Planetary Defense: Near-Earth Objects, Nuclear Weapons, and International Law

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ABSTRACT

The risk of a large Near-Earth Object (NEO), such as an asteroid, colliding with the Earth is low, but the consequences of that risk manifesting could be catastrophic. Recent years have witnessed an unprecedented increase in global political will in relation to NEO preparedness, following the meteoroid impact in Chelyabinsk, Russia in 2013. There also has been an increased focus amongst states on the possibility of using nuclear detonation to divert or destroy a collision-course NEO—something that a majority of scientific opinion now appears to view as representing humanity's best, or perhaps only, option in extreme cases. Concurrently, recent developments in nuclear disarmament and the de-militarization of space directly contradict the proposed "nuclear option" for planetary defense. In the context of significant developments that have occurred in relation to NEO impact risk over the last five years, this article analyses the question of whether a nuclear NEO response would (or could) be permissible under international law. Potential restrictions and prohibitions under treaty law are assessed, as are a range of mechanisms that may act to preclude possible illegality. The article concludes by advancing a tentative proposal for a move towards (strictly limited and safeguarded) legal preparedness.

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I. INTRODUCTION

> *Who knows whether, when a comet shall approach this globe to destroy it, as it often has been and will be destroyed, men will not tear rocks from their foundations by means of steam, and hurl mountains, as the giants are said to have done, against the flaming mass?*
>
> Lord Byron, 1822[1]

In director Michael Bay's schlocky sci-fi movie, *Armageddon*—which inexplicably became the highest grossing film worldwide in 1998[2]—master oil-driller Bruce Willis and an unlikely crew of misfits place a nuclear bomb inside an asteroid heading for Earth to blow it up and save humanity. *Armageddon* is a film full of blockbuster nonsense and implausibility. However, the notion at the heart of its plot, of using a nuclear explosion to avert a cataclysmic Near-Earth Object (NEO)[3] collision, is not one of science fiction.

Nuclear explosives have been explored seriously as an option for responding to potentially hazardous NEO impact since the 1960s.[4] Recent developments, however, mean that a fresh appraisal of this possibility is especially timely. The last five years experienced an unprecedented increase in international political will to respond to the threat posed by NEOs,[5] particularly following the 2013 meteoroid impact in Chelyabinsk, Russia.[6] Furthermore, it is not merely the case that the risk of harmful NEO collision has recently gained significant global "traction": this shift involved a much greater focus on the use of *nuclear* devices as a method of responding to that risk.[7] The "nuclear option" is now, for the first time,

1. THOMAS MEDWIN, CONVERSATIONS OF LORD BYRON: NOTED DURING A RESIDENCE WITH HIS LORDSHIP AT PISA, IN THE YEARS 1821 AND 1822 288 (1824).

2. NATASHA O'HEAR & ANTHONY O'HEAR, PICTURING THE APOCALYPSE: THE BOOK OF REVELATION IN THE ARTS OVER TWO MILLENNIA 178 (2015).

3. The term "NEO" covers a range of natural space objects: asteroids, comets, meteoroids, meteoroids, meteorites, etc. For the distinctions between them, see DONALD K. YEOMANS, NEAR-EARTH OBJECTS: FINDING THEM BEFORE THEY FIND US 6–12 (2d prtg. 2016); for descriptions of some these different types of NEO, see Paul Rogers, *Comet? Meteor? Asteroid? Here's How to Tell the Difference*, THE MERCURY NEWS (Mar. 10, 2013), https://www.mercurynews.com/2013/03/10/comet-meteor-asteroid-heres-how-to-tell-the-difference.

4. *See, e.g.*, PROJECT ICARUS: MIT STUDENT PROJECT IN SYSTEMS ENGINEERING (LOUIS A. KLEIMAN ed., 1968) (an example of influential early work on the subject).

5. *See* discussion *infra* Section II.

6. For more discussions of the 2013 Chelyabinsk impact, see *infra* notes 36-38 and accompanying text.

7. *See* discussion *infra* Section III.

truly on the global agenda. However, the last five years also has seen major advances in both nuclear disarmament and de-weaponization of space initiatives, shifts in political will that seemingly directly contradict the rise in support for nuclear explosive approaches to NEO response.

This article sets the notion of nuclear detonation as a means of diverting or destroying NEOs in scientific and political contexts, and then specifically examines whether such an act of nuclear planetary defense would (or could) comply with international law.[8] Voluminous legal literature exists concerning issues of nuclear non-proliferation, regulation, and disarmament.[9] Similarly, there is a large amount of space law scholarship,[10] including notable literature on the question of "planetary protection" in a general sense (focusing, for example, on matters such as

8. As a result of this focus, it is important to note two related areas with which this article does not engage. First, the emphasis herein on the *avoidance* of NEO impact means that legal obligations relating to the mitigation of the injurious consequences of an actual impact are not discussed. This is without prejudice to the importance of the law relating to measures such as pre-emptive disaster preparedness (e.g., evacuation, property protection, early-warning notification, etc.) and post-disaster response/rebuilding. *See generally* Evan R. Seamone, *When Wishing on a Star Just Won't Do: The Legal Basis for International Cooperation in the Mitigation of Asteroid Impacts and Similar Transboundary Disasters*, 87 IOWA L. REV. 1091 (2002); Evan R. Seamone, *The Duty to "Expect the Unexpected": Mitigating Extreme Natural Threats to the Global Commons Such as Asteroid and Comet Impacts with the Earth*, 41 COLUM. J. TRANSNAT'L L. 735 (2003); Evan R. Seamone, *The Precautionary Principle as the Law of Planetary Defense: Achieving the Mandate to Defend the Earth Against Asteroid and Comet Impacts While There is Still Time*, 17 GEO. INT'L ENVTL. L. REV. 1 (2004).

Secondly, this article is concerned with the "threshold" question of whether nuclear NEO response would be "lawful" or "unlawful." It does not, therefore, engage with subsequent legal questions concerning liability should damage/harm result from a planetary defense attempt, as most notably might arise under the Convention on International Liability for Damage Caused by Space Objects 1972 (entry into force Sept. 1, 1972) 961 U.N.T.S. 187. On liability in outer space generally, *see* Carl Q. Christol, *International Liability for Damage Caused by Space Objects*, 74 AM. J. INT'L L. 346 (1980). For a discussion of possible liability issues specially in the context of NEO response, see *Legal Aspects of NEO Threat Response and Related Institutional Issues: Final Report*, University of Nebraska-Lincoln Program on Space and Telecommunications Law, 18–24, 31 (Feb. 9, 2010), https://swfound.org/media/40426/legal_aspects_neo_response_institutional_issues_final_report.pdf.

9. *See, e.g.*, NUCLEAR NON-PROLIFERATION IN INTERNATIONAL LAW (Jonathan L. Black-Branch & Dieter Fleck eds., three volumes: vol. I 2014, vol. II 2015, vol. III 2016) (providing an extensive overview of the subject, with a wide range of contributing experts).

10. *See, e.g.*, HANDBOOK OF SPACE LAW (Frans von der Dunk & Fabio Tronchetti eds., 2015); ROUTLEDGE HANDBOOK OF SPACE LAW (Ram S. Jakhu & Paul Stephen Dempsey eds., 2017) (both providing recent overviews of the subject, with a wide range of contributing experts).

space debris and the environmental effects of human activity in space).[11] There have, however, been extremely few examinations of the particular issue of the legality of using nuclear explosive devices against NEOs; the limited literature on the question that does exist is comparatively brief, and, moreover, much of it was written in the 1990s.[12] This article updates, expands, and advances that work.

The first part of the article, comprising sections I–IV, is deliberately "non-legal" in nature. It sets out the wider context for nuclear NEO responses in a manner intended to be detailed but accessible for international lawyers (who may be unfamiliar with the scientific and political milieu in which the possibility of nuclear NEO response sits). Section I considers the risk and consequences of NEO impact. Section II then explores the recent global political shift towards preparedness for the manifestation of that risk at the state and inter-state levels. The means of responding to potentially harmful NEOs are considered in section III: in particular, the increased focus on *nuclear* approaches, and the reasons for this, are explored. The first part of the article concludes, in section IV, by considering counterarguments against the use of nuclear explosions to avert NEO impact, including through charting the recent progress in the nuclear disarmament and space de-militarization movements.

11. *See, e.g.*, E. Fasan, *Planetary Protection – Some Legal Questions*, 34 ADVANCES IN SPACE RESEARCH 2344–53 (2004) (providing a detailed literature review).

12. For the relevant literature from the 1990s, see Michael B. Gerrard & Anna W. Barber, *Asteroids and Comets: U.S. and International Law and the Lowest-Probability, Highest Consequence Risk*, 6 N.Y.U. ENVTL. L.J. 4, 32–48 (1997); John C. Kunich, *Planetary Defense: The Legality of Global Survival*, 41 AIR FORCE L. REV. 119 (1997); Eugene Brooks, *Dangers from Asteroids and Comets: Relevance of International Law and the Space Treaties*, 40 PROC. ON L. OUTER SPACE 234, 246–247 (1997); K. Sweet, *Planetary Preservation: The Need for Legal Provision*, 15 SPACE POL'Y 223 (1999); Paul R. Weissman, *The Comet and Asteroid Impact Hazard in Perspective*, *in* HAZARDS DUE TO ASTEROIDS AND COMETS 1191, 1206 (Tom Gehrels ed., 1994). There has been some relevant literature published since 2000: however, to the knowledge of the present author, all such examinations only have considered the particular question of *nuclear* responses as a small part of a wider discussion, assessing this briefly in a few pages. *See Legal Aspects of NEO Threat Response*, *supra* note 8, 25–28; Fabio Tronchetti, *International Legal Consideration of Cosmic Hazards and Planetary Defense*, *in* HANDBOOK OF COSMIC HAZARDS AND PLANETARY DEFENSE 1027, 1036–37 (Joseph N. Peltona & Firooz Allahdadi eds., 2015); Jinyuan Su, *Measures Proposed for Planetary Defence: Obstacles in Existing International Law and Implications for Space Arms Control*, 34 SPACE POL'Y 1, 2 (2015); Jinyuan Su, *Control Over Activities Harmful to the Environment*, *in* ROUTLEDGE HANDBOOK OF SPACE LAW 73, 85 (Ram S. Jakhu & Paul Stephen Dempsey eds., 2017); Virgiliu Pop, *Legal Considerations on Asteroid Exploitation and Deflection*, *in* ASTEROIDS: PROSPECTIVE ENERGY AND MATERIAL RESOURCES 659, 675–676 (Viorel Badescu ed., 2013); Seamone, *Wishing on a Star*, *supra* note 8, at 1106 n.73; Fasan, *supra* note 11, at 2346, 2349.

The second part of the article, comprising sections V–VII, shifts to an analysis of the legal aspects of nuclear NEO response. Section V considers possible prohibitions or restrictions on such action under existing treaty law. It is argued that the widely held view[13] that nuclear NEO response would be *prima facie* unlawful is likely correct, but not self-evident. Section VI then assesses existing mechanisms that may be able to preclude the apparent unlawfulness of such action. Given that the existing legal position is unclear and complex, section VII concludes with the tentative suggestion that a new (limited and safeguarded) legal exception should be created, operating through a bespoke multilateral body for decision-making and oversight.

II. NEO Impact Risk

Given the long-standing, tabloid-fueled climate of "asteroid paranoia" in modern western culture,[14] it is important not to overstate the threat that NEOs pose. At the same time, the very factors that have contributed to this "asteroid paranoia"—sensationalism in the media and entertainment industry—also mean that it is easy to dismiss calamitous NEO impact as a concern that should be reserved for science fiction fans and conspiracy theorists.[15] It therefore also is important not to understate the risk posed by NEOs.

Our planet is bombarded on a daily basis by NEOs.[16] However, the vast majority of NEOs (whether known or unknown) represent no risk whatsoever, because if they do cross paths with the Earth, they break up into harmless debris in its atmosphere.[17] It is only a particular, extremely small proportion of NEOs—a subset designated by the National Aeronautics and Space Administration (NASA) as Potentially Hazardous

13. *See infra* notes 160-162 and accompanying text.

14. *See* Felicity Mellor, *Negotiating Uncertainty: Asteroids, Risk and the Media*, 19 PUB. UNDERSTANDING OF SCI. 16 (2010); David Morrison, *Hyperbole in Media Reports on Asteroids and Impacts*, THE SKEPTICAL INQUIRER, Mar.-Apr. 2005, at 29.

15. Seamone, *Wishing on a Star*, *supra* note 8, at 1108-11.

16. JONATHAN POWELL, COSMIC DEBRIS: WHAT IT IS AND WHAT WE CAN DO ABOUT IT 130 (2017).

17. *See Small Asteroids Hit Earth More Often Than You Think*, NAT'L AERONAUTICS AND SPACE ADMIN., Nov. 16, 2014, https://science.nasa.gov/science-news/science-at-nasa/2014/16nov_bolides; Justin L. Koplow, *Assessing the Creation of a Duty under International Customary Law Whereby the United States of America Would be Obligated to Defend a Foreign State Against the Catastrophic but Localized Damage of an Asteroid Impact*, 17 GEO. INT'L ENVTL. L. REV. 273, 279 (2005).

Asteroids (PHAs)—that may pose any danger.[18] As of September 4, 2018, there are somewhere in the region of 1,900 known PHAs.[19]

Data on previous PHA impacts with Earth and the consequences of them remain imprecise.[20] It nonetheless has been argued by some scholars that there may have been as many as six extinction-level events stemming from NEO collision in the history of the planet,[21] including, of course, the widely accepted explanation for the demise of the dinosaurs around 65 million years ago.[22] Rather more recently, Jupiter was bombarded by fragments of the "Shoemaker-Levy Comet" for over a week in 1994,[23] with one large fragment causing a darkness to cover a region of the planet of around 12,000 km in diameter (roughly the size of Earth).[24] It has been postulated that had Shoemaker-Levy hit Earth instead of Jupiter—our near neighbor in astronomical terms—it may have wiped out all of humanity.[25]

The chance of a civilization-ending collision occurring any time soon, however, is very small; it thus represents a paradigmatic example of what risk analysts term a LP/HC (low-probability/high-consequence) event.[26]

18. PHAs are defined based on the coalescence of two factors: their size (larger than 140 meters in diameter), and their proximity to Earth (closer than 4,650,000 miles). *See* Center for Near-Earth Object Studies, *NEO Basics*, NAT'L AERONAUTICS AND SPACE ADMIN., https://cneos.jpl.nasa.gov/about/neo_groups.html.

19. The International Astronomical Union's Minor Planet Center provides a list of all known PHAs, updated daily, https://www.minorplanetcenter.net/iau/MPCORB/PHA.txt.

20. *See, e.g.*, Richard A.F. Grieve & David A. King, *The Geologic Record of Destructive Impact Events on Earth*, *in* COMET/ASTEROID IMPACTS AND HUMAN SOCIETY: AN INTERDISCIPLINARY APPROACH 1, 4 (Peter T. Bobrowsky & Hans Rickman eds., 2007) (in general, but particularly 4, noting that "the terrestrial impact record contains a number of biases …").

21. *See* Michael R. Rampino & Bruce M. Haggerty, *Extraterrestrial Impacts and Mass Extinctions of Life*, *in* HAZARDS DUE TO ASTEROIDS AND COMETS 827 (Tom Gehrels ed., 1994). However, there is some uncertainty on the exact number, and other scholars have estimated that there may only have been five such events, *see e.g.* Brooks, *supra* note 12, at 235.

22. *See generally* CHARLES FRANKEL, THE END OF THE DINOSAURS: CHICXULUB CRATER AND MASS EXTINCTIONS (1999).

23. *See generally* DAVID H. LEVY, IMPACT JUPITER: THE CRASH OF SHOEMAKER-LEVY 9 (1995).

24. THOMAS H. BURBINE, ASTEROIDS: ASTRONOMICAL AND GEOLOGICAL BODIES 225 (2017).

25. Seamone, *Wishing on a Star*, *supra* note 8, at 1104.

26. *See generally* LOW-PROBABILITY HIGH-CONSEQUENCE RISK ANALYSIS ISSUES, METHODS, AND CASE STUDIES (Ray Waller ed., 1984); Shu Li, Jin-Zhen Li, Yi-Wen Chen, Xin-Wen Bai, Xiao-Peng Ren, Rui Zheng, Li-Lin Rao, Zuo-Jun Wang & Huan Liu, *Can Overconfidence be Debiased by Low-Probability/High-Consequence Events?*, 30 RISK ANALYSIS 699 (2010). In relation to the LP/HC nature of NEO collision specifically, *see* Clark R. Chapman, *The Hazard of Near-Earth Asteroid Impacts on Earth*, 222 EARTH &

The "Torino Scale," employed by NASA to quantify NEO risk, states that such potentially extinction-causing impacts "occur on average once per 100,000 years, or less often."[27] Yet, while Torino Scale's risk assessment empirically models the statistical likelihood of harm based on known previous impacts and identified PHAs currently in outer space, it only does so as an *average*, which might be somewhat misleading.[28] NEO collision is random, not neatly periodic,[29] meaning that the Torino Scale's estimate should not be taken to indicate that the next such impact necessarily will be thousands of years in the future.

Further, much more likely than a "doomsday collision," albeit still being of relatively low probability, are collisions of a smaller scale that nonetheless could cause significant destruction on a local or regional scale.[30] A famous example[31] of such an impact is the NEO that exploded—due to entering the Earth's atmosphere at an especially high velocity[32]—above Tunguska, Siberia, Russia in 1908.[33] Despite being what today would be considered an NEO that was too small to qualify as a PHA,[34] and despite not actually even impacting on Earth's surface, the Tunguska NEO created an explosion of an estimated force of 10–20 megatons (TNT equivalent).[35] Much more recently, the 2013 Chelyabinsk meteoroid impact

PLANETARY SCI. LETTERS 1, 9 (2004); Gerrard & Barber, *supra* note 12, at 4; Seamone, *Wishing on a Star*, *supra* note 8, at 1095.

27. Center for Near-Earth Object Studies, *Torino Impact Hazard Scale: Assessing Asteroid and Comet Impact Hazard Predictions in the 21st Century*, NAT'L AERONAUTICS AND SPACE ADMIN., https://cneos.jpl.nasa.gov/sentry/torino_scale.html. *See also* Jason C. Reinhardt, Xi Chen, Wenhao Liu, Petar Manchev & M. Elisabeth Paté-Cornell, *Asteroid Risk Assessment: A Probabilistic Approach*, 36 RISK ANALYSIS 244 (2016).

28. *See* Chapman, *supra* note 26, at 8; Clark R. Chapman & David Morrison, *Correspondence: No Reduction in Risk of a Massive Asteroid Impact*, NATURE 421, 473 (2003).

29. Ben J. Zimmerman & Bong Wie, *Computational Validation of Nuclear Explosion Energy Coupling Models for Asteroid Fragmentation*, AIAA/AAS ASTRODYNAMICS SPECIALIST CONF., AIAA SPACE Forum (AIAA 2014-4146) 1 (2014).

30. *Id.*; Gerrard & Barber, *supra* note 12; Owen B. Toon, Kevin J. Zahnle, David Morrison, Richard P. Turco & Curt Covey, *Environmental Perturbations Caused by the Impacts of Asteroids and Comets*, 35 REV. OF GEOPHYSICS 41, 74-75 (1997).

31. For discussion of some of the more notable recorded NEO impacts in recent human history, *see* Gerrard & Barber, *supra* note 12, at 5; Weissman, *supra* note 12, at 1191-92.

32. Tony Philips, *The Tunguska Impact – 100 Years Later*, NASA SCI. NEWS, June 30, 2008, https://science.nasa.gov/science-news/science-at-nasa/2008/30jun_tunguska; Christopher F. Chyba, Paul J. Thomas & Kevin J. Zahnle, *The 1908 Tunguska Explosion: Atmospheric Disruption of a Stony Asteroid*, 361 NATURE 40 (1993).

33. Bill Napier & David Asher, *The Tunguska Impact Event and Beyond*, 50 ASTRONOMY & GEOPHYSICS 1.18 (Feb. 1, 2009).

34. *See supra* note 18.

35. Chyba, Thomas & Zahnle, *supra* note 32, at 40.

in Russia[36] injured over 1,000 people.[37] Chelyabinsk was the first NEO impact event in recorded history to cause widespread injury to persons and damage to property.[38]

It has been estimated (again, as an average) that major collisions such as Tunguska or Chelyabinsk—i.e., impacts that pose a lesser risk of harm than a civilization-ending collision, but still have the potential to be devastating—will occur once every 300 years.[39] This represents a significantly greater risk than the appearance of a "planet killer."

As a purely statistical matter based on an *average* predicted annual death rate across the next million years, it has been argued that NEO impact poses roughly the same risk to the individual as does the yearly occurrence of accidental drowning or death by naturally occurring fires in the U.S. alone, and a *greater* risk than choking to death on food or from accidental firearm discharge.[40] This said, the risk posed by NEO impact would, of course, involve a "bunched" death-tally resulting from a single impact, rather than being distributed relatively evenly each year, as are these other risks. Moreover, the fact that the occurrence of the next major NEO impact may be thousands of years in the future means the statistical risk takes on a notable level of abstraction when it comes to current human decision-making.[41] Equally, such an impact could occur significantly sooner.[42] The risk posed by NEOs is small, but real.[43]

36. *See, e.g.*, Ian Sample, *Scientists Reveal the Full Power of the Chelyabinsk Meteor Explosion*, THE GUARDIAN, Nov. 7, 2013, https://www.theguardian.com/science/2013/nov/06/chelyabinsk-meteor-russia; Ellen Barry & Andrew E. Kramer, *Shock Wave of Fireball Meteor Rattles Siberia, Injuring 1,200*, N.Y. TIMES, Feb. 15, 2013, https://www.nytimes.com/2013/02/16/world/europe/meteorite-fragments-are-said-to-rain-down-on-siberia.html?mcubz=3.

