# 1AC vs Sage MP

## FW

#### The standard is maximizing expected wellbeing.

#### 1] Humans are hard-coded to follow pleasure and pain, comes before other ethics

Berridge et al 13 [Kent C Berridge, Morten L Kringelbach “*Neuroscience of affect: brain mechanisms of pleasure and displeasure*” Published: Current Opinion in Neurobiology, Vol. 23, Issue 3, June 2013] [<https://doi.org/10.1016/j.conb.2013.01.017>; Pg. 298-300] [PDF available upon request] [Berridge: James Olds Distinguished University Professor of Psychology and Neuroscience at University of Michigan. Ph.D. University of Pennsylvania] [Kringelbach: Professor of Neuroscience, Aarhus University. Senior Research Fellow, The Queen's College.] || SM

Subcortical brain machinery for actually generating or causing a ‘liking’ reaction to core pleasure can be probed more extensively via brain manipulations in animals. Studies in our laboratory have identified neural pleasure generators by focusing on the sensory pleasure of sweetness. Sweet ‘liking’ is useful because affective facial expressions of taste pleasure ‘liking’ exist in newborn humans and in some animals, aiding the objective measure of hedonic impact. For example, parents often know when their baby expresses a ‘liking’ judgment of the deliciousness of a meal. Sweet foods elicit a contented licking of the lips, but bitter tastes instead elicit disgust gapes and headshakes. Homologous ‘liking’ orofacial expressions are elicited also in apes and monkeys, and even in rats and mice [47]. We have used brain manipulations of ‘liking’ reactions to identify brain mechanisms that generate and enhance such pleasures as sweetness (Figure 3). One surprising finding has been that neural generators of intense pleasure are much more restricted neurochemically than was previously envisioned. For instance, mesolimbic dopamine, probably the most popular brain neurotransmitter candidate for pleasure two decades ago, turns out not to cause pleasure or ‘liking’ at all. Rather dopamine more selectively mediates a motivational process of incentive salience, which is a mechanism for ‘wanting’ rewards but not for ‘liking’ them. When amplified by addictive drugs or by endogenous factors, dopamine helps generate intense levels of ‘wanting’, characteristic of drug addiction, eating disorders, and related compulsive pursuits. Why, then, are dopamine-promoting drugs such as cocaine or methamphetamine reportedly so pleasant? One possibility is that some psychostimulant euphoria comes from the ‘wanting’ component of reward: a world that seems more attractive may well carry an aura of euphoria. Another potential mechanism is that, distinct from raising dopamine in the synapse, such drugs might also induce secondary recruitment of additional neurobiological mechanisms that more directly cause hedonic pleasure. For instance, there is evidence to suggest that elevation of endogenous opioid signals may be recruited in limbic structure [62,63]. Such opioid recruitment in accumbens-pallidal hotspots described below would plausibly generate pleasure ‘liking’ [64]. Conceivably, the secondary recruitment of hedonic mechanisms might become somewhat sluggish with continual drug-taking, therefore requiring higher doses for the sought-after pleasurable high, even if dopamine-related sensitization enhanced circuit reactivity to produce more and more intense ‘wanting’ [60]. Hedonic hotspot network Another surprising finding has been that pleasures generators are much more anatomically restricted than previously envisioned, localized to particular subregions. We have identified several pleasure generators as small hedonic hotspots, nestled in subcortical structures. Opioid and endocannabinoid neurochemical signals do more effectively generate intense pleasures than dopamine — but only within the boundaries of such hotspots. For example, mu opioid stimulation by DAMGO microinjection within a hotspot of NAc (localized in the rostrodorsal quadrant of medial shell), or in another hotspot of ventral pallidum (in the posterior half of ventral pallidum), more than doubles the intensity of ‘liking’ reactions elicited by sweetness. But the same DAMGO microinjections elsewhere in the remaining 90% of NAc outside the hotspot generate only ‘wanting’ without enhancing ‘liking’ — much like dopamine (i.e. remaining 60% of medial shell and probably entire lateral shell and core; and even regions of dorsal striatum) (Figures 1 and 3). In addition, in the anterior half of ventral pallidum, DAMGO microinjection actually causes opposite suppression of ‘liking’ reactions. So far, no hedonic hotspots have yet been found in neocortex (though the search continues), but rather only in these subcortical structures. Continued failure to find a hedonic-enhancing hotspot in prefrontal cortex would be another reason to distinguish between cortical representation and subcortical causation of pleasure as different functions. Each accumbens-pallidum hotspot is only a cubic-millimeter in volume in rats (a human hotspot equivalent hould be approximately a cubic-centimeter, if scaled to whole-brain size). Functionally, hedonic hotspots seem quite specialized for intense pleasure generation compared to regions around them. Neurobiologically, hotspots may have unique anatomical or neurobiological features that distinguish them from the rest of their containing structure, and which perhaps permit the functional specialization for pleasure causation (Figure 1). Integrating neurochemical and anatomical findings, what makes opioid neurotransmitters more hedonic than dopamine is not that limbic opioid signals always generate ‘liking’. In most of NAc, neither does. Rather opioid stimulation has the special capacity to enhance ‘liking’ only if the stimulation occurs within an anatomical hotspot— whereas dopamine never does anywhere. Beyond NAc and ventral pallidum, opioid stimulation in all regions tested so far for other structures, such as neostriatum, amygdala, and so on, at best generate enhancement only of motivation ‘wanting’ without enhancing hedonic ‘liking’. Overall, the pattern indicates not only strong localization of hedonic function, but also neurochemical specificity of pleasure neurotransmitters. Functionally, hotspots in NAc and ventral pallidum interact together in a single integrated circuit. The two sites act as a functional unit for mediating pleasure enhancements. Each hotspot seems able to recruit the other to unanimously generate amplification of ‘liking’. For example, a single opioid microinjection into the NAc hotspot enhances also responsiveness of ventral pallidum hotspot neurons, reflected in neuronal firing patterns elicited by a sweet taste or in gene activation, at the same time as enhancing behavioral ‘liking’ reactions. Unanimous recruitment of both hotspots further appears to be required to magnify pleasure. Blocking either hotspot with an opioid-antagonist microinjection completely prevents opioid stimulation of the other hotspot from producing any ‘liking’ enhancement [72].Finally, the ventral pallidum hotspot may be especially important for maintaining normal levels of pleasure. Damage to ventral pallidum can cause even sweet sucrose taste to elicit purely negative gapes and other disgust reactions for days or weeks afterwards (C-Y Ho, ‘The ventral pallidum as a limbic pleasure generator, PhD Dissertation, Ann Arbor, University of Michigan, 2010) [8,73]. No other brain lesion of a single site so potently transforms sensory pleasure into purely negative affect. Of course, other brain structures do help generate intense aversive emotions when manipulated in other ways

