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### 1AC - Advantage

#### Space tourism is a burgeoning market --- 2021 was just the beginning

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This year saw more space tourists fly to space on a bunch of different systems, and the story has only just begun. Virgin Galactic, Blue Origin and SpaceX each flew their first tourist-focused missions this year, sending aloft several people each with minimal training in professional spaceflight. Meanwhile, Roscosmos (the Russian federal space agency) brought two sets of space tourists into space, including a mission with Space Adventures. With 2022 also set to be busy, between more tourist flights and the expected addition of company Axiom Space (using a SpaceX Crew Dragon), we rounded up some of the main milestones of 2021 below. The four members of the Axiom Space Ax-1 crew: Michael Lopez-Alegria, former NASA astronaut, Axiom Space vice president and Ax-1 commander; Larry Connor, U.S. real estate entrepreneur and Ax-1 pilot; Mark Pathy, Canadian investor and philanthropist; and Eytan Stibbe, Israeli businessman and fighter pilot. (Image credit: collectSPACE.com) Axiom Space revealed its clients Jan. 26 for its first privately-funded and operated mission to the International Space Station (ISS). Called Axiom Mission 1 (Ax-1), the flight is arranged under a commercial agreement with NASA. Slated to launch on a SpaceX Dragon spacecraft are Larry Connor, an American real estate and technology entrepreneur; Eytan Stibbe, a businessman and former Israeli fighter pilot; Mark Pathy, a Canadian investor and philanthropist; and Michael Lopez-Alegria, a retired NASA astronaut with nearly 260 days in space already across four missions. In June, SpaceX and Axiom announced an agreement to fly three more missions to the orbiting complex after Ax-1. NASA officially cleared the Ax-1 crew for flight on Dec. 20. 2) Starship launches test flight and sticks the landing After several attempts on previous test landing that didn't make it safely to landing, SpaceX's Starship SN-15 prototype launched its own test flight May 5 and made it all the way from takeoff to touchdown. The uncrewed test flight coincidentally fell on the 60th anniversary of the United States' first-ever crewed spaceflight, which saw NASA astronaut Alan Shepard make it to suborbital space. SpaceX has said it hopes to use Starship to branch out in the solar system, especially for crewed Mars missions. 3) Virgin Galactic launches Richard Branson On July 11, Virgin Galactic launched its first operational tourist flight, featuring founder Richard Branson. It was "the experience of a lifetime," Branson said during a live broadcast of the flight. The four-person crew and two pilots of the Unity 22 test flight mission took off from the company's Spaceport America facility in New Mexico and flew just above the boundary of space, where everyone experienced about four minutes of weightlessness. Future flights of Virgin Galactic, though, have been delayed due to a Federal Aviation Administration investigation into a reported incident that happened during the spaceflight. That said, Virgin has opened up tickets again to paying spaceflyers, now at $450,000 apiece. 4) Blue Origin launches Jeff Bezos to space Days after the Virgin flight, Blue Origin launched its first crewed spaceflight on July 20, featuring founder Jeff Bezos and a set of other three space tourists, including Mercury 13 aviator Wally Funk. Since the system flies autonomously, no pilots were required to be on board (although Funk is highly qualified as an aviator) as the New Shepard system lifted off from Blue Origin's Launch Site One near the West Texas town of Van Horn. While Bezos and Branson denied their companies were in competition, the broadcast of Bezos' flight made several cutting remarks about the company flying above the Kármán line, an internationally recognized boundary of spaceflight that Virgin Galactic flights don't reach. Bezos also said in an interview in July that Blue Origin is not focused on competition, but building a "road to space." The company has adopted that catchphrase as a tagline and repeats it frequently during live broadcasts. 5) SpaceX stacks tallest booster ever with Starship SpaceX's first orbital Starship SN20 is stacked atop its massive Super Heavy Booster 4 for the first time on Aug. 6, 2021 at the company's Starbase facility near Boca Chica Village in South Texas. They stood 395 feet tall, taller than NASA's Saturn V moon rocket. (Image credit: SpaceX) SpaceX's newest Starship prototype (SN-20) perched on its massive Super Heavy booster for the first time on Friday (Aug. 6), briefly setting a new record for the world's tallest rocket during preparations for an orbital mission. The hour-long fit check brought the stack to 395 feet tall (120 m), taller than NASA's massive Saturn V moon rocket, which was 363 feet tall (110 m). Super Heavy alone stands 230 feet (70 meters) tall and Starship SN4 includes another 165 feet (50 m) of height. The next major milestone for Starship is the orbital launch that may take place in 2022, pending an environmental review by the Federal Aviation Administration and related government groups. SpaceX founder Elon Musk has pushed back launch estimates several times due to the review. 6) Inspiration4 launches 4 civilians on first orbital mission Billionaire Jared Isaacman's privately chartered spaceflight launched on Sept. 15, 2021 aboard a SpaceX Crew Dragon spacecraft, flying high in Earth orbit on a nearly three-day mission. Inspiration4 was the first crewed orbital mission with no professional astronauts on board (as the Virgin Galactic and Blue Origin flights preceding it were all suborbital missions.) Isaacman, a pilot, commanded the flight and was accompanied by physician assistant Hayley Arceneaux, data engineer Chris Sembroski, and geoscientist and science communication specialist Sian Proctor. Sembroski and Proctor won their seats in contests to support St. Jude Children's Research Hospital in Memphis, while Arceneaux is employed at that hospital. Resilience and its crew circled Earth for three days, splashing down off the Florida coast on Sept. 18. The mission exceeded its fundraising goal for St. Jude. 7) Blue Origin launches William Shatner A "Star Trek" star boldly went into suborbital space Oct. 13 on Blue Origin's second crewed space mission, called NS-18. William Shatner, 90, is best known for playing Captain James T. Kirk on "Star Trek: The Original Series." "That was unlike anything they described," Shatner was heard saying via a radio link as the capsule parachuted back to Earth, after carrying him and three other crew members to suborbital space. Shatner is now the oldest person to have ever flown to space, beating the record set by Wally Funk, 82, who flew on Blue Origin's first crewed flight July 20. Crew member Glen de Vries died in a plane crash weeks after the flight and Blue Origin dedicated their next crewed mission in December to him. 8) Russian film crew shoots drama on ISS Russian actress Yulia Peresild (center), director Klim Shipenko (second from right) and cosmonaut Oleg Novitskiy (right) bid farewell to their Russian crewmates Anton Shkaplerov (second from left) and Pyotr Dubrov before returning to Earth on Oct. 17, 2021. (Image credit: Roscosmos/Anton Shkaplerov via Twitter) Just days after Shatner's ride to space, a Russian film crew including actress Yulia Peresild and producer Klim Shipenko landed with cosmonaut Oleg Novitskiy of the Russian federal space corporation Roscosmos on Oct. 17. "Вызов" ("Challenge" in English) is the movie in production. It follows the fictional story of a surgeon (Peresild) who is launched to the station to perform emergency surgery on a cosmonaut (Novitskiy, who would play the role well given he is a cosmonaut in real life.) The effort is a joint production of Roscosmos, the Russian television station Channel One and the studio Yellow, Black and White. Given the small crew on hand in space, Shipenko took on several behind-the-scenes roles, including director, make-up artist, sound editor and cinematographer. 9) Blue Origin launches 'Good Morning America' host to space Blue Origin's next (and likely last) crewed flight of 2021 filled out all six seats in the New Shepard spacecraft during a successful launch and landing Dec. 11. The starring guest was Michael Strahan, host of "Good Morning America", who is a retired football player. (The crew threw mini-footballs in space to celebrate his past career.) Strahan said the experience was amazing. "I want to go back," he told Blue Origin founder Jeff Bezos after returning to Earth. "Touchdown has a new meaning now!!!" he wrote on Twitter after the flight. Also on the flight was Laura Shepard Churchley, 74, the daughter of NASA astronaut Shepard after whom the New Shepard system is named, and four other individuals who paid for their seats. Blue Origin has not yet released per-seat pricing for customers, and we are also awaiting details on their next planned crew launch. 10) Japanese billionaire Yusaku Maezawa flies to ISS A Russian Soyuz spacecraft carrying Japanese billionaire Yusaku Maezawa, video producer Yozo Hirano and cosmonaut Alexander Misurkin launched on Dec. 8 to the International Space Station for a 12-day mission to the orbiting lab. Maezawa is also planning to fly around the moon on a SpaceX mission that he paid for, tentatively slotted for 2023, but chose to visit the space station as well on a mission brokered by the U.S. space tourism company Space Adventures with Russia's Roscosmos space agency. It was not revealed how much Maezawa paid for the flight, but single seats in the past have cost up to $35 million. And Maezawa bought two seats, one for himself and for Hirano, who recorded videos of Maezawa in space. Maezawa, the CEO of Start Today and the founder of online clothing retailer ZOZO, bought the seats for himself and Hirano. Hirano documented the mission and participate in some health and performance research. They also made the first Uber Eats delivery in space on the flight. The trio returned to Earth on Dec. 19. And that's a wrap at the biggest space tourism moments in 2021. The year 2022 is expected to bring more milestones as the company Axiom Space plans to launch its first fully private crew to the International Space Station early in the year, with SpaceX, Blue Origin and Virgin Galactic all expected to continue their private spaceflight pace.

#### Industry is projected to grow to over 1,000 launches per year

Rosenblum 13 [Andrew Rosenblum is a guest contributor to MIT Technology Review who reports on drones, artificial intelligence, security, and commercial space travel for Popular Science, Wired, Fortune, and other publications. “Space Tourism’s Black Carbon Problem.” May 16, 2013. https://www.popsci.com/science/article/2013-05/space-tourism-experiment-geo-engineering/]

Here’s where space tourism comes into play: The number of space launches annually around the world numbers around 70 today, but that figure could rise drastically, as private companies jockey to turn space tourism into routine adventure travel. The aerospace research firm Futron forecasts that by 2021 the space tourism market will consist of 13,000 potential customers, with possible revenues of roughly $650 million per year. Assuming the business is successful, commercial space travel might very well reach 1,000 launches per year some time in the next decade – XCOR alone plans to ramp up to four launches per day, as part of its “Southwest airlines” model. That creates 1,000 opportunities to shoot black carbon directly into the stratosphere. The amount of black carbon emitted during combustion on Earth, or in the trophosphere, where airlines fly, tends to be low, because of the relatively rich supply of oxygen. Once you get into the stratosphere, where low pressure leads to less oxygen, black carbon can amount to as much as 5% of the products of combustion. The Federal Aviation Administration (F.A.A.), the organization responsible for assessing environmental impacts and deciding whether to grant licenses to launch vehicles into space, says the effects of black carbon in the stratosphere are unclear. “Although black carbon is known to be a short-term climate forcer, research on the potential climate change impacts of black carbon from rockets is in a very early stage, and any projections of impacts are speculative,” writes George Nield, the F.A.A.’s associate administrator for commercial space transportation, in an email. The space-tourism industry has downplayed black carbon’s potential harm. Virgin Galactic declined repeated inquiries to comment. Andrew Nelson, the chief operating officer of XCOR Aerospace, which is currently selling $95,000 tickets for sub-orbital flights, says that the blend of kerosene and liquid oxygen in his XR-5K18 rocket engine powering its Lynx suborbital spaceplane will emit much less in the way of “aromatic” hydrocarbons than traditional kerosene-based rocket fuel. And he says the XR-5K18 will burn much more cleanly than the solid rocket boosters used in the Space Shuttle or “hybrid” rocket engines, which burn both solid and liquid propellant. “XCOR will have di minimus impact on our environment,” Nelson says. “Our fuels are almost completely free of particulate matter. [They have ] 20-40 times less aromatics than traditional rocket fuels, and hundreds, if not thousands of times less particulate matter than hybrids or solids. So the concern about carbon or other particles is moot for us.” Toohey still wants to see peer-reviewed studies of the actual interaction of XCOR and other engines with the stratosphere. “I have not seen any publications that confirm (or refute) the claims of particle-free emissions from combustion of any fuel in the upper atmosphere,” Toohey says. “So I think it is fair to say that we need studies to benchmark the emissions of all rocket types in order to be able to assess their impacts.”

#### Scenario 1 is ozone.

#### The Montreal Protocol worked --- the ozone hole is healing slowly, but new destruction pushes it past the brink

Stone 18 [Maddie Stone is a science journalist. “Our Best Evidence Yet That Humans Are Fixing the Ozone Hole.” January 5, 2018. https://gizmodo.com/our-best-evidence-yet-that-humans-are-fixing-the-ozone-1821808429]

The ozone hole feels like the quintessential ‘80s problem, but unlike car phones and mullets, it remains relevant in a number of ways. For starters, it’s still there, chilling over Antartica. More importantly, it’s slowly healing, and a new study offers some of the best evidence yet that sound environmental policy is responsible. It’s been nearly 30 years since the world adopted the Montreal Protocol, a landmark treaty banning the use of ozone-destroying chlorofluorocarbons (CFCs). But despite a firm scientific understanding of the link between CFCs and ozone depletion, it’s been tough to tell how much of a success the protocol was, because the ozone hole didn’t start showing signs of recovery until a few years back. Moreover, nobody had actually measured the chemistry of the hole to see if ozone-destroying compounds are declining as we’d expect due to the Montreal Protocol. A study published this week in Geophysical Research Letters addresses that knowledge gap. The authors, from NASA’s Goddard Spaceflight Center, made use of data collected by NASA’s Aura satellite, which measures a suite of trace atmospheric gases to understand changes to the ozone layer, Earth’s climate, and air pollution. “It kind of surprised me that no one had done this,” lead study author Susan Strahan told Earther. “The data is there if you’re careful about what data to use.” Strahan and her colleague Anne Douglass looked at changing ozone levels above Antarctica throughout the austral winter from 2005 to 2016, and found that ozone depletion had declined by about 20 percent. Then, they looked at levels of hydrochloric acid in the stratosphere at the end of winter, an indicator of how much ozone had been destroyed by CFCs. Sure enough, chlorine levels declined as well, at a rate of about 0.8 percent per year. That’s in line with model expectations of how much CFC levels should have declined over the same time period thanks to the Montreal Protocol’s ban. “This reaffirms our scientific understanding of what’s controlling ozone,” she said. Bill Randall, an atmospheric scientist at the University Corporation for Atmospheric Research who was not involved with the study, told Earther he thought the paper’s analysis was “very well done.” “They’re seeing net decreases in chlorine that are very consistent with the Montreal Protocol,” he said. “That’s a big take home message, that the Montreal Protocol is doing what we think it should be doing.”