37. *See* Sample, *supra* note 36; Andrey Kuzmin, *Meteorite Explodes over Russia, More than 1,000 Injured*, REUTERS, Feb. 15, 2013, https://www.reuters.com/article/us-russia-meteorite-idUSBRE91E05Z20130215; Tom Parfitt, *Russian Meteor Visits Shock and Awe on Chelyabinsk*, THE TELEGRAPH, Feb. 15, 2013, https://www.telegraph.co.uk/news/science/space/9873752/Russian-meteor-visits-shock-and-awe-on-Chelyabinsk.html.

38. *See* Su, *Measures Proposed for Planetary Defence*, *supra* note 12, at 2.

39. V.V. Lebedev, *Russia's Preparedness to Protect the Earth Against Asteroid Hazards*, 83 HERALD OF THE RUSSIAN ACADEMY OF SCI. 429, 429 (2013); Philips, *supra* note 32; Su, *Measures Proposed for Planetary Defence*, *supra* note 12, at 2.

40. Gerrard & Barber, *supra* note 12, at 12-13.

41. *See generally* Paul Slovic & Ellen Peters, *Risk Perception and Aff*ect, 15 CURRENT DIRECTIONS IN PSY'CAL SCI. 322 (2006) (discussing the divergence between statistical risk and perceived risk based on emotional response and experiential senses).

42. To take just one example, it recently was estimated by NASA that there is a 1 in 2,700 probability of the large "Bennu" asteroid colliding with the Earth on Sept. 22, 2135. *See* Cleve R. Wootson Jr., *There's a Small Chance an Asteroid will Smack into Earth in 2135. NASA is Working on a Plan*, WASH. POST, Mar. 19, 2018, https://www.

II. THE GLOBAL POLITICAL SHIFT TOWARDS PREPAREDNESS

NEO impact risk had long been largely dismissed at the state level.[44] In 1995, NASA astrophysicist David Morrison famously asserted that "more people work a typical shift at one fast-food restaurant than scan the skies for near-Earth asteroids."[45] Morrison's statement almost certainly was hyperbolic,[46] but it nonetheless is indicative of the limited resource allocation in relation to NEO risk in the mid-1990s in the U.S.

For decades NASA struggled to conduct NEO preparedness work because of the negligible budget that it was allocated.[47] Indeed, while NASA was commissioned by the U.S. House of Representatives to initiate exploratory work on NEO response in 1990,[48] it was not until 2005 that it received a mandate formally to begin developing plans for NEO interception (as opposed solely to identification/cataloguing).[49] Such state-level dismissal of NEO impact risk also was apparent outside of the U.S. This can be illustrated by a statement made by the Australian Minister of Science on the *60 minutes* CBS television show in 2002: he asserted that Australia was "not going to be spooked or panicked into spending scarce research dollars on a fruitless attempt to predict the next asteroid . . ." and stressed that NEO impact represented "hype . . . and even fear-mongering . . . ."[50]

A similar degree of indifference was also evident at the inter-state level. In 1995, for example, noted NEO specialist Tom Gehrels made an

washingtonpost.com/news/speaking-of-science/wp/2018/03/19/theres-a-small-chance-an-asteroid-will-smack-into-earth-in-2135-nasa-is-working-on-a-plan/?utm_term=.2fc0ac744aff.

43. *See, e.g.*, Brian Kaplinger, Bong Wie & David Dearborn, *Earth-Impact Modeling and Analysis of a Near-Earth Object Fragmented and Dispersed by Nuclear Subsurface Explosions*, 59 J. ASTRON'L SCI. 103, 103 (2012).

44. *See* Brooks, *supra* note 12, at 240 (arguing, in 1997, that most of the work on the subject was being conducted by "ad hoc non governmental institutions").

45. David Morrison, *Target: Earth!* 23 ASTRONOMY 34, 39 (1995).

46. Gerrard & Barber, *supra* note 12, at 8-9, n.22.

47. *See* Thomas Mallon, *The Asteroids Are Coming! The Asteroids Are Coming!*, N.Y. TIMES MAGAZINE, July 28, 1996, https://www.nytimes.com/1996/07/28/magazine/the-asteroids-are-coming-the-asteroids-are-coming.html (describing the NASA budget in the 1990s as "under siege.").

48. *See* Brooks, *supra* note 12, at 241.

49. *See* National Aeronautics and Space Administration Authorization Act 2005, 119 Stat. 2895, Pub. L. 109–155, 109th Cong., §321, 4(c).

50. Quoted *in* R.B. Adams, R. Alexander, J. Bonometti, J. Chapman, S. Fincher, R. Hopkins, M. Kalkstein & T. Polsgrove, *Survey of Technologies Relevant to Defense from Near-Earth Objects*, NATN'L AERONAUTICS & SPACE ADMIN. 14-15 (July 2004), https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20050081838.pdf.

impassioned plea at the first United Nations (UN) NEO conference in New York[51] for the UN finally to take a meaningful role in the coordination of efforts to minimize the global risk of NEO impact.[52] In 2004, Seamone noted in an article on NEO response, with a degree of exasperation, that there was no agency to take the lead on planetary defense at the international level, and no guidelines or framework to coordinate global NEO protection efforts.[53] As recently as 2010, a major report on the subject by the University of Nebraska stressed that an international framework for dealing with the issue was "conspicuously missing."[54]

Having said this, the UN had at least begun to take note of the risk of NEO impact in the 1990s. Subsequent to the UN-organized NEO conference in 1995,[55] the Third UN Conference on the Exploration and Peaceful Uses of Outer Space in 1999 formally recommended that the international coordination of activities related to NEOs be improved.[56] That recommendation resulted in the UN Committee on the Peaceful Uses of Outer Space (COPUOS) establishing the Action Team on Near-Earth Objects ("Action Team 14") in 2001.[57] Other inter-state institutions slowly had started to take note of the issue in the mid-1990s too: for example, in 1996, the Council of Europe passed a resolution encouraging its member states to fund and engage in international NEO detection and response efforts.[58] These early steps towards engaging with potential NEO impact at the inter-state level laid important groundwork, but were tentative and limited in themselves.

The floodgates of global political will only truly have opened in the last five years, particularly following the 2013 Chelyabinsk impact. Perhaps unsurprisingly, Russia's role in developing and implementing NEO preparedness strategies increased significantly as a result of

51. *See* John L. Remo, *Policy Perspectives from the UN International Conference on Near-Earth Objects*, 12 SPACE POL'Y 13 (1996).

52. Tom Gehrels, *A Proposal to the United Nations Regarding the International Discovery Programs of Near-Earth Asteroids*, 822 ANNALS OF N.Y. ACADEMY OF SCI. 603 (1997).

53. Seamone, *The Precautionary Principle*, *supra* note 8, at 10. *See also* Brooks, *supra* note 12, 241.

54. *Legal Aspects of NEO Threat Response*, *supra* note 8, at 1.

55. Remo, *supra* note 51.

56. Report of the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (Vienna, Jul. 19–30, 1999) res. 1, ¶ (1)(c)(i), (ii), (iii), U.N. Doc. A/CONF.184/6 (Oct. 18, 1999).

57. *Report of the Committee on the Peaceful Uses of Outer Space*, U.N. GAOR, 56th Sess., supp. no. 20, ¶¶ 44-61, U.N. Doc. A/56/20 (2001).

58. Council of Europe, Parliamentary Assembly, *Resolution on the Detection of Asteroids and Comets Potentially Dangerous to Humankind*, SPACEGUARD FOUNDATION, Mar. 20, 1996, http://spaceguard.rm.iasf.cnr.it/SGF/resol.html.

Chelyabinsk.[59] For example, various scientific centers and institutes in Russia have begun to undertake serious investigation into NEO response strategies since 2013,[60] and in March 2017, a major NEO roundtable was convened by the Russian Federation Council.[61]

Further, Russia's newfound enthusiasm for the issue was evident in its significant involvement in the "NEOShield" project funded by the European Union (EU). The EU, for its part, had—for the first time—begun to divert substantial resources towards research on NEOs, bankrolling NEOShield to carry out detailed analysis of the various mitigation options for preventing impacts. NEOShield has run (in two iterations) since 2012.[62]

Concurrent with these developments in Europe, President Obama's second term in office saw the cementation of NEO impact risk as a meaningful element of U.S. national and international policy. This process had begun during the presidency of George W. Bush, who signed into law the 2005 NASA Authorization Act.[63] Following the 2013 Chelyabinsk event, however, the Obama administration gave increased priority to the issue, culminating in the publication of the U.S. White House's *National Near-Earth Object Preparedness Strategy* in December 2016.[64] That document, produced by an inter-agency working group, for the first time

59. *See, e.g.*, Peter Fowler, *PM Medvedev Says Russian Meteorite KEF-2013 Shows "Entire Planet" Vulnerable*, NEWSROOM AMERICA, Feb. 15, 2013, https://www.newsroomamerica.com/story/347222/pm_medvedev_says_russian_meteorite_kef-2013_shows_entire_planet_vulnerable_html (reporting that Russian Prime Minister Dmitry Medvedev stated on the day of the Chelyabinsk impact that it demonstrated that "the entire planet" was vulnerable to NEO impact, and that Deputy Prime Minister Dmitry Rogozin stressed that the international community needed to develop NEO impact preparedness strategies).

60. *See* Lebedev, *supra* note 39, at 433-44 (listing these various bodies).

61. *See id.* at 433.

62. *See Former NEOShield Project*, https://www.neoshield.eu/neoshield1-summary, for information on the first iteration that ran from 2012 to 2015 (last visited Oct. 23, 2018). *See also The NEOShield-2: Science and Technology for Near-Earth Object Impact Prevention*, https://www.neoshield.eu/science-technology-asteroid-impact, for the second iteration and current project, started in 2015 (last visited Oct. 23, 2018). The Russian state space agency was a key collaborating partner in the first iteration, *see NEOShield Team*, https://www.neoshield.eu/neoshield1-summary/neoshield-1-team (last visited Oct. 23, 2018). *See also NEOShield-2: The Team*, https://www.neoshield.eu/science-technology-asteroid-impact/dlr-airbus-paris-surrey-aerospace (last visited Oct. 23, 2018) (listing the collaborating partners for the second iteration).

63. NASA Authorization Act 2005, *supra* note 49.

64. *National Near-Earth Object Preparedness Strategy*, Interagency Working Group for Detecting and Mitigating the Impact of Earth-Bound Near-Earth Objects (NEOS) (DAMIEN) OF THE NATN'L SCI. & TECH. COUNCIL 5 (Dec. 2016), https://www.nasa.gov/sites/default/files/atoms/files/national_near-earth_object_preparedness_strategy_tagged.pdf.

set out a comprehensive U.S. plan for responding to an impending large-scale NEO collision with Earth.[65]

At the UN, stemming from its initial spark activity in the 1990s, investigation into NEO impact had been ongoing throughout the 2000s.[66] However, again it seemingly was the Chelyabinsk meteoroid (and the resulting increase in political will on the part of some of the organization's most powerful member states), that provided the impetus for meaningful progress to be made at the UN. In particular, the increased efforts of COPUOS's Working Group on Near-Earth Objects (which was originally constituted in 2007, and then reconvened each year up to and including 2013)[67] and Action Team 14,[68] led to the creation of the International Asteroid Warning Network (IAWN) and the Space Mission Planning Advisory Group (SMPAG), which both formally were endorsed by the UN General Assembly in December 2013.[69]

IAWN's purpose is to coordinate international efforts to identify and track NEOs, and to link existing entities engaged in such work.[70] SMPAG's role also is to link and facilitate the cooperation of existing entities, including UN member states' space agencies, but its terms of reference concern the development international *responses* to NEO impact risk.[71]

65. *Id*.

66. For example, the recommendation of the Third UN Conference on the Exploration and Peaceful Uses of Outer Space in 1999, led not only to the creation of Action Team 14 in 2001 (*supra* note 57 and accompanying text), but also, later, to a year-long Working Group on Near-Earth Objects in 2007, which then was reconvened each year up to and including 2013. *See* UNGA Res 61/111, ¶ 16, U.N. Doc. A/RES/61/111 (Jan. 15, 2007); G.A. Res 62/217, ¶ 15, U.N. Doc. A/RES/62/217 (Feb. 1, 2008); G.A. Res 63/90, ¶ 15, U.N. Doc. A/RES/63/90 (Dec. 18, 2008); G.A. Res 64/86, ¶ 9, U.N. Doc. A/RES/64/86 (Jan. 13, 2010); G.A. Res 65/97, ¶ 7, U.N. Doc. A/RES/65/97 (Jan. 20, 2011); UNGA Res 66/71, ¶ 7, U.N. Doc. A/RES/66/71 (Jan. 12, 2012); G.A. Res 67/113, ¶ 7, U.N. Doc. A/RES/67/113 (Jan. 14, 2013). Also of note is the second major UN-organized NEO response conference held in 2011 in Pasadena, California, see *Asteroid Impact on Earth: Experts Review Global Response and Mitigation Steps*, NEWSWISE (Aug. 30, 2011) https://www.newswise.com/articles/view/580097/?sc=dwtr&xy=5028369.

67. *See supra* note 66.

68. *See supra* note 57 and accompanying text.

69. G.A. Res. 68/75, ¶ 8, U.N. Doc. A/RES/68/75 (Dec. 16, 2013) (endorsing the proposals of the COPUOS Scientific and Technical Subcommittee, *Report of the Scientific and Technical Subcommittee on its fiftieth session, held in Vienna from 11 to 22 February 2013*, particularly ¶¶ 11-14, U.N. Doc. A/AC.105/1038 (Mar. 7, 2013)).

70. *Statement of Intent for Participation in the International Asteroid Warning Network*, INTERNATIONAL ASTEROID WARNING NETWORK (IWAN) (Mar. 9, 2014), http://iawn.net/documents/iawn_statement_of_intent.pdf.

71. Space Missions Planning Advisory Group (SMPAG), *Terms of Reference for the Near-Earth Object Threat Mitigation Space Mission Planning Advisory Group*, EUROPEAN SPACE AGENCY, https://www.cosmos.esa.int/web/smpag/terms-of-reference-v0 (last visited Oct. 23, 2018).

Both IWAN and SMPAG thus are coordination bodies, rather than UN organs strictly speaking, but they nonetheless represent the emergence of a groundbreaking infrastructure. They are formally UN-mandated efforts to coordinate global data and management of NEO impact risk. The 2013 creation of these bodies was a major turning point in UN leadership on the NEO issue.[72]

The last five years thus have seen an unprecedented convergence of state political will and the creation of an (admittedly still embryonic) international institutional infrastructure.[73] When these developments are combined with concurrent advancements in science and technology,[74] it may be said that that humanity's potential to detect and, if necessary, respond to collision-course NEOs now is at a level that likely would have been considered implausible even at the start of the current decade.

72. Su, *Measures Proposed for Planetary Defence*, *supra* note 12, at 2.

73. *Compare*, e.g., the creation of the Intergovernmental Panel on Climate Change (IPCC), set up in 1988 by UNGA Res 43/53, ¶ 10, U.N. Doc. A/RES/43/53 (Dec. 6, 1988) (which is the international body for assessing the science related to climate change), and the United Nations Framework Convention on Climate Change 1992 (entry into force Mar. 21, 1994) 1771 U.N.T.S. 107 (which acted as the first notable step in the development of structured international processes in relation to climate change, *see* Daniel Bodansky, *The United Nations Framework Convention on Climate Change: A Commentary*, 18 YALE J. INT'L L. 451, 558 (1993)). The creation of the IPCC and the adoption of the Framework Convention on Climate Change occurred, respectively, 16 years and 20 years *after* the United Nations Conference on the Human Environment (Stockholm, June 5–16, 1972) U.N. Doc. A/CONF.48/14 and Corr.1 (*see*, in particular, Recommendation 70) had meaningfully placed climate change on the international agenda (*see* Richard Black, *Stockholm: Birth of the Green Generation*, BBC NEWS, June 4, 2012, https://www.bbc.co.uk/news/science-environment-18315205).

74. *See* National Research Council, DEFENDING PLANET EARTH: NEAR-EARTH-OBJECT SURVEYS AND HAZARD MITIGATION STRATEGIES 29-50 (2010); Josep M. Trigo-Rodríguez, Herbert Palme & Maria Gritsevich, *Barcelona Asteroid Day 2015: Revisiting the Threat by Asteroid and Comet Impact*, *in* ASSESSMENT AND MITIGATION OF ASTEROID IMPACT HAZARDS: PROCEEDINGS OF THE 2015 BARCELONA ASTEROID DAY 1, 2 (Josep M. Trigo-Rodríguez, Maria Gritsevich & Herbert Palme eds., 2017); G.B. Valsecchi & A. Milani Comparetti, *Evaluating the Risk of Impacts and the Efficiency of Risk Reduction*, *in* COMET/ASTEROID IMPACTS AND HUMAN SOCIETY: AN INTERDISCIPLINARY APPROACH 202, 208 (Peter T. Bobrowsky and Hans Rickman eds., 2007); *Legal Aspects of NEO Threat Response*, *supra* note 8, at 4; Su, *Measures Proposed for Planetary Defence*, *supra* note 12, at 2.

III. THE MEANS OF RESPONSE AND SUPPORT FOR THE "NUCLEAR OPTION"

More than ever before, the increased global capacity to respond to potentially harmful NEOs triggers the question of which method(s) of response humanity might seek to employ, should a collision-course NEO be detected.

A. Diversion vs. Destruction

Any approach to preventing NEO impact will need to 1) deflect/divert the NEO; or 2) destroy it.[75] It is evident that "[a]mong researchers in this field, the current accepted plan is to change the course of an asteroid as it approaches the Earth, not to blow it up."[76] This preference for "diversion" in the scientific community is because of the significantly greater kinetic force required for,[77] and the possibility of dangerous debris resulting from,[78] approaches that would involve the destruction of an NEO.

It is worth noting, however, that diversion may not be possible in late-warning cases. If an NEO was already close to impact when spotted, the time required to alter its course enough for it to miss Earth may mean that destruction became the only viable option.[79]

B. "Off-World" vs. "On-World" Approaches

Some NEO response experts have argued that any NEO diversion mission would be more likely to succeed if the interceptor were to be already stationed in outer space (what may be called an "off-world"

75. *See* Thomas J. Ahrens & Alan W. Harris, *Deflection and Fragmentation of Near-Earth Asteroids*, 360 NATURE 429 (1992); Sweet, *supra* note 12, at 224; Kunich, *supra* note 12, at 128.

76. John Basart & Bong Wie, *Mitigation of Asteroid Impact Threats*, 28 IEEE POTENTIALS 10, 11 (2009).

77. V.S. Sazonov & M.V. Yakovlev, *Explosion Method of Preventing Collisions of Asteroid-Comet Bodies with the Earth in the Case of their Late Detection*, 79 J. ENGINEERING PHYSICS & THERMOPHYSICS 476, 476 (2006).

78. Basart & Wie, *supra* note 76, at 11.

79. *See* Megan Bruck Syal, David S.P. Dearborn & Peter H. Schultz, *Limits on the Use of Nuclear Explosives for Asteroid Deflection*, 90 ACTA ASTRONAUTICA 103, 103–04 (2013); J. Sanchez, M. Vasile & G. Radice, *On the Consequences of a Fragmentation Due to a NEO Mitigation Strategy*, *in* PROCEEDINGS OF THE IAC-08-C1.3.10, 59TH INTERNATIONAL ASTRONAUTICAL CONGRESS, Strathprints version, 3-4 (2008); S. Konyukhov & N. Slyunyayev, *Conception of the Creation of Space Rocket Complex as Necessary Link for Anti-Asteroid Protection of the Earth*, 50 ACTA ASTRONAUTICA 629, 630 (2002).

approach), rather than it being launched at the NEO from the surface of the Earth (an "on-world" approach).[80] These experts reason that an interceptor launched from Earth may not reach the NEO in time,[81] or at least that a response initiated from Earth may allow time only for one attempt to divert the NEO, whereas interception from within space would be more likely to offer opportunities for multiple/cumulative interception attempts, increasing the chances of success.[82]

However, such conclusions have been contested. Other NEO response experts have argued that, depending on the circumstances, diversion may still be possible by means of a specially designed terrestrially-launched rocket,[83] or even that existing "on-world" missile systems could be employed to produce the desired effect.[84]

C. The Desirability of, and Steps Towards, Testing Possible Responses

Whatever NEO response measure might ultimately be employed, some scientific experts have stressed that it is highly desirable that any measures of NEO response are *tested*, not merely simulated, including by employing them against actual NEOs that are not on a collision course with Earth.[85] Stepping beyond computer simulations,[86] practical tests would allow for data collection to better determine the suitability of any given measure, predict the chances of success and optimal application, as well as highlight risks and environmental implications. Such data could be crucial

80. Claudio Maccone, *Planetary Defense from Space: Part 1 – Keplerian Theory*, 55 ACTA ASTRONAUTICA 99 (2004); Claudio Maccone, *Planetary Defense from Space: Part 2 (Simple) Asteroid Deflection Law*, 58 ACTA ASTRONAUTICA 662 (2006); Mark Bucknam & Robert Gold, *Asteroid Threat? The Problem of Planetary Defence*, 50 SURVIVAL 141, 149 (2008).