#### 2] Life has a priori value achieved through pleasure.

Amien Kacou 8 WHY EVEN MIND? On The A Priori Value Of “Life”, Cosmos and History: The Journal of Natural and Social Philosophy, Vol 4, No 1-2 (2008) cosmosandhistory.org/index.php/journal/article/view/92/184

Furthermore, that manner of finding things good that is in pleasure can certainly not exist in any world without consciousness (i.e., without “life,” as we now understand the word)—slight analogies put aside. In fact, we can begin to develop a more sophisticated definition of the concept of “pleasure,” in the broadest possible sense of the word, as follows: it is the common psychological element in all psychological experience of goodness (be it in joy, admiration, or whatever else). In this sense, pleasure can always be pictured to “mediate” all awareness or perception or judgment of goodness: **there is pleasure in all consciousness** of things good; pleasure is the common element of all conscious satisfaction. In short, **it is simply the very experience of liking things**, or the liking of experience, in general. In this sense, pleasure is, not only uniquely characteristic of life but also, the core expression of goodness in life—the most general sign or phenomenon for favorable conscious valuation, in other words. This does not mean that “good” is absolutely synonymous with “pleasant”—what we value may well go beyond pleasure. (The fact that we value things needs not be reduced to the experience of liking things.) However, what we value beyond pleasure remains a matter of speculation or theory. Moreover, we note that a variety of things that may seem otherwise unrelated are correlated with pleasure—some more strongly than others. In other words, **there are many things the experience of which we like**. For example: the admiration of others; sex; or rock-paper-scissors. But, again, **what they are is irrelevant** in an inquiry on **a priori value**—what gives us pleasure is a matter for empirical investigation. Thus, we can see now that, in general, something primitively valuable is attainable in living—that is, pleasure itself. And it seems equally clear that we have a priori logical reason to pay attention to the world in any world where pleasure exists. Moreover, we can now also articulate a foundation for a security interest in our life: since the good of pleasure can be found in living (to the extent pleasure remains attainable),[17] and **only in living**, therefore, **a priori**, life ought to be **continuously (and indefinitely) pursued** at least for the sake of preserving the possibility of finding that good. However, this platitude about the value that can be found in life turns out to be, at this point, insufficient for our purposes. It seems to amount to very little more than recognizing that our subjective desire for life in and of itself shows that **life has some objective value**. For what difference is there between saying, “living is unique in benefiting something I value (namely, my pleasure); therefore, I should desire to go on living,” and saying, “I have a unique desire to go on living; therefore I should have a desire to go on living,” whereas the latter proposition immediately seems senseless? In other words, “life gives me pleasure,” says little more than, “I like life.” Thus, we seem to have arrived at the conclusion that the fact that we already have some (**subjective) desire for life** shows life to have some (**objective) value**. But, if that is the most we can say, then it seems our enterprise of justification was quite superficial, and the subjective/objective distinction was useless—for all we have really done is highlight the correspondence between value and desire. Perhaps, our inquiry should be a bit more complex.

#### 3] Aggregation is inevitable for governments since they have to make tradeoffs – actor specificity o/w since different agents have different obligations.

#### 4] Extinction first:

#### A] Forecloses future improvement – we can never improve society because our impact is irreversible

#### B] Turns suffering – mass death causes suffering because people can’t get access to resources and basic necessities

#### C] Moral obligation – allowing people to die is unethical and should be prevented because it creates ethics towards other people

#### D] Objectivity – body count is the most objective way to calculate impacts because comparing suffering is unethical

#### E] Moral uncertainty – if we’re unsure about which interpretation of the world is true – we ought to preserve the world to keep debating about it

## Plan

#### I affirm: The appropriation of outer space by private entities is unjust via satellites.

#### Takaya et al 18

(“The Principle of Non-Appropriation and the Exclusive Uses of LEO by Large Satellite Constellations” Yuri Takaya-Umehara [Visiting researcher at the University of Tokyo since April 2017. She was affiliated to the Kobe University to provide a course on space law to post-graduate students (2011-2017). She chairs a working group on the formulation of global norms in space law organized by the Keio University since 2018. She obtained her Ph.D. degree at the IDEST of Paris XI University in France, LL.M. at the Leiden University in the Netherlands.] Quentin Verspieren [Ph.D. in public policy @ The University of Tokyo, Assistant Professor of Space Policy @UTokyo, General Manager, Global Strategy @ArkEdge Space Inc., Associate Research Fellow @ESPI] Goutham Karthikeyan [The University of Tokyo & Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency (ISAS-JAXA)] 2018 https://www.researchgate.net/publication/328094878\_The\_Principle\_of\_Non-Appropriation\_and\_the\_Exclusive\_Use\_of\_LEO\_by\_Large\_Satellite\_Constellations SM)

* LSC = large satellite constellations
* Outlines “L”SC thresholds

By investigating expected large satellite constellation projects and by reviewing existing interpretations of international space law, this paper argues that the exclusive use of specific LEO orbits by a large constellation of satellite could constitute a violation of the non-appropriation principle by means of occupation and by means of use, drawing a parallel between orbits as resources and the exploitation of tangible mineral resources in space. Based on this, the important question to be raised is what constitutes an exclusive use of a specific orbit. In other words, an important hurdle in the concrete evaluation of whether a planned or established constellation potentially violates the non-appropriation principle through an exclusive use of LEO resides in the lack of clear definition on what can be considered an exclusive use. While the authors claim that legal issue can be clearly solved in abstracto, it naturally shifts towards a regulatory challenge. This regulatory challenge consists in first defining qualitatively what is the exclusive use of an orbit before translating this definition into measurable, technical rules. In this paper, the authors define an exclusive use of an orbit by a state40 as any use that would prevent/hinder the usage of the same orbit by any other state. Translating this definition into an applicable regulation could consist in defining a threshold of orbital collision risk or a threshold of density of satellites along an orbit based on its altitude, shape, relative velocity of neighbouring objects, etc. It is however not the purpose of this space law paper. What is more appropriate here is to think about which organization or forum would be in charge of elaborating this technical definition. Serious candidates could be the ITU, with excellent track-record in dealing with the use of the GEO region but which would have to review its “first come, first served” principle, or the UNCOPUOS, aiming for the widespread adoption of a new piece of international law. Moreover, even if its rules suffer from a low implementation rates, the IADC would be an appropriate discussion platform thanks to its very deep technical focus. 6. Conclusion The various announced projects of LSC, also called mega-constellations, push existing regulations and practices to their limit, forcing researchers and practitioners around the world to rethink the applicability of existing space law principles to this new trend. In this paper, the authors, after providing background information on current LSC plans as well as recalling the legal status of the LEO region, investigate whether the deployment of an LSC having an exclusive use of an orbit constitutes a violation of the nonappropriation principle as stated in OST Article II. This paper concludes that: The exclusive use of an orbit by an LSC constitutes a violation of the non-appropriation principle by means of occupation due to the innate nature of orbit being a specific location in space that can be occupied, but most notably by means of use, considering orbits as “limited natural resources” and invoking parallels with the exploitation of natural resources in outer space; ITU’s “first come, first served” principle is reaching its limits with current LSC projects and should be re-evaluated; The main challenge ahead is not legal but technical and regulatory and consists in defining precisely what can constitute an exclusive use of an orbit and in translating such definition into a clear regulation or code of conduct.