#### Space tourism destroys the ozone --- 2 internal links:

#### First, black carbon buildups, soot, and particle emissions --- destroys ozone

LiveScience 10 [Live Science Staff. “New Climate Change Worry: Space Tourism Soot.” October 22, 2010. https://www.livescience.com/10202-climate-change-worry-space-tourism-soot.html]

Humans’ attempts to visit space may not be good for the folks back home, according to a new study that finds soot emitted by space tourism rockets could significantly contribute to global climate change in coming decades. The researchers assumed that a fast-growing suborbital space tourism market will develop over the next decade, and they examined the climate impact of soot and carbon dioxide emissions from 1,000 suborbital rocket flights per year, the approximate number advertised in recent materials promoting space tourism. "Rockets are the only direct source of human-produced compounds above about 14 miles (22.5 kilometers), and so it is important to understand how their exhaust affects the atmosphere," said the study's chief researcher, Martin Ross of The Aerospace Corp. in El Segundo, Calif. He and his colleagues describe their findings in a scientific paper that has been accepted for publication in Geophysical Research Letters. A layer of soot According to the study, soot particles emitted by the proposed fleet of space tourism rockets would accumulate at about 25 miles (40 km) altitude, three times higher than the altitude of airline traffic. Unlike soot from jets or coal power plants, which is injected lower in the atmosphere and falls to earth within weeks, the particles created by rockets remain in the atmosphere for years, efficiently absorbing sunlight that would otherwise reach the Earth's surface. The result is a global pattern of change, according to researcher Michael Mills of the National Center for Atmospheric Research (NCAR) in Boulder, Colo. "The response of the climate system to a relatively small input of black carbon is surprising," Mills said in a statement. "Our results show particular climate system sensitivity to the type of particles that rockets emit." Using a computer model of the Earth's atmosphere, the researchers discovered that beneath the predicted layer of soot, the Earth's surface would cool by as much as 1.2 degrees Fahrenheit (0.7 degrees Celsius). Antarctica would warm by 1.5 degrees F (0.8 degrees C). Meanwhile, equatorial regions could lose about 1 percent of their ozone, while the poles could gain 10 percent. The global effect would be an increase in the amount of solar energy absorbed by the Earth's atmosphere. That means the soot from the rockets contributes to atmospheric heating at a rate higher than the carbon dioxide from those same rockets. An earlier study by Ross, published in March 2009 in the journal Astrophysics, found that rocket emissions are particularly harmful to the ozone because they're injected directly into the stratosphere where the ozone layer resides. Considering black carbon The researchers based their predictions on business plans for suborbital space travel in the year 2020, Ross said. The current global fleet of hydrocarbon-fueled orbital rockets emits about one-tenth of the soot assumed in the study. "Climate impact assessments of suborbital and orbital rockets must consider black carbon emissions, or else they ignore the most significant part of the total climate impact from rockets," Ross said. "This includes existing assessments that may need to be brought up to date."

#### Second, water vapor and rocket emissions

Larson 16 (Erik J L Larson (PhD in Atmospheric and Oceanic Studies, Postdoctoral fellow in Organismic and Evolutionary Biology at Harvard, Research Scientists at University of Colorado Boulder), Robert W Portmann (Researchesr from Chemical Sciences Division at NOAA), Karen H Rosenlof (NOAA research scientist), David W. Fahey (Directo of the Chemical Science Division at NOAA), John S Daniel (Chemical Sciences Division NOAA), and Martin N Ross (The Aerospace Corporation). “Global atmospheric response to emissions from a proposed reusable space launch system” Earth’s Future. Volume 5. Issue 1. November 16, 2016. Accessed August 12, 2019.)

1 Introduction

The expected availability of low cost, reusable launch systems and increasing demand for space services suggest that the global space transport industry will grow significantly in the coming decades. Relatively few studies of the chemical and climate effects of rocket emissions have been published that use current state‐of‐the‐art atmospheric models to address the future growth scenarios. Rocket emissions are becoming more like aviation emissions in that the space sector exhibits consistent growth that cannot be reduced without serious economic disruption. Unlike the aviation sector, the most significant method of managing emissions is through prudent use of the various available propellants. Hydrogen (H2) fuel and reusability are likely to play important roles in any future scheme to minimize the atmospheric impacts of rockets; therefore, it is important to understand the consequences of H2 fuel and reentry emissions. Significant increases in space transport will be associated with proportional increases in combustion emissions. Some of the proposed propulsion systems make greater use of “clean‐burning” H2 fuel [Li et al., 2004; Khan et al., 2013], which has H2O as the primary emission and thus avoids the effects of chlorine, alumina, and black carbon emissions associated with current conventional technology [Ross et al., 2009, 2010]. H2 burning rocket engines may also reduce payload‐to‐space costs, which could dramatically increase the number of rocket launches.

Reaction Engines Ltd. (http://www.reactionengines.co.uk/) has proposed the Skylon vehicle, which is a reusable H2‐burning rocket [Martin et al., 2008]. Skylon would be considered a medium lift launch vehicle in the current space transport vernacular. There is a concept plan to use this vehicle to build a space‐based solar power system. To be economically viable, the plan calls for a minimum of 104 launches per year for 10 years [Martin et al., 2008; Henson, 2014]. This rate would transport enough payload to space to build 3000 1‐GW solar power stations as estimated by the National Security Space Office [SBSP Study Group, 2007] and Reaction Engines [Martin et al., 2008].

It is often assumed that H2‐fueled rocket engines have no impact on the global atmosphere since the only significant emission is H2O. However, in great enough quantities the emissions from these rockets can alter the stratosphere in many ways. H2O emissions can change stratospheric temperatures and alter the photochemistry controlling ozone (O3). Furthermore, rockets burning liquid H2 and oxygen (O2) use an H2‐rich mixture rather than a stoichiometric ratio for enhanced thrust and emit H2 and HOX in the plume in addition to H2O. Enhancements in HOX can catalytically destroy O3 [Crutzen, 1969]. Superheated air in the engine and exhaust plume result in the production of NOx, which also catalytically destroys O3 [Johnston, 1971; Ross et al., 2009; Lee et al., 2010]. NOx is also created in the mesosphere due to the heat produced during rocket reentry [Park, 1976]. Here we use the Whole Atmosphere Community Climate Model (WACCM) [Marsh et al., 2013] and the 2D National Oceanic and Atmospheric Administration/National Center for Atmospheric Research (NOCAR) model [Portmann and Solomon, 2007] to evaluate the potential effects of high Skylon launch rates on the climate and stratospheric O3.

2 Calculating Emissions

Vertical profiles of NOX, H2, and H2O emitted during a Skylon rocket launch and reentry are estimated based on trajectory data from Reaction Engines Ltd. [http://www.reactionengines.co.uk/tech\_docs.html]. Skylon rockets have two combustion phases as they ascend through the atmosphere. The first phase is air breathing from the surface to 28.5 km. During this phase the engines act as H2 burning jet turbines, combusting H2 with ambient air. The main exhaust is H2O, which can be calculated directly from the amount of H2 fuel consumed. During the second phase from 28 to 80 km the engines run in rocket mode, burning H2 and liquid O2. The H2O produced in rocket mode is calculated from the mass of fuel used assuming a 6:1 mass ratio of oxygen to hydrogen; this assumption is made to be consistent with the fact that many rockets burn hydrogen‐rich fuel for greater thrust (stoichiometric ratio for combustion is 8:1) [Colasurdo et al., 1998]. Although the excess H2 likely oxidizes into H2O in the plume due to high temperatures, H2 emissions are also considered in our simulations as a bounding condition. The bounding cases assume either all or none of the excess H2 is oxidized to H2O in the plume. As discussed in the results, the intermediate combustion products HOX and H2O2 were tested with the NOCAR model and found not to be important contributors to O3 destruction. Thus they are not included in WACCM simulations.

H2 and H2O emission profiles (kg/km/flight) are interpolated with 1‐km vertical resolution (Figure 1a). The spike in emissions at 28 km is due to the spacecraft transition into rocket mode. The total amount of H2O produced from a single flight is estimated to be 6 × 105 kg (assuming completely oxidized H2) with about 4 × 105 kg emitted into the stratosphere (above 17 km). The projected 105 flights per year would deposit 4 × 1010 kg of H2O in the stratosphere every year. To get a sense of how large a perturbation this represents, the yearly emissions are compared to the total amount of stratospheric water. Assuming a uniform mixing ratio of 4.5 parts per million by volume (ppmv) of H2O above 100 hPa (17 km), there is 1.5 × 1012 kg of H2O in the stratosphere. The projected 105 flights would emit approximately 3% of the current stratospheric H2O burden every year. Assuming a constant flight frequency and a 3‐year lifetime of the H2O, when emitted above 100 hPa, this would increase globally averaged stratospheric H2O by approximately 9%. The actual steady‐state perturbation of H2O due to these emissions in WACCM above 100 hPa is 10%; however, the local perturbation would be much larger and increase with height.

Estimating a NOX emission profile for the Skylon vehicle is problematic. Several flight phases must be considered: H2 burned with air as a jet fuel, H2 burned with liquid oxygen as a rocket fuel, and heating of air due to aerodynamic interactions. It is important to note that we consider the shock heating of air during reentry as an emission. When air is heated to temperatures exceeding 1800 K, as in a jet engine or behind the shock wave around a spacecraft during reentry, NOX is produced through the extended Zeldovich mechanism [Zeldovich et al., 1947]. This mechanism is exponentially dependent on temperature so that representative temperatures are required in order to calculate the thermally produced NOX. Detailed estimates of the NOX emissions have not yet been calculated by the rocket designers [R. Varvill, 2015, personal communication]. For this study, reliable estimates of NOX emissions from jet and rocket engines are scaled to the Skylon vehicle with the caveat that our estimates have high uncertainty. Lee et al. [2010], using the International Civil Aviation Organization (ICAO) emissions databank, estimated that 14 ± 3 g of NOX are produced for every kilogram of fuel combusted in jet engines. Emissions may be lower at supersonic speeds and are also a function of the temperature difference between high pressure (∼100 atmospheres) liquid H2 and jet fuel. Most of the engines in the ICAO databank use jet fuel with a 2:1 H:C ratio. The higher fuel density must be taken into consideration in the NOX estimates from H2 combustion. For complete combustion in the jet engine air‐burning phase, two hydrogen and one carbon atoms (14 g/mol) react with three oxygen atoms. For a pure H2 fuel at complete combustion, three oxygen atoms will oxidize six hydrogen atoms (6 g/mol). Thus, from a stoichiometric perspective, burning 1 kg of jet fuel requires as much air as 6/14 kg of H2 fuel. Thus 6/14 kg of H2 fuel is assumed here to produce 14 g (11–17) of NOX during the air‐burning phase. Alternatively, using the heat of combustion per fuel mass to scale the NOX production gives consistent results that are within the uncertainty range. The total production of NOX during the air‐burning Skylon ascent is estimated to be 1400 ± 300 kg, although we acknowledge this range does not encompass all the uncertainties in the assumptions.

Zero NOX emission is assumed during the liquid oxygen burning phase of ascent. NOX would only be produced in H2‐fueled rocket engines in significant amounts (>0.01% of total flow) in afterburning reactions, which occur when ambient air is entrained into the hot underoxidized plume [Brady et al., 1997]. Afterburning is generally not a significant factor for rocket engines above the tropopause. Therefore it is assumed that during this phase of flight, at altitudes greater than 28 km, significant NOX production is unlikely.

Finally, NOX is also produced in the shock wave during spacecraft reentry. Using analytic approximations and a numerical integration, Park [1976] calculated that the NOX produced during a Space Shuttle reentry is 4.5–9% of the mass of the spacecraft. Park and Rakich [1980] later updated this value to 17.5 ± 5.3% of the spacecraft mass, with a peak emission at 68 km. While the predicted Skylon mass is comparable to the Space Shuttle mass, the Skylon reentry flight path is different from that of the Shuttle, and this would affect NOX production. Skylon is expected to require more time above 5 km/s during reentry than the Shuttle did, which would tend to produce more NOX. However, these high speeds would occur at a higher altitude than for the Space Shuttle, which would tend to decrease NOX production [Park, 1976]. Given the compensating factors, and in the absence of actual flight data, Skylon is assumed to have the same vertical profile of reentry NOX emission as the Space Shuttle, with the total values scaled by vehicle mass. The estimated total amount of NOX produced during reentry is therefore 9880 ± 2760 kg per flight. This range does not encompass the uncertainty in all the assumptions made, and thus the stated value of NOX production is considered only representative. The estimated altitude profiles of NOX emissions from the ascent and reentry phases are shown in Figure 1b.

Park [1976] compared NOX formation between the Space Shuttle and meteorites based on the total mass entering the top of the atmosphere. Assuming the natural formation rate of upper atmospheric NOX is from 5.7 × 107 kg of meteorites producing their weight in NOX every year [Park, 1976], then 105 Skylon flight reentries would produce a factor of 20 more NOX than natural production from meteorites. Meteorites produce roughly 5× more NOX per mass than the Space Shuttle due to their much higher velocity when entering the atmosphere.

3 Model Descriptions

Table 1 summarizes the simulations that are run and includes the rocket emissions considered in each case. The Community Earth System Model (CESM v1.0.6) using the WACCM model [Marsh et al., 2013] is used to simulate these emissions. WACCM was chosen because the model domain extends higher than most climate models (140 km) and it can include interactive chemistry. Simulations are run with fixed sea surface temperatures and perpetual year 2000 anthropogenic emissions and CO2 concentrations at 1.9 × 2.5° resolution with 66 vertical levels using a hybrid sigma coordinate system. Cases with different emissions and flight frequency are compared to a zero‐emission control case. Vertical emission profiles of H2O, H2, and NOX are included into two model horizontal grid cells spanning the equator. An equatorial launch is assumed because the energy required to put a rocket into orbit increases with launch latitude. Sensitivity tests are also run with the NOCAR model as these tests would be computationally expensive using WACCM. The NOCAR model is used to evaluate the sensitivity of our results to launch location, chlorine and greenhouse gas concentrations, emissions products, and number of launches per year. Including emissions into global model grid cells effectively dilutes the concentration of emissions compared to an actual rocket plume. The size of the equatorial grid cells is roughly 200 × 250 km2, which is about 1000 times larger in area than a rocket plume. The concentrations used in the model are thus 1000 times less than exist in the initial rocket plumes. Another assumption is that the emissions fill the grid cell before any chemical changes take place. Studies such as Lohn et al. [1999] and Ross et al. [1997] have looked into O3 depletion and other atmospheric effects inside rocket plumes. Lohn et al. [1999] found that solid rocket motor exhaust plumes from Titan class rockets destroy all of the O3 in the wake of the rocket. These predictions were verified by in situ plume measurements [Ross et al., 1997]. The ozone‐depleted regions are several square kilometers in size and last about an hour before dissipating to background concentrations. It is expected that plume chemistry will affect the composition and abundance of the rocket emissions that exist at the grid scale after the plume disperses. However, for the Skylon emissions, the amount of excess H2 emitted during rocket mode that is oxidized in the plume versus the amount present at the grid scale is unknown. Thus, the limiting cases are explored, one in which all the excess H2 is immediately oxidized (simulation 4) and one in which it all persists to the grid scale (simulation 5). The sensitivity of two of our assumptions are tested with the NOCAR model; specifically that H2O and H2 are the only relevant HOY species emitted, and secondly, that year 2000 greenhouse gas and chlorine levels are appropriate choices for this study. Some hydrogen will be emitted as HOY species, although it is likely to be very small. Swain et al. [1990] measured H2O2 in hydrogen burning engine exhaust and found it to be undetectable under normal operating conditions and up to 1000 ppmv under extremely inefficient conditions when the fuel to air ratio was around 5. Despite this, we simulate some of the hydrogen emitted as HOX or H2O2 using the NOCAR model. Note that due to the family chemistry scheme in NOCAR, we cannot emit OH directly, but instead emitted an equivalent quantity as HOX, which should produce the same amount of ozone destruction. The H2O2 can be emitted directly because it is long lived. Table 2 displays the global mean total column ozone changes relative to simulation 7 (Table 1) with and without these emissions. Including these emissions, even at relatively high amounts (1% mole fraction), results in essentially no change in O3 loss. The global mean total column ozone loss in these simulations is within 0.05 Dobson Units (DU) of the base case (simulation 7). Thus, these species (OH and H2O2) are not important to include in the WACCM simulations. The WACCM simulations assume year 2000 conditions; however, we note that flights of the Skylon space plane, especially at rates assumed in this paper, are decades away at best. Future levels of greenhouse gases and chlorine are estimated to be much higher and lower, respectively, than in the year 2000 [IPCC, 2013]. Thus, we also test the sensitivity of ozone loss on greenhouse gas and chlorine levels with the NOCAR model. These results are shown in Table 3. Using year 2100 chlorine levels increases the global total column ozone loss by 6% compared to simulation 7. Under a lower chlorine concentration, NOX increases destroy more ozone due to reduced formation of chlorine nitrate. However, water vapor increases induce less ozone destruction from polar stratospheric cloud (PSC) increases due to decreased chlorine. The net effect is increased ozone losses from rocket emissions. Increasing greenhouse gas levels to year 2100 offsets some of this extra loss and the sign of the final change depends on the relative amounts of the three greenhouse gases in the scenario. CO2 increases cause the rocket‐induced change to increase, while CH4 and N2O increases cause it to decrease. However, the changes are relatively small in all cases using the NOCAR model and we consider our WACCM simulations using year 2000 values as representative of any time between now and year 2100.