81. Bucknam & Gold, *supra* note 80, at 149.

82. Maccone, *Planetary Defense from Space: Part 1*, *supra* note 80, at 992; Maccone, *Planetary Defense from Space: Part 2*, *supra* note 80, at 663.

83. *See, e.g.*, Konyukhov & Slyunyayev, *supra* note 79.

84. Kunich, *supra* note 12, at 128.

85. *See, e.g.*, Bucknam & Gold, *supra* note 80, at 152 (making this argument specifically with regard to nuclear options); Basart & Wie, *supra* note 76, at 12; Sweet, *supra* note 12, at 228; Weissman, *supra* note 12, at 1207; Seamone, *The Duty to "Expect the Unexpected"*, *supra* note 8, at 791-93.

86. *See generally* Nahum Melamed, *Development of a Handbook and an On-Line Tool on Defending Earth against Potentially Hazardous Objects*, 90 ACTA ASTRONAUTICA 165 (2013); Brian Kaplinger, Bong Wie & David Dearborn, *Nuclear Fragmentation/Dispersion Modeling and Simulation of Hazardous Near-Earth Objects*, 90 ACTA ASTRONAUTICA 156 (2013).

for decision-making and resource allocation prior to the actual appearance of a collision-course NEO (where time may be a crucial factor, and where the use of an untested approach may increase the risk of the response failing or causing unintended harm).[87]

As part of the recent general movement in the global political climate towards NEO preparedness, notable steps have been taken to test humanity's response capability in concrete settings. For example, in October 2017, NASA, IWAN and other agencies conducted various (non-kinetic[88]) preparedness and response tests on asteroid "TC4," as it passed by Earth at a distance of around 26,000 miles.[89] Even more significant is the Asteroid Impact and Deflection Assessment (AIDA) mission, initiated in 2015, which is a collaborative endeavor of the European Space Agency, NASA, Observatoire de la Côte d'Azur, and the Johns Hopkins University Applied Physics Laboratory.[90] AIDA will involve two separate launches, scheduled for October and December 2020 (with rendezvous predictions of May and October 2022, respectively).[91] These missions will constitute the first "real-world" (or, more accurately, "real-solar system") testing of a (non-nuclear) kinetic impact diversion technique, by attempting to ram and thus deflect the 800m "Didymos" asteroid.[92]

D. Scientific Support for Nuclear Approaches

Turning to the potential options themselves for NEO diversion (and, for cases where diversion would be impossible, destruction), various possible methods have been proposed, including a wide range of non-nuclear options. These non-nuclear proposals include "kinetic impact" (i.e., ramming the NEO, which is what the AIDA mission is seeking to test), the use of lasers, gravitational "tug boats" to drag the NEO (what are

87. *See generally* A. F. Cheng, J. Atchison, B. Kantsiper, A. S. Rivkin, A. Stickle, C. Reed, A. Galvez, I. Carnelli, P. Michel & S. Ulamec, *Asteroid Impact and Deflection Assessment Mission*, 115 ACTA ASTRONAUTICA 262 (2015) (discussing the benefits of practically testing diversion methods).

88. *See infra* note 93 and accompanying text (giving a brief overview of some of the various proposed methods, both kinetic and non-kinetic).

89. *See* Jet Propulsion Laboratory, National Aeronautics and Space Administration, *This is a Test: Asteroid Tracking Network Observes Close Approach*, Oct. 10, 2017, https://www.jpl.nasa.gov/news/news.php?feature=6969.

90. *See Asteroid Impact and Deflection Assessment (AIDA) Mission*, NATN'L AERONAUTICS & SPACE ADMIN., https://www.nasa.gov/planetarydefense/aida.

91. *Id.*

92. *Id.*; Cheng et al., *supra* note 87, at 262.

sometimes called "gravity tractors"), gravity "sling shots," and harnessing solar energy to super-heat the asteroid's surface.[93]

Crucially, however, "in recent years, advocates of the use of nuclear weapons . . . have been gaining ground."[94] Many experts in relevant fields increasingly argue that nuclear explosive technology represents the most effective, and perhaps in certain situations *the only*, option humanity may have for responding to extreme NEO impact scenarios. In March 2007, for example, NASA delivered a report to the U.S. Congress setting out the findings of an extensive survey of alternatives; a key conclusion in that report was that "[n]uclear standoff explosions [i.e., explosions near to an NEO as a means of diverting it] are assessed to be *10-100 times more effective* than . . . non-nuclear alternatives."[95] Given the likelihood of any NEO interception mission being both time and resource[96] constrained, nuclear devices also represent by far the most mass-efficient means of transporting large amounts of energy across long distances.[97]

Those who support the use of nuclear explosions for planetary defense do not argue that they will be suitable in all circumstances,[98] stressing that this approach should be reserved as a last resort in extreme cases.[99] For some potentially hazardous NEOs, non-nuclear options will be scientifically preferable (leaving aside, at this juncture, questions of politics and law).[100] However, nuclear explosions particularly have been supported

93. For discussion of proposed non-nuclear options, see Joseph Packer, Jeffrey A. Kurr & Adam Abelkop, *The Policy Trajectory of United States Asteroid Deflection Planning*, 1 TIMELY INTERVENTIONS: TRANSNAT'L J. PUB. POL'Y DEBATE 1, 4 (2013); H. J. Melosh, I. V. Nemchinov & Yu I. Zetzer, *Non-Nuclear Strategies for Deflecting Comets and Asteroids*, *in* HAZARDS DUE TO ASTEROIDS AND COMETS 1111 (Tom Gehrels ed. 1994).

94. Douglas Birch, *The Plans to Use Nuclear Weapons to Blow up Incoming Asteroids*, ATLANTIC, Oct. 16, 2013, https://www.theatlantic.com/technology/archive/2013/10/the-plans-to-use-nuclear-weapons-to-blow-up-incoming-asteroids/280593.

95. Center for Near Earth Object Studies, *Near-Earth Object Survey and Deflection Analysis of Alternatives: Report to Congress*, NATN'L AERONAUTICS & SPACE ADMIN. 2 (March 2007) (emphasis added). *See also* Bong Wie, *Hypervelocity Nuclear Interceptors for Asteroid Disruption*, 90 ACTA ASTRONAUTICA 146, 151 (2013) ("… a nuclear explosion is much more effective than any other non-nuclear alternative …").

96. *Legal Aspects of NEO Threat Response*, *supra* note 8, 33 (noting that cost is "a major aspect of … NEO mitigation campaigns …").

97. *Id.*; National Research Council, *supra* note 74, 76; YEOMANS, *supra* note 3, at 146.

98. *See generally* Kaplinger, Wie & Dearborn, *supra* note 43, at 104.

99. *See, e.g.*, National Research Council, *supra* note 74, particularly 4, 79; Packer, Kurr, & Abelkop, *supra* note 93, at 2; YEOMANS, *supra* note 3, at 148; *Legal Aspects of NEO Threat Response*, *supra* note 8, at 25.

100. *See* Megan Bruck Syal, J. Michael Owen & Paul L. Miller, *Deflection by Kinetic Impact: Sensitivity to Asteroid Properties*, 269 ICARUS 50 (2016) (specifically discussing kinetic non-nuclear approaches).

in relation to two circumstances: where the NEO is 1) especially large; or 2) especially close.[101]

Where the NEO is especially large, it has been claimed that diverting (or perhaps destroying) it by non-nuclear means is likely to be extremely difficult or impossible given the level of kinetic energy required. Writing in the hugely influential journal *Nature* in 1992, Ahrens and Harris concluded that "for larger objects [NEOs in the 1–10km diameter range] nuclear explosions *seem to be the only practical means of deflection*."[102] More than 20 years later, in 2013, Syal *et al.* made the same assertion: "At present, nuclear munitions are the *only available* technology capable of deflecting large bodies [NEOs exceeding 500m in diameter]."[103]

Similarly, a nuclear approach has been said to be necessary in cases where the NEO is especially close to Earth when it is detected.[104] It has been argued that *all* of the proposed non-nuclear methods would require a substantial lead time (over 10 years, and in some cases much longer),[105] or at least that non-nuclear methods involving "low energy" diversion/destruction of a "close" NEO would create significant amounts of potentially harmful debris.[106] Whereas it has been argued that the "high energy" use of nuclear explosions "may substantially reduce the amount of mass remaining on impact trajectories"[107] and could be employed in a much shorter timeframe.[108]

E. State-Level Support for Nuclear Approaches

Reflecting what now seemingly is the majority view in the scientific research, states (at least the major players) have focused particularly on developing nuclear methods of NEO diversion over the last five to ten years. In the U.S., NASA has begun to receive heavy investment for research into nuclear approaches, and a series of big-money grants have been awarded to researchers at American universities and institutes to fund

101. *See, e.g.*, National Research Council, *supra* note 74, 78; Bucknam & Gold, *supra* note 80, at 149; Wie, *supra* note 95, at 151; *Legal Aspects of NEO Threat Response*, *supra* note 8, at 25.

102. Ahrens & Harris, *supra* note 75, at 429 (emphasis added).

103. Syal, Dearborn & Schultz, *supra* note 79, at 103 (emphasis added). *See also* Gerrard & Barber, *supra* note 12, at 10; Su, *Measures Proposed for Planetary Defence*, *supra* note 12, at 2; Brooks, *supra* note 12, at 242, 246; National Research Council, *supra* note 74, 79.

104. *See, e.g.*, National Research Council, *supra* note 74, at 76.

105. Wie, *supra* note 95, at 146.

106. Sanchez, Vasile & Radice, *supra* note 79.

107. Kaplinger, Wie & Dearborn, *supra* note 86, at 156.

108. *Id.* at 156 ("This method could be available with as little as 10 days of lead time between intercept and the predicted impact date.").

parallel work.[109] Russia has also increased its focus on the nuclear option. From 2012–2015, for example, Russia's federal space agency led the strand of the EU-funded NEOShield project[110] that was aimed specifically at further developing viable nuclear explosive ways of diverting large NEOs.[111]

Of especial note is the fact that the U.S. and Russia have explored the possibility of *collaborating* on nuclear approaches to NEO response. In 2013, the two states concluded a wide-ranging, open-ended nuclear cooperation agreement,[112] and, while that agreement did not explicitly reference nuclear planetary defense, the accompanying release statement from the U.S. Department of Energy confirmed that a key project envisaged as falling under the auspices of Article III of the agreement was for the U.S. and Russia to work together on "defense from asteroids" by nuclear means.[113] The 2013 agreement was suspended by Russia in 2016 due to increased tensions between the states (primarily in relation to Crimea).[114] Nonetheless, given the shared history of the U.S. and Russia when it comes to nuclear weapons, the very fact that they seriously have explored the possibility of collaborating on nuclear planetary defense initiatives, to the point of taking steps to formalize this as an aspect of a cooperative agreement, shows how prominent the nuclear approach to NEO response has become for both states.

109. Birch, *supra* note 94.

110. *See supra* note 62 and accompanying text.

111. Roland Oliphant, *EU, Russia may Nuke Asteroids*, THE TELEGRAPH, Jan. 17, 2016, https://www.telegraph.co.uk/news/worldnews/europe/russia/12103720/EU-Russia-may-nuke-asteroids.html (citing a press release from Russia's federal space agency); John Hall, *Nuclear Weapons Could be Used to Blow Up Asteroids if They Threaten the Earth, Scientists Reveal*, INTERNATIONAL BUSINESS TIMES, Jan. 17, 2016, https://www.ibtimes.co.uk/nuclear-weapons-could-be-used-blow-asteroids-if-they-threaten-earth-scientists-reveal-1538425.

112. *Agreement between the Government of the United States of America and the Government of the Russian Federation on Cooperation in Nuclear- and Energy-Related Scientific Research and Development* (*United States-Russia Nuclear Research Agreement*) (2013), http://fissilematerials.org/library/u-s-department-of-energy-agreement-with-rosatom.pdf.

113. *United States, Russia Sign Agreement to Further Research and Development Collaboration in Nuclear Energy and Security*, United States Department of Energy, Sept. 16, 2013, https://energy.gov/articles/united-states-russia-sign-agreement-further-research-and-development-collaboration-nuclear.

114. *See Suspending the Russian-US Agreement on Cooperation in Nuclear- and Energy-Related Scientific Research and Development*, The Russian Government, Government Decisions, Orders and Directives, Oct. 5, 2016, http://special.government.ru/en/docs/24766.

At the global institutional level too, it is notable that the new UN-mandated body SMPAG listed, in its October 2016 work plan, the "study of the nuclear device option" as a key future activity for the group. Indeed, from a review of the full work plan, this is an activity that seems to have been given rather more prominence on SMPAG's agenda than parallel work relating to non-nuclear alternatives.[115]

Overall, nuclear options clearly have received significant increased support, in relation at least to the most extreme NEO threat scenarios, across the research community, some of the major state players, and at the inter-state level. Not only is NEO preparedness now truly on the global agenda for the first time, but the nuclear method of implementing it in particular is too.

IV. REASONS TO OPPOSE THE "NUCLEAR OPTION"

A. Scientific Opposition

It is important to note that there remains dissent amongst experts in NEO response as to the desirability of the nuclear approach. Scientists continue to develop possible non-nuclear approaches, and, in so doing, at least some explicitly eschew the use of nuclear devices.[116] In part, this competing stance is rooted in genuine differences of scientific opinion as to the efficacy of nuclear approaches and the avowed inefficacy of non-nuclear options in relation to particular NEO impact scenarios.

For example, it has been argued that the porous nature of some NEOs indicate that they will be more resistant to measures involving the direct application of kinetic energy than commonly is supposed, and therefore other methods (such as gravity-related sling shot techniques) will have a higher chance of success.[117] In contrast to those arguing that a nuclear blast would lessen the risk of harmful fragments raining down on Earth,[118] others have stressed that the risk of debris in fact would be *increased* by the

115. U.N. Office for Outer Space Affairs, Space Mission Planning Advisory Group, *Work Plan*, Document No. SMPAG—PL-001/1.2, 19–20 (Oct. 2016).

116. *See, e.g.*, Mohammad J. Mashayekhi & Arun K. Misra, *Effect of the Finite Size of an Asteroid on its Deflection Using a Tether–Ballast System*, 125 CELEST MECH DYN ASTR 363, 364–65 (2016); Jesse D. Koenig & Christopher F. Chyba, *Impact Deflection of Potentially Hazardous Asteroids Using Current Launch Vehicles*, 15 SCI. & GLOBAL SEC. 57 (2007).

117. *See, e.g.*, Syal, Owen & Miller, *supra* note 100, at 54-55; Packer, Kurr & Abelkop, *supra* note 93, at 4.

118. *See* Sanchez, Vasile & Radice, *supra* note 79.

destructive force of a nuclear explosion, leading to more harm than would have occurred had a non-nuclear method been employed.[119]

Such disagreements demonstrate that the scientific preference for nuclear methods certainly is not universal. However, even leaving aside differences of opinion over the science and questions of resulting efficacy, it is clear that the competing trend in the research community towards non-nuclear options also stems from wider political and social concerns related to nuclear armaments.[120]

B. "PNEs" and Nuclear Weapons

The use of a nuclear explosive device as a means of NEO response might arguably fall under the category of nuclear activity that has sometimes been referred to as "Peaceful Nuclear Explosions" (PNEs). In the early decades of the nuclear age, the U.S.[121] and the Soviet Union[122] exploded around 150 nuclear devices for peaceful civil and industrial purposes. However, while potentially useful as a descriptor of underpinning intent, the notion of a "PNE" is an illusory one in practice because, technologically, PNEs are identical to the testing or use of nuclear weapons (in terms of both the act and the results of that act).[123] This most vividly can

119. *See, e.g.*, Mashayekhi & Misra, *supra* note 116, at 364-65; Packer, Kurr & Abelkop, *supra* note 93, at 4.

120. *See, e.g.*, Mohammad J. Mashayekhi & Arun K. Misra, *Tether Assisted Near Earth Object Diversion*, 75 ACTA ASTRONAUTICA 71, 71 (2012); Melosh, Nemchinov & Zetzer, *supra* note 93, at 1130; Maccone, *Planetary Defense from Space: Part 2*, *supra* note 80, at 670.

121. *See* Jozef Goldblat, *The Nuclear Non-Proliferation Régime: Assessment and Prospects*, 256 RECUEIL DES COURS 9, 48 (1995) (noting that the U.S. carried out 27 PNEs between 1961 and 1973). For an overview of the U.S. PNE program, see SCOTT KAUFMAN, PROJECT PLOWSHARE: THE PEACEFUL USE OF NUCLEAR EXPLOSIVES IN COLD WAR AMERICA (2012).

122. *See* Milo D. Nordyke, *The Soviet Program for Peaceful Uses of Nuclear Explosions*, 7 SCI. & GLOBAL SEC. 1 (1998) (giving an overview of the Soviet Union's PNE program, which ran from 1965 to 1988, and, at 11, noting that during this period there were 122 Soviet PNEs).

123. *See* Robert D. Bartels, *The Nonproliferation Treaty and Peaceful Applications of Nuclear Explosions*, 20 STAN. L. REV. 1030, 1030-31, 1041-43 (1968); Nils-Olov Bergkvist & Ragnhild Ferm, *Nuclear Explosions 1945–1998*, FOA Defence Research Establishment, STOCKHOLM INTERNATIONAL PEACE RESEARCH INSTITUTE user rept., 6 (2000); Pop, *supra* note 12, at 675. This fact also has been stressed by states, *see, e.g.*, Letter dated Apr. 10, 1995 from the Deputy Director of the United States Arms Control and Disarmament Agency addressed to the Prov. Secretary-General of the 1995 Review and Extension Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons (New York, Apr. 17 – May 12, 1995), 1995 Review and Extension Conference of the Parties to the Treaty on the

be illustrated by India's 1974 Pokhran-I tests, which India described at the time as PNEs.[124] Despite India's assertions of peaceful use, the Pokhran-I tests were widely considered to amount to the testing of nuclear weapons,[125] signaling India's *de facto* entry into the "nuclear weapons club."

The risk of states hiding behind avowed "peaceful use" to develop, test or use nuclear weapons—coupled with fears over the environmental harm that can be caused even by genuinely "peaceful" nuclear explosions—led to PNEs becoming politically unacceptable in the 1970s and 1980s.[126] The use of PNEs correspondingly declined, with no such explosions having occurred—or at least having been declared and verified—since the last Soviet PNE in 1988.[127] As a concept rooted in the first four decades of the nuclear age, the "PNE" has been inherently associated with terrestrial civil engineering activities. Nonetheless, the modern unacceptability of PNEs in such contexts usefully acts to highlight a key problem with proposed nuclear approaches to NEOs today.

In effect, the nuclear option for NEO response is, irrespective of intent, a proposal *to use nuclear weapons in space*. This clearly denotes the retention and possibly even further development[128] of nuclear weapons on Earth, and the consequent possibility of them being used for other, aggressive purposes, including in space. The nuclear approach to planetary defense engages a range of concerns that stretch well beyond the scientific.

Non-Proliferation of Nuclear Weapons, NPT/CONF.1995/17 (Apr. 14, 1995) (the United States, stating, 22 years after the last American PNE, that it "regards such explosions [PNEs] as indistinguishable from military tests.").

124. *See* P.R. Chari, *Pokharan-I: Personal Reflections*, 80 INSTITUTE OF PEACE & CONFLICT STUDIES, Special Report (1999), http://www.ipcs.org/pdf_file/issue/SR80-Chari-Final.pdf.

125. *See* MARIO CARRANZA, SOUTH ASIAN SECURITY AND INTERNATIONAL NUCLEAR ORDER: CREATING A ROBUST INDO-PAKISTANI NUCLEAR ARMS CONTROL REGIME 44 (2009). *See also* Christer Ahlström, *Arrows for India? – Technology Transfers of Ballistic Missile Defence and the Missile Technology Control Regime*, 9 J. CONFLICT & SEC. L. 103, 119 (2004) (describing the Pokhran-I tests as being "allegedly peaceful.").

126. JOZEF GOLDBLAT, ARMS CONTROL: THE NEW GUIDE TO NEGOTIATIONS AND AGREEMENTS 55 (2d ed., 2002).

127. *Id*. *See also* UNITED STATES DEPARTMENT OF STATE DISPATCH, *Threshold Test Ban Treaty (TTBT) and Peaceful Nuclear Explosions Treaty (PNET)* 3 CONSOLIDATING PEACEFUL REVOLUTION IN THE AMERICAS 333 (1992) ("The last peaceful nuclear explosion announced by the Soviet Union was in 1988.").

128. *See* Bucknam & Gold, *supra* note 80, 153 (suggesting that NEO preparedness may require new underground nuclear testing to perfect the devices required).