#### Mega-constellations are coming now - space companies are planning to launch thousands of satellites – even low failure rates cause massive debris fields in orbit, Mcfall-Johnsen 20

[Morgan Mcfall-Johnsen, science reporter at Insider with a Bachelor of Science in Journalism from Northwestern University, 11-3-2020, "About 1 in 40 of SpaceX's Starlink satellites may have failed. That's not too bad, but across a 42,000-spacecraft constellation it could spark a crisis.," Business Insider, [https://www.businessinsider.com/spacex-starlink-internet-satellites-percent-failure-rate-space-debris-risk-2020-10[/Kankee](https://www.businessinsider.com/spacex-starlink-internet-satellites-percent-failure-rate-space-debris-risk-2020-10%5b/Kankee) [recut Lynbrook MD]

SpaceX is launching satellites into space by the dozens to realize Starlink, a globe-encircling constellation of spacecraft that beam affordable, high-speed internet across Earth. So far, the scheme — envisioned by SpaceX founder Elon Musk in 2015 — seems to be working. The aerospace company has even opened a public beta test across the northern US and southern Canada for $99 a month, plus $499 for a startup kit. "Other countries to follow as soon as we receive regulatory approval," Musk tweeted on October 8. However, the unprecedented project has left a trail of seemingly unresponsive spacecraft in its wake. All of the satellites are designed to be maneuverable in space using an ion engine, and even deorbit themselves to burn up in Earth's atmosphere. But satellites with malfunctioning communication or propulsion systems can fly uncontrolled and pose a hazard to other satellites, and even astronauts, circling Earth. SpaceX launched its first batch of 60 prototypes in May 2019 and, to date, has flown 895 total Starlink internet satellites. But so far around 2.5% of those spacecraft may have failed, according to data collected by Jonathan McDowell, an astronomer at the Harvard-Smithsonian Center for Astrophysics. "I would say their failure rate is not egregious," McDowell told Business Insider in early October. "It's not worse than anybody else's failure rates. The concern is that even a normal failure rate in such a huge constellation is going to end up with a lot of bad space junk." Some of those failures may be intentional tests, but how many (if any) is not publicly known because SpaceX hasn't released such information. As a result, astronomers like McDowell have resorted to analyzing satellite-movement data gleaned from SpaceX and the US government, showing which Starlink satellites have fallen back toward Earth and which ones are not maneuvering. (McDowell's failure calculations do not include 45 "version 0.9" satellites that SpaceX is known to have intentionally deorbited.) Before the end of October, McDowell was measuring a 3% apparent failure rate, but a recent reanalysis indicates improvement in the newest Starlink batches. Of the last 413 "version 1.0" satellites, only one appears to have died, giving these batches a failure rate of just 0.2%. Still, McDowell notes that many of these satellites have only been in space for a few months, so more of them are likely to fail going forward. "Nevertheless it does seem that the reliability of the satellites has noticeably increased," he tweeted on October 29. SpaceX has permission from the US government to launch nearly 12,000 Starlink satellites through 2027, though it's asked to launch 30,000 more for a total of nearly 42,000. In either case, SpaceX is on track to form a "megaconstellation" that outnumbers all prior spacecraft ever launched by humanity. If 3% of the maximum planned Starlink constellation fails, that could mean 1,260 dead, 550-pound satellites the size of a desk aimlessly circling the planet. A 2.5% failure rate could mean more than 1,000 inoperative spacecraft. There were about 3,200 nonfunctional satellites in Earth's orbit as of February, according to the European Space Agency. Many of these dead spacecrafts regularly threaten to collide with others and create a space-debris crisis. In mid October, for example, satellite trackers flagged a "very high risk" close pass between a dead satellite and a discarded rocket body, with one company calculating a 10% chance of collision. (Fortunately, they didn't.) SpaceX says its satellites will naturally deorbit, or burn up in Earth's atmosphere, if their propulsion systems don't work. But that process can take up to five years, according to Starlink's website. In the meantime, defunct satellites rocket around Earth faster than a bullet, with nobody to steer them away from other spacecraft that may fly in their path. SpaceX did not acknowledge Business Insider's requests for comment. However, in filings to the Federal Communications Commission, SpaceX has downplayed the risk, stating that it "views satellite failure to deorbit rates of 10 or 5 percent as unacceptable, and even a rate of 1 percent is unlikely." If 1% of its satellites did fail with no capacity to maneuver, the company said, "there is approximately a 1 percent chance per decade that any failed SpaceX satellite would collide with a piece of tracked debris." The company also claimed that its practices "effectively eliminate the chance that such rates will ever occur." Dead satellites can collide and build up a space-debris crisis SpaceX is not alone in pushing to launch large numbers of internet satellites. OneWeb, which the UK government recently purchased out of bankruptcy, has already launched 74 satellites for its proposed constellation of 48,000, while Amazon aims to launch more than 3,200 for its Kuiper fleet. It's unclear how many dead satellites those constellations might also leave in orbit. Since nobody can maneuver them, failed satellites sometimes hurtle toward other spacecraft — including the International Space Station and its crew of astronauts. Even if a satellite crashes into another satellite with no humans on board, it can create perilous conditions. "We replace two satellites with essentially two shotgun blasts of debris," Dan Ceperley, the CEO of satellite-tracking company LeoLabs, told Business Insider in January. That month, two dead satellites almost crossed paths and exploded into hundreds of thousands of bits of debris. It wouldn't have been the first such explosion, and it doesn't take many to exacerbate the debris problem. In 2007, China tested an anti-satellite missile by obliterating one of its own weather satellites. Two years later, one American and one Russian spacecraft accidentally collided. Those two events alone increased the amount of large debris in low-Earth orbit by about 70%. India conducted its own anti-satellite missile test in 2019, and the explosion created an estimated 6,500 pieces of debris larger than an eraser. All in all, more than 500 such "fragmentation events" have created nearly 130 million bits of debris in Earth's orbit. Those chunks of debris zip around the planet at more than 17,500 mph, or roughly 10 times the speed of a bullet. That's not only a problem for robotic spacecraft, but ones carrying people. Just last month, a piece of debris careened within a mile of the football field-sized space laboratory. To avoid a collision, mission controllers fired the thrusters of an attached Russian cargo spaceship to maneuver the station out of possible harm's way. The three crew members sealed themselves inside an ISS segment with a Soyuz spaceship, so they could escape if the debris struck. If the space-junk problem gets extreme, a chain of collisions could spiral out of control and surround Earth in a practically impassable field of debris. This possibility is known as the Kessler syndrome, after Donald J. Kessler, who worked for NASA's Johnson Space Center and calculated in a 1978 paper that it could take hundreds or even thousands of years for such debris to clear up enough to make spaceflight safe again. "It is a long-term effect that takes place over decades and centuries," Ted Muelhaupt, who leads The Aerospace Corporation's satellite system analysis, previously told Business Insider. "Anything that makes a lot of debris is going to increase that risk." The sheer number of objects in Earth's orbit may already be having a Kessler-like effect, as Rocket Lab CEO Peter Beck described last week."This has a massive impact on the launch side," he told CNN Business, adding that rockets "have to try and weave their way up in between these [satellite] constellations." Starlink is already a space-debris hazard SpaceX has barely launched 2% of its planned constellation, but it has already had a close call. In September 2019, the European Space Agency had to maneuver one of its spacecraft at the last minute to avoid possibly colliding with a Starlink satellite. The chance of that crash was 1 in 1,000. While that may sound low, NASA routinely moves the ISS for chances of 1 in 100,000. The ESA said it had to move its satellite because SpaceX had "no plan to take action." SpaceX said it missed the ESA emails about the issue due to a "bug" in its communications systems. Overall, close approaches like that seem to be happening more frequently. "We are seeing recently a decided uptick in the number of conjunctions," Dan Oltrogge, an astrodynamicist at Analytical Graphics, Inc, where he uses a software that has been assessing conjunction data since 2005, told Business Insider. "And it looks to be very well aligned with the new large-constellation spacecraft that have been launched." As new satellite constellations launch, regulatory agencies like the FCC may need to evaluate how many dead spacecraft they're willing to accept. "What is an acceptable failure rate?" McDowell said. "That, I'm maybe not competent to have an opinion on."

