nuclear weapons it could feel free to push harder. A nuclear-armed Iran would likely step up support to terrorist and proxy groups and engage in more aggressive coercive diplomacy. With a nuclear-armed Iran increasingly throwing its weight around in the region, we could witness an even more crisis prone Middle East. And in a poly-nuclear Middle East with Israel, Iran, and, in the future, possibly other states, armed with nuclear weapons, any one of those crises could result in a catastrophic nuclear exchange.

#### No limited nuclear wars – extinction.

Webber 19 – Dr Philip Webber has written widely on nuclear issues and is Chair of Scientists for Global Responsibility (SGR) – a membership organisation promoting responsible science and technology. We will all end up killing each other and one nuclear blast could do it. 5/18/19. [METRO.UK “We will all end up killing each other and one nuclear blast could do it,” <https://metro.co.uk/2019/05/18/we-will-all-end-up-killing-each-other-and-one-nuclear-blast-could-do-it-9370115/>] Recut Justin

The nuclear armed nations have inadvertently created a global Doomsday machine, built with 15,000 nuclear weapons.

Most (93%) have been built by Russia and in the US, 3,100 of them are ready to fire within hours.

Pre-programmed targets include main cities as well as a range of military and civilian targets across the world primarily in the UK, Europe, US, Russia and China but also in Japan, Australia and South America.

One nuclear blast, one mistake, one cyber attack could trigger it.

But first a reminder about the incredible destructive power of a nuclear weapon. Modern nuclear warheads are typically 20 times larger than either of the two bombs that obliterated Hiroshima and Nagasaki at the end of the Second World War. What just one nuclear warhead can do is unimaginable. We’ve drawn some of the key features to scale against cityscapes in the UK for a Russian SS-18 RS 20V (NATO designation ‘Satan’) 500kT warhead. US submarines deploy a similar weapon – the Trident II Mk5, 475kT warhead. A deafening, terrifying noise will be created, like an intense thunder that lasts for 10 seconds or longer.

After a blinding flash of light bright destroying the retina of anyone looking, and a violent electromagnetic pulse (EMP) knocking out electrical equipment several miles away, a bomb of this size quickly forms an incandescent fireball 850 metres across.

This is about the same height as the world’s tallest building, the Burj Khalifa. Drawn against the London Canary Wharf financial district or the Manchester skyline, the huge fireball dwarfs one Canary Sq. (240m), the South Tower Deansgate (201m) and the Beetham Tower Hilton, (170m). The fireball engulfs both city centres completely, melting glass and steel and forms an intensely radioactive 60m deep crater zone of molten earth and debris. A devastating supersonic blast wave flattens everything within a radius of two to three km, the entire Manchester centre, an area larger than the City of London, with lighter damage out to eight km. Most people in these areas would be killed or very seriously injured.

The fireball quickly rises forming an enormous characteristic mushroom shaped cloud raining highly radioactive particles (fallout). It rises to 60,000 ft (18,000m) – twice the altitude of Everest – and is 15 miles, 24km across.

This is one warhead. There are 10 such warheads on each of Russia’s 46 missiles (460 in total) and 48 on each of eight US Trident submarines (384 in total). In reality, in a nuclear conflict all of these warheads and a further 956 ready-to-fire are likely to be launched.

Whilst this scale of destruction is horrific and hundreds of millions of people would be killed in a few hours from a combination of blast, radiation and huge fires, there are also terrible longer-term effects.

Scientists predict that huge city-wide firestorms combined with very the high-altitude debris clouds would severely reduce sunlight levels and disrupt the world’s climate for a decade causing drought, a prolonged winter, global famine and catastrophic impacts for all life on earth and in the seas due to intense levels of UV with the destruction of the ozone layer.

But even at the level of a few hundred nuclear warheads, the consequences of a nuclear war would be extremely severe across the world far beyond the areas hit directly. A nuclear conflict between India and Pakistan with ‘only’ 100 small warheads would kill hundreds of millions and cause climate damage leading to a global famine. The sheer destructive nature of nuclear explosions combined with long lasting radiation, means that nuclear weapons are of no military use. ‘Enemy’ territory would be unusable for years because of intense radiation – especially when nuclear power stations and reprocessing plants are hit.