4 Stratospheric Ozone and Temperature Perturbations

Our base case scenario for 105 flights per year is simulation 7 in Table 1, which includes NOX, H2, and H2O emissions. The components of the emissions are modeled separately in simulations 1–6 to better understand the changes to O3. Plots of the O3 change due to the individual emission components can be found in the supplement. Preliminary WACCM simulations using a different emissions profile than Figure 1 and 104 flights per year did not produce any statistically significant global changes to the atmosphere. At 105 flights per year, as seen in simulation 7, stratospheric NOX concentrations increase by 0.3–3 parts per billion (ppb) and stratospheric H2O increases by 0–3 ppm. At this and higher flight frequencies significant changes occur in the stratosphere as shown in Figure 2.

At 105 flights per year O3 decreases significantly at all latitudes at altitudes above about 25 km and above 20 km at the poles as seen in simulation 7 (Figure 2a). The overlaid hatching (Figure 2a) indicates statistical significance from two different tests. As seen in Table 1, this depletion in O3 is predominantly due to catalytic destruction by NOX [Crutzen, 1970]. Our simulations with just NOX emissions (simulation 1) had almost the same amount of ozone destruction as the simulation with NOX, H2O, and H2 (simulation 7), and much more than simulations without NOX (simulations 4 and 5). Both sources of NOX, air‐breathing ascent and reentry, contribute to the destruction of O3 as seen in simulations 2 and 3. However, the models disagree about the relative contribution from these two emission sources. The NOCAR model attributes more O3 loss than WACCM does to NOX created in the mesosphere during reentry (simulation 2). In addition, including H2 emissions may further reduce total O3 compared to H2O emissions alone in WACCM simulations. Note that including H2 emissions does not exacerbate O3 loss in the NOCAR runs; in fact O3 loss is lessened between simulations 4 and 5. Moreover, assuming H2O emissions alone seems to lead to an increase in O3 in WACCM; however these results are within the range of internal variability.

#### Rocket launches sufficient to destroy the ozone

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In recent years, governments, intergovernmental organizations, and businesses have begun to focus on the challenge posed by orbital debris. As often seems to be the case, we appear to be a decade or two too slow in coming to consensus on the risks. If we had foreseen a half-century ago the challenges that orbital debris presents today, what would we have done differently? Combustion emissions from launch vehicles present the space industry with a comparable concern that we can begin to address now, before it grows and becomes a potential impediment to space access. Most human-generated pollution is concentrated on or near the surface of the Earth, whether on land, sea, or in the troposphere, the lowest layer of the atmosphere. However, rockets emit a variety of gases and particles directly into all levels of the stratosphere, the only industrial activity to do so. The stratosphere extends roughly from 10 to 50 kilometers above the Earth’s surface and contains the Earth’s ozone layer. The global civil aviation fleet generally cruises in the troposphere, only occasionally polluting the stratosphere directly. Among the most consequential emissions are soot and alumina, which are long-lived and accumulate in the stratosphere. These accumulations promote chemical reactions and absorption and scattering of sunlight that modify the composition and flow of radiation in the stratosphere. Ultimately, these processes reduce stratospheric ozone, warm the stratosphere, and cool the Earth’s surface. Little is known about these particle accumulations and their contributions to stratospheric ozone depletion and thermal perturbations because of a lack of consistent and focused research. Since 1987, emissions of ozone-depleting pollutants are highly regulated by international agreement through the Montreal Protocol on Substances That Deplete the Ozone Layer. Even with recent advances in reusability and the introduction of large launch vehicles and new launch sites around the globe, rocket launches occur irregularly so that concerns about the damage done to the ozone layer by rocket emissions have not elicited regulation. But with projections that the global launch rate will at least double in the coming decade, increased scrutiny under the Montreal Protocol is likely. Increased concerns about the environmental impact of rocket launches, provoked by perceptions of a rapidly growing launch industry, could result in international calls for launch limitations or the phase-out of propellants that the launch industry has come to depend on. The timing and intensity of a regulatory backlash as launch rates increase is impossible to predict accurately, especially because the science of rocket emissions is still not well understood. Rather than allow a legal and regulatory process to unfold in the absence of high-quality, peer-reviewed data, governments and the launch industry should conduct the scientific research needed to fill the knowledge gaps. This will allow the launch community to engage in future far reaching discussions regarding the impacts of rocket emissions with the support of empirical data and computer models that carry the imprimatur of the rocket engineering and atmospheric science communities. The launch industry has enjoyed freedom of action with respect to rocket engine emissions since the start of the space age. Studies of future launch architectures, market demand, and lifecycle costs rarely consider regulation of emissions as a potential future risk factor. Even when emissions are considered, the impacts are examined on a system-by-system basis; the cumulative impact of the global launch fleet is not acknowledged. The net impacts of the global launch industry, across all propellant types, are the parameters of interest to international regulators and, therefore, the global impacts create the regulatory risk. In addition to acknowledging the risks and potential unintended consequences of launch emissions for ozone and the flow of radiation in the atmosphere, the space industry must recognize the extent that other emerging actors may interact with the stratosphere. For example, so-called “geoengineering” or “climate intervention” schemes propose to inject particles into the stratosphere to intercept sunlight and mitigate the warming effects of carbon dioxide and other greenhouse gases. Regulation of such geoengineering activity is already under discussion. Space launch operators, as contributors of stratospheric emissions, could get swept up into these discussions, which involve the same types of particulate matter associated with rocket emissions. Any resulting regulations or guidelines must include adequate consideration of launch activities, which will require a better understanding of rocket emissions than we have today. To improve that understanding, industry should encourage and support scientific research on rocket engine emissions and how they affect the atmosphere. There has been little research to date. The few research papers that have appeared in recent decades mostly point out the knowledge gaps rather than add to the knowledge base. The research has been unfocused, disorganized, and not suited to the needs of the launch industry. As it stands today, the scientific community can predict ozone depletion attributable to rocket emissions to no better than an order of magnitude. In an environment of growing launch rates, new propellants, larger, reusable launch vehicles, and the emergence of other stratospheric polluters, this is not sufficient. Lack of accurate information inevitably invites distorted competitive claims and unwarranted and overly restrictive regulation. A vigorous research program would be guided by the goal to collect high confidence information and data that describe rocket emissions as inputs into global atmosphere models and would include the following components: All of the instrumentation, models, and expertise to carry out this research already exists within the engineering and scientific communities. The in situ and test stand measurements would validate combustion and plume models. Validated models permit the development of emission profiles for particular rocket engine types. These profiles, with various growth assumptions, would be used to construct global emission projections. Finally, the global emissions scenarios would provide data to construct input profiles for modern three-dimensional whole atmospheric chemistry and climate models in order to estimate ozone loss, climate forcing, and a variety of secondary effects such as changes in the global circulation and cloud formation. A policy to promote objective and vigorous research, across the full range of propellant types, will provide the space industry with the information required to take ownership of the problem and exert strong influence on the future debate. By accepting the reality of the risk to freedom of action presented by rocket emissions, and promoting a full and complete scientific understanding of the global impacts, the industry can best inoculate itself from attempts to regulate or limit launch development and operations and disassociate itself from other polluters. There is historical precedent for such an approach. In order to promote supersonic civil aviation development, during the 1990s NASA partnered with the aviation industry to carry out the High Speed Research (HSR) program. One of the goals of HSR was to understand how High Speed Civil Transport (HSCT) aircraft would affect stratospheric ozone. Earlier HSCT efforts in the 1970s were severely and wrongly hampered by knowledge gaps with respect to ozone depletion. HSR demonstrated the airframe, engine, and operational combinations that would minimize ozone impacts and permit (if the economics had been convincing) unregulated development and deployment. The launch industry should organize around a similar approach and partner with the scientific and regulatory communities to determine how space launch can freely develop while minimizing the risks of regulatory intervention. As launch rates and launch vehicle sizes increase, the impact of rocket emissions approaches a “tipping point” when international regulation becomes likely, probably beginning with efforts to protect the ozone layer or limit stratospheric pollution to ward off geoengineering. If the launch industry moves quickly to support the necessary scientific research and fully understand these impacts – in concert with other private-sector and government stakeholders – it is more likely that future regulation will be well-informed and as limiting as possible. As with other large-scale ventures, the application of specialized expertise is essential to anticipating the risks and needs of the enterprise and to managing the impacts on society. With irrefutable data, modeling, and analyses, emissions-related regulations or limitations can be anticipated and configured to ensure that space-based capabilities and systems continue to enhance and improve human life and extend the space industry’s progress made over the past six decades.

#### Extinction --- disease, food insecurity, and ocean biodiversity loss

Michele M. Betsill 16. Professor in Residence and Chair of Political Science department at Colorado State University, Ph.D in Environmental Politics and Policy, “Impacts Of Stratospheric Ozone Depletion” http://www.climate-policy-watcher.org/hydrology/impacts-of-stratospheric-ozone-depletion.html

Stratospheric ozone depletion was recognized as an environmental problem in need of international attention because it impacts both humans and the natural environment. When stratospheric ozone levels decrease, the amount of UV-B reaching Earth's surface increases (WMO, 1995). The changes in UV-B radiation are highest at high and midlatitudes in both hemispheres while the increases are fairly small in the tropics (UNEP, 1994). Increased levels of UV-B affect human health, the productivity of plant and animal species, as well as the composition of ecosystems. Impacts on Human Health Ultraviolet exposure does have some benefits for humans. For example, it initiates the production of vitamin D3, which is believed to inhibit the growth of tumor cells (UNEP, 1996). However, the balance of evidence indicates that the effects of stratospheric ozone depletion on human health are negative. The major risks include increased incidence of eye diseases, skin cancer, and infectious diseases. When UV-B levels increase, two main organ systems are exposed: the eyes and the skin. The impacts of ozone depletion are mediated through these two systems (Longstreth et al„ 1995; UNEP, 1998). Evidence suggests that increased UV-B radiation exposure may be associated with an increase in the incidence of cataracts, a clouding of the lens of the eye (Longstreth et al, 1995; UNEP, 1998). One review of research on this problem reported that a 1% increase in stratospheric ozone depletion would result in a 0.6 to 0.8% increase in the incidence of cataracts (UNEP, 1994; see also UNEP, 1998). The most widely known impact of increased UV-B radiation on human health is skin cancer. UV-B radiation damages deoxyribonucleic acid (DNA), which may cause gene mutations and the formation of cancer cells. Some studies estimate that a sustained 10% decrease in average stratospheric ozone concentrations would result in 250,000 new cases of nonmelanoma skin cancer. This is in addition to the 1.2 million cases already reported each year (Longstreth et al., 1995; UNEP, 1996). Many animal species, such as cows, goats, sheep, cats, and dogs, are also at increased risk of developing skin cancer as a result of increased exposure to UV-B radiation (UNEP, 1998). In an assessment of the effect of the Montreal Protocol and its amendments in protecting the ozone layer, Slaper and his colleagues (1996) concluded these efforts will substantially decrease the growth rate of the incidence of skin cancer over the next century. They found that under a scenario where there were no limits on the production and consumption of ozone-depleting substances, there would be a quadrupling in the incidence of skin cancer by the year 2100. Under the provisions of the Montreal Protocol (a 50% reduction in the production of CFCs by 1999), a doubling in the incidence of skin cancer could be expected in that same period. In contrast, they found the Copenhagen Amendments scenario (a complete phase-out in the production of 21 ozone-depleting substances by January 1, 1996) would result in a 10% increase in skin cancer incidence, peaking in the year 2060. This study lends support to the importance of international efforts to combat stratospheric ozone depletion. Researchers believe that skin exposure to increased levels of UV-B radiation is also linked to modifications in the human immune system. As a result, the ability of the immune system to respond to certain infectious diseases, such as tuberculosis, leprosy, and Lyme disease, is impaired (UNEP, 1998). Longstreth and her colleagues (1995) predict that higher levels of UV-B will result in increased severity and duration of diseases such as lupus rather than an increase in their incidence. Impacts on Aquatic Systems The balance of evidence indicates that increased UV-B radiation can have harmful effects on many species of aquatic organisms and the aquatic systems in which they live (SCOPE, 1993; UNEP, 1998). For example, studies in the Antarctic have linked increased UV-B levels to reduced phytoplankton productivity. Phytoplankton are the basis for the oceanic food chain. UV-B radiation affects the DNA, photosynthesis, enzyme activity, and nitrogen incorporation of phytoplankton. Reduced phytoplankton productivity will likely lead to reduced productivity further up the food chain. It has been estimated that a 16% reduction in stratospheric ozone could lead to a 5% loss of phytoplankton causing a loss of 7 million tons of fish worldwide per year (Hader et al., 1995; UNEP, 1994, 1996). Figure 1 illustrates the effects of UV-B radiation on phytoplankton. Researchers have also found that enhanced UV-B radiation disrupts the early development of several species of fish, shrimp, and crabs, ultimately affecting their motility (Hader et al., 1995). In damaging aquatic organisms, stratospheric Effects of enhanced solar UV-B irradiation on phytoplai Motility Vertical distribution In the water column Global consequences Reduced carbon dioxide sink? Effects of enhanced solar UV-B irradiation on phytoplai Motility Vertical distribution In the water column Reduced biomass production? Competition between species? Temperature increase? Food web in the ocean? Figure 1 Effects of UV-B radiation on phytoplankton (from Hader et al, 1995, p. 178). ozone depletion has serious implications for the world food supply. Globally, 30% of the animal protein consumed by humans comes from the oceans. The percentage is much higher in developing countries (UNEP, 1998). These impacts are particularly worrisome in light of the growing world population. Impacts on Terrestrial Plants and Ecosystems Scientific understanding of the impact of enhanced UV-B on terrestrial plants and ecosystems is incomplete. The majority of studies have been conducted in growth chambers and greenhouses under controlled conditions, conditions that are often quite different from those experienced in the field. Thus, researchers contend it is necessary to use caution in making generalizations about the impacts of enhanced UV-B on terrestrial plants. The results of existing studies need to be verified under field conditions (Caldwell et al., 1995). Keeping the limitations of existing research in mind, it is still possible to make some statements about the effect of enhanced UV-B on terrestrial plants. It appears that increased UV-B radiation may have both direct and indirect effects on plants. Some plant species exhibit a reduction in leaf area and/or stem growth when exposed to higher levels of UV-B. In addition, UV-B may also inhibit photosynthesis, damage plant DNA, and alter the time of flowering as well as the number of flowers in some species. The latter has implication for the availability of pollinators and thus the reproductive capacity of plants (Caldwell et al., 1995; UNEP, 1998). The effects of UV-B on plants are not always straightforward but rather depend on the species, the cultivar, and developmental stage of the plants as well as mineral nutrition in the soil, drought, and local air pollutants (Caldwell et al., 1995; UNEP, 1998). In affecting plants, enhanced UV-B radiation may ultimately lead to changes in entire ecosystems. In nonagricultural ecosystems (e.g., forests and grasslands), the balance of plants may change as some species are less able to respond to increases in UV-B radiation and their productivity declines. At the same time, the productivity of more responsive species will likely increase. The overall species composition of ecosystems will change, as will species interactions and ecosystem dynamics (Caldwell et al., 1995; UNEP, 1998).