#### Large constellations cause debris and collisions, Murtaza et al 20

[Abid Murtaza, educator at the School of Electronic and Information Engineering at Beihang University pursuing a Ph.D. in space technology applications with Beihang University, Syed Jahanzeb Hussain Pirzada, educator at the School of Cyber Science and Technology at Beihang University pursuing a Ph.D. in space technology applications with Beihang University, Tongge Xu, Associate Professor with the School of Cyber Science and Technology at Beihang University, and Liu Jianwei, educator at the School of Electronic and Information Engineering at Beihang University, 03-09-2020, “Orbital Debris Threat for Space Sustainability and Way Forward (Review Article),” IEEE, [https://ieeexplore.ieee.org/abstract/document/9028136]/Kankee](https://ieeexplore.ieee.org/abstract/document/9028136%5d/Kankee) [recut Lynbrook MD]

Despite the potential as mentioned above, the big question on their impact on the space debris environment has also become the most critical concern for every space concern entity. Concerning the space debris collision threat, SpaceX and OneWeb have both selected an altitude (above 1100 km) that is less densely populated. Additionally, both have told the FCC that their constellation will comply with international mitigation standards, such as reentry to earth Earth’s atmosphere being accomplished within approximately one year after completion of their mission. Additionally, OneWeb’s Orbital Debris Mitigation Plan reports that the probability of a OneWeb satellite becoming disabled as a result of collisions with small debris is 0.003, while SpaceX stated that “there is approximately 1% chance per decade that, any failed SpaceX satellite would collide with a piece of tracked debris” [97]. Apart from the claims of SpaceX and OneWeb, some studies have been performed to understand the effect of these constellations on the space environment and the reliability and collision possibilities of the mega constellation with this populated debris environment [10], [98], [99]. A study shows that there is substantial uncertainty in the prediction of the reliability of mega constellation satellites, with considerable risk to the space environment. This is because much of the information about mega constellation satellites, including the detailed designs, is not available [10]. Another recent study shows that a high probability exists for the occurrence of at least one catastrophiccollision, i.e., 5% for OneWeb and 45.8% for SpaceX constellations, during an operational phase of 5 years [97]. The study [98] showed that it was estimated that an impact of approximately 3 cm in diameter would lead to a catastrophic collision of a OneWeb sized satellite, while the proposed size of a SpaceX constellation satellite is larger than a OneWeb satellite. The study also shows that the satellites in the constellation would have a 35% probability of fragmenting during the described mission lifecycle catastrophically. Thus, what we can confidently say is that despite the claims of mega constellation proposers, there are serious concerns, doubts, and uncertainty about the interaction of debris and satellites in mega constellations that exist. NASA has recently completed a parametric study to understand how significantly proposed large satellite constellation can contribute to the existing orbital debris problem. The objective was to quantify the potential negative debris-generation effects from mega constellation to the LEO environment and provide recommendations for mitigation measures [99]. The results show that for the 25-year decay rule at the end of their missions, with a 90% reliability of post-mission disposal, the additional debris population increase with respect to that without these big constellations is approximately 290% in 200 years. Even with 95% post-mission disposal reliability for the mega constellation spacecraft, the additional population increase is still close to 100% as shown in Fig. 12. While with 99% post-mission disposal, the additional population increase is reduced to 22%. The cumulative numbers of catastrophic collisions are shown in Fig. 13, which shows that in 90% scenario a non-linear increase from 27 to a total of 260 catastrophic collisions in 200 years. In 95% scenario, the total number of catastrophic collisions is 90 in 200 years. Based on results from this study NASA recommended that 99% spacecraft PMD reliability is needed to mitigate the serious long-term debris generation potential from mega constellation similar in scope to the study scenarios. Besides this, there are many aspects which are nevertheless not under the control of anyone, such as a collision of two large retired satellites or rocket bodies. Additionally, there could be many hypothetical scenarios that could lead to a catastrophic collision. For example, the accuracy error in tracking the debris data thorough SSN, the human or technical errors in estimated the timing of the collision threats, failure in a collision avoidance maneuver by satellites due to onboard control problems or anomalies in the propulsion system, and any deliberate political reasons and so on. Additionally, so far there is no legal restriction of using ASAT. So, what if the use of ASAT continues in future just like India did recently? Also what if the war between two advanced nations extends from ground to space that could result in the use of ASAT weapons to destroy the satellites of enemies? Thus, the argument is that there could be any reason for a catastrophic collision, and one or more such accident could make the situation worse, which would have severe consequences for everyone especially such as Kessler syndrome. Hence, we can say that mega constellation projects, despite their potential benefits are not going to help in improving debris and space environment in any way; instead, fair chances of worsening of debris and space environment can be envisioned from the above discussion. It might be negligence if we deliberately continue to underestimate debris challenge and its potential threat to the space environment in the future. SECTION VII.Legal and Regulatory Issues