Even if your own country is not hit, radiation and climate damage will spread across the globe. No one escapes the consequences.

But the nuclear nations argue that they build and keep nuclear weapons to make sure that they are never used. After all no one would be stupid enough to actually launch a nuclear weapon facing such terrible retaliation? It sounds obvious. If you threaten any attacker with terrible nuclear devastation of course they won’t attack you. That might be true most of the time. It is very unlikely that any country would launch a nuclear attack deliberately. But there are two very major problems. First, a terrorist organisation with a nuclear weapon cannot be deterred in this way. Secondly, there are several ways in which a nuclear war can start by mistake. A report by the prestigious Chatham House in 2014 documents 30 instances between 1962 and 2002 when nuclear weapons came within minutes of being launched due to miscalculation, miscommunication, or technical errors. What prevented their use on many of these occasions was the intervention of individuals who, against military orders, either refused to authorise a nuclear strike or relay information that would have led to launch. Examples include a weather rocket launch mistaken for an attack on Russia, a US satellite misinterpreting sunlight reflecting off clouds as multiple missiles firings, a 42c chip fault creating a false warning of 220 missiles launched at the United States. Such risks are heightened during political crises.

The risk of mistake is very high because, in a hangover from the Cold War, the USA and Russia each keep 900 warheads ready to fire in a few minutes, in a ‘launch on warning’ status, should a warning of nuclear attack come in.

These nuclear weapons form a dangerous nuclear stand-off – rather like two people holding guns to each other’s heads.

With only a few minutes to evaluate a warning of nuclear attack before warheads would strike, one mistake can trigger disaster. A similar nuclear stand-off exists between India and Pakistan.

## 1AC – Framing

#### The standard is maximizing expected well-being – to clarify, saving lives.

#### 1] Death outweighs— A] You don’t have any wellbeing if we’re all dead B] Reversibility - Someone who died can’t come alive again C] Objectivity- body count is the most objective way to calculate impacts

#### 2] Consequentialism is true

Sinnott-Armstrong 3 [Walter Sinnott-Armstrong is Chauncey Stillman Professor of Practical Ethics in the Department of Philosophy and the Kenan Institute for Ethics at Duke University., Consequentialism (Stanford Encyclopedia of Philosophy), 5-20-2003, Accessible Online at https://plato.stanford.edu/entries/consequentialism/] SW 8-26-2017