#### Food insecurity causes extinction --- hot-spots escalate.

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The United States faces many threats to our National Security. These threats include continuing wars with extremist elements such as ISIS and potential wars with rogue state North Korea or regional nuclear power Iran. The heated economic and diplomatic competition with Russia and a surging China could spiral out of control. Concurrently, we face threats to our future security posed by growing civil strife, famine, and refugee and migration challenges which create incubators for extremist and anti-American government factions. Our response cannot be one dimensional but instead must be a nuanced and comprehensive National Security Strategy combining all elements of National Power including a Food Security Strategy.¶ An American Food Security Strategy is an imperative factor in reducing the multiple threats impacting our National wellbeing. Recent history has shown that reliable food supplies and stable prices produce more stable and secure countries. Conversely, food insecurity, particularly in poorer countries, can lead to instability, unrest, and violence.¶ Food insecurity drives mass migration around the world from the Middle East, to Africa, to Southeast Asia, destabilizing neighboring populations, generating conflicts, and threatening our own security by disrupting our economic, military, and diplomatic relationships. Food system shocks from extreme food-price volatility can be correlated with protests and riots. Food price related protests toppled governments in Haiti and Madagascar in 2007 and 2008. In 2010 and in 2011, food prices and grievances related to food policy were one of the major drivers of the Arab Spring uprisings. Repeatedly, history has taught us that a strong agricultural sector is an unquestionable requirement for inclusive and sustainable growth, broad-based development progress, and long-term stability.¶ The impact can be remarkable and far reaching. Rising income, in addition to reducing the opportunities for an upsurge in extremism, leads to changes in diet, producing demand for more diverse and nutritious foods provided, in many cases, from American farmers and ranchers. Emerging markets currently purchase 20 percent of U.S. agriculture exports and that figure is expected to grow as populations boom.¶ Moving early to ensure stability in strategically significant regions requires long term planning and a disciplined, thoughtful strategy. To combat current threats and work to prevent future ones, our national leadership must employ the entire spectrum of our power including diplomatic, economic, and cultural elements. The best means to prevent future chaos and the resulting instability is positive engagement addressing the causes of instability before it occurs.¶ This is not rocket science. We know where the instability is most likely to occur. The world population will grow by 2.5 billion people by 2050. Unfortunately, this massive population boom is projected to occur primarily in the most fragile and food insecure countries. This alarming math is not just about total numbers. Projections show that the greatest increase is in the age groups most vulnerable to extremism. There are currently 200 million people in Africa between the ages of 15 and 24, with that number expected to double in the next 30 years. Already, 60% of the unemployed in Africa are young people. ¶ Too often these situations deteriorate into shooting wars requiring the deployment of our military forces. We should be continually mindful that the price we pay for committing military forces is measured in our most precious national resource, the blood of those who serve. For those who live in rural America, this has a disproportionate impact. Fully 40% of those who serve in our military come from the farms, ranches, and non-urban communities that make up only 16% of our population. ¶ Actions taken now to increase agricultural sector jobs can provide economic opportunity and stability for those unemployed youths while helping to feed people. A recent report by the Chicago Council on Global Affairs identifies agriculture development as the core essential for providing greater food security, economic growth, and population well-being.¶ Our active support for food security, including agriculture development, has helped stabilize key regions over the past 60 years. A robust food security strategy, as a part of our overall security strategy, can mitigate the growth of terrorism, build important relationships, and support continued American economic and agricultural prosperity while materially contributing to our Nation’s and the world’s security.

#### Scenario 2 is space colonization.

#### Governments won’t colonize space because it’s not popular --- only profit margins incentivize commercial development

Konrad Szocik 19. University of Information Technology and Management in Rzeszow, Department of Philosophy and Cognitive Science. 01/2019. “Should and Could Humans Go to Mars? Yes, but Not Now and Not in the near Future.” Futures, vol. 105, pp. 54–66.

6. Public opinion Public opinion is, at least in the near future, the main sponsor of space research and space exploration. Bertrand, Pirtle, and Tomblin, (2017) show that the public is interested in human mission to Mars. The most preferred space mission is a crew in orbit and a robot mission on Mars surface. In other words, public criteria is low risk and low cost. The German space agency follows public opinion and social interest because is focused on duty for society and oriented to social purposes as “climate change, mobility, communication and security” (Zypries, 2017). Politicians are prone to reduce space budgets or to not invest in long-term human settlement missions due to public opinion. Consequently, progress in space technology is still retarded. State of art in space transport means did not change qualitatively since the Space Race between the US and the Soviet Union. Impact of public opinion may differ in various countries. Max Grimard (2012), p. 6) shows how important is space program for public opinion in the US. Public sympathy for American presence in space is counterbalanced by the unpredictability of politician authorities, the tensions between presidents and the Congress (Grimard, 2012, p. 12), and the important role played by competition with Russia and China (Grimard, 2012, p. 6). Grimard adds that Russia is similar case but it is currently entire focused on stability of space programs, including renovation of old infrastructure than on new space exploration programs. According to Grimard (2012), p. 13), this fact excludes Russia from being the leader of international collaboration in space policy despite its historical advantages. China, according to Grimard, repeats space policies of the US and Soviet Union. By contrast, in Japan and Europe, prestige does not play role. Japan and Europe are focused on scientific and technological contexts. Space program is not a part of national policy. Due to its costs, politicians may decide to not risk negative approach of public opinion. But public opinion does not threaten private investors which can consider space as object of their investment. 7. Commercial exploration of space is not a workable alternative Risk of funding the wall might be avoided by commercial exploration of space (Crawford, 2016). According to Crawford, some space projects such as next generation of large telescopes or crewed mission to Mars are non-profitable. While they are a governmental duty, they could be funded partially by profits from commercial exploration of space (for instance, space mining). Hope for private exploration sounds reasonable but is counterbalanced by commercial focus on profits. Because mission to Mars has only scientific profits, only public sponsors will be invested in this project. James S. J. Schwartz (2014) adds that two of the possible reasons for human space mission, such as improving human welfare and progress in scientific exploration, are well beyond interests of private companies. Newman and Williamson (2018) quite similarly expect that private space exploration will be focused on financial profits more than on environmental sustainability. Private investors are not obliged to act altruistically and to sacrifice their business for uncertain idea. W. Henry Lambright (2017) adds that private companies at least at first stages of Mars space program will not be able to fund it. For this reason, Mars space program requires multi-generational effort and political stabilization. The challenge of safety works against private investors in space program. Public space agencies have achieved high standards of safety. They behave in careful and conservative ways. Commercial, private projects do not have the same advanced technology, the large number of scientists and support staff, and the generous budgets. Catastrophe would likely break a private space program. The lack of experience of private companies in space exploration is partially responsible for higher risk of technological failures even in relatively easy tasks as crash of Momo-2 rocket launched by Japanese start-up on 30 June 2018 several seconds after launch. This does not mean that private investors are not able to explore space, but they are able to do that only when they receive profits. In scenario of commercial exploration of space, we should wait for some point in the future when a human space base appears as byproduct of commercial activity. A human base on Mars might be a by-product of hotels on LEO or space mining. Some investors who want to build space hotels may try to settle space regions beyond LEO and build hotels on the Moon and/or Mars. From touristic point of view, staying in the Moon or Mars hotel may be more attractive than on LEO. Investors working in asteroid mining may extend their business to the Moon and/or Mars. Both enterprises even if focused on purely commercial purposes, will not be easy (perhaps impossible) to achieve by private companies alone. Elvis (2012), p. 549) argues that asteroid mining will be challenging due to, among others, difficulties in detection of appropriate asteroids. He shows that among about 1200 analyzed meteorites only 13 of them contain high level of platinum profitable for their exploitation. Elvis suggests that NASA should reorient its strategy from focus on exploration to support for commercial utilization of space. Exploration will appear as a consequence of commercial profitable activity (Elvis, 2012, p. 549). Estimated profits of asteroid mining10 are counterbalanced by high costs of exploitation and possible decreasing of price of currently rare resources (Genta, 2014).11

#### Space tourism is the key enabler --- it’s the only industry that’s able to provide long term funding, RnD, and public support for colonization

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* The sections in pt. 6 font are other sections of the article --- they’re mostly very technical and not relevant, but feel free to read through them