#### Private actors are uniquely key to avoid debris cascades – they have lower safety standards and won’t cooperate with others, Yuan 21

[Alda Yuan, Public Health Analyst U.S. Department of Health and Human Services and visiting attorney at the Enivornmental Law Institute with a JD from Yale, 2021, “FILLING THE VACUUM: ADAPTING INTERNATIONAL SPACE LAW TO MEET THE PRESSURES CREATED BY PRIVATE SPACE ENTERPRISES,” Hein Online, [https://heinonline.org/HOL/P?h=hein.journals/denilp49&i=27]/Kankee](https://heinonline.org/HOL/P?h=hein.journals/denilp49&i=27%5d/Kankee) [recut Lynbrook MD]

C. Non-state Actors Introduce Practical Challenges that Endanger the Future of Space Travel If companies are permitted to access space without a proper legal framework or sufficient coordination, the practical risks may doom the project of humanity in outer space for the near future. The opening anecdote dramatized the risks, but the fact that a chain of cascading destruction might preclude the use of whole bands of outer space or make launches impossible is not farfetched. 99 Indeed, it is already happening.0 Because space missions always create debris and there is a correlation between the number of objects orbiting earth and the chances of collision, which thereby creates more debris, even no further activity in space will eventually result in a belt of debris encircling the earth.10 1 This cascade effect, called the Kessler Syndrome, 102 has the potential to speed up astronomically if activities in outer space expand without contingent regulation and mitigation measures.1 1 3 At current rates and in the absence of a catastrophic event, lower earth orbit, in particular, might reach a tipping point within the next ten to fifty years.1 4 If the space debris problem is permitted to reach this tipping point, access to space may well be cut off for the near future because it will be impossible to launch satellites.1 5 Given that we do not have the technology to clean up debris yet, space travel faces an existential threat. In light of this, most space-faring states cooperate, working together to develop guidelines and pool resources to track the debris already orbiting the earth to minimize the chances of a collision.106 Given the high speeds the debris travels at, approximately 10 km/second,107 and the amount of damage even tiny pieces can do, 108 the existing tracking systems are not an absolute fix. At these speeds, a piece of debris weighing a mere two grams can produce an impact force equivalent to a kilogram of TNT.109 More than three hundred thousand pieces of debris greater than one cm in diameter," and therefore capable of causing enormous damage, orbit the earth while the US Space Surveillance Network (SSN) system can only track objects over five cm in diameter." There are millions of fragments smaller than one cm, which are impossible to track and yet can still cause significant damage.11 2 Still, the tracking system is important. In the last twenty years, the International Space Station has carried out several avoidance maneuvers to avoid potential collision with pieces of space debris being tracked by the SSN system.113 Between April of 2011 and April of 2012, the ISS performed four evasive maneuvers." 4 On two additional occasions, the crew fell back to the Soyuz since there was no time to set up an evasive maneuver." 5 This sort of cooperation works given the limited number of actors involved and the aligned interests of the nation-state parties. Commercial space companies do not have the same incentives to cooperate to share data and new technologies. This is why many have called for the creation of a new convention on managing orbital debris. 16 However, escalation of the Kessler Syndrome is not the only problem that might arise by failing to accommodate for the rise of the commercial corporations, so such a convention would not eliminate the threat. For instance, many satellites use nuclear power sources (NPS), which can break up upon reentry." As early as 1978, the Cosmos-954 incident scattered radioactive debris over Canada.118 Other accidents of this type could raise fallout concerns, especially if they occur over more densely populated regions. In an attempt to alleviate this risk and decrease the chances of collisions, various nations have cooperated to design and standardize methods of decommissioning satellites. 119 One strategy is to supply spacecraft with additional fuel and nudge it out of orbit so it will burn up in the atmosphere over the ocean. 120 Another is to push the ailing satellite into a graveyard orbit. 121 These methods require additional research and design and incur additional costs. 12 2 Private companies may not spontaneously take the steps necessary to comport with the common practices of space-faring nations. Thus, the rise of private corporations, while opening up new possibilities, may also threaten space travel itself and the international legal order in which coordination currently occurs. The coordination necessary to prevent and manage the unique problems that arise in space requires a more pragmatic framework. Directly binding private non-state actors benefits the international community because it prevents abusive practices and permits the coordination of efforts that make space safer. However, it will also benefit the private sector by providing companies with a background legal structure, neutral dispute resolution, and common guidelines to even the playing field. More importantly, if companies not subject to regulation and oversight are permitted to operate in outer space, disasters cannot be effectively prevented. In that case, space exploration and the benefits stemming from it might be closed off for all. III. SPACE IS A GLOBAL COMMONS UNDER CUSTOMARY INTERNATIONAL LAW

#### 3 impacts:

#### More space debris means we trap ourselves on Earth, Weiner 17

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The tiny pieces of junk orbiting the Earth could have a major impact on space exploration. Not everything we send into space comes back down. In fact, there are millions of pieces of junk, ranging from tiny flecks of paint to entire satellites currently taking up space around the Earth's atmosphere. As of now, space agencies are already tracking 750,000 pieces of space debris orbiting the Earth. This space pollution is a major problem--because of how fast objects orbiting Earth travel, even a paint fleck a few millimeters long can cause serious damage when it hits something. The more that this space junk proliferates, the harder and harder it will be to send anything up into space. We could literally trap ourselves on Earth if we're not careful. Luckily, scientists are working on ways to prevent this. One NASA program called Space Debris Elimination proposes shooting atmospheric gasses into space to destabilize the debris' orbit and send it plummeting back to Earth, where it will burn up in our atmosphere. Another proposal from the ESA tackles the larger pieces of debris, like old satellites. Their idea is to send a machine into space called the E-DeOrbit, which would literally shoot a net at old satellites and drag them back into the atmosphere with a small rocket. Neither of these solutions would address the millions of tiny bits of trash floating around the Earth, so the best idea for now is to prevent more from building up. If not, we could find ourselves trapped in a prison of our own making.