C. Developments in Nuclear Non-Proliferation and the De-Militarization of Space

Simultaneous with the rise in global preparedness in relation to NEO impact risk, and in support for nuclear responses to it in particular, there has been startling progress in the international nuclear disarmament movement in recent years. Although its roots stretch back further,[129] a significant change may be said to have begun with the widespread state support at the 2010 review conference[130] of the 1968 Treaty on the Non-Proliferation of Nuclear Weapons (NPT)[131] for a new treaty banning nuclear weapons outright.[132]

With astonishing speed, this proposal culminated in the adoption of the final text of the Treaty on the Prohibition of Nuclear Weapons (TPNW)[133] on July 7, 2017, with the treaty opening for signature on September 20, 2017. The TPNW for the first time provides for a comprehensive legal prohibition on the development, possession and use of nuclear weapons.[134] It can be seen as representing a generational high-water mark for nuclear disarmament.[135] Of the 120 states that debated the final

129. Such as to the creation, in 2007, of the International Campaign to Abolish Nuclear Weapons (ICAN), https://www.icanw.org/, or the UN Secretary-General Ban Ki-moon's 2008 "5-point plan" for nuclear disarmament: *Secretary-General's address to the East-West Institute entitled "The United Nations and Security in a Nuclear-Weapon-Free World"*, Oct. 4, 2008, https://www.un.org/sg/en/content/sg/statement/2008-10-24/secretary-generals-address-east-west-institute-entitled-united.

130. *2010 Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT)*, May 3–28, 2010, https://www.un.org/en/conf/npt/2010.

131. Treaty on the Non-Proliferation of Nuclear Weapons (NPT) art. 3, July. 1, 1968, U.N.T.S. 161.

132. *See* UNITED NATIONS, REVIEW CONFERENCE OF THE PARTIES TO THE TREATY ON THE NON-PROLIFERATION OF NUCLEAR WEAPONS (NPT), http://www.un.org/en/conf/npt/2010; TIM WRIGHT, THE MOMENTUM BUILDS FOR NUCLEAR ABOLITION, IN REVIEW CONFERENCE 2010, TOWARDS NUCLEAR ABOLITION (Report by the International Campaign to Abolish Nuclear Weapons, June 2010).

133. Treaty on the Prohibition of Nuclear Weapons (TPNW) 2017, U.N. Doc. A/CONF.229/2017/8 (July 6, 2017) [CN.475.2017.TREATIES-XXVI-9, Aug. 9, 2017 (opening for signature); CN.476.2017.TREATIES-XXVI-9, Aug. 9, 2017 (issuance of certified true copies)].

134. *Id.*, particularly art. 1.

135. Daniel Joyner, *The Treaty on the Prohibition of Nuclear Weapons*, EJIL: TALK!, July 26, 2017, https://www.ejiltalk.org/the-treaty-on-the-prohibition-of-nuclear-weapons ("… we are witnessing a generational event of significance …"). ICAN was awarded the Nobel Peace Prize for its efforts to secure the adoption of the TPNW text. *See Anti-Nuclear Weapons Group ICAN wins Nobel Peace Prize*, BBC NEWS, Oct. 6, 2017, https://www.bbc.co.uk/news/world-europe-41524583.

text, only one voted against it (the Netherlands) and only one abstained (Singapore); as of September 5, 2018, the TPNW already has 60 signatories and 14 ratifications.[136]

Equally, 63 UN member states—including, crucially, all the nuclear powers—were not represented at the debates on the TPNW's final text at all: one must not overstate the impact of the TPNW's adoption. Currently, the treaty has limited potential legal implications,[137] as the treaty is not yet in force[138] and does not have the support of any of the nuclear states.[139] It is possible that the TPNW may struggle ever to have meaningful legal reach, even in terms of influencing customary international law development.[140]

While the possible legal implications of the TPNW for nuclear NEO response, were it to enter into force, will be considered in subsection V.*D*, it is important to stress at this juncture that the *political* implications of the TPNW's adoption are both undeniable and immediate.[141] Abandoning the piecemeal approaches of the previous law, the TPNW prohibits the possession and use of nuclear weapons *in toto*. At the very least, it thus represents an unprecedented statement of intent on the part of the 120 UN member states that voted for its adoption, placing notable pressure on the nuclear powers.[142] This speaks volumes as to the political tensions that would be triggered by any planetary defense efforts that were to feature the use of nuclear explosions.

Similarly, there have been parallel—if less well publicized—developments in the movement to ensure the complete non-militarization of

136. For the status of the TPNW, see United Nations Treaty Collection, Chapter 9: Treaty on the Prohibition of Nuclear Weapon (2017), https://treaties.un.org/pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVI-9&chapter=26&clang=_en.

137. *See* Michael Rühle, *The Nuclear Weapons Ban Treaty: Reasons for Scepticism*, *NATO REV. MAG.*, May 19, 2017, https://www.nato.int/docu/review/2017/Also-in-2017/nuclear-weapons-ban-treaty-scepticism-abolition/EN/index.htm (critiquing the TPNW's legal potential).

138. *See* TPNW, *supra* note 133, art. 15(1) (entry into force will be "90 days after the fiftieth instrument of ratification, acceptance, approval or accession has been deposited.").

139. *See* Beatrice Fihn, *The Logic of Banning Nuclear Weapons*, 59 SURVIVAL 43, 45 (2017) (noting that it is unlikely that any of the nuclear powers will sign the TPNW in the near future).

140. Gaukhar Mukhatzhanova, *The Nuclear Weapons Prohibition Treaty: Negotiations and Beyond*, ARMS CONTROL TODAY (September 2017), http://www.armscontrol.org/print/8865#endnote18 ("[t]here is an extremely long way to go for the treaty to become customary international law."). *See also Nuclear Ban Treaty Doesn't Contribute to Customary International Law: India*, THE WIRE (July 18, 2017) https://thewire.in/159057/nuclear-ban-treaty-customary-law.

141. *See* Joyner, *supra* note 135.

142. *See* Fihn, *supra* note 139, particularly at 47-48.

outer space.[143] Most notably, the 2014 Draft Treaty on Prevention of the Placement of Weapons in Outer Space and of the Threat or Use of Force against Outer Space Objects (PPWT)[144] aims for the first time categorically to prohibit the placement of any weapons whatsoever in outer space.[145] The PPWT's legal implications are even further down the "potential" pipeline at the present time than is the case for the TPNW. It is a draft treaty that is not in force, is not open for signature, has not yet had its text adopted, and has faced notable opposition from certain states.[146] Over the last year, however, some states have made very clear their desire for the draft PPWT to be adopted,[147] suggesting that it may be gaining increased traction in the international community.

143. *See generally* United Nations Office for Disarmament Affairs, Conference on Disarmament Documents Related to Prevention of an Arms Race in Outer Space (last updated Sept. 8, 2014), https://www.un.org/disarmament/geneva/cd/documents-related-to-prevention-of-an-arms-race-in-outer-space (particularly documents from the mid-2000s onwards).

144. Draft Treaty on Prevention of the Placement of Weapons in Outer Space and of the Threat or Use of Force against Outer Space Objects (PPWT 2014) 2014, annexed to Letter dated June 10 2014 from the Permanent Rep. of the Russian Federation and the Permanent Rep. of China to the Conference on Disarmament addressed to the acting Secretary-General of the Conference transmitting the updated Russian and Chinese texts of the draft treaty on prevention of the placement of weapons in outer space and of the threat or use of force against outer space objects (PPWT) introduced by the Russian Federation and China, CD/1985 (June 12, 2014). The 2014 draft treaty was updated from a previous version from 2008. *See* Draft Treaty on Prevention of the Placement of Weapons in Outer Space and of the Threat or Use of Force against Outer Space Objects (PPWT 2008) 2008, annexed to Letter dated Feb. 12 2008 from the Permanent Rep. of the Russian Federation and the Permanent Rep. of China to the Conference on Disarmament addressed to the Secretary-General of the Conference transmitting the Russian and Chinese texts of the draft treaty on prevention of the placement of weapons in outer space and of the threat or use of force against outer space objects (PPWT) introduced by the Russian Federation and China, CD/1839 (Feb. 29, 2008).

145. PPWT 2014, *supra* note 144, preamble.

146. *See, e.g.*, *Amid Commemoration of Landmark Treaty's Fiftieth Anniversary, Joint Meeting of First, Fourth Committees Discusses Keeping Weapons Away from Outer Space*, U.N. G.A., 4th Com., Press Release, 72nd Sess., 11th mtg., U.N. Doc. GA/SPD/640, Oct. 12, 2017, https://www.un.org/press/en/2017/gaspd640.doc.htm (Jessica West, noting that there exist "sharp divisions" amongst states over the PPWT).

147. *See, e.g.*, *id.* (Venezuela); *Anniversaries of Sputnik I Launch, Milestone Treaty's Entry into Force Spotlighted as Fourth Committee Takes Up Peaceful Uses of Outer Space*, U.N. GA, 4th Com., Press Release, 72nd Sess., 10th mtg., U.N. Doc. GA/SPD/639, Oct. 11, 2017, https://www.un.org/press/en/2017/gaspd639.doc.htm (Venezuela); *Do Not Let Political Differences Distract You, General Assembly President Urges Member States, as Fourth Committee Continues Outer Space Debate*, U.N. GA, 4th Com., Press Release, 72nd Sess., 12th mtg., U.N. Doc. GA/SPD/641, Oct. 13, 2017, https://www.un.org/press/en/2017/gaspd641.doc.htm (Cuba).

It is perhaps unlikely that the draft PPWT will be adopted in its current form, although a revision of the text to facilitate consensus remains a possibility. The legal implications of the PPWT (as the current draft stands) for nuclear NEO responses, were it to be adopted and entered into force, briefly will be explored in subsection V.*E*. At the very least, it is important to note that states' serious consideration of a treaty outlawing any and all weapons in space, and the clear support for it by a significant number of them, could be of notable political significance for the possibility of nuclear planetary defense.

D. "Asteroids" as a Pretext: A Question of Competing Risks

It might be speculated that the increased support for and investigation into nuclear approaches to NEO response at the state-level is driven not (or not solely) by a desire to ensure effective planetary protection. It also may stem from the fact that the notion of "asteroid threat" acts to clothe the continued possession of nuclear weapons by a handful of states in the robes of altruism,[148] precisely at a time when the global political climate is one of increasing pressure on them to relinquish such armaments. For states that want neither to give up their nuclear weapons nor suffer the political fallout that their continued failure to disarm may entail, the need to retain nuclear weapons to protect the planet represents a convenient narrative.

Indeed, one might question whether the (undoubtedly low) risk of catastrophic harm caused by NEO impact outweighs the (perhaps rather more likely) risk of a catastrophic use of nuclear weapons on Earth,[149] or even the aggressive use of a nuclear arsenal that had been deployed in space.[150] Even if a nuclear weapon was used genuinely and solely to divert an NEO, this still would entail significant environmental risks, as is the case with any nuclear detonation.[151] It can be reasonably argued that humanity may be better served by responding to the threat posed by the

148. In 1996, for example, China claimed that it was necessary for it to continue to undertake underground nuclear tests so that it would be ready to respond to an NEO if necessary, and refused to engage with certain non-proliferation agreements on that basis. The international community viewed this claim as a smoke screen for military nuclear development. *See* Patrick E. Tyler, *Chinese Seek Atom Option to Fend Off Asteroids*, N. Y. TIMES, Apr. 27, 1996, https://www.nytimes.com/1996/04/27/world/chinese-seek-atom-option-to-fend-off-asteroids.html; William J. Broad, *For Killer Asteroids, Respect at Last*, N.Y. TIMES, May 14, 1996, https://www.nytimes.com/1996/05/14/science/for-killer-asteroids-respect-at-last.html; Brooks, *supra* note 12, at 250; Gerrard & Barber, *supra* note 12, at 18.

149. Sweet, *supra* note 12, at 224.

150. Gerrard & Barber, *supra* note 12, 16, at 19-20.

151. *Id.* at 19, 25; *Legal Aspects of NEO Threat Response*, *supra* note 8, at 40.

existence and use of nuclear weapons rather than that posed by a hypothetical asteroid.

Such questions as to the *desirability* of the nuclear approach are crucial and must be kept in mind, but one also must be realistic. Complete nuclear disarmament is not going to occur any time soon, and the foregoing sections have indicated that if a collision-course NEO is identified, humanity now is significantly more likely to respond to that threat by nuclear means than ever has been the case before. The genuine possibility of nuclear planetary defense means that a wide range of issues must be examined. The remainder of this article assesses just one of them: the legal implications of nuclear NEO response.

V. RESTRICTIONS AND PROHIBITIONS IN TREATY LAW

In 1996, John Remo, who was the chair of the first UN conference on NEOs in 1995, commented that "[i]nternational law and practice does not address [the issue of NEO impact] . . . directly."[152] This statement remains true today. There are no treaties that relate specifically to responses to impending NEO impact,[153] nor have any "NEO response norms" developed in customary international law.[154] Similarly, in the wider context of international law's nuclear non-proliferation regime, the 1968 NPT[155]—a treaty that is often said to represent the "cornerstone" of that regime[156]—notably does not prohibit the use of PNEs; indeed, it deliberately left room for the American and Soviet PNE programs that existed[157] at the time of its drafting.[158]

152. Remo, *supra* note 51, 17. *See also* Tronchetti, *supra* note 12, at 1027-28, 1036.

153. Seamone, *Wishing on a Star*, *supra* note 8, at 1118.

154. *See* Brooks, *supra* note 12, at 243.

155. NPT, *supra* note 131.

156. *See, e.g.*, DANIEL JOYNER, INTERNATIONAL LAW AND THE PROLIFERATION OF WEAPONS OF MASS DESTRUCTION 8 (2009); Winston Nagan & Erin Slemmens, *National Security Policy and Ratification of the Comprehensive Test Ban Treaty*, 32 HOUS. J. INT'L L. 1, 40 (2009-2010).

157. *See supra* notes 121-122 and accompanying text.

158. The states designated by NPT, *supra* note 131, art. IX(3) as "nuclear weapons states" (being those states that had "manufactured and exploded a nuclear weapon or other nuclear explosive device prior to 1 January 1967", i.e., the United States, the United Kingdom, Russia (formerly the Soviet Union), France, and China) are not prohibited from conducting PNEs under the NPT. Moreover, *id.* art. V even provides for the contracting "non-nuclear weapon states" (i.e., all those NPT states party that do not meet the definition in *id.* art. IX(3)) to receive the benefits of PNEs in certain qualified circumstances (although it did not allow for them to acquire PNE devices themselves).

However, this lack of bespoke law on NEO impact (and the non-existence of a PNE prohibition in the most crucial nuclear non-proliferation law treaty) does not mean that an act of nuclear planetary defense would exist in a legal vacuum.[159] This section examines relevant restrictions or prohibitions that exist in binding treaty law, as well as in the form of "soft law" (in treaties that are not in force).

Both in the (limited) scholarly literature[160] and the wider media,[161] a pervading conception, albeit not entirely unquestioned,[162] is that existing international law would outright prohibit the use of nuclear explosions to divert or destroy an NEO. This view probably is correct, but the unlawfulness of nuclear planetary defense is not as clear as some have suggested. Moreover, as will be explored in section VI, there remain various possible legal means of *precluding* that apparent unlawfulness that require assessment. The current legal status of nuclear NEO response is both complex and uncertain.

A. Outer Space Treaty

The 1967 Outer Space Treaty (OST)[163] necessarily is the starting point for any legal analysis of outer space issues in general, and thus for nuclear planetary defense in particular.[164] As of September 5, 2018, the OST has 107 states party, including—importantly—all of the nuclear powers.[165] Of particular relevance to the question of nuclear NEO response is OST Article IV, which *inter alia* provides that states party". . . undertake not to

159. *See* Mohammed Bedjaoui, *Classicism and Revolution in the Elaboration of the Principles and Rules of Space Law*, in PERSPECTIVES ON INTERNATIONAL LAW 441, 447 (Nandasiri Jasentuliyana ed., 1995) (arguing that it has long been unquestionable that there is no "legal vacuum" in outer space, irrespective of recurring claims to the contrary); Pop, *supra* note 12, 659-60.

160. *See, e.g.*, *Legal Aspects of NEO Threat Response*, *supra* note 8, at 3, 28; Su, *Control Over Activities Harmful to the Environment*, *supra* note 12, at 85; Su, *Measures Proposed for Planetary Defence*, *supra* note 12, at 2; Weissman, *supra* note 12, at 1206; YEOMANS, *supra* note 3, 146.

161. *See, e.g.*, Oliphant, *supra* note 111; Birch, *supra* note 94.

162. *See, e.g.*, Kunich, *supra* note 12.

163. Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (Outer Space Treaty, OST) 1967 (entry into force Oct. 10, 1967), 610 U.N.T.S. 205.

164. Kunich, *supra* note 12, at 129; Fasan, *supra* note 11, at 2345.

165. For a full list of OST states party, *see* United Nations Office for Disarmament Affairs, Treaty Database, http://disarmament.un.org/treaties/t/outer_space. Note that, at the time of writing, the United Nations Treaty Collection, https://treaties.un.org/pages/showDetails.aspx?objid=0800000280128cbd is out of date in this regard, having not been updated to include Nicaragua and Malta (both of which became OST parties in 2017).

place in orbit around the Earth any objects carrying nuclear weapons or any other kinds of weapons of mass destruction, install such weapons on celestial bodies, or station such weapons in outer space in any other manner . . . [and that] . . . the testing of any type of weapons . . . on celestial bodies shall be forbidden . . ."[166]

Some commentators have suggested that OST Article IV[167] may prohibit nuclear NEO response outright.[168] This conclusion would be incorrect, however, even on a strict textual reading. While Article IV provides that nuclear weapons (indeed, any weapons of mass destruction) cannot be placed in Earth's orbit, stationed on celestial bodies (such as the moon) or otherwise stationed in outer space (for example, in a space station), they can be launched *into* space without contravening the provision.[169] As such, OST Article IV does not prohibit the launching of a

166. OST, *supra* note 163, art. IV. This OST obligation is further reinforced by the Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (Moon Treaty) 1979 (entry into force Jul. 11, 1984) 1353 U.N.T.S. 3, art. 3(3) of which provides that "States Parties shall not place in orbit around or other trajectory to or around the moon objects carrying nuclear weapons or any other kind of weapons of mass destruction or place or use such weapons on or in the moon." The Moon Treaty only has 18 states party as of September 5, 2018, none of which are nuclear powers (*see* United Nations Treaty Collection, https://treaties.un.org/Pages/ViewDetails.aspx?src=IND&mtdsg_no=XXIV-2&chapter=24&lang=en), but while it is not currently binding on the relevant states, Moon Treaty Article 3(3) nonetheless acts to place a further legal emphasis on the OST Article IV obligations that *are* binding on them.

167. As well as Article 3(3) of the Moon Treaty for those states to which it applies. *See id*.

168. *See* Bucknam & Gold, *supra* note 80, 152; Koplow, *supra* note 17, at 305; Su, *Measures Proposed for Planetary Defence*, *supra* note 12, at 2; Su, *Control Over Activities Harmful to the Environment*, *supra* note 12, at 85; Gerrard & Barber, *supra* note 12, at 35.

169. The reason that Article IV does not prohibit the launching of weapons of mass destruction *into* space, but only from being in one manner or another *stationed* there, would seem to be a legacy of the Cold War era drafting of the OST. A number of scholars have inferred from the wording of Article IV (and its *travaux préparatoires*) that—while the superpowers wished to avoid nuclear weapons being permanently *stationed* in space (hanging over the Earth "Sword of Damocles-like")—they wanted to retain the possibility of undertaking nuclear strikes against each other via intercontinental ballistic missiles launched out of the atmosphere on a trajectory that then returned them to their terrestrial target (*see, e.g.*, Robert L. Bridge, *International Law and Military Activities in Outer Space*, 13 AKRON L. REV. 649, 655 (1980); Michael G. Gallagher, *Legal Aspects of the Strategic Defense Initiative*, 111 MIL. L. REV. 11, 41 (1986); Kunich, *supra* note 12, 130-31). This inference is persuasive, although it should be noted that, unsurprisingly, no such underlying intent was made explicit by the superpowers during the process of the OST's drafting (*see*, for the various documents comprising the treaty's *travaux préparatoires*, United Nations Office for Outer Space Affairs, Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies:

rocket- or missile-borne nuclear weapon from Earth into space on a direct course to intercept an NEO (i.e., the "on-world" approach).[170] It will be recalled that some scientific experts have argued that interceptors for NEO diversion would stand a much better chance of success if they already were stationed in space; it equally will be recalled that others have questioned this.[171] Difference of opinion in the science aside, it is clear that the "on-world" approach, which at least some experts support, would remain untouched by OST Article IV.

In contrast, Article IV would seem to rule out an "off-world" approach. This conclusion is not straightforward, however, because one might question what constitutes a "nuclear weapon" for the purposes of OST Article IV: the OST does not define what it means by the term.[172] Some have argued that even the "off-world" approach may not violate Article IV, because the peaceful intention underpinning NEO response would mean that it would not involve the use of a nuclear "weapon" at all.[173] In other words, it has been suggested that a "PNE" used against an NEO would not be a "nuclear weapon" for the purposes of the OST. Perhaps most notably, writing in 1997, Kunich took the view that a "weapon" is to be defined by how it is used, not by its inherent properties: "David killed Goliath with a rock . . . but a rock only *becomes* a weapon when it is so used . . ."[174]

This perhaps is a reasonable conclusion for a rock. However, let us consider a gun instead. A firearm conceivably could be used, say, as a doorstop or as a paperweight. Nonetheless, unlike a rock, it would be difficult intuitively to consider a gun put to such a use as having alchemically changed into something other than a "weapon." Perhaps this is because a gun 1) is something *designed* to be used as a weapon; 2) could be (re)employed with great ease as a weapon at any time; and 3) carries an inherent risk of accidental discharge that rocks do not. Keeping in mind the requirement in Article 31(1) of 1969 Vienna Convention on the Law of

Overview, https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/travaux-preparatoires/outerspacetreaty.html).