Even if consequentialists can accommodate or explain away common moral intuitions, that might seem only to answer objections without yet giving any positive reason to accept consequentialism. However, most people begin with the presumption that we morally ought to make the world better when we can. The question then is only whether any moral constraints or moral options need to be added to the basic consequentialist factor in moral reasoning. (Kagan 1989, 1998) If no objection reveals any need for anything beyond consequences, then consequences alone seem to determine what is morally right or wrong, just as consequentialists claim. This line of reasoning will not convince opponents who remain unsatisfied by consequentialist responses to objections. Moreover, even if consequentialists do respond adequately to every proposed objection, that would not show that consequentialism is correct or even defensible. It might face new problems that nobody has yet recognized. Even if every possible objection is refuted, we might have no reason to reject consequentialism but still no reason to accept it. In case a positive reason is needed, consequentialists present a wide variety of arguments. One common move attacks opponents. If the only plausible options in moral theory lie on a certain list (say, Kantianism, contractarianism, virtue theory, pluralistic intuitionism, and consequentialism), then consequentialists can argue for their own theory by criticizing the others. This disjunctive syllogism or process of elimination will be only as strong as the set of objections to the alternatives, and the argument fails if even one competitor survives. Moreover, the argument assumes that the original list is complete. It is hard to see how that assumption could be justified. Consequentialism also might be supported by an inference to the best explanation of our moral intuitions. This argument might surprise those who think of consequentialism as counterintuitive, but in fact consequentialists can explain many moral intuitions that trouble deontological theories. Moderate deontologists, for example, often judge that it is morally wrong to kill one person to save five but not morally wrong to kill one person to save a million. They never specify the line between what is morally wrong and what is not morally wrong, and it is hard to imagine any non-arbitrary way for deontologists to justify a cutoff point. In contrast, consequentialists can simply say that the line belongs wherever the benefits outweigh the costs (including any bad side effects). Similarly, when two promises conflict, it often seems clear which one we should keep, and that intuition can often be explained by the amount of harm that would be caused by breaking each promise. In contrast, deontologists are hard pressed to explain which promise is overriding if the reason to keep each promise is simply that it was made (Sinnott-Armstrong 2009). If consequentialists can better explain more common moral intuitions, then consequentialism might have more explanatory coherence overall, despite being counterintuitive in some cases. (Compare Sidgwick 1907, Book IV, Chap. III; and Sverdlik 2011.) And even if act consequentialists cannot argue in this way, it still might work for rule consequentialists (such as Hooker 2000). Consequentialists also might be supported by deductive arguments from abstract moral intuitions. Sidgwick (1907, Book III, Chap. XIII) seemed to think that the principle of utility follows from very general principles of rationality and universalizability.Other consequentialists are more skeptical about moral intuitions, so they seek foundations outside morality, either in non-normative facts or in non-moral norms. Mill (1861) is infamous for his “proof” of the principle of utility from empirical observations about what we desire (cf. Sayre-McCord 2001). In contrast, Hare (1963, 1981) tries to derive his version of utilitarianism from substantively neutral accounts of morality, of moral language, and of rationality. Yet another argument for a kind of consequentialism is contractarian. Harsanyi (1977, 1978) argues that all informed, rational people whose impartiality is ensured because they do not know their place in society would favor a kind of consequentialism. Broome (1991) elaborates and extends Harsanyi's argument. Other forms of arguments have also been invoked on behalf of consequentialism (e.g. Cummiskey 1996, P. Singer 1993; Sinnott-Armstrong 1992). However, each of these arguments has also been subjected to criticisms. Even if none of these arguments proves consequentialism, there still might be no adequate reason to deny consequentialism. We might have no reason either to deny consequentialism or to assert it. Consequentialism could then remain a live option even if it is not proven.

#### 3] Only consequentialism explains degrees of wrongness—if I break a promise to meet up for lunch, that is not as bad as breaking a promise to take a dying person to the hospital. Only the consequences of breaking the promise explain why the second one is much worse than the first which is the most intuitive.

#### 4] Extinction outweighs

Pummer 15 [Theron, Junior Research Fellow in Philosophy at St. Anne's College, University of Oxford. “Moral Agreement on Saving the World” Practical Ethics, University of Oxford. May 18, 2015] AT