#### Satellite crashes cause a laundry list of problems, Haroun et al 21

[Fawaz Haroun, Law @ University of Lagos, Shalom Ajibade, Law @ University of Lagos, Philip Oladimeji, Law @ University of Lagos, John Igbozurike, Law @ University of Lagos, “Toward the Sustainability of Outer Space: Addressing the Sustainability of Space Debris,” New Space, <https://www.liebertpub.com/doi/pdf/10.1089/space.2020.0047>] /Triumph Debate [recut Lynbrook MD]

Debris pose risks to both Earth and space. With respect to access to space and space resources, debris endangers both current and prospective space missions. NASA notes that most space debris can reach speeds \*8,046.72 meter per second (almost 7 times faster than a bullet), fast enough for a relatively small piece of orbital debris to inflict severe damages on a spacecraft or satellite.3 Majority of the world’s population rely on satellite technologies and applications every day.11 Indeed, satellites have many essential uses, including communications, photograph and mapping, remote sensing and Geographic Information System (essential to geographical studies), weather forecast, global positioning system, and the defense industry.12 When pieces of space debris increase, they pose a great threat not only to the orbital paths of these satellites, but also to their operational span, due to possible collisions.11 In the same vein, debris also affect safety of humans in space. The prospects of more human presence in orbit are becoming more realistic every day. Organizations are planning space missions for tourism. For example, both SpaceX and Virgin Galactic intend to begin private passengers’ flights to space in early 2020s decade.13 Moreover, current manned missions such as the International Space Station (ISS) are always considered to be at risk of debris situations. Unsurprisingly, NASA records that the ISS has made 3 collision avoidance maneuvers in 2020 alone.14 Asides the effects of debris in space, there is also direct danger to Earth. Large items from space can re-enter Earth successfully without totally burning up in the atmosphere, and this can result in nuclear contamination of Earth’s surface.15 This danger was made apparent when a Soviet satellite fell to Earth in 1978, scattering radioactive particles over northern Canada; this crash required extensive cleanup of the area.16 There are other instances of debris falling onto Earth. On April 27, 2000, 3 different places in South Africa experienced space debris crashes.17 Similarly, on May 13, 2020, a Chinese rocket falling back to Earth uncontrollably may have dropped debris in 2 nearby Ivorian villages.18 These events force us to consider where the next debris drop will be, perhaps somebody’s roof, or in a field of playing kids. There is no doubt that something needs to be done in light of the aforementioned risks.

#### Satellites are key to environmental monitoring – debris collapses it and causes climate extinction, Biggs 18

(Ben Biggs 18, PhD Researcher in Computer Vision and Deep Learning at the University of Cambridge, “How Satellites Can Protect Planet Earth From Disaster”, HowItWorks Daily, 12/22/2018, https://www.howitworksdaily.com/how-satellites-can-protect-planet-earth-from-disaster/)

It might not look it, but our planet is a fragile place. A delicate balance of pressure, temperature and gases keeps us alive, as our atmosphere lets in enough heat for us to thrive – but not too much that we get too toasty. For many years our planet has looked after itself with ease. Now, with humans on the scene, things are changing more than ever, from climate changetomass deforestation. If our planet is going to survive long into the future it’s going to need our help. Fortunately, we’ve got plenty of missions that are working for the benefit of our world already. Using observation satellites in orbit, scientists have been monitoring Earth for decades, watching how the planet pulsates and changes over time. From orbit we can watch how species migrate, identify and predict environmental changes and even fix problems. A great example of this was the global effort to repair a hole in the ozone above the Antarctic back in 1987. Two years prior, scientists had discovered that chemicals known as chlorofluorocarbons (CFCs) – produced by fridges and aerosols, among other things – were causing the hole to grow. As a result countries around the world agreed to phase out the use of CFC as part of the Montreal Protocol. In early 2018, NASA announced that its Aura satellite had watched the hole successfully close, with it expected to fully repair as early as 2060. It was proof that we could work together to change the planet for the better. Aura is part of a broader NASA project called the Earth Observing System (EOS). This programme, which began in 1997, has seen NASA launch missions and instruments into orbit. This has included the groundbreaking Landsat series of satellites, which have provided surface images of the whole globe. Then there’s the Terra mission that launched in 2009 and studies clouds, sea ice and more from orbit. Most of these satellites are in polar orbits, which means they orbit the planet from top to bottom so that it rotates underneath and gives them a global view. Planning for the EOS began back in the 1980s, with NASA keen to regularly fly instruments for at least 15 years. “Human activity has altered the condition of the Earth by reconfiguring the landscape, by changing the composition of the global atmosphere, and by stressing the biosphere in countless ways,” they noted in a handbook in 1993. “There are strong indications that natural change is being accelerated by human intervention.” More than two dozen missions have been launched as part of the EOS to date. Among the programme’s many accomplishments, scientists watched as an ice shelf collapsed on the Antarctic Peninsula in 2002 using the Terra satellite. The same satellite, along with the Aqua satellite launched in 2002, has provided a global view of how the vegetation cycle changes over the course of a year and the effect the climate has on it. Those same two satellites have also allowed us to see how summer sea ice in the Arctic is decreasing, which means that more of the Sun’s light is being absorbed rather than being reflected, raising global temperatures. The EOS has helped in other ways too, such as enabling scientists to keep a close eye on the levels of toxic gases like carbon monoxide being emitted from massive fires in the atmosphere. This allows people on the ground to be alerted to these dangers, and they can in turn be advised to limit their outdoor activity to protect their health. The EOS is even helping to track and monitor rare animals, such as chameleons in Madagascar. Here, scientists have been able to use satellite imagery, combined with known habitats of the animals, to map out where they are likely to be living. It would take survey teams on the ground thousands of years to replicate this information without satellites. It’s not just NASA that has been keeping a close eye on the planet. The European Space Agency (ESA) runs the Copernicus project, billed as the world’s largest single Earth observation campaign. Previously known as the Global Monitoring for Environment and Security (GMES) programme, it began with the launch of the Sentinel-1A satellite in April 2014. This radar imaging satellite provides images both day and night and during all weather conditions, and these are being used to map sea ice, track oil spills and more. This has been followed by half a dozen more missions, with the latest – Sentinel-3B – launching on 25 April 2018. This mission is focusing on monitoring the behaviour and health of the oceans, but it has a wide range of abilities. It flies in formation with its predecessor, Sentinel-3A, and together the two of them can provide global data for Earth across an entire day. The satellitescan measure the temperature over oceans, as well as the colour and height of the sea. They can also monitor wildfires from space, check the health of vegetation and map the way that land is being used around the world. And there are more Sentinel satellites on the way. In the coming years we’ll see the Sentinel-4 and Sentinel-5 missions launch, studying the composition of our planet’s atmosphere, while Sentinel-6 will measure global sea surface height for ocean and climate studies. “Copernicus will help shape the future of our planet for the benefit of all,” said the ESA, also noting that it isthe “most ambitious Earth observation programme to date,” one that will provide accurate and timely data on the environment, climate change and more. All of this data is vital for directing climate policy and other human activities on Earth. By observing our planet around the clock from space we can see the direct effect that humans are having on it. These are not the only climate-monitoring missions run by NASA and the ESA. The former has a number of other missions, including the Deep Space Climate Observatory, which observes the sunlit side of Earth. The latter has eight missions on the books in its Earth Explorer programme, including a mission to study how Earth’s gravity field varies over the surface of the planet, called the Gravity field and steady-state Ocean Circulation Explorer (GOCE), which ended in 2013. In 2016, countries of the world came together to sign the Paris Climate Agreement, a global effort to reduce carbon emissions to prevent the global average temperature rising by two degrees Celsius above pre-industrial levels. While the US later infamously reneged from this agreement, it was proof that with enough level-headed minds, minds that can see the data from missions showing how the planet is changing, we can take action. Humans continue to have a major effect on the planet, for better or worse, and monitoring that change is vital to our planet’s survival.