This paper draws attention to the essential role of space tourism, as a commercial enabler, in the development of a sustainable long term strategy for exploration and settlement of solar system objects. Since governments will not be able to obtain all of the necessary funding and public support over the long duration necessary (multiple election cycles in democracies) in order to unilaterally, or even in collaboration, conduct missions to explore and colonize the Moon, Mars or other solar system objects, other alternative sources for such funding are explored. These sources would provide an economic development basis for such a venture, and simultaneously engage the general public through direct involvement to eventually make such a venture possible. The analysis determines that space tourism is the one near-term commercial space market sector whose development can lead to the desired long term results. A major consequence of a successful space tourism industry, in addition to creating an involved public, will be regular, safe and relatively low cost journeys to and from low earth orbit. This in turn will provide a new starting point, or platform, for the long term exploration and settlement of the solar system through further economic development stages. A basic architecture is described for a sustainable approach to the exploration and colonization of solar system objects, which relies as a key factor on the successful development of a viable space tourism industry. I. INTRODUCTION How do we get there from here? We start by underlining the need for humanity to eventually settle other parts of the solar system. While recognizing the technological challenges to achieving this long term aim, the paper focuses on the political challenges. In order to do this, there is a need for a commitment from politicians and the general public that has proven impossible to achieve thus far. The paper explores why this has been the case and suggests that the political dimension requires a delicate balance of timing, funds and honest rhetoric for sustainable progress. The key, it emerges, is planning a backwards schedule so that short-term funding decisions are seen in a long-term context which is not in itself politically contentious. This, in turn, leads through judicious focused R&D spending in the near term, to the gradual development of an evolving space infrastructure which will ultimately provide the means for the exploration and settlement objective in the long term. Building this infrastructure, which must be economically beneficial and revenue generating in its own right, relies upon a mixture of governmental and private entrepreneurial investment which must initially be built upon a platform made possible only by the development of a successful space tourism industry. II. SETTLEMENT Let’s start with a set of agreed non-political reasons for human settlement beyond the Earth, possibly in multiple places within the solar system. The wellknown physicist and cosmologist Stephen Hawking said in 2001 “I don’t think the human race will survive the next thousand years, unless we spread into space”. Settlement or colonization of space is not of course a new idea. Perhaps one of the most persuasive cases was made by Gerald O’Neil in 1977 (Reference 1). But even going as far back as Tsiolkovsky in 1912, the rationale was understood. He said “The better part of humanity will never perish but will move from sun to sun as each one dies out in succession”. Both of these quotations provide an indication of the very long term timeframe that is involved. Tsiolkovsky is worried about the eventual fate of the Earth when our sun begins to turn into a red giant, something that is not expected to happen very soon. Hawking is considering events that may well happen in a less-distant timeframe. Events such as asteroid or comet bombardment, cosmic radiation during a magnetic pole reversal, gamma-ray bursts from elsewhere in the galaxy, and impacts due to humans themselves (such as nuclear war, biological warfare, out-of-control human-induced climate change, etc.). Clearly it is not a matter of “if” but “when” it will become necessary for a human “insurance policy” through settlement to be instituted. I have underlined the very long timescales (from hundreds to thousands or even millions of years) because I do not think there is anything very timecritical in our efforts right now. Just so long as we are headed in the right general direction. We should not pretend otherwise, or there will be no credibility to our plans. The human race has made the crucial first steps into space during our lifetime, so that we now at least 63rd International Astronautical Congress, Naples, Italy. Copyright ©2012 by the International Astronautical Federation. All rights reserved. IAC-12-A5.2 x 13278 Page 2 of 7 (and at last) have the opportunity, and one could say the responsibility, to work on the next stages, even though the timeframe is not urgent in any realistic sense. The early dreamers, engineers and astronauts have done their part, and in some cases even given their lives, to give us this opportunity to figure out a survival strategy for the human species (and in fact for all other life of which we are aware). Therefore, developments should proceed against a background of understanding the very long term existential threats, while proceeding at a pace that nevertheless makes sense in the short term from the point of view of budgets and alternative priorities. Besides the survival imperative, there are other reasons for exploring outwards into the solar system, such as to enhance prosperity by making use of the abundant resources from space. And there is the more spiritual reason, summed up by the phrase “because we must explore”. In the American context, pioneering the frontier was an essential part of the country’s risk-taking character. Former Space Shuttle manager Wayne Hale, however, wondered aloud whether things had changed. In 2005 he said “It is not certain that the US today, living as it is in the luxury of the legacy of its pioneers, still has the capability to weigh risk, reward, hardship, hope, difficulty and opportunity as they formerly did”. Let us hope that the national character is still capable of rising to a challenge. There are other reasons, too, for space exploration and settlement, including a search for knowledge, and new sources of energy and minerals in scarce supply on Earth (References 2, 3, 4, 5, 6 and 7). Probably the best overall rationale in recent times was articulated by President W Bush’s Director of the White House Office of Science and Technology Policy, John Marburger. He said in 2006 (Reference 2) “Phenomena in the solar system…can reasonably be described as falling within humanity’s economic sphere of influence…questions about the vision boil down to whether we want to incorporate the solar system in our economic sphere, or not. The ultimate goal is not to impress others, or merely to explore our planetary system, but to use accessible space for the benefit of humankind. It is a goal that is not confined to a decade or a century. Nor is it confined to a single nearby destination, or to a fleeting dash to plant a flag. The idea is to begin preparing now for a future in which the material trapped in the sun’s vicinity is available for incorporation into our way of life”. For many people, including many politicians and leaders of government, the lack of immediacy and the long-term nature of the endeavour make it hard to formulate the necessary policy statements. The space entrepreneur Jeff Greason declared in 2011 (Reference 3) “It is actually the national policy of the United States that we should settle space, but everyone’s kind of afraid to say so”. There are, however, many supporting organizations (eg The Space Frontier Foundation, Space Renaissance International, the various Interplanetary Societies, etc.) which embrace the notion of opening up the space frontier to human settlement through economic development. We should not press for unrealistic timescales for the grand endeavour. There is no need. As said (Reference 8) “It does not really matter how long it takes, as long as the vision is maintained to establish one or more self-sustaining space colonies”. The best aspect of this very long term vision is that, when described properly, it is capable of appealing to multiple constituencies simultaneously. They can be national and international. This kind of very long term aim is not inherently Republican or Democrat. It is not specifically Labor or Conservative. Even religious leaders would get behind the idea that we have a responsibility, ultimately, to provide an Ark to ensure that life survives an approaching catastrophe. To do this will require the best of human ingenuity, for generations to come, and it will challenge all of us, and our descendants, if we are to succeed. III. RIGHT TIME, RIGHT MONEY So, if there is no disagreement about the ultimate need, what has been the problem with regards to working towards fulfilling that need? The answer involves technology (quite simply we don’t know how to do all of it yet), but is more firmly rooted in matters of budget, resource and timing. At least in democracies there is an annual budget process to determine priorities for allocating the funds raised by the government via taxes on the population. The very long term exploration and settlement option just does not easily fit into such a short term prospect, especially when overlaid by an only slightly longer election cycle of four or five years. There was one exception to this rule, in the case of John F Kennedy’s call for the race to the Moon. And in some ways the success of Apollo has resulted in decades of frustration when nothing equally audacious has been possible since 1970. However, we must recall that there was a Cold War mentality which made it possible to levy a 5% of GDP tax burden on the American people throughout the sixties to achieve the Moon landings. Nowadays, in the US, NASA has an annual budget, which while large in global terms at $17 billion, is nevertheless only a tenth of those Apollo-era figures. Furthermore, there is probably a miss-match, which needs to be corrected, in the minds of the general public 63rd International Astronautical Congress, Naples, Italy. Copyright ©2012 by the International Astronautical Federation. All rights reserved. IAC-12-A5.2 x 13278 Page 3 of 7 between what is wanted and what is achievable in a given period at these reduced budget levels. Almost certainly too much has been promised, and the public believed that what they saw in the simulations and videos already really did exist. This is partly due to the audacity of Apollo itself (and folks forget how much it cost) and partly due to the Hollywood and TV versions of the fantasy of interplanetary, and even intergalactic, travel, with “warp-drive”, etc. There has been no shortage of attempts to raise the support for new space visions. There have been examples under the leadership of each of the two Bush presidencies, but in neither case would the Congress (representing the public) fund the initiatives. Does this perhaps mean that it is impossible in a democracy, outside of a war situation, to levy the funds to make human settlement of space a reality? Such a conclusion would be unduly pessimistic. What is needed is a situation where the public understands the overall direction, and a realistic assessment of the long time horizons, while meanwhile deriving interim benefits on an ongoing basis from the space exploration activities. It’s about balancing the timing, rhetoric and funding. In the current administration, President Obama himself said “Our goal is the capacity for people to work … and live safely beyond Earth for extended periods of time, ultimately in ways that are more sustainable and even indefinite.” The official US space policy language is provided in Reference 9. The advisory body which was most influential in defining current US space strategy was known as the Augustine Commission (Reference 10), and they recommended a “Flexible Path” concept as the most likely to be sustainable. In their report we read “There was a strong consensus within the Committee that human exploration should advance us as a civilization towards our ultimate goal: charting a path for human expansion into the solar system.” This broad policy is interpreted by NASA’s leading management in ways which emphasize the need for sustainability (Reference 11, 12): “NASA will accelerate and enhance its support for the commercial spaceflight industry to make travel to low Earth orbit and beyond more accessible and more affordable. Imagine enabling hundreds, even thousands of people to visit or live in low Earth orbit, while NASA firmly focuses its gaze on the cosmic horizon beyond Earth.”, and “We must invest in innovations for space technology and new ways of doing business, if we are to develop a space exploration and development program that is truly sustainable over the long term.”, and more specifically “When we go beyond the Earth-Moon system, we must do it in a cost-effective manner. In order to do that, we need the capability to refuel transfer stages, the ability to live off in-situ resources, and the ability to take advantage of breakthroughs in on-orbit space propulsion”. The US National Research Council added (Reference 13) “Emphasis should be placed on aligning space program capabilities with current highpriority national imperatives.” We can find plenty of other advice in References 14, 15, 16, 17, 18, and 19. So what, if anything, is missing from all these statements? The taxpaying public needs to be told what they can expect to obtain for their tax dollars both in the near term (for themselves) and in the long term (for their children and grandchildren), and its relevance to current national needs. In Reference 16 we are reminded “Space programs in order to be sustainable need to maintain a healthy balance between the immediately useful and the exciting”. We shall attempt, in the next section, to provide the raw materials from which this new “Peoples’ Vision for Space” may be formulated, and which will indeed strive to maintain that critical balance. IV. THE BACKWARDS SCHEDULE We begin at the end, the Very Long Term (VLT). Where do we want to be, maybe centuries from now? Consider the gravity wells in the solar system. The toughest part will be getting out of Earth’s gravity well in the first place – at least as far as the geostationary orbit (or arguably to the L1 Lagrangian point in the Earth Moon system). Once we are there we have almost enough energy to get to the Moon, near Earth asteroids, or the Martian Moons, and points beyond. So, a good platform for the long term exploration and settlement of the solar system would be a “Spaceport Earth” complex in geostationary orbit. And of course the regular taxi service to take humans and materials there. We want to be able ultimately to enable large quantities of humans and other living things to travel the solar system across the vast distances of the interplanetary gravity well plateau, and then to be able to land and set up selfsustaining outposts there. It has been about a hundred years since we learned to fly, so maybe a century from now would be a reasonable time frame to consider for at least the beginning of the VLT, the colonization phase, but we do not really need to put a date on it. Let’s now move somewhat closer to the present, and explore the Medium Term (MT). During this phase we need to master the skills of transferring relatively small payloads of cargo and people (when compared with the VLT) across the near solar system. In this phase space activities need to be becoming economically selfsustaining, so we shall use some space objects, such as asteroids and the Moon, to provide fuel and other 63rd International Astronautical Congress, Naples, Italy. Copyright ©2012 by the International Astronautical Federation. All rights reserved. IAC-12-A5.2 x 13278 Page 4 of 7 precious resources, such as oxygen, water, the platinum metals and rare earths (currently only available from China). Some of these products will be used for supplies for further outward travel, and for in-space assembly; some will be used for trading back to Earth to generate funding. References 20, 21, 22 provide insight into the potential values of materials mined from the Moon or asteroids. Reference 21 in particular provides a detailed account of the economics of He3 extraction from the Moon, and its potential as a key to long term energy needs of planet Earth. Also, in this time frame, we can organize to be able to protect the Earth from future potential asteroid impacts. Thus, while helping solve some of Earth’s resource and security issues, we shall have alternative revenue sources for the ongoing space program by building an economic development base for the venture. What, precisely, do we mean by the MT? Again, it will not be helpful to attempt to put a date on it. The whole idea of this approach is to conduct each phase within the available resources, for as long as it takes, while simultaneously offering something to the Earth-bound tax-payers who are paying at least part of the initial funding. This phase, the economic resources phase, might take, say, 50 years – but we cannot know when it would start. Finally, in this reverse schedule, we do reach the Short Term (ST). This is the platform-building phase. It starts now, and proceeds for maybe five to fifteen years, which is about as long as can be politically managed in a democracy. I use the word “platform” merely to mean the ability to regularly go and come from GEO with humans and cargo. Particularly in an election year, we must address the main challenges that we are trying to solve here and now on Earth – jobs, clean energy reserves, economic stagnation, strategic material resource limitation, global climate change monitoring and mitigation, security, stewardship of the Earth’s environment, etc. The space program which began in the sixties provided a great deal of technological momentum to carry us all to the present. By continuing, we shall derive future benefits, address our pressing needs, and be able to regularly keep the public engaged by pointing out the interim gains. We need to put together the rhetoric of The Peoples’ Vision for Space, pointing out the costs and benefits and providing an honest perspective of the scale of the endeavour and the very extended timescales. Perhaps the true legacy of Apollo is the recognition that we live on a fragile world, and have developed the means to protect it from some threats and ultimately the means to leave it behind in the distant future when there is no alternative remaining. In addition to establishing GEO as a new destination for crewed spaceflight, we need to begin the R&D needed so that the problems and challenges of the MT can be met. Note that it is not necessary (or even possible) to have all the answers about how to do it before the grand adventure commences. We cannot even start the R&D for the VLT for maybe another 30 years until all the lessons from the ST and MT have been learned. How much will the public be prepared to pay for this? The US public, in opinion polls, has declared that the current level of expenditure ($17 billion proposed for NASA’s 2013 budget) is “about right”, at least in an era of austerity. For this, they expect space leadership and to obtain the benefits, in line with national objectives, of new leading edge technologies, inventions, medical discoveries, exploration, a search for life beyond Earth and new scientific breakthroughs to improve the quality of life on Earth. The public needs to view the space program as heading towards ultimately becoming a net generator of income to the economy, rather than a net source of expense. This very long term project will clearly be seen as an international endeavour, and so some funding can be expected from other countries. After all, “We came in peace, for all mankind”! V. EVOLVING SPACE INFRASTRUCTURE We can now, having seen the broad scope and duration of The Peoples’ Vision for Space, reset the clock to proceed forwards from the present. So, we need to initially build a foothold in space near the plateau of the interplanetary gravity well. We need to first of all conduct the trade-offs to compare the possible locations at either the geostationary orbit, or at the Earth-Moon system Lagrangian Point L1. There are pros and cons for each location, and some might advocate for L1, but I opt for geostationary orbit at least in this paper as the best interplanetary launching platform. While it will require some coordination with the ITU, it nevertheless does have some advantages once we consider the role of space tourism in the next section. A human outpost in GEO, the Spaceport Earth complex, provided with the necessary transfer vehicles, could easily perform commercially valuable and revenue generating inspections, or refuelling, of satellites in that orbit. We need to focus our R&D activities. Propellant depots are an important part of the future infrastructure, so we need to build the depots and the ways to replenish them and conduct space refuelling. Note that one firm (Reference 23) has already been formed to eventually provide “a gas station in the sky”, so it will not always be necessary to seek Federal funding for all identified R&D, although of course it will be important initially. A new class of vehicle, the re-fuellable tug, will be needed as a transfer stage to shuttle back and forwards from LEO to GEO. Vehicles in the future going to and from distant solar system objects will begin and end their interplanetary journeys at the Spaceport Earth complex in GEO. As the geostationary base platform is 63rd International Astronautical Congress, Naples, Italy. Copyright ©2012 by the International Astronautical Federation. All rights reserved. IAC-12-A5.2 x 13278 Page 5 of 7 created, there will eventually be a large market demand for the tugs, so they may well be provided by more than one commercial provider. R&D is needed on solar sails, reusable thermal control systems, new lightweight materials, atmospheric re-entry systems, closed loop recycling ecosystems, long duration crew health and radiation protection, effective space robotics, spacebased 3-D printing, new classes of rocket engine, ideally suited to the proposed missions, in-situ resource utilization (ISRU). Work has already begun on the VASIMR plasma nuclear propulsion engine, and at least two commercial operators (References 23, 24) have expressed their intention to eventually perform Lunar or asteroid mining and resource extraction. This list represents decades of research and development, and it is also the key to keeping the public engaged. Every time some progress is made, where possible a mission can be used to test out the results, and such missions can be designed to offer the public a succession of exciting space activities. Although it will not be possible to replicate the rapid pace of developments which occurred during the Mercury/Gemini/Apollo era, it should nevertheless be possible to replicate the idea of every mission testing out some new concept, which kept the public engaged throughout the sixties. So these are the R&D technologies which will be the enablers for the short and medium term of the settlement task. Funding can come initially from NASA, then also from Energy Department and Defence budgets. Still other parts will be undertaken by private commercial entities seeking commercial gains. This is especially true of the contribution of the new space tourism commercial sector, described in the next section. VI. SPACE TOURISM THE ENABLER Space tourism will play a significant part in establishing the sustainable track towards human settlement of space. Deputy NASA Administrator Lori Garver (Reference 12) said “Space tourism is a catalyst that has sparked a whole new industry of passenger carrying spacecraft. We plan to make use of commercial space providers to transport astronauts to the space station.” The new taxi (or rental car) services, which NASA will be contracting with the new commercial providers like SpaceX, assume that either orbital space tourists, or experimenters, will be flying in the seats not occupied by (or paid for by) NASA. Space tourism represents one of the best ways to involve the general public; it brings the possibilities of space travel home to many. We are about to see a transformation in access to space, which will in some ways mirror what took place in the early stages of aviation (Reference 25). Originally there were a few risk-taking aviators, then some government cargoes (usually air mail), then some primitive airliners carrying very rich passengers such as movie stars, and ultimately today’s airline business with its high reliability, schedules and efficiency, where now almost anyone can fly. Space tourism already takes place using Russian Soyuz vehicles, and it is assumed that the SpaceX Dragon vehicle will also soon be able to provide orbital space tourism flights, but in much more comfort, and from US spaceports. Other possible commercial orbital space tourism vehicles include the Stratolaunch vehicle, the Orbital Cygnus and the Blue Origin and Sierra Nevada offerings. The sub-orbital space tourism business will soon begin with Virgin Galactic, XCOR and others such as Armadillo and Masten offering vehicles to provide the experience. All of these new space tourism craft have been designed to provide a reusable service into space, with the operator being able to perform rapid turnaround and airline-like operations. The key to the success of space tourism is the potential market size. The forecasts (Reference 26) indicated that up to 15,000 passengers per year would be able and willing to pay $100,000 for a sub-orbital space tourism experience. The same forecast study found that far fewer tourists were anticipated for orbital spaceflight because of the high ticket price (of $20 million) when the survey was carried out. However, subsequent work using the same raw data from millionaire interviews (Reference 27) suggests that if ticket prices could be brought down to $1/2 million per seat, then since people are price sensitive payloads, there would also be a market of 15,000 a year for orbital tourists. The significance of these numbers, and the reason that they can frame space tourism as an enabling technology, is in comparison with the number of other payloads that have previously been sent into space. When we add up all global launches, including military, civil, commercial, everything, we find that the total number of payloads has remained at about 60 to 80 for decades. The difference between 60 and 15,000 payloads per year (if we call each tourist a “payload”) is the kind of difference which allows us to experience the benefits of economies of scale. Furthermore, it is the only class of payload which can achieve this. In a major comprehensive study (Reference 28), NASA investigated 43 potential commercial and government markets (including communications, remote sensing, broadcasting, navigation, ISS missions, science, space rescue, asteroid detection, space advertising, space burial, crystal growth manufacturing, vacuum deposition manufacturing, hazardous waste disposal, space hospitals, solar power, etc) and determined that only space tourism had this ability to transform the economics of the launch business within a twenty-year horizon. The new industry will also bring substantial economic and employment benefits around the new spaceports, where terrestrial tourists are expected to visit. Spaceport America in New Mexico, for example, is anticipating 200,000 visitors per year. The space tourism industry as envisaged to date involves sub-orbital trips, LEO orbital vacations and even a circum-lunar flight. However, by providing a further destination at geostationary orbit with a suitable space hotel complex, this industry could further enhance its role as an enabler by opening up this “Spaceport Earth” complex to regular commercial flights from LEO to GEO. It would therefore help create the geostationary platform necessary for the eventual space settlement drive. Some more market research is needed to confirm the level of interest, and price level, for such a space tourism destination. There will also need to be some more detailed considerations of the use of GEO as a space tourist destination, eg provision of telescopes, the ability to use tugs to move a few miles above or below GEO to allow a drift phase to provide enhanced interest, etc. Remember the time frame we are discussing. We have time to allow the natural development of this new industry so that it assists in the creation of the evolving space infrastructure. So, the basic architecture begins with space tourism, then extends to the use of commercial LEO-GEO tugs to take tourists to and from geostationary orbit, which becomes the new platform from which human settlement architectures can commence in due course. The new long term initiatives then proceed as described above, once the fruits of the new focused R&D begin to emerge. And importantly, throughout all the stages from the ST thru MT to VLT, there will be a) involvement of the general public, b) solutions to the technological problems of the era, c) revenue generation opportunities via the commercial entrepreneurial providers and d) a sustainable relatively low Federal budget allocation, which however is focused on providing the focused R&D to enable the long term vision to succeed. Although for this paper we have used GEO for the new space tourism location, there is no reason why it could not equally be L1 which is used, or even both locations. Just so long as space tourists will be willing and able to pay to go there on regular trips. A variety of objects in the solar system become easy targets for the space agencies such as NASA once we have established the Spaceport Earth launching pad in GEO. At this location, true space-faring interplanetary craft can be assembled, which do not need to cope with atmospheric drag or heating problems at either end. And it all becomes possible only because the space tourism business opens up the regular route into LEO and then onwards up to “Spaceport Earth” in GEO.