There appears to be lot of disagreement in moral philosophy. Whether these many apparent disagreements are deep and irresolvable, I believe there is at least one thing it is reasonable to agree on right now, whatever general moral view we adopt: that it is very important to reduce the risk that all intelligent beings on this planet are eliminated by an enormous catastrophe, such as a nuclear war. How we might in fact try to reduce such existential risks is discussed elsewhere. My claim here is only that we – whether we’re consequentialists, deontologists, or virtue ethicists – should all agree that we should try to save the world. According to consequentialism, we should maximize the good, where this is taken to be the goodness, from an impartial perspective, of outcomes. Clearly one thing that makes an outcome good is that the people in it are doing well. There is little disagreement here. If the happiness or well-being of possible future people is just as important as that of people who already exist, and if they would have good lives, it is not hard to see how reducing existential risk is easily the most important thing in the whole world. This is for the familiar reason that there are so many people who could exist in the future – there are trillions upon trillions… upon trillions. There are so many possible future people that reducing existential risk is arguably the most important thing in the world, even if the well-being of these possible people were given only 0.001% as much weight as that of existing people. Even on a wholly person-affecting view – according to which there’s nothing (apart from effects on existing people) to be said in favor of creating happy people – the case for reducing existential risk is very strong. As noted in this seminal paper, this case is strengthened by the fact that there’s a good chance that many existing people will, with the aid of life-extension technology, live very long and very high quality lives. You might think what I have just argued applies to consequentialists only. There is a tendency to assume that, if an argument appeals to consequentialist considerations (the goodness of outcomes), it is irrelevant to non-consequentialists. But that is a huge mistake. Non-consequentialism is the view that there’s more that determines rightness than the goodness of consequences or outcomes; it is not the view that the latter don’t matter. Even John Rawls wrote, “All ethical doctrines worth our attention take consequences into account in judging rightness. One which did not would simply be irrational, crazy.” Minimally plausible versions of deontology and virtue ethics must be concerned in part with promoting the good, from an impartial point of view. They’d thus imply very strong reasons to reduce existential risk, at least when this doesn’t significantly involve doing harm to others or damaging one’s character. What’s even more surprising, perhaps, is that even if our own good (or that of those near and dear to us) has much greater weight than goodness from the impartial “point of view of the universe,” indeed even if the latter is entirely morally irrelevant, we may nonetheless have very strong reasons to reduce existential risk. Even egoism, the view that each agent should maximize her own good, might imply strong reasons to reduce existential risk. It will depend, among other things, on what one’s own good consists in. If well-being consisted in pleasure only, it is somewhat harder to argue that egoism would imply strong reasons to reduce existential risk – perhaps we could argue that one would maximize her expected hedonic well-being by funding life extension technology or by having herself cryogenically frozen at the time of her bodily death as well as giving money to reduce existential risk (so that there is a world for her to live in!). I am not sure, however, how strong the reasons to do this would be. But views which imply that, if I don’t care about other people, I have no or very little reason to help them are not even minimally plausible views (in addition to hedonistic egoism, I here have in mind views that imply that one has no reason to perform an act unless one actually desires to do that act). To be minimally plausible, egoism will need to be paired with a more sophisticated account of well-being. To see this, it is enough to consider, as Plato did, the possibility of a ring of invisibility – suppose that, while wearing it, Ayn could derive some pleasure by helping the poor, but instead could derive just a bit more by severely harming them. Hedonistic egoism would absurdly imply she should do the latter. To avoid this implication, egoists would need to build something like the meaningfulness of a life into well-being, in some robust way, where this would to a significant extent be a function of other-regarding concerns (see chapter 12 of this classic intro to ethics). But once these elements are included, we can (roughly, as above) argue that this sort of egoism will imply strong reasons to reduce existential risk. Add to all of this Samuel Scheffler’s recent intriguing arguments (quick podcast version available here) that most of what makes our lives go well would be undermined if there were no future generations of intelligent persons. On his view, my life would contain vastly less well-being if (say) a year after my death the world came to an end. So obviously if Scheffler were right I’d have very strong reason to reduce existential risk. We should also take into account moral uncertainty. What is it reasonable for one to do, when one is uncertain not (only) about the empirical facts, but also about the moral facts? I’ve just argued that there’s agreement among minimally plausible ethical views that we have strong reason to reduce existential risk – not only consequentialists, but also deontologists, virtue ethicists, and sophisticated egoists should agree. But even those (hedonistic egoists) who disagree should have a significant level of confidence that they are mistaken, and that one of the above views is correct. Even if they were 90% sure that their view is the correct one (and 10% sure that one of these other ones is correct), they would have pretty strong reason, from the standpoint of moral uncertainty, to reduce existential risk. Perhaps most disturbingly still, even if we are only 1% sure that the well-being of possible future people matters, it is at least arguable that, from the standpoint of moral uncertainty, reducing existential risk is the most important thing in the world. Again, this is largely for the reason that there are so many people who could exist in the future – there are trillions upon trillions… upon trillions. (For more on this and other related issues, see this excellent dissertation). Of course, it is uncertain whether these untold trillions would, in general, have good lives. It’s possible they’ll be miserable. It is enough for my claim that there is moral agreement in the relevant sense if, at least given certain empirical claims about what future lives would most likely be like, all minimally plausible moral views would converge on the conclusion that we should try to save the world. While there are some non-crazy views that place significantly greater moral weight on avoiding suffering than on promoting happiness, for reasons others have offered (and for independent reasons I won’t get into here unless requested to), they nonetheless seem to be fairly implausible views. And even if things did not go well for our ancestors, I am optimistic that they will overall go fantastically well for our descendants, if we allow them to. I suspect that most of us alive today – at least those of us not suffering from extreme illness or poverty – have lives that are well worth living, and that things will continue to improve. Derek Parfit, whose work has emphasized future generations as well as agreement in ethics, described our situation clearly and accurately: “We live during the hinge of history. Given the scientific and technological discoveries of the last two centuries, the world has never changed as fast. We shall soon have even greater powers to transform, not only our surroundings, but ourselves and our successors. If we act wisely in the next few centuries, humanity will survive its most dangerous and decisive period. Our descendants could, if necessary, go elsewhere, spreading through this galaxy…. Our descendants might, I believe, make the further future very good. But that good future may also depend in part on us. If our selfish recklessness ends human history, we would be acting very wrongly.” (From chapter 36 of On What Matters)