170. *See Legal Aspects of NEO Threat Response*, *supra* note 8, at 26; Sweet, *supra* note 12, at 226; Kunich, *supra* note 12, at 130.

171. *See* discussion *supra* Subsection III.*B*.

172. *See* Su, *Control Over Activities Harmful to the Environment*, *supra* note 12, at 85.

173. *See, e.g.*, Kunich, *supra* note 12, at 138-43; Su, *Measures Proposed for Planetary Defence*, *supra* note 12, at 2 (making, but then not necessarily subscribing to, this argument); Sweet, *supra* note 12, at 227 (making, but not necessarily subscribing to, this argument).

174. Kunich, *supra* note 12, at 140 (emphasis in original).

Treaties (VCLT)[175] that treaty provisions be interpreted based on their "ordinary meaning," the present author would argue that a gun still would be considered a "weapon," irrespective of how it was currently being used. Scaling this argument up to nuclear explosive devices, while recalling that there is no technological difference between a PNE and a nuclear weapon,[176] any such device would be more analogous to the "gun" than the "rock." As far as the "ordinary meaning" of the text goes, a spade is a spade, and a nuclear weapon used in space against an asteroid still would be a nuclear weapon.[177]

Yet even if this is accepted, it does not establish that a nuclear weapon used solely against an NEO would be a "nuclear weapon" for the purposes of the OST. The holistic nature of the rules of treaty interpretation[178] means that strict textual analysis of the provision's "ordinary meaning" in the abstract amounts to the adoption of an erroneous approach. VCLT Article 31(1) adopts a teleological understanding of treaty interpretation, requiring one to assess the ordinary meaning of the "terms of the treaty in their context and in the light of its object and purpose."[179]

Identifying a treaty's object and purpose is a tricky business,[180] but one can identify elements of the OST that offer some indications in this regard. For example, the preamble[181] and many of the operative provisions of the OST repeatedly reference the goal of ensuring that the exploration

175. Vienna Convention on the Law of Treaties (VCLT) May 23, 1969 (entry into force Jan. 27, 1980) 1155 U.N.T.S. 331.

176. *See supra* notes 123-125 and accompanying text.

177. *See* Brooks, *supra* note 12, at 247. *See also* Legality of the Threat or Use of Nuclear Weapons, Advisory Opinion, I.C.J. 226 ¶ 35 (July 8, 1996) (the ICJ seemingly defining nuclear weapons based on their characteristics and without reference to how they are used).

178. *See Commentaries on Draft Article on the Law of Treaties*, Report of the International Law Commission on the work of its eighteenth session, May 4–Jul. 19, 1966, U.N. Doc. A/6309/Rev.1, 219–20 http://legal.un.org/ilc/documentation/english/reports/a_cn4_191.pdf; Appellate Body Report, European Communities – Customs Classification of Frozen Boneless Chicken Cuts, 2005, WTO, WT/DS269/AB/R–WT/DS286/AB/R 176 (Sept. 12 2007); WEI ZHUANG, INTELLECTUAL PROPERTY RIGHTS AND CLIMATE CHANGE: INTERPRETING THE TRIPS AGREEMENT FOR ENVIRONMENTALLY SOUND TECHNOLOGIES 162–64 (2017); DANIEL JOYNER, INTERPRETING THE NUCLEAR NON-PROLIFERATION TREATY 22–25 (2012).

179. VCLT, *supra* note 175, art. 31(1).

180. *See* Jan Klabbers, *Some Problems Regarding the Object and Purpose of Treaties*, 8 FINN. YRBK INT'L L. 138 (1997). *See also* VCLT, *supra* note 175, art. 31(2) (A treaty's "context" for the purposes of interpretation comprises its text, preamble, and annexes, as well as any agreements and instruments made in connection with its conclusion).

181. *See id. See also* Max Hulme, *Preambles in Treaty Interpretation*, 164 U. PA. L. REV. 1281, 1300 (2016) (noting the importance of a treaty's preamble for identifying its object and purpose).

and use of outer space is for exclusively peaceful purposes.[182] The treaty also regularly reiterates the need for space exploration and use to be for the benefit (variously) of all "peoples,"[183] "countries,"[184] or "states."[185] The core object and purpose of the OST thus can be seen as focused on the peaceful use of outer space for the common benefit of mankind.

It may also be worth noting the requirement in OST Article V to render to astronauts "all possible assistance in the event of accident, distress, or emergency landing . . . ."[186] This obligation in itself clearly applies only to astronauts, but it has been suggested that it may be indicative of a wider purpose of the OST to mobilize communal resources in instances of "danger" in the outer space context.[187] Similarly, OST Article IX *inter alia* requires states to be "guided by the principle of co-operation and mutual assistance," and to avoid "adverse changes in the environment of the Earth."[188] These obligations are framed in the context of the possible consequences of space exploration, rather than in relation to natural threats coming from space itself, but could be interpreted as indicating contextual notions of cooperation and mutual assistance in the interests of all states, and, perhaps most notably for the NEO response question, the protection of Earth.[189]

Taking these various elements together to create a picture of the object and purpose of the OST, it could be argued that the term "nuclear weapons" in Article IV should be read—in a teleological sense, albeit in a way that perhaps appears to contradict its "ordinary meaning" in the abstract—as not including the use of nuclear explosive devices exclusively employed for planetary defense.[190] Such an action would in theory be

182. OST, *supra* note 163, preamble (two references), art. IV (three references), art. IX (two references), and art. XI. *See generally* Kubo Mačák, *Silent War: Applicability of the* Jus in Bello *to Military Space Operations*, 94 INT'L L. STUD. 1, 15 (2018) (noting the view that the OST, and, thus, space law more broadly, is "predicated" on the core idea of the exclusive peaceful use of outer space).

183. OST, *supra* note 163, preamble.

184. *Id.* art. I.

185. *Id.* art. IX.

186. *Id.* art. V.

187. Seamone, *Wishing on a Star*, *supra* note 8, at 1134 (making this point regarding NEO threats, but not specifically in relation to interceptive responses).

188. OST, *supra* note 163, art. IX.

189. *See Legal Aspects of NEO Threat Response*, *supra* note 8, at 13-14 (making the related point that these obligations may amount to a "general responsibility to distribute information to states that could use such information to avert or limit the impact of natural disasters [originating in space].")

190. *See* Tronchetti, *supra* note 12, at 1030 (arguing on this basis that "international action for planetary defense is, at least indirectly, supported" by the OST, albeit not specifically referring to nuclear approaches); Pop, *supra* note 12, at 673.

peaceful, an instance of mutual assistance for the benefit of all mankind and aimed at the protection of Earth's environment. It could thus be viewed as being in conformity with (and perhaps even in avoidance of the *frustration of*) the object and purpose of the OST.[191] It is this teleological argument, not Kunich's purely textual one,[192] which may cast doubt on the apparent illegality of the "off-world" NEO nuclear option under the OST.

However, this possible contextual reading is far from conclusive. For example, the OST preamble additionally refers to the need to "refrain from placing in orbit around the earth any objects carrying nuclear weapons"[193] (mirroring Article IV), as well as condemning action that may increase the likelihood of "any threat to the peace, breach of the peace or act of aggression"[194] in outer space. This further highlights that the peaceful use of outer space is paramount for the OST, but also particularly emphasizes the non-nuclear weaponization of space and the non-militarization of space more generally.

Likewise, while the OST Article IX obligation to avoid "adverse changes in the environment of the Earth"[195] might point towards a contextual interpretation of Article IV that would allow for nuclear planetary defense, it might just as easily be read to suggest an underpinning legal context within which the risk to Earth's environment resulting from any use of a nuclear weapons reinforces the abstract "ordinary meaning" of the Article IV text. It would be reasonable to conclude that the object and purpose of the OST prioritizes avoiding the placement nuclear weapons in space above all else.[196]

One might resort to supplementary means of treaty interpretation as per VCLT Article 32, given that it is fairly clear from the foregoing that reference to the primary methods in VCLT Article 31 "[l]eaves the meaning ambiguous or obscure"[197] when it comes to nuclear NEO response. Indeed, it even may be argued—if one were to conclude that OST

191. *See Legal Aspects of NEO Threat Response*, *supra* note 8, at 27-28; Koplow, *supra* note 17, 288; Fasan, *supra* note 11, at 2346.

192. Kunich admittedly does briefly buttress his textual argument by stating that this interpretation would be supported by the wider object and purpose of the OST, *see* Kunich, *supra* note 12, at 142.

193. OST, *supra* note 163, preamble.

194. *Id.*

195. *Id.* art. IX.

196. *See* Su, *Measures Proposed for Planetary Defence*, *supra* note 12, at 2 (an interpretation of the OST that allowed for nuclear NEO response would "encounter substantial disagreements, as it would weaken norms of existing international space law significantly and run the risk of a nuclear race in outer space.").

197. VCLT, *supra* note 175, art. 32.

Article IV would prohibit the use of nuclear weapons even in cases where this could be humanity's only hope of survival—that the application of the VCLT Article 31 rules might lead to "a result which is manifestly absurd or unreasonable."[198]

A review of the *travaux préparatoires* of the OST indicates, somewhat unsurprisingly, that Article IV was drafted with a view to Cold War fears of a nuclear arms race in space.[199] The drafters were focused on peaceful uses of space and the avoidance of aggressive nuclear deployment, not on responses to natural threats emerging from the heavens.[200] As such, it is possible to argue that the provision never was intended to be an "asteroid suicide pact," and that it should be interpreted on that basis. This is a reasonable conclusion, but, of course, the *travaux préparatoires* again could be read as telling a different story, because the stationing of "PNE" devices in space precisely can be seen as amounting to the militarization of space *in effect*. As with all other VCLT interpretative methods, supplementary reference to the treaty's drafting leaves unresolved the status of an "off-world" nuclear NEO response under the OST.

A final issue regarding the OST relates to the *testing* of nuclear explosive responses. It will be recalled that many NEO experts have asserted the importance of testing planetary defense measures.[201] It also will be recalled that OST Article IV prohibits the testing of "any type of weapons . . . on celestial bodies", irrespective of wherefrom the device was

198. *Id*. *See Legal Aspects of NEO Threat Response*, *supra* note 8, at 27 (making this argument about unreasonableness/absurdity).

199. *See, e.g.*, Comm. on the Peaceful Uses of Outer Space, Legal Sub-Committee, 5th Sess., sum. rec. 62nd mtg. (July 19, 1966) at 7, U.N. Doc. A/AC.105/C.2/SR.62 (Oct. 24, 1966) (Poland, stating, when discussing the draft of what became Article IV, that "the arms race and the conflicts which took place on earth were bound to affect space, and every effort should therefore be made to limit the arms race wherever possible."); Comm. on the Peaceful Uses of Outer Space, Legal Sub-Committee, 5th Sess., sum. rec. 70th mtg. at 6 (Aug. 3, 1966), U.N. Doc. A/AC.105/C.2/SR.70 (Oct. 21, 1966) (Soviet Union, arguing that the draft article would proscribe the placing in outer space of "a rocket armed with a nuclear warhead, *because such equipment would obviously not be being used for scientific research*", emphasis added); Comm. on the Peaceful Uses of Outer Space, Legal Sub-Committee, 5th Sess., sum. rec. 57th mtg. (July 12, 1966) at 6-7, U.N. Doc. A/AC.105/C.2/SR.57 (Oct. 20, 1966) (United States, suggesting, with specific reference to the stationing of weapons of mass destruction, that the "central objective was to ensure that outer space and celestial bodies were reserved exclusively for peaceful purposes."); Committee on the Peaceful Uses of Outer Space, Legal Sub-Committee, 5th Sess., sum. rec. 66th mtg. (Jul. 25, 1966) at 4, U.N. Doc. A/AC.105/C.2/SR.66 (Oct. 21, 1966) (Hungary, contextualizing the draft provision as being about the use of space "for military purposes."); *id.* at 7 (Soviet Union, noting that the provision related to a "total ban on the use of outer space for military purposes.").

200. Gerrard & Barber, *supra* note 12, at 34; Sweet, *supra* note 12, at 225-26.

201. *See supra* notes 85-87 and accompanying text.

launched. It has been suggested that Article IV would therefore preclude the testing of *both* "off-world" *and* "on-world" nuclear NEO interceptors, "even on the smallest, most remote asteroid."[202]

This claim as to the implications of Article IV for "on-world" nuclear NEO response testing can be questioned. Its accuracy depends on whether an NEO would be considered a "celestial body," and there is no agreed definition of a "celestial body" in the space law context.[203] However, the majority view has been to focus on whether the object is "immovable" in the sense of land/territory on Earth: if so, then it is a celestial body, and if not, then it is not.[204] Further, the Moon Treaty makes it clear that it applies to "celestial bodies," but that it does "not apply to extraterrestrial materials which reach the surface of the earth by natural means."[205] This implies that bodies that could naturally reach Earth's surface are not to be considered "celestial bodies," at least for the purposes of the Moon Treaty. As such, NEOs—which can reach Earth naturally, and which are not "immovable" (after all, an attempt to divert them would be the *raison d'être* of any test mission)—likely would not qualify as "celestial bodies." They could therefore be the subject of an "on-world" nuclear diversion test without this violating the OST, even if the nuclear device used was considered to be a "weapon."

Overall, both the actual use and the testing of nuclear weapons against an NEO would be lawful under the OST if launched from Earth (i.e., "on-world"). In contrast, in the view of the present author, the use (or testing) of such a device that was already stationed in outer space ("off-world") would be in violation of the OST, but it must be said this conclusion is premised on uncertain interpretative gymnastics rather than legal clarity. All that one can say for sure is that the "off-world" approach would be legally questionable, if perhaps not unquestionably illegal, under the OST.[206]

202. Gerrard & Barber, *supra* note 12, at 34.

203. Pop, *supra* note 12, at 660.

204. *Id.* at 660-64.

205. Moon Treaty, *supra* note 166, art. 1. *See* Brian Abrams, *First Contact: Establishing Jurisdiction Over Activities in Outer Space*, 42 GA. J. INT'L & COMP. L. 797, 804-05 (2014).

206. *See* Sweet, *supra* note 12, 228 ("[i]t is true that *one interpretation* of the Outer Space Treaty … permits non-aggressive military uses of space …"; emphasis added).

B. Limited Test-Ban Treaty

Leaving aside the OST, nuclear NEO response may be unlawful[207] under another Cold War era convention: the 1963 Limited Test-Ban Treaty (LTBT).[208] As of September 5, 2018, the LTBT has 125 states party, including the majority of the nuclear powers (although, crucially, not France, China, or the Democratic People's Republic of Korea (DPRK)).[209] LTBT Article I(1)(a) *inter alia* states:

"Each of the Parties to this Treaty undertakes to prohibit, to prevent, and not to carry out any nuclear weapon test explosion, or any other nuclear explosion, at any place under its jurisdiction or control . . . in the atmosphere; beyond its limits, including outer space; or under water, including territorial waters or high seas . . ."[210]

The fundamental goal of the LTBT, as its name suggests, is to prohibit the *testing* of nuclear weapons (in three particular environments, including, explicitly, outer space).[211] While the status of testing a nuclear weapon against an NEO arguably may be lawful under the OST (so long as the test interceptor was launched "on-world"),[212] the LTBT prohibits "*any* nuclear weapon test explosion . . . in outer space."[213] Again, some might take the view that such a prohibition on testing would be notably problematic for developing an effective NEO response.[214] In the view of the present author, however, while the testing of planetary defense measures in general is desirable, when it comes to the nuclear option, the abstract testing of nuclear weapons in space *simply in the name of preparedness* would entail

207. Su, *Measures Proposed for Planetary Defence*, *supra* note 12, at 2; Su, *Control Over Activities Harmful to the Environment*, *supra* note 12, at 85; Brooks, *supra* note 12, at 246; Pop, *supra* note 12, at 676.

208. Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water (Limited Test-Ban Treaty, LTBT, also more commonly known in some parts of the world as the Partial Test-Ban Treaty, PTBT), 1963, 480 U.N.T.S. 43 (entry into force Oct. 10, 1963).

209. For the status of and parties to the LTBT, see United Nations Office for Disarmament Affairs, Treaty Database, http://disarmament.un.org/treaties/t/test_ban.

210. LTBT, *supra* note 208, art. I(1)(a).

211. *See, e.g.*, United Kingdom of Great Britain and Northern Ireland and United States of America: Memorandum of Position Concerning The Cessation of Nuclear Weapons Tests [ENDC/78], Letter dated 10 April 1963 from the Co-Chairman of the Conference of the Eighteen-Nation Committee on Disarmament to the Secretary-General, transmitting the third interim progress report of the Conference, UN Disarmament Comm., U.N. Doc. DC/207 (Apr. 12, 1963), annex 1.C (preparatory discussions for the LTBT, focused on developing "an agreement on a nuclear weapon *test ban*", emphasis added).

212. *See supra* notes 201-205 and accompanying text.

213. LTBT, *supra* note 208, art. I(1)(a) (emphasis added).

214. *See supra* notes 85-87 and accompanying text.

too high a cost. The LTBT thus desirably resolves any uncertainty under the OST as to the legal possibility of conducting nuclear tests in space (at least for LTBT states party).[215]

The LTBT goes further than merely prohibiting nuclear testing, however, in that it also outlaws "*any other nuclear explosion* . . . in outer space."[216] This means that, despite the treaty's focus on nuclear testing, the text of the LTBT Article I(1)(a) would seem to prohibit all nuclear explosions in space (test or otherwise).[217] This language additionally means that the reader should be spared another discussion of the meaning of "nuclear weapons" in the LTBT context. In contrast to the OST, the LTBT prohibition is not limited to nuclear "weapons": it covers "any . . . nuclear explosion," irrespective of purpose.[218]

Further, the requirement not to carry out any nuclear explosion "at any place"[219] would appear to rule out—again, unlike the OST—nuclear explosions that occur in space even if they were launched "on-world."[220] The very occurrence of a nuclear explosion in outer space would violate the ordinary meaning of Article I(1)(a), wherever the device originated from: both the "on-world" and "off-world" usage of any nuclear explosive device against an NEO would appear to be ruled out for LTBT states party. On that basis, Brooks categorically concluded in 1997 that the LTBT "flatly bans any [nuclear] explosion in outer space [including as an NEO response action]."[221]

Others have questioned this conclusion, however.[222] Kunich (being the staunchest advocate of the lawfulness of nuclear NEO response in the scholarship) has noted[223] that the preamble to the LTBT—as indicative of its underpinning object and purpose, which its provisions must be read in light of—refers to the treaty's intent to move towards the elimination of "testing of all kinds of *weapons*, including *nuclear weapons*,"[224] and to "achieve the discontinuance of all test explosions of *nuclear weapons* for

215. *See* Gerrard & Barber, *supra* note 12, at 36 (such a test would "clearly violate the Partial Test Ban Treaty.").

216. LTBT, *supra* note 208, art. I(1)(a) (emphasis added).

217. Kunich, *supra* note 12, at 145.

218. *Id.*; *Legal Aspects of NEO Threat Response*, *supra* note 8, at 26; Su, *Measures Proposed for Planetary Defence*, *supra* note 12, at 2.

219. LTBT, *supra* note 208, art. I(1)(a).

220. Su, *Measures Proposed for Planetary Defence*, *supra* note 12, at 2.

221. Brooks, *supra* note 12, at 246.

222. *See* Tronchetti, *supra* note 12, at 1037; Kunich, *supra* note 12, at 145-46.

223. *Id*.

224. LTBT, *supra* note 208, preamble (emphasis added).

all time . . . ."[225] This would imply that the object and purpose of the LTBT predominantly is concerned with military applications of nuclear explosive devices—which of course it is[226]—a fact that might drag us kicking and screaming back into tortuous considerations of the meaning of a "weapon."

However, we can be spared this, in part because the preamble also states that "the *principal* aim"[227] of the LTBT was to represent "the speediest possible achievement of an agreement on *general and complete disarmament*,"[228] and that a further aim is "to put an end to the contamination of man's environment by radioactive substances."[229] The military application of nuclear devices may be the reason behind these goals, but they manifest in a wider object and purpose that prioritizes disarmament and the non-discharge of nuclear radiation at all costs (at least in the atmosphere, high seas and outer space), without drawing any distinction between nuclear weapons and PNEs.

This reading is strengthened when one considers the LTBT's *travaux préparatoires*. It is clear that the term "or any other nuclear explosion" in Article I(1)(a) was inserted deliberately to avoid the circumvention of the aim of that provision through an assertion of "peaceful use."[230] Thus, despite Kunich's contention to the contrary, the references in the LTBT's preamble to "nuclear *weapons*" are not enough to support a credulity-defying interpretation of the "ordinary meaning" of the term "or any other nuclear explosion" in Article I(1)(a), as read in context and in light of the LTBT's overall object and purpose, so as to allow for nuclear NEO responses.[231]

Another permissive interpretation of the LTBT advanced in this context relates to the fact that LTBT Article I(1) prohibits nuclear explosions at any place "under [the state's] jurisdiction or control."[232]

225. *Id.* (emphasis added).

226. *See, e.g.*, UNGA Res. 1762 (XVII), U.N. Doc. A/RES/1762(XVII) (Nov. 5, 1962) ("the continuation of nuclear weapon tests is an important factor in the acceleration of the nuclear arms race and that the conclusion of an agreement prohibiting such tests would contribute to paving the way towards … [nuclear] disarmament."); Report of the First Committee of the General Assembly, The Urgent Need for Suspension of Nuclear and Thermo-Nuclear Tests, UN GAOR, 17th Sess., U.N. Doc. A/5279 (Nov. 5, 1962).