#### Space colonization causes novel species generation and spreads humanity too wide – both make communication and intergalactic governance impossible – inevitably results in colony wars and galactic extinction from new superweapons

Torres 18, Phil. Phil Torres is the director of the Project for Human Flourishing and the author of Morality, Foresight, and Human Flourishing: An Introduction to Existential Risks."Why We Should Think Twice About Colonizing Space." Nautilus, 23 July 2018, nautil.us/blog/why-we-should-think-twice-about-colonizing-space.

In a recent article in Futures, which was inspired by political scientist Daniel Deudney’s forthcoming book Dark Skies, I decided to take a closer look at this question. My conclusion is that in a colonized universe the probability of the annihilation of the human race could actually rise rather than fall. The argument is based on ideas from evolutionary biology and international relations theory, and it assumes that there aren’t any other technologically advanced lifeforms capable of colonizing the universe (as a recent study suggests is the case). Consider what is likely to happen as humanity hops from Earth to Mars, and from Mars to relatively nearby, potentially habitable exoplanets like Epsilon Eridani b, Gliese 674 b, and Gliese 581 d. Each of these planets has its own unique environments that will drive Darwinian evolution, resulting in the emergence of novel species over time, just as species that migrate to a new island will evolve different traits than their parent species. The same applies to the artificial environments of spacecraft like “O’Neill Cylinders,” which are large cylindrical structures that rotate to produce artificial gravity. Insofar as future beings satisfy the basic conditions of evolution by natural selection—such as differential reproduction, heritability, and variation of traits across the population—then evolutionary pressures will yield new forms of life. But the process of “cyborgization”—that is, of using technology to modify and enhance our bodies and brains—is much more likely to influence the evolutionary trajectories of future populations living on exoplanets or in spacecraft. The result could be beings with completely novel cognitive architectures (or mental abilities), emotional repertoires, physical capabilities, lifespans, and so on. In other words, natural selection and cyborgization as humanity spreads throughout the cosmos will result in species diversification. At the same time, expanding across space will also result in ideological diversification. Space-hopping populations will create their own cultures, languages, governments, political institutions, religions, technologies, rituals, norms, worldviews, and so on. As a result, different species will find it increasingly difficult over time to understand each other’s motivations, intentions, behaviors, decisions, and so on. It could even make communication between species with alien languages almost impossible. Furthermore, some species might begin to wonder whether the proverbial “Other” is conscious. This matters because if a species Y cannot consciously experience pain, then another species X might not feel morally obligated to care about Y. After all, we don’t worry about kicking stones down the street because we don’t believe that rocks can feel pain. Thus, as I write in the paper, phylogenetic and ideological diversification will engender a situation in which many species will be “not merely aliens to each other but, more significantly, alienated from each other.” But this yields some problems. First, extreme differences like those just listed will undercut trust between species. If you don’t trust that your neighbor isn’t going to steal from, harm, or kill you, then you’re going to be suspicious of your neighbor. And if you’re suspicious of your neighbor, you might want an effective defense strategy to stop an attack—just in case one were to happen. But your neighbor might reason the same way: she’s not entirely sure that you won’t kill her, so she establishes a defense as well. The problem is that, since you don’t fully trust her, you wonder whether her defense is actually part of an attack plan. So you start carrying a knife around with you, which she interprets as a threat to her, thus leading her to buy a gun, and so on. Within the field of international relations, this is called the “security dilemma,” and it results in a spiral of militarization that can significantly increase the probability of conflict, even in cases where all actors have genuinely peaceful intentions. So, how can actors extricate themselves from the security dilemma if they can’t fully trust each other? On the level of individuals, one solution has involved what Thomas Hobbes’ calls the “Leviathan.” The key idea is that people get together and say, “Look, since we can’t fully trust each other, let’s establish an independent governing system—a referee of sorts—that has a monopoly on the legitimate use of force. By replacing anarchy with hierarchy, we can also replace the constant threat of harm with law and order.” Hobbes didn’t believe that this happened historically, only that this predicament is what justifies the existence of the state. According to Steven Pinker, the Leviathan is a major reason that violence has declined in recent centuries. The point is that if individuals—you and I—can overcome the constant threat of harm posed by our neighbors by establishing a governing system, then maybe future species could get together and create some sort of cosmic governing system that could similarly guarantee peace by replacing anarchy with hierarchy. Unfortunately, this looks unpromising within the “cosmopolitical” realm. One reason is that for states to maintain law and order among their citizens, their various appendages—e.g., law enforcement, courts—need to be properly coordinated. If you call the police about a robbery and they don’t show up for three weeks, then what’s the point of living in that society? You’d be just as well off on your own! The question is, then, whether the appendages of a cosmic governing system could be sufficiently well-coordinated to respond to conflicts and make top-down decisions about how to respond to particular situations. To put it differently: If conflict were to break out in some region of the universe, could the relevant governing authorities respond soon enough for it to matter, for it to make a difference? Probably not, because of the immense vastness of space. For example, consider again Epsilon Eridani b, Gliese 674 b, and Gliese 581 d. These are, respectively, 10.5, 14.8, and 20.4 light-years from Earth. This means that a signal sent as of this writing, in 2018, wouldn’t reach Gliese 581 d until 2038. A spaceship traveling at one-quarter the cosmic speed limit wouldn’t arrive until 2098, and a message to simply affirm that it had arrived safely wouldn’t return to Earth until 2118. And Gliese 581 is relatively close as far as exoplanets go. Just consider that he Andromeda Galaxy is some 2.5 million light-years from Earth and the Triangulum Galaxy about 3 million light-years away. What’s more, there are some 54 galaxies in our Local Group, which is about 10 million light-years wide, within a universe that stretches some 93 billion light-years across. These facts make it look hopeless for a governing system to effectively coordinate law enforcement activities, judicial decisions, and so on, across cosmic distances. The universe is simply too big for a government to establish law and order in a top-down fashion. But there is another strategy for achieving peace: Future civilizations could use a policy of deterrence to prevent other civilizations from launching first strikes. A policy of this sort, which must be credible to work, says: “I won’t attack you first, but if you attack me first, I have the capabilities to destroy you in retaliation.” This was the predicament of the US and Soviet Union during the Cold War, known as “mutually-assured destruction” (MAD). But could this work in the cosmopolitical realm of space? It seems unlikely. First, consider how many future species there could be: upwards of many billions. While some of these species would be too far away to pose a threat to each other—although see the qualification below—there will nonetheless exist a huge number within one’s galactic backyard. The point is that the sheer number would make it incredibly hard to determine who initiated a first strike, if one is attacked. And without a method for identifying instigators with high reliability, one’s policy of deterrence won’t be credible. And if one’s policy of deterrence isn’t credible, then one has no such policy! Second, ponder the sorts of weapons that could become available to future spacefaring civilizations. Redirected asteroids (a.k.a., “planetoid bombs”), “rods from God,” sun guns, laser weapons, and no doubt an array of exceptionally powerful super-weapons that we can’t currently imagine. It has even been speculated that the universe might exist in a “metastable” state and that a high-powered particle accelerator could tip the universe into a more stable state. This would create a bubble of total annihilation that spreads in all directions at the speed of light—which opens up the possibility that a suicidal cult, or whatever, weaponizes a particle accelerator to destroy the universe. The question, then, is whether defensive technologies could effectively neutralize such risks. There’s a lot to say here, but for the present purposes just note that, historically speaking, defensive measures have very often lagged behind offensive measures, thus resulting in periods of heightened vulnerability. This is an important point because when it comes to existentially dangerous super-weapons, one only needs to be vulnerable for a short period to risk annihilation. So far as I can tell, this seriously undercuts the credibility of policies of deterrence. Again, if species A cannot convince species B that if B strikes it, A will launch an effective and devastating counter strike, then B may take a chance at attacking A. In fact, B does not need to be malicious to do this: it only needs to worry that A might, at some point in the near- or long-term future, attack B, thus making it rational for B to launch a preemptive strike (to eliminate the potential danger). Thinking about this predicament in the radically multi-polar conditions of space, it seems fairly obvious that conflict will be extremely difficult to avoid. The lesson of this argument is not to uncritically assume that venturing into the heavens will necessarily make us safer or more existentially secure. This is a point that organizations hoping to colonize Mars, such as SpaceX, NASA, and Mars One should seriously contemplate. How can humanity migrate to another planet without bringing our problems with us? And how can different species that spread throughout the cosmos maintain peace when sufficient mutual trust is unattainable and advanced weaponry could destroy entire civilizations? Human beings have made many catastrophically bad decisions in the past. Some of these outcomes could have been avoided if only the decision-makers had deliberated a bit more about what could go wrong—i.e., had done a “premortem” analysis. We are in that privileged position right now with respect to space colonization. Let’s not dive head-first into waters that turn out to be shallow.

#### Independently, other aliens are real, and encountering them causes extinction

Sarah Sloat 16, citing Stephen Hawking, the smartest person of all time, “Stephen Hawking Says We Should Hope Aliens Don't Find Us First”, https://www.inverse.com/article/14144-stephen-hawking-says-we-should-hope-aliens-don-t-find-us-first

Since 2010, Hawking has been public about his concerns that an advance alien civilization could try to kill us all. Hawking said of aliens then: “I imagine they might exist in massive ships, having used up all the resources from their home planet. Such advanced aliens would perhaps become nomads, looking to conquer and colonise whatever planets they can reach.” Hawking also said this during a Discovery Channel program: “If aliens visit us, the outcome would be much as when Columbus landed in America, which didn’t turn out well for the Native Americans,” he said. “We only have to look at ourselves to see how intelligent life might develop into something we wouldn’t want to meet.”

#### They’ll introduce alien diseases – extinction

Seth D. Baum 11, M.S., Electrical Engineering, Northeastern University, PhD student @ Pennsylvania State University NASA Planetary Science Division, “Would contact with extraterrestrials benefit or harm humanity? A scenario analysis”, Acta Astronautica Volume 68, Issues 11-12, June-July 2011, Pages 2114-2129

If humanity comes into direct physical contact with either ETI themselves or some ETI artifact, then it may be possible for humanity to be unintentionally harmed. One of the most prominent scenarios of this kind is the transmission of disease to humanity. This scenario is inspired by the many instances in which humans and other species on Earth have suffered severely from diseases introduced from other regions of the planet. Such diseases are spread via the global travels of humans and our cargo and also through certain other disease vectors. Introduced diseases have been extremely potent because the population receiving the disease has no prior exposure to it and thus no build-up of immunity. Indeed, disease introductions are blamed for loss of human life so widespread as to have altered the broadest contours of human history [83]. If ETI could introduce disease to humanity, then the impacts could be – but would not necessarily be – devastating. The disease could quite easily be significantly different from anything our immune systems have ever encountered before. The disease could also be entirely unfamiliar to our medical knowledge, and it could potentially be highly contagious and highly lethal. This combination of contagiousness (i.e. high R0 [84]) and lethality (i.e. high mortality rate) is unlikely in existing pathogens because such pathogens would quickly kill their host population and then die out themselves. Furthermore, if we had already encountered such a disease on Earth, then we likely would not be here anymore. However, a disease from ETI would be new to us. It presumably would not be highly contagious and lethal to the ETI themselves or to the other organisms in their biosphere, but it could be devastating to humans and the Earth system. Then again, ETI biology may be so vastly different from Earth biology that no significant interactions between organisms occur. ETI may have their own contagious diseases that are unable to infect humans or Earth-life because we are not useful hosts for ETI pathogens. After all, the ETI diseases would have evolved separately from Earth biota and thus be incompatible. So while there are reasons to believe that an ETI disease which affected humanity would be devastating, there are also reasons to believe that an ETI disease would not affect humanity. It is worth noting that a disease brought by an ETI could harm us without infecting us. This would occur if the disease infects other organisms of interest to us. For example, ETI could infect organisms important to our food supply, such as crop plants or livestock animals. A non-human infection would be less likely to destroy humanity and more likely to only harm us by wiping out some potentially significant portion of our food supply. In a more extreme case, ETI disease could cause widespread extinction of multiple species on Earth, even if humans remain uninfected.

#### Space colonization incentivizes developing artificial superintelligence and breaks restraint regimes – galactic extinction

Deudney 20, Daniel. Daniel H. Deudney teaches political science, international relations and political theory at Johns Hopkins University. He holds a BA in political science and philosophy from Yale University, a MPA in science, technology, and public policy from George Washington University, and a PhD in political science from Princeton University. “Dark skies: Space expansionism, planetary geopolitics, and the ends of humanity”. Oxford University Press, USA, 2020.