#### Additionally - if we’re unsure about which interpretation of the world is true, we should preserve the world to keep debating about it

## 1AC – Underview

#### Public funding is the basis of most innovation – private companies have no impact

Aronoff 18

(KATE ARONOFF is a staff writer at The New Republic and author of Overheated: How Capitalism Broke the Planet — And How We Fight Back. <https://inthesetimes.com/article/elon-musk-spacex-tesla-falcon-heavy-launch> , 2-8)

(KATE ARONOFF is a staff writer at The New Republic and author of Overheated: How Capitalism Broke the Planet — And How We Fight Back. <https://inthesetimes.com/article/elon-musk-spacex-tesla-falcon-heavy-launch> , 2-8)

Scientific American gawked, ​“Elon Musk Does It Again,” praising the ​“bold technological innovations and newfound operational efficiencies that allow SpaceX to not only build its rockets for less money, but also reuse them.” That view — shared by several other outlets — fits comfortably with the Tony Stark-like image Musk has crafted for himself over the years: a quirky and slightly off-kilter playboy genius inventor capable of conquering everything from outer space to the climate crisis with the sheer force of his imagination. One of Musk’s long-term goals is to create a self-sustaining colony on Mars, and make humanity an interplanetary species. He hopes to shoot two very wealthy people around the moon at some point this year. Musk has invested an awful lot of public money into making those dreams a reality. But why should Americans keep footing the bill for projects where only Musk and his wealthy friends can reap the rewards? Enter: the case for nationalizing Elon Musk, and making the U.S. government a major stakeholder in his companies. The common logic now holds that the private sector — and prodigies like Musk, in particular — are better at coming up with world-changing ideas than the public sector, which is allegedly bloated and allergic to new, outside-the-box thinking. Corporations’ hunt for profits and lack of bureaucratic constraints, it’s said, compel cutting-edge research and development in a way that the government is simply incapable of. With any hope, more of these billionaires’ breakthroughs than not will be in the public interest. The reality, as economist Mariana Mazzucato argues in her 2013 book The Entrepreneurial State: Debunking Public vs. Private Sector Myths, is very different. Many of the companies that are today considered to be headed by brilliant savants — people like Steve Jobs and, yes, Elon Musk — owe much of their success to decades of public sector innovation, through repackaging technologies developed over the course of several decades into new products. Take the iPhone, essentially a collection of Defense Department research and National Science Foundation-grant projects packed into one shiny machine. “The prospect of the State owning a stake in a private corporation may be anathema to many parts of the capitalist world,” Mazzucato writes, ​“but given that governments are already investing in the private sector, they may as well earn a return on those investments.” As she notes, Musk’s future-oriented empire — Tesla Motors, SolarCity and SpaceX — has benefitted from around $5 billion in local, state and federal government support, not to mention many years of foundational public research into programs like rocket technology. SpaceX itself exists largely for the sake of competing for government contracts, like its $5.5 billion partnership with NASA and the U.S. Air Force. The U.S. Department of Energy invested directly in that company, as well as in Tesla’s work on battery technology and solar panels. The latter is perhaps the biggest success story of the Department of Energy stimulus grant that also supported Solyndra, a solar energy company reliably held up by the Right as an example of the government’s failure to make wise investment decisions. ​“Taxpayers footed the bill for Solyndra’s losses — yet got hardly any of Tesla’s