227. LTBT, *supra* note 208, preamble (emphasis added).

228. *Id.* (emphasis added).

229. *Id.*

230. *See, e.g.*, ARTHUR DEAN, TEST BAN AND DISARMAMENT: THE PATH OF NEGOTIATION 100-01 (1966) (commentary on the drafting of the LTBT text by one of the negotiators/drafters).

231. Brooks, *supra* note 12, at 246 (stating in reference to LTBT art. I(1)(a) that "certainly the 'ordinary meaning' of a 'nuclear explosion' is quite clear.").

232. LTBT, *supra* note 208, art. I(1). The Cold War era intent behind the prohibition's limitation to areas under a state's "jurisdiction and control" was to allow for the possibility

Gerrard and Barber have suggested that a collision-course NEO would not be under the "jurisdiction or control" of any state, and thus that "the detonation of nuclear weapons would not be prohibited by the letter of [LTBT Article I(1)(a)]."[233]

Wider space law makes it clear that jurisdiction and control in outer space is legally retained for human-originated objects, space stations, instrumentalities, and personnel.[234] Simply put, a state has jurisdiction/control over what it launches into space.[235] NEOs, though, are naturally occurring objects, and given that outer space and its natural contents are not subject to national appropriation,[236] Gerrard and Barber's assertion that no state would have jurisdiction or control over an NEO would seem correct.

However, while an NEO itself would not be under a state's jurisdiction/control, any space object carrying a nuclear weapon likely would be. On that basis, the response mission may still fall foul of LTBT Article I(1)(a): any *delivery system* for a the nuclear explosion in outer space would be under a state's jurisdiction/control even though its target was not.[237]

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of the superpowers using of nuclear weapons against an enemy in one of the LTBT protected environments during wartime. *See Nuclear Test Ban Treaty*, Hearings before the Committee on Foreign Relations, United States Senate, 88th cong., 1st Sess., on exec. mtg., 74-78 (1963).

233. Gerrard & Barber, *supra* note 12, at 35.

234. GBENGA ODUNTAN, SOVEREIGNTY AND JURISDICTION IN THE AIRSPACE AND OUTER SPACE: LEGAL CRITERIA FOR SPATIAL DELIMITATION 172-90 (2012).

235. *See, e.g.*, OST, *supra* note 163, art. VIII (a "State Party to the Treaty on whose registry an object launched into outer space is carried shall retain jurisdiction and control over such object, and over any personnel thereof …").

236. *See, e.g.*, *id.* art. I ("[o]uter space … is not subject to national appropriation by claim of sovereignty …").

237. It is worth here noting LTBT, *supra* note 208, art. I(1)(b), which—additional to Article I(1)(a)—further provides that any nuclear explosion is prohibited "in any other environment if such explosion causes radioactive debris to be present outside the territorial limits of the State under whose jurisdiction or control such explosion is conducted …" Any nuclear detonation in space would result in the presence of radioactive debris (*see* Richard Latter & Robert E. Lelevier, *Detection of Ionization Effects from Nuclear Explosions in Space*, 68 J. GEOPHYSICS REV. 1643, 1643 (1963) ("For space [nuclear] explosions, ionization of the atmosphere results from the direct radiations emitted by the explosions. These radiations include … the material debris from the nuclear device itself.")), with this debris necessarily being outside of the territorial limits of all states (i.e., in outer space). At first glance, one might therefore conclude that the prohibition in Article I(1)(b) would mean that nuclear NEO response in outer space would still violate the LTBT, irrespective of questions of "jurisdiction and control". However, this would be incorrect: LTBT, *supra* note 208, Article I(1)(b) concerns "*other* environments" (emphasis added), meaning that it

Overall, the most convincing interpretation of the LTBT is that it would indeed prohibit a nuclear NEO response of any kind (whether "on-world" or "off-world"), as well as the testing of any such action. The LTBT would appear less ambiguously and more comprehensively to prohibit nuclear NEO responses than does the OST. Nonetheless, as with the OST, this remains a conclusion to some extent born of eye-of-the-beholder treaty interpretation rather than anything approaching legal certainty on the issue, especially when it comes to the question of "jurisdiction or control." Plus, it is crucial to keep in mind that three of the nuclear powers are not parties to the LTBT anyway, including, perhaps most pertinently in the space-faring context, China.

C. Comprehensive Nuclear-Test-Ban Treaty

It is next necessary to consider the 1996 Comprehensive Nuclear-Test-Ban Treaty (CTBT)[238] in the nuclear NEO response context. CTBT Article I(1) prohibits "any nuclear weapon test explosion or any other nuclear explosion."[239] Therefore, unlike the LTBT, it is not limited to specific environments, nor is it applicable only to areas under the state in question's jurisdiction/control. Wider teleological interpretative approaches would be unlikely to alter the clear ordinary meaning of the CTBT Article I(1) text in a way that would allow for a nuclear NEO response. This is not least because the CTBT's preamble reflects the wording of Article I(1), making it explicit that the key goal of the treaty is the "cessation of all nuclear weapon test explosions *and all other nuclear explosions*."[240] It thus rightly has been concluded that CTBT Article I(1) would rule out all nuclear NEO responses: the implication of its prohibition for nuclear planetary defense is unequivocal.[241]

However, while it has been widely signed and ratified, the CTBT still has not yet entered into force.[242] It therefore does not bind states, meaning

governs nuclear explosions that occur in environments *other than* those detailed in art. I(1)(a) (a list that, of course, includes outer space).

238. Comprehensive Nuclear-Test-Ban Treaty (CTBT) 1996, U.N. Doc. A/50/1027 (Aug. 26 1996).

239. *Id.* art. I(1).

240. *Id.* preamble (emphasis added).

241. Pop, *supra* note 12, at 676; *Legal Aspects of NEO Threat Response*, *supra* note 8, at 26.

242. As of September 5, 2018, 183 states have signed the CTBT and 166 states have ratified it (*see* Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization, Status of Signature and Ratification, http://www.ctbto.org/the-treaty/status-of-signature-and-ratification). However, the CTBT will only enter into force following ratification by all of the states listed in Annex 2, as per CTBT, *supra* note 238, art. XIV.

that Article I is not directly applicable to the nuclear NEO response question. This is not necessarily the end of the story when it comes to the CTBT though. It has been argued that the states that have signed the treaty still may be bound by its core obligations, despite the fact that it is not yet in force.[243] Pursuant to VCLT Article 18, states that have consented to be bound by treaties have an obligation not to do anything that would "defeat the object and purpose" of the treaty in question.[244] Given that most of the normative eggs of the CTBT are found in the basket of Article I, this might mean that signatory states (which include all of the nuclear powers aside from India, Pakistan, and the DPRK) are bound by that article's terms. This possible implication of VCLT Article 18 for the binding nature of Article I of the CTBT remains disputed,[245] however, and even if signatory states indeed were indirectly bound in this way, three of the nuclear powers still would remain outside of its reach as non-signatories.

A strong case also can be made that the comprehensive nuclear test-ban set out in the CTBT has become customary international law.[246] If so, this would mean that all states—persistent objectors aside[247]—would be bound by it.[248] However, to the extent that the CTBT ban is mirrored in custom, this probably is limited to the requirement not to *test*: it would be difficult to see it as extending also to the "any other nuclear explosion" aspect of Article I(1).[249]

243. *See* Masahiko Asada, *CTBT: Legal Questions Arising from its Non-Entry-into-Force*, 7 J. CONFLICT & SEC. L. 85, 94-103, 121-22 (2002); David S. Jonas, *The Comprehensive Nuclear Test Ban Treaty: Current Legal Status in the United States and the Implications of a Nuclear Test Explosion*, 39 N.Y.U. J. INT'L L. & POL. 1007, 1029-40 (2007); Lisa Tabassi, *The Nuclear Test Ban:* Lex Lata *or* de Lege Ferenda*?*, 14 J. CONFLICT & SEC. L. 309, 313-21 (2009).

244. VCLT, *supra* note 175, art. 18 ("A State is obliged to refrain from acts which would defeat the object and purpose of a treaty when … it has expressed its consent to be bound by the treaty, pending the entry into force of the treaty and provided that such entry into force is not unduly delayed.").

245. *See, e.g.*, David S. Jonas & Thomas N. Saunders, *The Object and Purpose of a Treaty: Three Interpretive Methods*, 43 VAND. J. TRANSNAT'L L. 565, 567-68 (2010).

246. *See, e.g.*, James A. Green, *India and a Customary Comprehensive Nuclear Test-Ban: Persistent Objection, Peremptory Norms and the 123 Agreement*, 51 INDIAN J. INT'L L. 3, 9-18 (2011); Grant Guthrie, *Nuclear Testing Rocks the Sub-Continent: Can International Law Halt the Impending Nuclear Conflict Between India and Pakistan*, 23 HASTINGS INT'L & COMP. L. REV. 495, 508–18 (1999–2000); Tabassi, *supra* note 243, at 309-52; Peter Hulsroj, Jus Cogens *& Disarmament*, 46 INDIAN J. INT'L L. 1, 8-10 (2006).

247. On persistent objection, see generally JAMES A. GREEN, THE PERSISTENT OBJECTOR RULE IN INTERNATIONAL LAW (2016).

248. Green, *supra* note 246, at 18-33.

249. *See, e.g.*, Guthrie, *supra* note 246, at 518 (referring to the "custom against nuclear *testing*" stemming from the CTBT, emphasis added).

The legal consequences of the CTBT for nuclear NEO response thus are unclear and, if it has any, they would be indirect. It may be argued that the signatory states are bound by CTBT Article I through VCLT Article 18, and that the CTBT's influence on customary international law may also act legally to restrict nuclear planetary defense. Neither of these possible legal implications can be asserted with any certainty. Were the CTBT to come into force, though, any uncertainty would be removed: it would rule nuclear NEO response out entirely for its states party.

D. Treaty on the Prohibition of Nuclear Weapons

As already has been noted,[250] the TPNW is not yet in force and the nuclear powers all conspicuously have not engaged with it. Its impact thus currently is far more significant in a political sense than a legal one. Nonetheless, it is interesting to explore what the legal implications of the TPNW would be for nuclear planetary defense were it to come into force (and, particularly, were it to come into force for the nuclear powers), either directly or rather more plausibly through the development of customary international law that reflected it. TPNW Article 1 *inter alia* requires states party

"never under any circumstances to . . . [d]evelop, test, produce, manufacture, otherwise acquire, possess or stockpile nuclear weapons or other nuclear explosive devices [or] . . . [u]se or threaten to use nuclear weapons or other nuclear explosive devices . . . ."[251]

This categorical prohibition on, amongst other things, any possession or usage of any nuclear explosive device whatsoever goes even further than the (already stringent) restrictions of the CTBT. The preamble of the TPNW highlights the treaty's focus on

"the catastrophic humanitarian consequences that would result from *any use of nuclear weapons*, . . . the consequent need to *completely eliminate such weapon*s, [and] . . . the risks posed by the *continued existence of nuclear weapons*, including from *any nuclear-weapon detonation* by accident, miscalculation or design."[252]

There is no question that any interpretation of Article 1, whether in isolation or taken in the context of the wider object and purpose of the TPNW, would outlaw a nuclear NEO response entirely. The TPNW's *raison d'être* is to realize total nuclear disarmament and the complete absence of any nuclear explosion (anywhere, at any time, for any reason).

250. *See supra* notes 133- 136 and accompanying text.
251. TPNW, *supra* note 133, art. 1.
252. *Id.* preamble (emphasis added).

The non-binding TPNW may be only "soft law" at present, but it nonetheless sets out a "hard" "soft law" prohibition, in that its meaning is unequivocal and it is framed as a mandatory obligation rather than as an aspirational or progressive one.[253] This "legal" clarity adds, at a minimum, political context to the much less clear legal restrictions on nuclear NEO response that stem from the existing Cold War era treaties.

E. Draft Treaty on Prevention of the Placement of Weapons in Outer Space and of the Threat or Use of Force against Outer Space Objects

The 2014 PPWT, which remains an unadopted and controversial draft text, is of even less legal relevance at present than the TPNW.[254] Nonetheless, it is worth briefly exploring what its legal implications would be for nuclear NEO response (again, subject to disclaimers about this being only potential in a legal sense).

PPWT Article II states, commendably simply, that parties undertake "[n]ot to place any weapons in outer space."[255] This prohibition is not merely limited to weapons *stationed* in space, as is the case under the OST. "On-world" weapons launched into space would run afoul of it too. Moreover, unlike the OST, the draft PPWT aims for clarity in setting out this obligation by explicitly defining what a "weapon" actually *is* in the context of outer space:

"[a weapon is] any outer space object or component thereof which has been produced or converted to destroy, damage or disrupt the normal functioning of objects in outer space, on the Earth's surface or in its atmosphere, or to eliminate human beings or components of the biosphere which are important to human existence, or to inflict damage on them by using any principles of physics."[256]

The PPWT further defines an "object" in this context as "any device placed in outer space and designed for operating therein."[257]

These definitional clarifications—helpful as they are in a wider sense when it comes to understanding the obligations contained in the draft

253. *See, generally* Arnold N. Pronto, *Understanding the Hard/Soft Distinction in International Law*, 48 VAND. J. TRANSNAT'L L. 941 (2015); Christine M. Chinkin, *The Challenge of Soft Law: Development and Change in International Law*, 38 INT'L & COMP. L. Q. 850 (1989).

254. *See supra* notes 144-147 and accompanying text.

255. PPWT 2014, *supra* note 144, art. II.

256. *Id.* art. I(b).

257. *Id.* art. I(a).

treaty—unfortunately do not clarify things in relation to the specific question of nuclear NEO response. Under the PPWT definition, NEOs are not "objects," as they are neither "placed in outer space" nor "designed to operate" in outer space (indeed, they are not "designed" at all). As such, a device "produced or converted" specifically to "to destroy, damage or disrupt" an NEO seemingly would not be a "weapon" for the purposes of PPWT Article II.

However, the "dual use" nuclear weapon/PNE issue again causes interpretative uncertainty here. One would need to conclude whether a nuclear explosive device used against an NEO had been *produced* for that purpose, or in fact had been "produced or converted to destroy, damage or disrupt" (man-made) objects, or "to eliminate human beings," and simply then repurposed. If a nuclear weapon was produced from scratch specifically to be launched at an incoming NEO, might this mean that it was not in fact produced to "to eliminate human beings," and thus that it fell outside of the PPWT's reach? Or, would the fact that the advent of nuclear weapons *per se* was with a view to the elimination of, or at least to act as a threat of the elimination of, human beings mean that any and all such weapons inherently would be prohibited?

A teleological appraisal of the PPWT does not help clarify matters. For example, the draft text explicitly recalls the OST's prohibition on the placement of any objects carrying nuclear weapons or any other kinds of weapons of mass destruction in orbit in its preamble,[258] suggesting a core nuclear disarmament underpinning, but it also makes it clear that nothing in the treaty should be interpreted as preventing the peaceful use of space,[259] which might point one towards an allowance for PNEs in an extreme case of planetary defense.

Thus, while the CTBT and TPNW contain clear (if currently non-binding, at least directly) provisions that would prohibit a nuclear NEO response, the PPWT is another example of a treaty drafted without NEOs in mind that would cause significant uncertainty if it ever became necessary to attempt to apply it in that context.

F. Anti-Ballistic Missile Treaty

Finally in this section it is necessary to take brief note of a treaty that *no longer* is in force. A consequence of the fact that much of the legal literature on planetary defense was written in the 1990s is that writings on the subject devoted a notable amount of ink to the 1972 Anti-Ballistic

258. *Id.* preamble.
259. *Id.* art. III.

Missile Treaty (ABMT)[260] between the U.S. and Soviet Union. It was widely accepted that the ABMT would represent a serious legal impediment to either state (or subsequently the Soviet Union's successor states) using nuclear weapons in planetary defense.[261]

However, the U.S. withdrew from the ABMT in 2002, resulting in its termination.[262] This means that the ABMT is no longer of any relevance to this or any legal question, other than as "a historical footnote."[263] It is noted herein only to serve to update the existing literature, given the prominence of the ATBT in much of the previous scholarship on the subject.

VI. POSSIBILITIES FOR PRECLUDING THE APPARENT UNLAWFULNESS OF NUCLEAR NEO RESPONSE

Uncertainties in interpretation mean that it is difficult to conclude categorically that current treaty law (for those treaties in force, at least) outlaws nuclear NEO response outright, although on balance, most nuclear NEO missions would fall afoul of (some, or all of) the treaty provisions discussed in the previous section. It certainly may be said that there exists significant doubt as to the lawfulness of any such action, especially for the states party to the LTBT. This section therefore explores ways in which the *prima facie* illegality of nuclear NEO response potentially could be precluded under existing legal mechanisms, should an impact-bound NEO appear.

A. Treaty Withdrawal

One proposed[264] option to circumvent the seeming illegality of the nuclear option has been for relevant states simply to withdraw from the

260. Treaty between the United States of America and the Union of Soviet Socialist Republics on the Limitation of Anti-Ballistic Missile Systems (Anti-Ballistic Missile Treaty, ABMT) 1972 (entry into force Oct. 3, 1972) 944 U.N.T.S. 13.

261. This particularly was on the basis that *id.* art. V(1) required parties *inter alia* not to deploy "space-based" ABMs. *See, e.g.*, Sweet, *supra* note 12, at 227-28; Gerrard & Barber, *supra* note 12, 36-37; Kunich, *supra* note 12, at 150-57.

262. For discussion, *see* David Gray, *"The Law", Termination of the ABM Treaty and the Political Question Doctrine: Judicial Succor for Presidential Power*, 34 PRESIDENTIAL STUD. Q. 156 (2004).

263. Pop, *supra* note 12, at 676.

264. *See* Kunich, *supra* note 12, at 149; Tronchetti, *supra* note 12, at 1037; *Legal Aspects of NEO Threat Response*, *supra* note 8, at 27; Su, *Measures Proposed for Planetary Defence*, *supra* note 12, at 3.

treaties that otherwise may prohibit them from effectively acting to protect the planet.

Parties can withdraw from the OST without needing to invoke any particular justifying circumstances, with the withdrawal taking effect after a 12-month notice period.[265] The LTBT also allows for a right of withdrawal, after only a 3-month notice period, but requires that the withdrawal be in relation to "extraordinary events" that jeopardize the state's "supreme interests."[266] The CTBT, TPNW and PPWT all contain largely identical withdrawal provisions to the LTBT, in that they require that any withdrawal from them is necessary to protect essential state interests from extraordinary events, although the notice period in each case is different: 6 months,[267] 12 months,[268] and 6 months,[269] respectively. Of course, this currently is academic for the TPNW and PPWT, as they are not yet in force; nor is the CTBT, although if it is seen as indirectly binding its signatory states, the provision for them to withdraw from it would exist.

A verified, large, collision-course NEO reasonably could be considered to represent an "extraordinary event" jeopardizing the "supreme interests" of the state—indeed, likely multiple and perhaps even all states—allowing for withdrawal from the LTBT (as well as from the CTBT/TPNW/PPWT, were they to come into force). Given that it is the state itself that determines the existence of such extraordinary circumstances, there would be little question that withdrawals from these treaties in the NEO impact scenario would be lawful (and, for the OST, no justification is required for withdrawal at all).

The "withdrawal approach" nonetheless may be problematic for two reasons. First, there is a risk that in some cases, waiting 12 or even only 3 months for a withdrawal notice to take effect may defeat the very reason for the withdrawal in the first place. Doing nothing for a period of months after an NEO was first identified could mean that it was then too late to respond to it.[270]

Second, the notion of powerful, nuclear states unilaterally withdrawing from fundamental, cornerstone treaties of space law (the OST) and nuclear non-proliferation (the LTBT) because of an emerging NEO threat would be extremely concerning. As a matter of law, withdrawal may be a viable solution to the illegality of a nuclear planetary defense operation, but it would be far from a desirable one in terms of the integrity

265. OST, *supra* note 163, art. XVI.
266. LTBT, *supra* note 208, art. IV
267. CTBT, *supra* note 238, art. IX.
268. TPNW, *supra* note 133, art. 17.
269. PPWT 2014, *supra* note 144, art. XII.
270. *Legal Aspects of NEO Threat Response*, *supra* note 8, at 27.

of the entire regimes of international space and nuclear non-proliferation law. Much of the success of these regimes has precisely stemmed from the widespread ratification of their key treaties, including (for the most part) by the nuclear powers. Even if enough time remained to act after the required notice period(s), it would seem unsatisfactory for states to do so unilaterally[271] by extricating themselves from essential legal frameworks that have much wider implications for human good.