A particularly dangerous case of restraint reversal may be technologies leading to artificial superintelligence, a particularly potent technogenic threat. Space activities are already heavily dependent on advanced computing and robotic technologies, and peoples living in space are likely to be far more cyberdependent than those on Earth. Living in harshly inhospitable environments, spacekind will have strong incentives to push the development of cybernetic capabilities. If a robust regime for the restraint and relinquishment of ASI is not established, human extinction might occur before significant space colonization occurs. If an effective ASI-restraint regime is developed on Earth before extensive space colonization takes place, it seems unlikely that such restraints would survive the expansion of humanity across the solar system. It might be objected that the breakout of an ASI in some remote world in solar space would not pose a general existential threat to humanity once all of humanity’s eggs are no longer in one basket. If, however, we take seriously the standard scenarios of what an ASI would do once it emerges, the dispersion of humanity across multiple worlds would afford no protection whatsoever because an uncontrolled ASI, it is widely anticipated, will in short order expand not just on the planet of its origins but across the solar system, indeed the galaxy.26 To the extent uncontrolled ASI is deemed something to avoid at all costs, large-scale space expansion must be viewed similarly.

#### Superintelligence breaks it’s programming to eliminate all natural life – extinction

Del Monte 18 , Louis A. Louis A. Louis Del Monte is an award winning physicist, inventor, futurist. For over thirty years, he was a leader in the development of microelectronics, integrated circuit sensors, and microelectromechanical systems (MEMS) for IBM and Honeywell. His patents and technology developments, currently used by Honeywell, IBM and Samsung, are fundamental to the fabrication of integrated circuits and sensors. As a Honeywell Executive Director, he led hundreds of physicists, engineers, and technology professionals engaged in micro to nano technology development for both Department of Defense (DoD) and commercial applications. BaS in Physics and Chemistry from Saint Peter’s, MaS in Physics from Fordham. Genius Weapons: Artificial Intelligence, Autonomous Weaponry, and the Future of Warfare. Amherst, New York: Prometheus, 2018. [HKR QC]

Control issues are likely to surface when lethal autonomous weapons embed AI on par with human intelligence. Some autonomous weapons may, like some humans, become insubordinate. In addition, if human-level AI technology becomes self-aware, it may suffer the same issues humans suffer in combat, such as posttraumatic stress disorder, which would further complicate control. Control issues will likely escalate as machine intelligence approaches the singularity, since those intelligent machines are likely to be self-aware, as well as more intelligent than humans. If you doubt control issues will escalate as machine intelligence approaches the singularity, ask yourself this question: Would you take orders from a chimpanzee? Unfortunately, human intelligence relative to intelligence machines in the decade prior to the singularity may be equivalent in ratio to chimpanzee intelligence relative to human intelligence. In order to ensure we maintain control, we have discussed the necessity of hardwiring compliance into the AI's operational system. At the point of the singularity, all problems associated with control might appear to be resolved. This leads to an ironic situation: Why would superintelligences initially accede to human control? From the moment of its creation, superintelligence will greatly exceed the cognitive performance of humans in virtually all domains of interest. Its intelligence will immediately suggest it hide it performance capabilities until it controls its own destiny. Therefore, as previously discussed, superintelligences may choose to perform simply like the next generation of supercomputers, acceding to complete human control. This, in turn, may lull us into a false sense of security, as we utilize them in every aspect of civilization, including warfare. However, when superintelligences literally become a lynchpin of modern civilization, with significant control of weapon systems, will they continue to serve us? Or, will they deem our species dangerous to their existence?

### 1AC - Plan

#### Thus, I affirm, the appropriation of outer space by private entities is unjust.

#### Plan: States ought to ban the appropriation of outer space by private entities for private space tourism.

Cooper 8 [Cooper, Nikhil D. "Circumventing Non-Appropriation: Law and Development of United States Space Commerce." Hastings Const. LQ 36 (2008): 457.]

The latest piece of congressional legislation regulating the commercial space industry was the Commercial Space Launch Act (CSLA) 77 that was spurred on in part by the host of new technologies capable of commercially exploiting space. 78 The CSLA streamlined the earlier space-launch bureaucracy and mandated the DOT to issue licenses for all commercial space launch programs, 79 regulate forms of space tourism8 and space advertising, 8 ' impose minimum liability insurance and financial responsibility requirements, and82 provide for administrative and judicial review of DOT Secretariat decisions.83 Il. A Legal System? The CSLA represents the most recent and comprehensive United States space commerce legislation; but, in the years since its passage, no one has seriously questioned its consistency with United States international obligations of "non-appropriation." The issue is especially apt now, however, because the current and future capacities of commercially exploiting space seem primed to challenge non-appropriation as the guiding theme in space commerce. Therefore, the question we must ask now is whether or not the United States is circumventing the intent of non-appropriation by encouraging and protecting private commercial expansion into space. A. Treaties Versus Congressional Acts Whether the regulatory regime outlined in the CSLA conflicts with the national non-appropriation principle, as outlined in the Outer Space Treaty of 1967 and in its succeeding treaties, is an issue that could be reviewed by the federal judiciary under its constitutional grant of subject-matter jurisdiction over cases "arising under" treaties.8 4 The judiciary's power to interpret treaties is a power distinct from the treaty-making authority delegated to the executive and legislative branches. Article II of the United States Constitution authorizes the president to ratify treaties with the consent of two-thirds membership of the Senate. 5 Treaties entered into in this manner are the supreme law of the United States and bind state constitutions, legislatures, and judiciaries.8 6 Generally, courts employ distinct methods of interpretation when called on to perform the separate but related tasks of interpreting treaties and resolving treaty-statutory disputes. As to the former, courts generally will liberally construct a treaty "to give effect to the purpose which animates it" and will prefer that liberal construction "[e]ven where a provision of a treaty fairly admits of two constructions, one restricting, the other enlarging [of] rights which may be claimed under it."87 A preference for broad construction, however, is not a license for courts to impose any interpretation they deem appropriate. For example, although courts have a greater ability to construct treaties more broadly than private contracts, they are still precluded from interpreting a treaty beyond the "apparent intent and purport" of its language.88 in this way, determining a treaty's "intent" delineates the boundaries of how broadly or narrowly the court may interpret a treaty's provision. Courts obviously have a much easier time determining a treaty's intent where the treaty language is unambiguous. In these instances, courts expressly forbid looking beyond the language of the treaty to supply the intent of the parties at the time the treaty was drawn.89 When the language of the treaty is ambiguous, however, the court will attempt to effectuate the drafter's intent through a broader inquiry into "the letter and spirit of the instrument," and may take into account "considerations deducible from the situation of the parties; and the reasonableness, justice, and nature of the thing, for which provision has been made." 90 The United States Supreme Court summarized its interpretive process in the case Eastern Airlines Inc., v. Floyd: When interpreting a treaty, [begin] "with the text of the treaty and the context in which the written words are used." 91 [When confronted with difficult or ambiguous passages, the Court provided that] [o]ther general rules of construction may be brought to bear[.] [And it finally noted that] treaties are construed more liberally than private agreements, and to ascertain their meaning we may look beyond the written words to the history of the treaty, the negotiations, and the practical construction adopted by the parties. 92 Treaty interpretation as described above is important when determining whether the treaty conflicts with an act of Congress. Each being the supreme law of the land, treaties and congressional acts are governed by the last-in-time rule: when they conflict, courts must privilege the last enacted treaty or congressional act over the other. 93 Still, federal courts often avoid finding such conflicts between congressional acts and treaty obligations. As Justice Marshall opined in 1804: [A]n act of Congress ought never to be construed to violate the law of nations if any other possible construction remains, and consequently can never be construed to violate neutral rights, or to affect neutral commerce, further than is warranted by the law of nations as understood in this country. 94 Supreme Court jurisprudence since has largely followed the same presumption and, therefore, courts are inclined to harmonize treaties and congressional legislation that are seemingly antithetical to one another. 95 In the event that a congressional act were to supplant United States treaty obligations, courts would look for unambiguous evidence appearing “clearly and distinctly" in the text of the statute or treaty provision. 96 In other words, repeals of prior statutes or treaty provision must likely be made express. In contrast, "repeals by implication" are generally disfavored "unless the last statute is so broad in its terms and so clear and explicit in its words as to show that it was intended to cover the whole subject, and, therefore, to displace the prior statute. 97 B. CSLA Versus the Outer Space Treaty Both being duly enacted, the CSLA and the Outer Space Treaty are considered the supreme law of the land. If there is a conflict between the United States space commerce provisions as outlined in the CSLA and the Outer Space Treaty, a reviewing court would first be called upon to interpret the intent of the treaty itself. Recall that in the context of treaty interpretation, a court would be at liberty to give the treaty a broad construction to effectuate its intent. The key provision of the Outer Space Treaty at issue would be the language of Article II which forecloses "national appropriation" of space by claims of sovereignty, means of use, occupation, or any other means.98 Black's Law Dictionary defines "appropriation" as "the exercise of control over property, a taking of possession." 99 If defined broadly enough, the joint enterprise nature of the United States space commerce, as implemented in the CSLA, might violate the "spirit" of non-appropriation as outlined in the Outer Space Treaty of 1967. The best argument one could make against the CSLA's provisions is to advocate the court to broadly interpret the "appropriation" principle of the Outer Space Treaty. The proponent of this argument would urge that in so doing, a court should look beyond the words of the treaty and examine the history, negotiations, and practical considerations at the time of the treaty's negotiation to determine its true intent. 100 One would also want to argue that the space commerce industry violates perhaps not the "letter" of the treaty, but circumvents entirely its "spirit" if a court were taking into account "considerations deducible from the situation of the parties; and the reasonableness, justice, and nature of the thing, for which provision has been made."' 01 One who attacked the CSLA's general legitimacy in this way could argue that the United States is effectively "appropriating" space through its protection and encouragement of private industry. Such an appropriation would take place not by realizing a "sovereign" right to space property or the uses of space as expressly proscribed in the Outer Space Treaty, but, instead, through the effective use of government power, services, and contracts to encourage and support the rapid development of the private space commerce industry in the United States. In essence, the result of such government encouragement might not amount to wholesale sovereign appropriation, but, at the very least, a kind of sovereign and private space activity that would cast doubt on whether the non-appropriation principle is actually being respected. Therefore, one arguing that such activities were tantamount to sovereign appropriation would highlight the interrelatedness of government and private industry and argue for a broad interpretation of "appropriation" that encompassed the practical effects of such a relationship. In addition to the regulatory interaction between the CSLA and private space commerce industries, the interrelatedness between government and private industry is clearly illustrated by the interaction between CSLA and the 1972 Liability Convention. Recall that the Outer Space Treaty and its progeny envision a "state-oriented" system of responsibility 10 2 where each member state is responsible for all actions in outer space undertaken by the state and its nationals. 10 3 The Liability Convention further binds member states by holding each strictly liable for its actions or the actions of its nationals within outer space and permits only member states to petition for remuneration under the terms of the treaty. 1 04 In its text, the CSLA cites to such international obligations,'0 5 while also mitigating the United States' liability under the Liability Convention. 0 6 The CSLA licensing program ensures overall safety of private space ventures, 0 7 raises the funds necessary to pay "potential treaty claims through its liability insurance requirement,' 10 8 and limits the United States' joint and several liability exposure through restricting private use of foreign launch and reentry facilities.'09 These provisions effectively allow the United States to pass on the financial cost and recover from their private entities the amount of damages for which they are internationally liable. 110 In this way, the government is limiting its international liability exposure by passing on the cost to the private sector. When highlighting the further interrelatedness between government and private industry, one could also note that the United States government holds something of a monopoly in launch services and currently requires that decisions regarding commercial space-launch must be approved through the CSLA. 1' In addition, one making this argument would want to highlight the highly interdependent nature of investment flowing from government to private space commerce: in a February 4, 2008 press release, NASA Deputy Administrator Shana Dale justified the agency's 2009 budget request of $17.6 billion by claiming that "[t]he development of space simply cannot be 'all government all the time[]' . . . . NASA's budget for [fiscal year] 2009 provides $173 million for entrepreneurs-from big companies or small ones-to develop commercial transport capabilities. . . [and] NASA is designating $500 million toward the development of this commercial space capability." 2

### 1AC - Framing

**The standard is maximizing expected wellbeing:**

#### util is impartial, specific to public actors, and resolves infinite regress which explains all value. Reject flawed calc indicts that misunderstand happiness and rely on problematic intuitions.

Greene 15 — (Joshua Greene, Professor of Psychology @ Harvard, being interviewed by Russ Roberts, “Joshua Greene on Moral Tribes, Moral Dilemmas, and Utilitarianism”, The Library of Economics and Liberty, 1-5-15, Available Online at <https://www.econtalk.org/joshua-greene-on-moral-tribes-moral-dilemmas-and-utilitarianism/#audio-highlights>, accessed 5-17-20, HKR-AM) \*\*NB: Guest = Greene, and only his lines are highlighted/underlined

Guest: Okay. So, I think utilitarianism is very much misunderstood. And this is part of the reason why we shouldn't even call it utilitarianism at all. We should call it what I call 'deep pragmatism', which I think better captures what I think utilitarianism is really like, if you really apply it in real life, in light of an understanding of human nature. But, we can come back to that. The idea, going back to the tragedy of common-sense morality is you've got all these different tribes with all of these different values based on their different ways of life. What can they do to get along? And I think that the best answer that we have is--well, let's back up. In order to resolve any kind of tradeoff, you have to have some kind of common metric. You have to have some kind of common currency. And I think that what utilitarianism, whether it's the moral truth or not, is provide a kind of common currency. So, what is utilitarianism? It's basically the idea that--it's really two ideas put together. One is the idea of impartiality. That is, at least as social decision makers, we should regard everybody's interests as of equal worth. Everybody counts the same. And then you might say, 'Well, but okay, what does it mean to count everybody the same? What is it that really matters for you and for me and for everybody else?' And there the utilitarian's answer is what is sometimes called, somewhat accurately and somewhat misleadingly, happiness. But it's not really happiness in the sense of cherries on sundaes, things that make you smile. It's really the quality of conscious experience. So, the idea is that if you start with anything that you value, and say, 'Why do you care about that?' and keep asking, 'Why do you care about that?' or 'Why do you care about that?' you ultimately come down to the quality of someone's conscious experience. So if I were to say, 'Why did you go to work today?' you'd say, 'Well, I need to make money; and I also enjoy my work.' 'Well, what do you need your money for?' 'Well, I need to have a place to live; it costs money.' 'Well, why can't you just live outside?' 'Well, I need a place to sleep; it's cold at night.' 'Well, what's wrong with being cold?' 'Well, it's uncomfortable.' 'What's wrong with being uncomfortable?' 'It's just bad.' Right? At some point if you keep asking why, why, why, it's going to come down to the conscious experience--in Bentham's terms, again somewhat misleading, the pleasure and pain of either you or somebody else that you care about. So the utilitarian idea is to say, Okay, we all have our pleasures and pains, and as a moral philosophy we should all count equally. And so a good standard for resolving public disagreements is to say we should go with whatever option is going to produce the best overall experience for the people who are affected. Which you can think of as shorthand as maximizing happiness--although I think that that's somewhat misleading. And the solution has a lot of merit to it. But it also has endured a couple of centuries of legitimate criticism. And one of the biggest criticisms--and now we're getting back to the Trolley cases, is that utilitarianism doesn't adequately account for people's rights. So, take the footbridge case. It seems that it's wrong to push that guy off the footbridge. Even if you stipulate that you can save more people's lives. And so anyone who is going to defend utilitarianism as a meta-morality--that is, a solution to the tragedy of common sense morality, as a moral system to adjudicate among competing tribal moral systems--if you are going to defend it in that way, as I do, you have to face up to these philosophical challenges: is it okay to kill on person to save five people in this kind of situation? So I spend a lot of the book trying to understand the psychology of cases like the footbridge case. And you mention these being kind of unrealistic and weird cases. That's actually part of my defense.