profits,” Mazzucato notes. As Mazzucato finds, the private sector hasn’t done much to earn its reputation as a risk-taker. Corporations and venture capitalists often adopt conservative thinking and fall into ​“path dependency,” and are generally reluctant to invest in important early-stage research that won’t necessarily turn a profit in the short-run. This kind of research is inherently risky, and the vast majority of this kind of protean R&D (research and development) fails. For every internet — birthed in the Defense Department — there are a well over a dozen Solyndras, but it’s virtually impossible to have one without the other. The problem runs deeper still. Whereas in the past public sector research has been able to attract top-tier talent, the myth that the private sector can do what the State can’t has created a negative feedback loop whereby bright young scientists and engineers flock toward a private sector that goes on to further its reputation for being the place where the real innovation is happening. The alternative Mazzucato suggests is to socialize risk and reward alike, rather than simply allowing companies that enjoy the benefits of public innovation to funnel their profits into things like stock buybacks and tax havens — or, for that matter, flamethrowers. When companies like SpaceX make it big, they’d be obligated to return some portion of their gains to the public infrastructure that helped them succeed, expanding the government’s capacity to facilitate more innovative development. All this is not to say that there isn’t a critical role to play for people like Jobs and Musk in bringing new technology to the market. In all likelihood, Tesla’s Powerwall and SolarCity panels will play a key role in our transition off of fossil fuels. But lionizing Musk as the sole creator of the Powerwall and this week’s space launch stands to perpetuate a dangerous series of myths about who’s responsible for such cutting-edge development. Through smart supply-and-demand-side policy, states can play a crucial role in shaping and creating markets for the technologies we’ll need to navigate the 21st century. This can happen not just through R&D but also through developments like fuel efficiency standards, which encourage carmakers to prioritize vehicles that run off of renewable energy. Given the mounting reality of climate change and the necessity to rapidly switch over to a clean energy economy, there’s also a bigger question about how actively the state should be encouraging certain kinds of research and manufacturing. During World War II, the United States essentially had a planned economy: By 1945, around a quarter of manufacturing in the country was under state control. The reason for that was simple — the U.S. government saw an existential threat, and directed some of its biggest corporations to pitch in to stop it or else risk getting taken over by the state. There’s some Cold War nostalgia to hoisting shiny objects into orbit — a telegenic show of America’s technological supremacy. But it may not be much solace to coastal residents forced to flee in the coming decades, whose homes are rendered unlivable by a mixture of extreme weather and crumbling, antiquated infrastructure. And if you’ve watched any number of big-budget sci-fi productions over the last several years, it’s not hard to imagine Musk’s Martian colony spinning off into some Elysium-style eco-apartheid, where the rich — for the right price — can escape to new worlds while the rest of us make do on a planet of dystopian slums, swamps and deserts. Today, the risk posed by climate change is greater still than that posed by fascism on the eve of World War II, threatening to bring about a planet that’s uninhabitable for humans, and plenty hostile to them in the meantime. In such a context, do we need to launch cars into space? Maybe not. If the public sector is going to continue footing the bill for Elon Musk’s fantasies, though, he should at least have to give back some credit, and a cut of the profits.