B. Treaty Suspension by Consent

While the option of state withdrawal is made explicit in both the OST and the LTBT, neither treaty makes any provision for their respective suspension. Yet VCLT Article 57 allows that a treaty can be temporarily suspended for all or some of its parties not just when the treaty explicitly provides for this, but also "[a]t any time by consent of all the parties after consultation with the other contracting States."[272] Article 20 of the Draft Articles on State Responsibility further confirms that consensual treaty suspension—as with consent in relation to the non-performance of any obligation in international law given by the state(s) to which it is owed—acts to preclude the wrongfulness of an act that without such consent would otherwise constitute a violation of the treaty.[273]

Although such a possibility has not been advanced in the existing literature on planetary defense, it is conceivable that the states parties to the OST and LTBT collectively could agree to suspend these treaties so as to allow for a nuclear NEO response mission to be launched. This would remedy the concerns associated with the "treaty withdrawal" option.[274] First, no formal period of notice would be required: consent for suspension can be given "in advance or even at the time [that the act] is occurring."[275] Second, suspension would not result in a single state (or small number of states) unilaterally extricating themselves from crucial treaties, but instead would amount to a collective decision to allow for action that otherwise would violate them. This would help to protect against abusive appeals to "asteroid threats" as a pretext for military activity. It also would be

271. On the general desirability of multilateral legal approach, see *infra* notes 374-381 and accompanying text.

272. VCLT, *supra* note 175, art. 57(b).

273. *Text of the Draft Articles on Responsibility of States for Internationally Wrongful Acts, with commentaries*, Report of the International Law Commission, 53rd Sess., U.N. Doc. A/56/10, 72-77 (2001), art. 20 and accompanying commentary.

274. *See* discussion *supra* Section VI.*A*.

275. U.N. Doc. A/56/10, *supra* note 273, at 74.

inherently temporary. Rather than meaning that a state abandoned its obligations indefinitely through withdrawal, the relevant treaties would only be suspended for as long as was necessary to implement planetary defense, and then would apply to all states party just as before.[276]

Treaty suspension thus may be a more appealing option than treaty withdrawal, but it would replace one set of concerns with another. On balance, a multilateral approach would—in the view of this author[277]—be preferable to a unilateral one, but suspension could be seen as being *too* multilateral in nature. Treaty suspension would require the consent of *every single state party* to the LTBT and, at least if an "off-world" approach was contemplated, the OST too.[278] The states party to these treaties are not identical, of course, which would add further levels of complexity in reaching agreement. In any event, the high number of parties to both conventions (125 and 107, respectively), and the fact that they represent particularly fundamental treaties for the nuclear non-proliferation and space law regimes, might suggest that universal agreement would be rather difficult to achieve in relation to suspending even one of them so as to allow for nuclear weapons to be used in outer space.[279]

Some writers have expressed the concern that any approach involving collective decision-making by a large number of states in relation to NEO response may create a "too many cooks in the kitchen" problem, leading to potentially catastrophic inaction.[280] At the very least, one might reasonably fear that the need for universal consent may mean that suspension of the relevant treaties would not occur in time. There may be no requirement for a formal notice period as would be the case with the "treaty withdrawal" approach, but this does not mean that treaty suspension necessarily would be a quicker way of seeking to preclude wrongfulness in a context where the clock would be ticking.

Treaty suspension ultimately represents another legally viable option for planetary defense, and one that would desirably engage the wider international community rather than a single "white knight" state. It still would be *ad hoc* and reactive, however, and the necessity of universal agreement likely would mean that it would be a difficult option to implement successfully.

276. *See* VCLT, *supra* note 175, art. 72.

277. *See infra* notes 374-381 and accompanying text.

278. *See* U.N. Doc. A/56/10, *supra* note 273, at 176; VCLT, *supra* note 175, art. 57(b).

279. It also should be recalled that the consent on the part of each of these states must be "valid", in that, for example, it would need to be given by an appropriate authority and not coerced. *See* U.N. Doc. A/56/10, *supra* note 273, at 175.

280. *See* Gerrard & Barber, *supra* note 12, at 46; Seamone, *The Precautionary Principle*, *supra* note 8, at 22.

C. Self-Defense

An almost universally advanced argument in the limited legal literature on NEO response is that the probable illegality of nuclear NEO response could be precluded by the exercise of the right of self-defense.[281] On the face of it, one can see why this approach has been so strongly advocated. Self-defense explicitly is sanctified in Article 51 of the UN Charter as an "inherent" right for states to defend themselves.[282] It also can be exercised collectively on behalf of other states.[283] This would indicate that in cases where the physical consequences of an NEO impact were going to be regional rather than global, states that were not anywhere near the predicted point of impact still could act to protect others.[284] The right clearly "applies to attacks from outer space" too, at least in the sense that a state can respond in self-defense to an attack against one of its space objects that was launched from another state's space object.[285]

An inherent right of *defense* that can be executed collectively, including in space, would intuitively seem to be a perfect fit for NEO response mission intended to defend a notable part, if not all, of humanity.[286] However, despite the overwhelming support for the "self-defense" approach in the literature, it is not in fact a suitable legal mechanism for precluding the unlawfulness of a nuclear NEO response.

Self-defense, conceptually, is focused on a defensive response to human-authored attacks or threats of attack,[287] and exists as an exception to the *ad bellum* prohibition on the use of force.[288] That prohibition is set out

281. *See Legal Aspects of NEO Threat Response*, *supra* note 8, 10-11, at 26; Gerrard & Barber, *supra* note 12, at 39; Kunich, *supra* note 12, at 132; Sweet, *supra* note 12, at 226-27; Tronchetti, *supra* note 12, at 1029, 1032, 1035; Pop, *supra* note 12, at 674; Koplow, *supra* note 17, at 280–83; Seamone, *The Precautionary Principle*, *supra* note 8, at 6; Seamone, *Wishing on a Star*, *supra* note 8, at 1106, n.73.

282. U.N. Charter, art. 51.

283. *Id*.

284. Koplow, *supra* note 17, at 282-83.

285. ODUNTAN, *supra* note 234, at 256; BIN CHENG, STUDIES IN INTERNATIONAL SPACE LAW 10 (1997).

286. *Legal Aspects of NEO Threat Response*, *supra* note 8, at 11.

287. *See, e.g.*, Cliff Farhang, *Self-Defence as a Circumstance Precluding the Wrongfulness of the Use of Force*, 11 UTRECHT L. REV. 1 (2015) (examining various ways of conceptualizing the right of self-defense in international law, all of which relate to a response to a form of human-authored aggression).

288. *See, e.g.*, U.N. Doc. A/56/10, *supra* note 273, at 177 ("the existence of a general principle admitting self-defence *as an exception to the prohibition against the use of force* in international relations is undisputed"; emphasis added).

in Article 2(4) of the UN Charter,[289] which outlaws "the threat or use of force against the territorial integrity or political independence *of any state* . . . ."[290] Forcible action against an asteroid or comet would not be directed "against . . . any state," but, instead, against a large space rock. This means that the prohibition of the use of force would not be breached by a planetary defense action.[291] Resorting to self-defense therefore would amount to an attempt to employ an exception to a rule that would not be violated by the action undertaken, as a way to try to justify the fact that that action was in violation of *other* rules of international law (LTBT, OST, etc.).

It admittedly is true that self-defense—despite intrinsically acting as an exception to the prohibition on the use of force—can in some cases[292] preclude the wrongfulness of obligations other than the prohibition itself.[293] The International Court of Justice (ICJ) famously concluded in 1996, for example, that in extreme circumstances the use of nuclear weapons may be lawful as an action in self-defense, including through insulating the state using such weapons in a defensive manner against the wrongfulness of the breach of (some) norms of international law beyond Article 2(4).[294] So perhaps self-defense can preclude the wrongfulness of obligations stemming from the LTBT *et al.* in the planetary defense context after all.

In its commentary to the Draft Articles on State Responsibility, however, the International Law Commission (ILC) made it clear that "[s]elf-defence may justify non-performance of certain obligations other than that under Article 2, paragraph 4, of the Charter of the United Nations, *provided that such non-performance is related to the breach of that provision*."[295] Again, it is difficult to see how the non-performance of

289. U.N. Charter, *supra* note 282, art. 2(4). The prohibition also is mirrored in customary international law, *see, e.g.*, MYRA WILLIAMSON, TERRORISM, WAR AND INTERNATIONAL LAW: THE LEGALITY OF THE USE OF FORCE AGAINST AFGHANISTAN IN 2001 103 (2009); James A. Green, *Questioning the Peremptory Status of the Prohibition of the Use of Force*, 32 MICH. J. INT'L L. 215, 222 (2011); Hermann Mosler, *The International Society as a Legal Community*, IV RECUEIL DE COURS 1, 283 (1974); Michael Bothe, *Terrorism and the Legality of Pre-Emptive Force*, 14 EUR. J. INT'L L. 227, 228 (2003).

290. U.N. Charter, *supra* note 282, art. 2(4) (emphasis added).

291. *Legal Aspects of NEO Threat Response*, *supra* note 8, at 26; Su, *Measures Proposed for Planetary Defence*, *supra* note 12, at 2-3.

292. *See* U.N. Doc. A/56/10, *supra* note 273, at 178 (noting that self-defense cannot, for instance, allow for derogation from international humanitarian law or human right law norms).

293. *Id*.

294. Nuclear Weapons, *supra* note 177, ¶¶ 30, 38-44, 97.

295. U.N. Doc. A/56/10, *supra* note 273, at 178 (emphasis added). *See also Fragmentation of International Law: Difficulties Arising from the Diversification and Expansion of International Law*, Report of the Study Group of the International Law

obligations under the LTBT *et al.* can be viewed as being "related to the breach" of a prohibition that would not even be *prima facie* engaged by a planetary defense mission.[296] The applicability of self-defense to nuclear NEO response thus appears highly questionable.[297]

Even if one (dubiously) were to conclude that the "inherent" nature of the right of self-defense was sufficient to interpret it more broadly so as to dismiss such concerns,[298] the application of the substance of the right to NEOs still would be extremely problematic. First, stemming from the nature of self-defense as an exception to the prohibition on the use of force, Article 51 provides for the exercise of the right in response to an "armed attack."[299] Although nothing in the UN Charter identifies exactly what an "armed attack" *is*,[300] it would take a notably liberal interpretation of the term to see it as encompassing naturally occurring threats from space.[301] Whatever risk they pose, asteroids neither are "armed" nor "attacking."

Second, Article 51 states that for self-defense to be triggered, an armed attack must have *occurred*.[302] Waiting for an NEO impact to have "occurred" before acting to stop it would defeat the purpose of so doing, of course: there would be no repelling the army back after an attack when the "army" in question was a giant space rock. If it were legally framed as self-defense, any NEO response action would thus necessarily be an action of *anticipatory* self-defense.[303] There exists a long-standing and well-known debate as to whether action in self-defense can lawfully be taken in an anticipatory manner (i.e., before the "armed attack" has "occurred"

Commission (finalized by Martti Koskenniemi), 58th Sess., U.N. Doc. A/CN.4/L.682, 52–53 (2006) (defining self-defense as "*lex specialis* in relation to the principle of non-use of force in art. 2(4)."); VCLT, *supra* note 175, art. 73 (the VCLT's provisions "shall not prejudge any question that may arise in regard to a treaty … from the outbreak of hostilities *between States*", emphasis added).

296. *See* James A. Green & Francis Grimal, *The Threat of Force as an Action in Self-Defense Under International Law*, 44 VAND. J. TRANSNAT'L L. 285, 306-07 (2011) (stating, in reference to self-defense, that "[i]t would be nonsensical for a particular manifestation of a type of conduct to constitute an exception to a rule that does not prohibit that type of conduct in the first instance.").

297. Seamone, *The Duty to "Expect the Unexpected," supra* note 8, at 758; Tronchetti, *supra* note 12, at 1029.

298. *See* Gerrard & Barber, *supra* note 12, at 39.

299. U.N. Charter, *supra* note 282, art. 51.

300. *See* James A. Green, *The* Ratione Temporis *Elements of Self-Defence*, 2 J. USE OF FORCE & INT'L L. 97, 99 (2015).

301. Tronchetti, *supra* note 12, at 1033; Su, *Measures Proposed for Planetary Defence*, *supra* note 12, at 3.

302. U.N. Charter, *supra* note 282, art. 51.

303. Koplow, *supra* note 17, at 281.

contrary to what the text of Article 51 would seem to require).[304] This is not the place to explore that debate, but there is increasing consensus amongst scholars[305] (and, seemingly, albeit less clearly, amongst states)[306] that anticipatory action will be considered lawful if the attack being responded to is an *imminent* one.

NEO interception may require months (or years) to implement.[307] Some experts admittedly have argued that, unlike most options, a *nuclear* approach could be successfully implemented in a matter of days.[308] Even if this were correct, however, it would seem desirable that any interception mission be launched as soon as the collision-course NEO was properly identified and verified. An NEO mission therefore may not sit comfortably with the requirement of imminence. It is true that an understanding of imminence recently has been advanced in relation to self-defense that relates more to the degree of certainty as to the occurrence of the impending attack than to its temporal proximity,[309] but it is far from certain

304. *See, e.g.*, OLIVIER CORTEN, THE LAW AGAINST WAR: THE PROHIBITION ON THE USE OF FORCE IN CONTEMPORARY INTERNATIONAL LAW 406-43 (2010); KINGA TIBORI SZABÓ, ANTICIPATORY ACTION IN SELF-DEFENCE: ESSENCE AND LIMITS UNDER INTERNATIONAL LAW (2011); Terry D. Gill, *The Temporal Dimension of Self-Defence: Anticipation, Pre-Emption, Prevention and Immediacy*, *in* INTERNATIONAL LAW AND ARMED CONFLICT: EXPLORING THE FAULTLINES: ESSAYS IN HONOUR OF YORAM DINSTEIN 113 (Michael N. Schmitt & Jelena Pejic eds., 2007); Gregory A. Raymond & Charles W. Kegley, Jr., *Preemption and Preventative War*, *in* THE LEGITIMATE USE OF FORCE: THE JUST WAR TRADITION AND THE CUSTOMARY LAW OF ARMED CONFLICT 99 (Howard M. Hensel ed., 2008); Ashley S. Deeks, *Taming the Doctrine of Pre-Emption*, *in* THE OXFORD HANDBOOK OF THE USE OF FORCE IN INTERNATIONAL LAW 661 (Marc Weller ed., 2015).

305. *See, e.g.*, DEREK W BOWETT, SELF-DEFENCE IN INTERNATIONAL LAW 187-93 (1958); CHRISTIAN HENDERSON, THE PERSISTENT ADVOCATE AND THE USE OF FORCE: THE IMPACT OF THE UNITED STATES UPON THE *JUS AD BELLUM* IN THE POST-COLD WAR ERA 171–93 (2010); NOAM LUBELL, EXTRATERRITORIAL USE OF FORCE AGAINST NON-STATE ACTORS 55–63 (2010).

306. For a discussion of relevant state practice, *see* JAMES A. GREEN, THE INTERNATIONAL COURT OF JUSTICE AND SELF-DEFENCE IN INTERNATIONAL LAW 96-98 (2009).

307. NIKOS PRANTZOS, OUR COSMIC FUTURE: HUMANITY'S FATE IN THE UNIVERSE 54 (2000); Wie, *supra* note 95, at 146.

308. Kaplinger, Wie & Dearborn, *supra* note 86, at 156.

309. *See, e.g.*, Daniel Bethlehem, *Principles Relevant to the Scope of a State's Right of Self-Defense Against an Imminent or Actual Armed Attack by Nonstate Actors*, 106 AM. J. INT'L L. 775, 772-73, 775-76 (2012); Jeremy Wright, the United Kingdom Attorney General's Speech at the International Institute for Strategic Studies, *The Modern Law of Self-Defence* (Jan. 11, 2017), http://www.gov.uk/government/news/legal-basis-for-striking-terror-targets-set-out; George Brandis, the Australian Attorney-General's speech at the TC Beirne School of Law, University of Queensland (Apr. 11, 2017), subsequently published by *EJIL:Talk!*, http://www.ejiltalk.org/the-right-of-self-defence-against-imminent-armed-attack-in-international-law/.

whether an NEO that was months/years away from impact would be seen as representing an "imminent" attack sufficient for anticipatory action in self-defense to be taken.[310]

The "self-defense approach" may also engage significant *ad bellum* controversies as to whether the right can be exercised in cases where the author of the armed attack is not a state,[311] a debate that is centered on the question of the lawfulness of responses to attacks by non-state actors. There is notable jurisprudence and scholarship indicating that the author of an armed attack must be a state.[312] There also is significant support and evidence underpinning a contrary position, allowing for self-defense as a response against non-state actors.[313] Leaving the worms of that debate trapped firmly inside their can, it nonetheless may be said that neither side credibly can claim that it is settled. That fact in itself would suggest that, in an NEO impact scenario, where there would be *no* author of the "armed attack" *at all*, the already murky waters of attempting to apply the right of self-defense further may be muddied.

On the basis of all of the foregoing, Su—seemingly alone amongst the handful of legal scholars who have written on the NEO response topic—has correctly held "it could be safely posited that to defend against a natural disaster [such as NEO impact] is not self-defense in the legal sense."[314]

310. *See generally* Noam Lubell, *The Problem of Imminence in an Uncertain World*, *in* THE OXFORD HANDBOOK OF THE USE OF FORCE IN INTERNATIONAL LAW 695 (Marc Weller ed., 2015) (examining uncertainty as to what "imminence" means in the self-defense context).

311. Su, *Measures Proposed for Planetary Defence*, *supra* note 12, at 3.

312. *See, e.g.*, Military and Paramilitary Activities in and Against Nicaragua (Nicar. v. U.S.), Merits, 1986 I.C.J. 14, ¶ 195 (June 27); Legal Consequences of the Construction of a Wall in the Occupied Palestinian Territory, Advisory Opinion, 2004 I.C.J. 135, ¶ 139 (July 9); Armed Activities on the Territory of the Congo (Dem. Rep. Congo v. Uganda), Merits, 2005 I.C.J. 168, ¶ 146 (Dec. 19, 2005); Laurie O'Connor, *Legality of the Use of Force in Syria against Islamic State and the Khorasan Group*, 3 J. USE OF FORCE & INT'L L. 70 (2016); Iain Scobbie, *Words My Mother Never Taught Me: In Defence of the International Court*, 99 AM. J. INT'L L. 76, 80-81 (2005).

313. *See, e.g.*, Kimberley N Trapp, *Actor-Pluralism, the "Turn to Responsibility" and the* Jus ad Bellum: *"Unwilling or Unable" in Context*, 2 J. USE OF FORCE & INT'L L. 199 (2015); Sean D. Murphy, *Self-Defence and the* Israeli Wall *Advisory Opinion: An* Ipse Dixit *from the ICJ?*, 99 AM. J. INT'L L. 62, 67–70 (2005); Ruth Wedgwood, *The ICJ Advisory Opinion on the Israeli Security Fence and the Limits of Self-Defense*, 99 AM. J. INT'L L. 52, at 57-59 (2005).

314. Su, *Measures Proposed for Planetary Defence*, *supra* note 12, at 3. *See also* Su, *Control Over Activities Harmful to the Environment*, *supra* note 12, at 85.

D. UN Security Council Authorization

Amongst the writers who have worked on the legal aspects of NEO response, a few have concluded that the powers of the UN Security Council "in principle certainly are broad enough to encompass . . . a NEO threat-related decision-making framework."[315] This conclusion credibly can be reached, but is not self-evident. Given that the Security Council is vested with "primary responsibility for the maintenance of international peace and security,"[316] though, it is easy to see why the inherent security implications of nuclear planetary defense might lead one to conclude that authorization by the Council would be a suitable—some have argued *the only* suitable[317]—mechanism for establishing lawfulness.

Situating decision-making with the Security Council also can be seen as a desirably "multilateral" option.[318] The Council admittedly is only constituted of 15 states, which may to some extent belie the idea that it would represent a collective, community-orientated mechanism, especially given that its five permanent members also all are nuclear powers. Yet the small membership of the Security Council may act to balance the desirability of a multilateral approach against fears[319] that "too many cooks" might mean that no timely decision could be taken.

The Security Council has the power under Chapter VII of the UN Charter to implement measures to maintain or restore international peace and security.[320] It is clear that the exercise of this power does not need to be in response to a particular violation of international law by a state,[321] meaning that the fact that any NEO threat would not stem from a previous breach of international law would not be problematic. The Council's ability to implement binding measures is simply triggered by the occurrence of "a threat to the peace, breach of the peace or act of aggression."[322]

315. *Legal Aspects of NEO Threat Response*, *supra* note 8, at 16-17. *See also id.* at 12-13, 26, 29; Su, *Measures Proposed for Planetary Defence*, *supra* note 12, at 4.

316. U.N. Charter, *supra* note 282, art. 24(1).

317. Gerrard & Barber, *supra* note 12, at 46; Tronchetti, *supra* note 12, at 1033-35.

318. *See infra* notes 374-381 and accompanying text.

319. *See supra* note 280 and accompanying text.

320. U.N. Charter, *supra* note 282, art. 40-42.

321. ERIKA DE WET, THE CHAPTER VII POWERS OF THE UNITED NATIONS SECURITY COUNCIL 183–84 (2004); Terry D. Gill, *Legal and Some Political Limitations on the Power of the UN Security Council to Exercise its Enforcement Powers under Chapter VII of the Charter*, 26 NETH. YRBK INT'L L. 33, 62 (1992).

322. U.N. Charter, *supra* note 282, art. 39.

The existence of one or more of these triggering circumstances is self-determined by the Council,[323] allowing for substantial discretionary scope as to the circumstances in which its Chapter VII powers can be employed.[324] This discretion is not unlimited, in that the existence of "a threat to the peace, breach of the peace or act of aggression" must be interpreted in the light of the object and purpose of Charter regime and the Council's function within that structure,[325] but its limits have been stretched significantly by the Council since the end of the Cold War.[326]

An impending NEO impact would be almost impossible to conceptualize as an "act of aggression" (or even a "breach of the peace"), but its likely transboundary, devastating effects mean that a reasonable argument could be made that a collision-course NEO could be considered a "threat to the peace."[327] Notably, however, the Council largely has refrained from developing its understanding of a "threat to the peace" to incorporate natural disasters *in genere*,[328] or specific environmental security threats such as climate change.[329] This is not to say that the Council could

323. *See* DANESH SAROOSHI, THE UNITED NATIONS AND THE DEVELOPMENT OF COLLECTIVE SECURITY 3, 106 (1999).