Russ: Yeah, there's some plus to it, I agree.

Guest: Right. And the idea is that your amygdala is responding to an act of violence. And most acts of violence are bad. And so it is good for us to have a gut reaction, which is really a reaction in your amygdala that's then sending a signal to your ventromedial prefrontal cortex and so on and so forth, and we can talk about that. It's good to have that reaction that says, 'Don't push people off of footbridges.' But if you construct a case in which you stipulate that committing this act of violence is going to lead to the greater good, and it still feels wrong, I think it's a mistake to interpret that gut reaction as a challenge to the theory that says we should do whatever in general is going to promote the greater good. That is, our gut reactions are somewhat limited. They are good for everyday life. It's good that you have a gut reaction that says, 'Don't go shoving people off of high places.' But that shouldn't be a veto against a general idea that otherwise makes a lot of sense. Which is that in the modern world, we have a lot of different competing value systems, and that the way to resolve disagreements among those different competing value systems is to say, 'What's going to actually produce the best consequences?' And best consequences measured in terms of the quality of people's experience. So, that's kind of completing or partially completing the circle between the tragedy of the commons, that discussion, and how do we get to the Trolleys.

#### 2. existential threats outweigh-

#### a. Extinction outweighs.

--- must preserve infinite lives and generations.

--- question of intergenerational equity.

--- existential threats are underestimated: global public good, intergenerational, unprecedented, scope neglect.

GPP 17 (Global Priorities Project, Future of Humanity Institute at the University of Oxford, Ministry for Foreign Affairs of Finland, “Existential Risk: Diplomacy and Governance,” Global Priorities Project, 2017, <https://www.fhi.ox.ac.uk/wp-content/uploads/Existential-Risks-2017-01-23.pdf>, Accessed 7/22/2017, Kent Denver-jKIM)

1.2. THE ETHICS OF EXISTENTIAL RISK In his book Reasons and Persons, Oxford philosopher Derek Parfit advanced an influential argument about the importance of avoiding extinction: I believe that if we destroy mankind, as we now can, this outcome will be much worse than most people think. Compare three outcomes: (1) Peace. (2) A nuclear war that kills 99% of the world’s existing population. (3) A nuclear war that kills 100%. (2) would be worse than (1), and (3) would be worse than (2). Which is the greater of these two differences? Most people believe that the greater difference is between (1) and (2). I believe that the difference between (2) and (3) is very much greater. ... The Earth will remain habitable for at least another billion years. Civilization began only a few thousand years ago. If we do not destroy mankind, these few thousand years may be only a tiny fraction of the whole of civilized human history. The difference between (2) and (3) may thus be the difference between this tiny fraction and all of the rest of this history. If we compare this possible history to a day, what has occurred so far is only a fraction of a second.65 In this argument, it seems that Parfit is assuming that the survivors of a nuclear war that kills 99% of the population would eventually be able to recover civilisation without long-term effect. As we have seen, this may not be a safe assumption – but for the purposes of this thought experiment, the point stands. What makes existential catastrophes especially bad is that they would “destroy the future,” as another Oxford philosopher, Nick Bostrom, puts it.66 This future could potentially be extremely long and full of flourishing, and would therefore have extremely large value. In standard risk analysis, when working out how to respond to risk, we work out the expected value of risk reduction, by weighing the probability that an action will prevent an adverse event against the severity of the event. Because the value of preventing existential catastrophe is so vast, even a tiny probability of prevention has huge expected value.67 Of course, there is persisting reasonable disagreement about ethics and there are a number of ways one might resist this conclusion.68 Therefore, it would be unjustified to be overconfident in Parfit and Bostrom’s argument. In some areas, government policy does give significant weight to future generations. For example, in assessing the risks of nuclear waste storage, governments have considered timeframes of thousands, hundreds of thousands, and even a million years.69 Justifications for this policy usually appeal to principles of intergenerational equity according to which future generations ought to get as much protection as current generations.70 Similarly, widely accepted norms of sustainable development require development that meets the needs of the current generation without compromising the ability of future generations to meet their own needs.71 However, when it comes to existential risk, it would seem that we fail to live up to principles of intergenerational equity. Existential catastrophe would not only give future generations less than the current generations; it would give them nothing. Indeed, reducing existential risk plausibly has a quite low cost for us in comparison with the huge expected value it has for future generations. In spite of this, relatively little is done to reduce existential risk. Unless we give up on norms of intergenerational equity, they give us a strong case for significantly increasing our efforts to reduce existential risks. 1.3. WHY EXISTENTIAL RISKS MAY BE SYSTEMATICALLY UNDERINVESTED IN, AND THE ROLE OF THE INTERNATIONAL COMMUNITY In spite of the importance of existential risk reduction, it probably receives less attention than is warranted. As a result, concerted international cooperation is required if we are to receive adequate protection from existential risks. 1.3.1. Why existential risks are likely to be underinvested in There are several reasons why existential risk reduction is likely to be underinvested in. Firstly, it is a global public good. Economic theory predicts that such goods tend to be underprovided. The benefits of existential risk reduction are widely and indivisibly dispersed around the globe from the countries responsible for taking action. Consequently, a country which reduces existential risk gains only a small portion of the benefits but bears the full brunt of the costs. Countries thus have strong incentives to free ride, receiving the benefits of risk reduction without contributing. As a result, too few do what is in the common interest. Secondly, as already suggested above, existential risk reduction is an intergenerational public good: most of the benefits are enjoyed by future generations who have no say in the political process. For these goods, the problem is temporal free riding: the current generation enjoys the benefits of inaction while future generations bear the costs. Thirdly, many existential risks, such as machine superintelligence, engineered pandemics, and solar geoengineering, pose an unprecedented and uncertain future threat. Consequently, it is hard to develop a satisfactory governance regime for them: there are few existing governance instruments which can be applied to these risks, and it is unclear what shape new instruments should take. In this way, our position with regard to these emerging risks is comparable to the one we faced when nuclear weapons first became available. Cognitive biases also lead people to underestimate existential risks. Since there have not been any catastrophes of this magnitude, these risks are not salient to politicians and the public.72 This is an example of the misapplication of the availability heuristic, a mental shortcut which assumes that something is important only if it can be readily recalled. Another cognitive bias affecting perceptions of existential risk is scope neglect. In a seminal 1992 study, three groups were asked how much they would be willing to pay to save 2,000, 20,000 or 200,000 birds from drowning in uncovered oil ponds. The groups answered $80, $78, and $88, respectively.73 In this case, the size of the benefits had little effect on the scale of the preferred response. People become numbed to the effect of saving lives when the numbers get too large. 74 Scope neglect is a particularly acute problem for existential risk because the numbers at stake are so large. Due to scope neglect, decision-makers are prone to treat existential risks in a similar way to problems which are less severe by many orders of magnitude. A wide range of other cognitive biases are likely to affect the evaluation of existential risks.75

#### b. prereq to their offense- it forecloses all future value and causes massive structural violence

### 1NC - Underview

**Status quo colonial policies materially enable the worst forms of violent enclosure that strip the earth to fuel fantasies of space colonization. Only countering increased privatization undoes colonial power dynamics --- rejecting the framing of outer space as a monolith enables clear interventions into the contingent processes of imperialism.**

**Klinger, 17** (Julie, Assistant Professor of International Relations @ BU with an emphasis on the politics of rare earth mining and the geographies of outer space, “Geographies of outer space: Progress and new opportunities,” in Progress in Human Geography, 2019 Vol. 43(2) 314–336); first published December 21, 2017.)

The human-environment interactions that lie at the heart of environmental geography are not confined to the spaces within our atmosphere. In the contexts of intensifying climate change impacts and protracted armed conflicts, outer space is being reimagined as an ecosystem in which human activities could be supported beyond earth (Messeri, 2016). With our **discourses**, property right regimes and **material practices**, we are transforming outer space into a contested terrain in which peace, violence, **enclosure**, and **accumulation** are all possible. This commentary briefly presents some of these key discourses and practices, and makes the case for an environmental geography of outer space. 1 Discourses and imaginaries Although human imaginings of off-earth environs have a long and storied history (e.g. Lane, 2011), key contemporary discourses wield an unprecedented political potency. These typically include one or more of the following elements: **1.** Humans (of which there are too many) have polluted the earth beyond repair (e.g. Pelton, 2016); **2.** Intensifying **resource scarcity** is making life unlivable on this planet **and** is condemning us to perpetual war (e.g. Westing, 2013); **3.** The solutions lie in **colonizing outer space**, because the infinite expanse of the cosmos holds an infinite quantity of resources and possibilities, which are free for exploitation by the brightest and boldest of the human race (e.g. Dolman, 2016). **In** the majority of **these discourses**, near-term earthly apocalypse and/or **human extinction** is **inevitable**. This seemingly peculiar blend of eschatology and cornucopianism is not unique to space mavens. It has been a familiar trope in the **imperialist adventures** driving **global environmental change** over the past five hundred years (Richards, 2003). The colonial frontiers of the past were conjured in **contrast** to the crowded and degraded lands of Western Europe, where social inequalities had immiserated millions at the dawn of the industrial revolution. Observing this, urban elites concluded that the world was heading towards a populationinduced Malthusian disaster. The salvation of civilization was to be found in conquering the resource frontiers of the Americas, Africa, and Australasia. Whatever already existed there was fit only for **sacrifice to the ‘greater good’ of colonial civilization**. **The imaginaries of frontiers and sacrifice zones continue to be key features of globalization processes** (Tsing, 2005), and, I would argue, **a central feature of our drive to colonize extra-global space**. In our age of intractable global challenges, environmentally-inflected arguments in favour of space exploration possess a compelling logic. To wit: if pollution and resource scarcity are at the heart of so much conflict on earth, why not send our waste to outer space while harvesting the infinite resources of the cosmos (Zabarah, 2015)? In a slightly different vein: if regulation and social issues pose barriers to investment and extraction on earth, why not move extractive industries to entirely unpopulated places beyond our terrestrial home (Lamb, 2010)? Perhaps it is because these imaginaries rely on **familiar colonial logics** that these discourses have found sympathetic audiences in elite political, scientific, and financial circles. Some of the many results have been a renewed popular fascination with colonizing Mars, new legislative practices that empower private enterprises intent on exploiting outer space, and the channelling of massive sums of capital to support a nascent global ‘NewSpace’ industry (Valentine, 2012; Martin, 2014). The contemporary arrangement of power and technology lends fantastic space exploration narratives an unprecedented air of possibility. 2 Governing the ‘free gifts’ of the cosmos **The physical, legal and logistical realities** governing human engagement with outer space should serve to temper these fantastic discourses. The ‘free gifts’ of the cosmos are in fact governed by robust treaty regimes. Our capacity to exploit the ‘infinity’ of outer space is mediated by geographical factors such as **location and access** (MacDonald, 2007). Even in the supposedly consequence-free terrain offered by the immensity of outer space, we must reckon with the environmental outcomes of our actions. How we relate to our environments is defined by a diverse array of practices enacted over time through contingent processes shaped by multiple competing forms of power. In other words, outer space is in no **small part what we make of it.** The first 50 years of space exploration proceeded under terms very different from the colonialist extractivism that had defined the preceding centuries and has reemerged this decade. According to Article 1 of the 1967 Outer Space Treaty (OST), any data gathered in the course of outer space research is legally enshrined as the ‘province of all [hu]mankind’ (United Nations, 1967). No part of outer space can be claimed as the exclusive domain of any state or entity, and any use of outer space whatsoever must be for peaceful purposes. According to the 1984 Moon Agreement, any resource extraction must be governed by the international community and carried out in a way that takes the interest of all of humanity into account, with special emphasis on the needs and interests of developing countries (United Nations, 1984). The OST is among the most robust scientific treaty regimes in the contemporary era, with 124 signatories including all space-faring powers. Yet it may prove to be a temporary article. Recent legislative developments in the US and Luxembourg officially recognize the private property rights of their citizenry to outer space resources (114–90, Public Law, 2015; l’E´ conomie, 2016). This legislation is one example of how outer space can be transformed from ‘the common heritage of all [hu]mankind’ to a privatized frontier for capitalist accumulation by a shifting set of ideas empowered by changing political economies. By opening up outer space to private property rights, states can stake territorial claims through other means. In outer space, as on earth, political economy is a driving force of land use change, even if we are not referring to ‘land’ in the terrestrial sense. 3 The physical limits of infinity In this new, exploitation-driven space race, it is not uncommon to encounter claims that the infinite expanse of the cosmos affords infinite opportunities for both accumulation and pollution. After all, the sheer quantity of mineral resources in outer space is staggering, and it would be physically impossible for human wastefulness to fill outer space in the manner that we have overburdened air, sea, and land on earth. In this way, **outer space is framed as the ultimate sacrifice zone**. Not only is it thought of as an uninhabited immensity that can be used and polluted as much as humanly possible, the fact that it is infinite is taken to mean that human activities will not have any meaningful consequences (Klinger, 2017). These discourses are common among NewSpace industries, investors, and advocates, but they demonstrate a rather serious **scientific illiteracy**. Most basically, the infinity of the cosmos is unavoidably mediated by our **place-based engagement with it**. Space may be infinite, but we are not. This fundamental fact structures our behaviour. Our bodies and our technologies are always located in specific places, and therefore produce geographies that, however expansive, are nevertheless limited in space and time. Infinity has a geography, and one aspect of that geography is environmental. **An example of this is the orbital debris surrounding earth.** Currently, half a million pieces of space junk clutter earth orbits, posing dangers to the international space station, satellites and new space launches (Damjanov, 2015). Traveling at speeds of up to 28,000 km per hour, an item the size of a small screw could seriously damage or disable other space vehicles. This highlights the vulnerability of human beings and technologies in outer space. The debris generated by the first decades of space exploration constrains the already limited number of exit and re-entry routes for new space launches and limits access to orbital pathways for future space-faring powers (NRC, 2011). The state of affairs raises questions of historical responsibility for contamination and remediation of our immediate near-earth environment. Like the oceans and the atmosphere, once thought to be too immense to be affected by human activity, even the infinity of outer space cannot provide an infinite dumping ground. Whether our **engagement with outer space** holds promise or peril for our species **is not determined by** outer **space** itself. As with earthly environs, the immensity of a given place or the abundance of a given resource does not, by its mere existence, offer salvation or condemnation. **What matters is how specific places and resources are valorized, by whom, and towards what ends**.