#### Megaconstellations like Starlink make astronomy during astronomical twilight impossible – that moots asteroid detection, Fish 20

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Starlink is the Elon Musk-owned SpaceX satellite broadband project aiming to eventually launch tens of thousands of satellites to Earth orbit to deliver internet around the world. But although admirable idea, astronomers increasingly believe Starlink will affect humanity’s ability to save itself from annihilation from an asteroid collision. Dr Jonathan McDowell, an astronomer at the Harvard Smithsonian Center for Astrophysics believes the nascent Starlink has already adversely impacted the vital search for new asteroids able to inflict death from above. He told Express.co.uk: Although SpaceX Starlink is not yet posing a problem for spotting asteroids, it is a nuisance. “But Starlink is going to be a problem within a couple of years while they put up all these satellites. “There are 300 Starlink satellites up right now, with 60 more going up in a few days. “But SpaceX is planning for up to 12,000 satellites or even more. “So while a constellation of 300 is a pain in the neck, we can handle it – 12,000 is going to make it very difficult, especially for these asteroids.” Starlink poses a unique problem for astronomers due to both their eventual quantity and their relatively low orbiting distance. Most astronomers work in the middle of the night, when the sky is as dark as possible because they are looking at distant galaxies. However, asteroids on a possible collision course with Earth, are close in the sky to the Sun, meaning astronomers have to look as close to the Sun as possible. Unfortunately, this takes place as soon as the Sun sets – but this twilight period is exactly when most of the Starlink satellites are illuminated. Although the Sun is set on Earth, it hasn’t set 300 miles up, meaning Starlink satellites are still reflecting the Sun. At any given time, there could be hundreds of these satellites illuminated as astronomers attempt to observe the twilight sky, a period known as the astronomical twilight, which is the first few hours of the night. Dr McDowell said: “So early in the night, there’s going to be lots of these things, making it very difficult to take a picture without one of these things, leaving a bloody great streak across your image. “I think that will make this the science difficult. “If there’s 10 streaks on every astronomical image – which I don’t think we’re going to see but that’s the logical extreme – then you’re completely hosed as we say in America. “It’s unclear just how bad it’s going to be right now, but it’s not an order of magnitude away from the really bad case. “And even if Starlink ends up being not so bad, allowing astronomers to work around it without an extreme amount of effort, the next constellation might be worse. “It’s not out of bounds that someone could put up a constellation that would make this kind of astronomy completely impossible. “Therefore, I think there needs to be discussion about the night sky as a shared resource for humanity and who should regulate it and who should decide how it gets changed.”

#### Asteroids cause extinction and without top-notch detection technology, a hit is inevitable, Dreier 21

(Casey Dreier is Senior Space Policy Adviser for The Planetary Society, an independent nonprofit organization based in California. “Why an Asteroid Strike Is Like a Pandemic”, July 25, 2021, <https://www.scientificamerican.com/article/why-an-asteroid-strike-is-like-a-pandemic/>, accessed 12/3/21)

Imagine the following scenario. Scientists identify a potential global threat, but initial data are spotty—not enough to spur drastic action. Rapidly, relentlessly, the threat grows. What once was preventable becomes inevitable. The world has no choice but to endure the disaster at the cost of trillions of dollars and millions of lives. This is the story of COVID pandemic—but it could equally well be the story of a catastrophic strike by a large asteroid. As we emerge from the worst of COVID-19, we should heed this lesson: low-probability, high-impact events do occur; but they can be mitigated if we prepare and act early enough. Asteroids are like viruses in a sense: they number in the tens of millions but only a few types pose a threat to humans. For asteroids, it’s the “near-Earth” variety—those with orbits that come close to our own—that we must worry about. Also as with viral outbreaks, the likelihood of a catastrophe is unlikely in any given year, but almost inevitable over time. And just as we can in principle develop vaccines against emerging viruses before they cause too much damage, creating immunity without making people sick, we can similarly use modern technology to develop a level of global immune response to asteroid collisions. But this requires ongoing investments in research and preparedness—and while the U.S. spent more than $6.5 billion dollars on pandemic preparedness over the past decade (with admittedly mixed results), the nation spent less than a tenth of that on the work of asteroid detection and deflection. This is far too low. In fact, impacts from space happen all the time, but they are generally small and harmless. The Earth is peppered with meteors throughout the year that are mere inches across or less, which burn up as shooting stars when they enter our atmosphere. The threat comes from the bigger ones, which are house-sized or larger. These strike less frequently, but they do happen. In 2013, a 60-foot-diameter meteor exploded over the city of Chelyabinsk, injuring thousands of people. The really big ones—miles across—are even rarer, occurring every few hundred million years or so. But the damage they do can be catastrophic. Think of the mass extinction 65 million years ago that wiped out most of the dinosaurs. The good news is that we’ve found most of those and, fortunately for us, Earth is not in their crosshairs. But there is a middle ground that demands our attention: “city killer” asteroids that are about around the size of a football field and could unleash 10,000 times the energy of the atomic bomb that leveled Hiroshima. They seem to hit us every few thousand years, on average. There are likely many tens of thousands of them with orbits near Earth’s, yet we’ve only found about one third of these. And finding them is hard. Even the big ones are tiny, cosmically speaking, and are camouflaged against the blackness of space by their charcoal-like dark surfaces. Ground-based telescopes, which measure reflected light, struggle to see these small, dim objects. Only a few hundred are discovered each year. To significantly improve the rate of detection we need to move off the Earth, to the realm of the asteroids. We need a telescope in space. The Near-Earth Object (NEO) Surveyor is a modest space telescope currently under consideration by NASA. Instead of looking at reflected light, it would seek out heat signatures of asteroids, which glow with infrared radiation against the cold background of space. And in space, where there’s no bad weather and daytime that limit observations, the NEO Surveyor could find more city-killer asteroids in the next 10 years than have been discovered by all the telescopes on Earth over the past three decades. The mathematics of orbital mechanics that characterizes asteroids can be as heartless as the exponential growth that goes with viral outbreaks. And as with broad testing regimes that have been used during COVID, a dedicated effort to discover potentially hazardous asteroids will be the key to preventing disaster. It’s possible to alter an incoming asteroid’s orbit to protect the Earth, but that becomes increasingly more difficult depending on how close we are to impact. It is far easier to act years (if not decades) in advance. After more than a decade in bureaucratic purgatory, where the NEO Surveyor has struggled to gain approval, the project appears ready to move forward. The Biden administration recently proposed to fund this mission in its latest NASA budget; Congress should support this request. It will take years to build and launch, but as early as 2026 we may see the start of the first dedicated effort to understand the scope of the asteroid threat. We also need to invest in deflection technology, the “vaccine” of the asteroid response. Fortunately, NASA is close to launching a mission called the Double Asteroid Redirection Test (DART). In 2022, the spacecraft will ram into the tiny “moon” that orbits the near-Earth asteroid Didymos, slightly changing its orbit. Scientists will compare the exact degree of change to their predictions, which will help them understand how to alter asteroid orbits more effectively in the future. This is only a test, but it could serve the same function as the years of basic research into the field of mRNA vaccines that ultimately paid off when applied to COVID. We must also continue to support sky surveys by ground telescopes, which can support the work of space-based missions. The Vera Rubin Observatory, for example, now under construction in Chile and especially good at finding fast-moving objects in the solar system, will greatly assist in asteroid detection. (The proposed “megaconstellations” of Earth-orbiting satellites by Amazon, SpaceX, OneWeb, and others threaten to overwhelm our view of these dim objects and make asteroid detections more difficult. There is no easy solution to this, beyond further confirming the need for space-based detectors located in quieter regions of the solar system.) The coronavirus pandemic has many humbling lessons for humanity. But let this be one of them: low-probability, high-impact disasters do occur; and there is no higher impact disaster than a large asteroid collision with the Earth. We know that early awareness enables early action. Big problems later on can be prevented by small investments now. Let’s not be caught off-guard again.