#### No China war

Nye 21 – Joseph S. Nye, Jr. is a professor at Harvard University and author of Do Morals Matter? Presidents and Foreign Policy from FDR to Trump, March 2nd ("What Could Cause a US-China War?", Project Syndicate, Available online at https://www.project-syndicate.org/commentary/what-could-cause-us-china-war-by-joseph-s-nye-2021-03, Accessed 3-3-2021)

CAMBRIDGE – When China’s foreign minister, Wang Yi, recently called for a reset of bilateral relations with the United States, a White House spokesperson replied that the US saw the relationship as one of strong competition that required a position of strength. It is clear that President Joe Biden’s administration is not simply reversing Trump’s policies. Some analysts, citing Thucydides’ attribution of the Peloponnesian War to Sparta’s fear of a rising Athens, believe the US-China relationship is entering a period of conflict pitting an established hegemon against an increasingly powerful challenger. I am not that pessimistic. In my view, economic and ecological interdependence reduces the probability of a real cold war, much less a hot one, because both countries have an incentive to cooperate in a number of areas. At the same time, miscalculation is always possible, and some see the danger of “sleepwalking” into catastrophe, as happened with World War I. History is replete with cases of misperception about changing power balances. For example, when President Richard Nixon visited China in 1972, he wanted to balance what he saw as a growing Soviet threat to a declining America. But what Nixon interpreted as decline was really the return to normal of America’s artificially high share of global output after World War II. Nixon proclaimed multipolarity, but what followed was the end of the Soviet Union and America’s unipolar moment two decades later. Today, some Chinese analysts underestimate America’s resilience and predict Chinese dominance, but this, too, could turn out to be a dangerous miscalculation. It is equally dangerous for Americans to over- or underestimate Chinese power, and the US contains groups with economic and political incentives to do both. Measured in dollars, China’s economy is about two-thirds the size of the US economy, but many economists expect China to surpass the US sometime in the 2030s, depending on what one assumes about Chinese and American growth rates. Will American leaders acknowledge this change in a way that permits a constructive relationship, or will they succumb to fear? Will Chinese leaders take more risks, or will Chinese and Americans learn to cooperate in producing global public goods under a changing distribution of power? Recall that Thucydides attributed the war that ripped apart the ancient Greek world to two causes: the rise of a new power, and the fear that this created in the established power. The second cause is as important as the first. The US and China must avoid exaggerated fears that could create a new cold or hot war. Even if China surpasses the US to become the world’s largest economy, national income is not the only measure of geopolitical power. China ranks well behind the US in soft power, and US military expenditure is nearly four times that of China. While Chinese military capabilities have been increasing in recent years, analysts who look carefully at the military balance conclude that China will not, say, be able to exclude the US from the Western Pacific.2 On the other hand, the US was once the world’s largest trading economy and its largest bilateral lender. Today, nearly 100 countries count China as their largest trading partner, compared to 57 for the US. China plans to lend more than $1 trillion for infrastructure projects with its Belt and Road Initiative over the next decade, while the US has cut back aid. China will gain economic power from the sheer size of its market as well as its overseas investments and development assistance. China’s overall power relative to the US is likely to increase.1 Nonetheless, balances of power are hard to judge. The US will retain some long-term power advantages that contrast with areas of Chinese vulnerability. One is geography. The US is surrounded by oceans and neighbors that are likely to remain friendly. China has borders with 14 countries, and territorial disputes with India, Japan, and Vietnam set limits on its hard and soft power. Energy is another area where America has an advantage. A decade ago, the US was dependent on imported energy, but the shale revolution transformed North America from an energy importer to exporter. At the same time, China became more dependent on energy imports from the Middle East, which it must transport along sea routes that highlight its problematic relations with India. The US also has demographic advantages. It is the only major developed country that is projected to hold its global ranking (third) in terms of population. While the rate of US population growth has slowed in recent years, it will not turn negative, as in Russia, Europe, and Japan. China, meanwhile, rightly fears “growing old before it grows rich.” India will soon overtake it as the most populous country, and its labor force peaked in 2015. America also remains at the forefront in key technologies (bio, nano, information) that are central to twenty-first-century economic growth. China is investing heavily in research and development, and competes well in some fields. But 15 of the world’s top 20 research universities are in the US; none is in China. Those who proclaim Pax Sinica and American decline fail to take account of the full range of power resources. American hubris is always a danger, but so is exaggerated fear, which can lead to overreaction. Equally dangerous is rising Chinese nationalism, which, combined with a belief in American decline, leads China to take greater risks. Both sides must beware miscalculation. After all, more often than not, the greatest risk we face is our own capacity for error.