#### The risk of asteroids supersedes every impact - human cognitive reluctance prevents acknowledging its propensity for extinction, Koplow 19

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Astronomers are fond of observing that the real question is not "whether" Earth will again be struck by a large asteroid, but "when." We can detect around the planet the remnants of scores of impact craters of diverse size and age left by previous NEOs, and the pockmarks are even more obvious on the Moon and other celestial bodies, where erosion has not degraded their silhouettes. As asteroids pinball around the Solar System, it is only a matter of time before the next jarring impact-time that might be measured in months or in millions of years. The potential consequences of such a collision beggar belief Prehistoric experience demonstrates that all of human civilization, as well as most or all other forms of life on Earth, may hang in the balance. Even a more moderately sized asteroid could devastate a community or a country in an instant. As Igor Ashurbeyli assesses the stakes, developing countermeasures to this apocalyptic threat "must become the most important task that humanity must solve in the 2 1st century. "211 But the time frame matters, too. If we knew, hypothetically, that an extinction-level event was not going to occur for thousands or millions of years, why would we devote time, attention, and money to it now? A known risk of extermination, eons into the future, would pose profound philosophical and psychological conundrums, but preemptively responding to it would not be on anyone's active "to-do list" for generations. Still, timing matters in another way, too. With our present state of astronomical intelligence, we cannot be certain about our planet's prolonged safety, and we must exhibit appropriate modesty about our confidence in the completeness of the inventory of known NEOs. Accordingly, the planet may not have much advance notice about the next Chicxulub, and we may be no more able than the dinosaurs to immediately invent our way out of an unanticipated fatal space specter. Frances Lyall and Paul B. Larsen summarize the issue this way: "Time might be too short adequately to deal with the crisis-missile or other technology has to be prepared." 2 12 It is difficult for humans to think rationally about this sort of problem-it is hard to get our collective minds around such enormous consequences and such tiny probabilities simultaneously-especially when people have so little first-hand experience with the causal phenomenon. A 2010 study by the National Academy of Sciences referred to this as a classic "zero times infinity" problem that thwarts human cognitive processing.213 Cass Sunstein and Richard Zeckhauser label the resulting bias in decision-making as "probability neglect"-a propensity to misunderstand the fearsome risks that are so difficult to conceptualize.2 14 Behavioral economics literature abounds with examinations of the collective non-rationality in our species' approach to high-severity/low-probability events, leading to extreme discounting of remote future catastrophes, to the detriment of individuals and society.2 15 The underdeveloped state of international law on trans-border disasters reflects this cognitive deficit. Perhaps this should not be surprising-the tasks of preventing, responding to, and rebuilding after global catastrophes are daunting. These are topics that sovereign states, as well as individual human beings, shy away from addressing-they are uncomfortable to think about; they can involve sharing resources, as well as sympathy, with foreigners; and they seem to call for spending immense sums of money on vanishingly remote contingencies. It will never be easy to marshal political support for developing, improving, and sustaining planetary defense capabilities that in all likelihood will never be exercised during any government official's term in office or even lifetime.216 Nevertheless, planetary defense represents one of the occasions in which these psychological barriers must be overcome. The extended time frame in dealing with asteroids places special burdens on the effort to think rationally about very-low-probability dangers, because the people at risk are (likely) not ourselves but our far-distant progeny, generations so remote that the emotional connection to them is strained. We can appreciate that the good work of IAWN and SMPAG today may help increase the odds of our species' survival, but we must also be aware that the counter-asteroid technology available to earthlings a century or two from now will surely surpass today's puny capabilities in ways we cannot imagine.2 17 Collision with a body of 3-5 km diameter) could kill, say, half the world's population (soon to reach eight billion people) sometime in the next million years. On an actuarial basis, that works out to 4,000 statistical deaths annually. That is surely a significant fatality rate-enough to warrant substantial financial investment-even though the incidents would be extraordinarily "lumpy," in the sense that for almost all of those one million years, there would be no deaths at all due to asteroids, but in one year there would be an unprecedented catastrophe. At this rate, asteroids would rank above many other natural and bizarre phenomena that people fear (and that societies attempt to do something about), such as floods, tornados, airplane crashes, terrorism, or choking. Asteroids, however, would still fall far below other leading causes of death, such as automobile accidents, communicable diseases, and tobacco use. 2 18 This weird combination of probabilities and consequences promotes what many call the "giggle factor": humans' seemingly congenital reluctance to discuss planetary defense seriously without retreating to the silliest tropes about alien attacks or sci-fi thrillers. The topic seems to be ripped from kitschy movie trailers, not news headlines. 2 19 An additional fear factor here is the danger of surprise. If a significant asteroid were to arrive without warning-as in the Chelyabinsk incident-the afflicted country might perceive that it had been attacked by a hostile neighbor, rather than by a fickle Mother Nature. If, by further malign luck, the event happened to occur during a period of heightened international tensions, the propensity to misinterpret, and to respond precipitously, would rise. The unforeseen space object could thus catalyze a larger human-caused tragedy.2 20 The easiest part of the policy prescription is to recommend that more should be done to gather and disseminate the relevant data about NEOs. NASA, IAWN, and other actors should press forward zealously to enhance the inventory of known asteroids and should expand their efforts to track and characterize those that might plausibly pose a threat. This survey may get expensive: space-based telescopes may be necessary in order to detect space objects that canbe obscured by the Sun, and long-distance space missions may be required in order to collect more information about the structure, composition, and flight characteristics of asteroids of interest.