324. *See* DAVID SCHWEIGMAN, THE AUTHORITY OF THE SECURITY COUNCIL UNDER CHAPTER VII OF THE UN CHARTER: LEGAL LIMITS AND THE ROLE OF THE INTERNATIONAL COURT OF JUSTICE 33-36 (2001).

325. DE WET, *supra* note 321, at 133-77; ANTONIOS TZANAKOPOULOS, DISOBEYING THE SECURITY COUNCIL: COUNTERMEASURES AGAINST WRONGFUL SANCTIONS 60-64 (2011).

326. *See* Jennifer M. Welsh, *The Security Council and Humanitarian Intervention*, *in* THE UNITED NATIONS SECURITY COUNCIL AND WAR: THE EVOLUTION OF THOUGHT AND PRACTICE SINCE 1945 535 (Vaughn Lowe, Adam Roberts, Jennifer Welsh & Dominik Zaum eds., 2008).

327. Tronchetti, *supra* note 12, at 1034.

328. Milena Costas Trascasas, *Access to the Territory of a Disaster-Affected State*, *in* INTERNATIONAL DISASTER RESPONSE LAW 221, at 239-40 (Andrea de Guttry, Marco Gestri & Gabriella Venturini eds., 2012); Scott Sheeran & Catherine Bevilacqua, *The UN Security Council and International Human Rights Obligations: Towards a Theory of Constraints and Derogation*, *in* ROUTLEDGE HANDBOOK OF INTERNATIONAL HUMAN RIGHTS LAW 371, 399 (Scott Sheeran & Nigel Rodley eds., 2013).

329. The Security Council has grappled with the security implications of climate change for over decade, since first debating the issue in April 2007 (U.N. SCOR, 62nd Sess., 5663rd mtg., U.N. Doc. S/PV. 5663 (Apr. 17, 2007)): for example, it recently recognized "the adverse effects of climate change and ecological changes on the stability of the [Lake Chad Basin] Region" (UNSC Res 612349, U.N. Doc. S/RES/2349, ¶ 26 (Mar. 31, 2017)). However, the Council has stopped short of identifying climate change as a "threat to the peace" in the sense of Article 39. *See* Trudy Fraser, *From Environmental Governance to Environmental Legislation: The Case of Climate Change at the Security Council*, in THE SECURITY COUNCIL AS GLOBAL LEGISLATOR 225 (Vesselin Popovski & Trudy Fraser eds., 2014) (in general, but particularly 229–35); Vaughn Lowe, Adam Roberts, Jennifer Welsh & Dominik Zaum, *Introduction*, *in* THE UNITED NATIONS SECURITY COUNCIL AND WAR: THE

not or would not identify NEO impact as a threat to the peace. Were it to do so though, this would go beyond what it has commonly considered to amount to such a triggering threat in comparable contexts, which may at least cast doubt on the potential for it to act.

Further, even assuming that a determination was made by the Security Council that an incoming NEO indeed represented a "threat to the peace," questions would remain as to whether the Council then could authorize a nuclear explosion in outer space in response. Article 103 of the UN Charter famously is explicit that obligations under the Charter prevail over "any other international agreement,"[330] whereas Article 25 of the Charter stipulates that member states are required to implement the binding decisions of the Security Council.[331] It often is said that the combination of Articles 103 and 25 means that where Council-mandated actions conflict with obligations in other treaties, the illegality of the breach of those obligations is excused.[332] The Council, therefore, *prima facie* could authorize action that otherwise would violate, say, the LTBT.

Yet, the Council cannot authorize states to violate any norm of international law that it wishes.[333] It is widely agreed, for example, that it cannot act or authorize states to act in a manner that would be contrary to norms that have acquired the status of *jus cogens*.[334] Some commentators have suggested that OST Article IV[335] may have acquired this character, while others at least have implied that the ban in LTBT Article I(1) may be

EVOLUTION OF THOUGHT AND PRACTICE SINCE 1945 1, 35 (Vaughn Lowe, Adam Roberts, Jennifer Welsh & Dominik Zaum eds., 2008).

330. U.N. Charter, *supra* note 282, art. 103.

331. *Id.* art. 25.

332. *See* Vera Gowland-Debbas, *Responsibility and the United Nations Charter*, *in* THE LAW OF INTERNATIONAL RESPONSIBILITY 115, 130-31 (James Crawford, Alain Pellet, Simon Olleson & Kate Parlett eds., 2010); Gabriël H. Oosthuizen, *Playing the Devil's Advocate: the United Nations Security Council is Unbound by Law*, 12 LEIDEN J. INT'L L. 549, 555-58 (1999). *See also* U.N. Doc. A/56/10, *supra* note 273, at 365, art. 59.

333. *See, generally*, Jared Schott, *Chapter VII as Exception: Security Council Action and the Regulative Ideal of Emergency*, 6 NW. J. INT'L HUM. RTS. 24 (2008).

334. SUFYAN DROUBI, RESISTING UNITED NATIONS SECURITY COUNCIL RESOLUTIONS 34-38 (2014); TZANAKOPOULOS, *supra* note 325, at 70-72; DE WET, *supra* note 321, at 187-91; Dapo Akande, *The International Court of Justice and the Security Council: Is There Room for Judicial Control of Decisions of the Political Organs of the United Nations?*, 46 INT. & COMP. L. Q. 309, 322-23 (1997).

335. *See, e.g.*, RUWANTISSA ABEYRATNE, SPACE SECURITY LAW 57 (2011); G. S. Sachdeva, *Select Tenets of Space Law as* Jus Cogens, *in* RECENT DEVELOPMENTS IN SPACE LAW: OPPORTUNITIES & CHALLENGES 7, 26 (R. Venkata Rao, V. Gopalakrishnan & Kumar Abhijeet eds., 2017); Yevgeniya Oralova, Jus Cogens *Norms in International Space Law*, 6 MEDITERRANEAN J. SO. SCI. 2015 421, 423 (2015).

peremptory.[336] Despite their undeniably crucial importance, however, neither OST Article IV nor LTBT I(1) can be considered to constitute a *jus cogens* norm: there simply has not been sufficient recognition and acceptance of these rules as having such status by the international community of states.[337]

Nonetheless, even when it comes to the large corpus of non-peremptory *jus dispositivum*, the Security Council does not have unlimited power to deviate from existing legal requirements.[338] The Council must, as a *minimum*, act in accordance with the purposes and principles of the UN, as per Article 24(2) of the Charter.[339] It cannot authorize violations of human rights[340] or international humanitarian law (IHL)[341] standards, for example, not least because both human rights and humanitarianism represent key purposes of the organization.[342] The UN's purposes also include the maintenance of international peace and security, of course,[343] and even a limited, non-aggressive use of nuclear weapons in space still would have significant implications for the maintenance of international

336. *See* Tabassi, *supra* note 243, at 347-50 (not explicitly stating that LTBT art. I(1) is peremptory, but arguing that an even more comprehensive prohibition, reflecting that found in the CTBT, may now be *jus cogens*, which surely would include the more limited obligation in the LTBT); Adam Steinfeld, *Nuclear Objections: The Persistent Objector and the Legality of the Use of Nuclear Weapons*, 62 BROOK. L. REV. 1635, 1640, 1680-85 (1996) (also not explicitly stating that the LTBT art. I(1) is *jus cogens*, but arguing that the general corpus of the nuclear non-proliferation regime—built on wider rules of IHL, human rights and environemntal law—*is* peremptory, which, again, presumably would include the LTBT prohibition).

337. *See* GREEN, *supra* note 247, at 217 (rejecting the assertions of Tabassi, *supra* note 243, and Steinfeld, *supra* note 336 in this regard); Camilla G. Guldahl, *The Role of Persistent Objection in International Humanitarian Law*, 77 NORD. J. INT'L L. 51, 84 (2008) (arguing that the claims of Steinfeld, *supra* note 336 as to peremptory status are "untenable"); Michel Bourbonnière & Ricky J. Lee, *Legality of the Deployment of Conventional Weapons in Earth Orbit: Balancing Space Law and the Law of Armed Conflict*, 18 EUR. J. INT'L L. 873, 879-80, 897 (2008) (expressing doubt as to the peremptory status of OST art. IV, albeit not entirely ruling this out).

338. *See* TZANAKOPOULOS, *supra* note 325, at 72–84.

339. U.N. Charter, *supra* note 282, art. 24(2). *See* DE WET, *supra* note 321, at 191-215.

340. TZANAKOPOULOS, *supra* note 325, at 79-81; David Leary, *Balancing Liberty and the Security Council: Judicial Responses to the Conflict between Chapter VII Resolutions and Human Rights Law under the Council's Targeted Sanctions Regime*, *in* ADJUDICATING INTERNATIONAL HUMAN RIGHTS: ESSAYS IN HONOUR OF SANDY GHANDHI 69 (James A. Green & Christopher P.M. Waters eds., 2015) (although arguing that this fact has not necessarily stopped the Council potentially encroaching on human rights standards); Akande, *supra* note 334, at 323-25.

341. Akande, *supra* note 334, at 320.

342. U.N. Charter, *supra* note 282, art. 1(1).

343. *Id*.

peace and security. This fact might suggest that the Council would—if it were to authorize a nuclear NEO response—be acting in a manner that could violate its Article 24(2) obligation.

In the particular context of nuclear planetary defense though, where peace and security potentially are threatened both by the incoming peril and the proposed remedy, so long as the NEO threat was verified and genuine, a reasonable counterargument could be made. The Council probably would not be precluded from authorizing nuclear planetary defense if it saw this as the only appropriate, proportional[344] means of avoiding catastrophic harm. It surely then would need to authorize nuclear interception explicitly and unequivocally, and only as a "one off" act. Any authorization that was more open-ended than that would run the risk of the Council acting beyond (and perhaps even contrary to) its mandate.

Overall, a case can be made that the Security Council would possess a (restricted) power to authorize a nuclear NEO response, albeit that uncertainty would remain until this were ever tested. A further concern, however, beyond the legal power of the Council in this regard, would be political likelihood of it being able to act. All it would take was one of the five permanent members to view assertions as to the need for a nuclear response to avert a purported NEO impact as a pretext for nuclear aggression in space, and its inevitable veto would mean that the Council would be unable to authorize the action in any event. This hardly seems an unrealistic scenario,[345] especially given that the state or states that were seeking to launch a nuclear interception mission almost certainly would insist on retaining control over the weapons concerned, rather than, say, ceding them to UN operational control.[346]

E. Necessity

The concept of necessity in international law stretches back centuries,[347] but its modern existence under customary international law[348] is set out in Article 25 of the ILC's Draft Articles on State Responsibility.[349] As per Article 25, necessity can preclude the

344. *See, generally*, TZANAKOPOULOS, *supra* note 325, at 64-67.

345. *Contra* Tronchetti, *supra* note 12, at 1034 (arguing that it would be unlikely that the veto would be used in relation to NEO response actions).

346. Koplow, *supra* note 17, at 305.

347. *See* DIANE A. DESIERTO, NECESSITY AND NATIONAL EMERGENCY CLAUSES: SOVEREIGNTY IN MODERN TREATY INTERPRETATION 63-121 (2012).

348. *See* Gabčíkovo–Nagymaros Project (Hungary/Slovakia), Judgment, 1997 I.C.J. 7, ¶ 51 (Sept. 25); 2004 I.C.J. 135, *supra* note 312, ¶ 140.

349. U.N. Doc. A/56/10, *supra* note 273, 194, art. 25.

wrongfulness of an act in breach of international law if that act is "the only way for the State to safeguard an essential interest against a grave and imminent peril; and . . . [d]oes not seriously impair an essential interest" of other states or the wider international community.[350]

Applying these requirements to the nuclear NEO response scenario,[351] the impact of a large NEO on the surface of Earth would have the potential to threaten the existence of at least one state. It would be reasonable to conclude that acting to avert such an impact would qualify as the safeguarding of an "essential interest."[352] Further, when it comes to necessity, the "essential interests" of a state are not limited merely to threats to its very existence.[353] Thus, the avoidance of a smaller-scale, but still catastrophic, NEO collision could also qualify.[354]

Whether the impending impact would amount to a "grave" peril would depend on the circumstances.[355] There would need to be a high degree of certainty that the impact would occur, of course, and that the consequences of that impact would be significantly harmful (which would depend on factors including the size, composition, trajectory, and speed of the NEO in question).[356] The fact that an act justified by necessity must be "the only way" for the state to protect against the relevant "peril"[357] also would mean that there would need to be a relatively high degree of certainty that a nuclear explosion would be the only effective method of diverting the NEO (or, at least, that it be very clear that this represented the best chance of so

350. *Id. See also* Gabčíkovo–Nagymaros, *supra* note 348, ¶ 52 ("these conditions reflect customary international law").

351. The possible application of necessity to nuclear NEO response has been almost entirely overlooked in the previous literature, although *see* Su, *Control Over Activities Harmful to the Environment*, *supra* note 12, at 85; Su, *Measures Proposed for Planetary Defence*, *supra* note 12, at 3.

352. *Id.* at 3.

353. Roberto Ago, *Eighth Report on State Responsibility by the Special Rapporteur – The Internationally Wrongful Act of the State, Source of International Responsibility (Part 1)*, U.N. Doc. A/CN.4/318/Add.5-7, 14, 19 (1980); Roman Boedt, *State of Necessity as a Justification for Internationally Wrongful Conduct*, 3 YALE HUM. RTS. & DEV. L.J. 1, 15 (2000); Sarah Heathcote, *Circumstances Precluding Wrongfulness in the ILC Articles on State Responsibility: Necessity*, *in* THE LAW OF INTERNATIONAL RESPONSIBILITY 491, 496 (James Crawford, Alain Pellet & Simon Olleson eds., 2010).

354. Su, *Measures Proposed for Planetary Defence*, *supra* note 12, at 3.

355. *Id.* at 3; Boedt, *supra* note 353, at 28.

356. Su, *Measures Proposed for Planetary Defence*, *supra* note 12, at 3.

357. U.N. Doc. A/56/10, *supra* note 273, at 194, art. 25; 2004 I.C.J. 135, *supra* note 312, ¶ 140.

doing).[358] Further, the need for the peril to be actual and not merely envisioned[359] likely would mean that preparatory actions taken before a collision-course NEO was identified—such as pre-emptively stationing nuclear weapons "off-world" or testing a nuclear NEO response—could not be legally excused by a plea of necessity.

The application of necessity also would require that the act was undertaken to avert "imminent" peril.[360] As discussed in the context of the right of self-defense,[361] while some experts have argued that it may be possible to implement nuclear planetary defense in a matter of days, it may well require more lead-time, and, nonetheless, it would be desirable for any interception mission to be launched as soon as was possible. This means that NEO response might not sit comfortably with the notion of imminence. In the context of necessity, however, the ICJ has made it clear that "a 'peril' appearing in the long term might be held to be 'imminent' as soon as it is established . . . that the realization of that peril, however far off it may be, is not hereby any less certain and inevitable."[362] Thus, in principle, an NEO that was months or even years away from Earth still may be considered to represent an "imminent" peril for the purposes of a necessity defense, again depending on the degree of scientific confidence in the occurrence of an impact and its injurious implications.

Finally, the act must not seriously impair an essential interest of other states for its illegality to be precluded by the necessity justification.[363] At least in relation to a genuine act of planetary defense, a case could be made that the diversion of an NEO may in fact do the opposite: protecting not just the state acting, but others too.[364]

Necessity is treated as an exceptional condition precluding wrongfulness, subject to strictly applied requirements to protect against abuse.[365] However, its restrictive features would seem entirely appropriate in the nuclear planetary defense context. The nuclear option, if entertained at all, should be reserved only for extreme cases where high degrees of certainty exist about the occurrence of significant harm and the lack of viable non-nuclear alternatives for averting it. The limitations that necessity

358. U.N. Doc. A/56/10, *supra* note 273, at 203 ("a measure of uncertainty about the future does not necessarily disqualify the state from invoking necessity …"). *See also* Heathcote, *supra* note 353, at 498.

359. *Id.* at 497-98; Gabčíkovo–Nagymaros, *supra* note 348, ¶ 54.

360. U.N. Doc. A/56/10, *supra* note 273, at 194, art. 25.

361. *See supra* notes 302-310 and accompanying text.

362. Gabčíkovo–Nagymaros, *supra* note 348, ¶ 54.

363. U.N. Doc. A/56/10, *supra* note 273, 194, art. 25.

364. Su, *Measures Proposed for Planetary Defence*, *supra* note 12, at 3.

365. U.N. Doc. A/56/10, *supra* note 273, at 195, 202; Gabčíkovo–Nagymaros, *supra* note 348, ¶ 51.

would place on abstract, preparatory measures and testing would be desirable too, in light of the risks of aggressive repurposing. Necessity would only justify a use of nuclear weapons as a last resort where the NEO threat was verified, grave, and contextually imminent: it thus represents an appealing possible option for precluding wrongfulness.

Despite its increased acceptance in modern international law, however, the defense of necessity is not uncontroversial, and issues have persisted about its scope and application in particular cases,[366] as have fears about its potential abuse.[367] Employing it to allow for *the use of nuclear weapons in space* may run into significant political opposition. This is especially likely given the inherently unilateral nature of a necessity defense. While the ICJ has been very clear that necessity claims must be subject to external objective evaluation,[368] the invocation of necessity by a state or small group states, would, as with treaty withdrawal or self-defense, stem from the "defenders" alone. As with the other defenses explored in this section, necessity still would amount to an uncertain, reactive, and *ad hoc* legal response.

VIII. A TENTATIVE PROPOSAL FOR LEGAL PREPAREDNESS

Where does all this leave us? On the one hand, a majority of scientific experts indicate that in certain circumstances the use of a nuclear explosive device may be humanity's best, or only, means of averting a catastrophe resulting from a large NEO impacting on Earth's surface.[369] On the other hand, it has been argued in this article that while significant uncertainties remain, it would appear to be the case that a nuclear NEO response, if ever required, would be prohibited by existing treaty law.[370]

One simply might take the view that this state of affairs is desirable. The inherent (security, environmental) risks of adopting a nuclear approach for planetary defense, coupled with the notably low risk of significant NEO impact occurring any time soon, may lead us to conclude that the game is

366. *See, e.g.*, Case concerning the difference between New Zealand and France concerning the interpretation or application of two agreements, concluded on 9 July 1986 between the two States and which related to the problems arising from the Rainbow Warrior Affair, Award, 1990 R.I.A.A., vol. XX, 215, ¶78 (Apr. 30); Marie Christine Hoelck Thjoernelund, *State of Necessity as an Exemption from State Responsibility for Investments*, 13 MAX PLANCK YRBK U.N. L. 423, 443-49 (2009).

367. *See generally* Robert D. Sloane, *On the Use and Abuse of Necessity in the Law of State Responsibility*, 106 AM. J. INT'L L. 447 (2012).

368. Gabčíkovo–Nagymaros, *supra* note 348, ¶¶ 51, 54.

369. *See* discussion *supra* Section II.

370. *See* discussion *supra* Section V.

not worth the candle. If anything, one might argue from this perspective that the legal uncertainties as to the application of the apparent prohibitions in the OST, LTBT, and (perhaps, indirectly) CTBT to NEO responses should be clarified so that nuclear planetary defense unquestionably would be unlawful. This may be something of a "head in the sand" approach when it comes to NEO threats in themselves, but in the wider context it would be a perfectly reasonable one.

If one accepts that a nuclear response may be desirable as a last resort, however, another option would be to turn to existing legal mechanisms to preclude its *prima facie* unlawfulness, as were explored in section VI. Despite the widespread scholarly support for it, the right of self-defense almost certainly would be inapplicable here,[371] but a state may be able to preclude the wrongfulness of a nuclear NEO mission that it was undertaking if it withdrew from the relevant treaties,[372] or, preferably, invoked the defense of necessity.[373] These options are legally plausible but not unproblematic, particularly as both would constitute unilateral legal shields for planetary defense.

This author takes the view that it would be significantly preferable for any NEO response effort (and thus any legal approach that might seek to restrict or validate it) to be cooperative and multilateral in nature. A collision-course NEO likely would threaten the essential security interests of many, if not all, states.[374] As with all global environmental concerns, multilateral, cooperative strategies would seem to be the most appropriate approach to mitigating that threat,[375] allowing for the sharing of expertise and especially resources/cost.[376] All states inherently have a "stake" in NEO risk, meaning that one even can argue that, as a matter of social justice, they all possess a corresponding entitlement to at least some form of engagement with (or input into) any response initiative.[377] A multilateral approach to *nuclear* responses in particular also would be crucial not just because of the shared nature of NEO impact risk, but also the risks associated with nuclear weapons. If humanity is willing to entertain the possibility of using nuclear weapons in this manner, a transparent,

371. *See* discussion *supra* Section VI.*C*.
372. *See* discussion *supra* Section VI.*A*.
373. *See* discussion *supra* Section VI.*E*.
374. Seamone, *The Precautionary Principle*, *supra* note 8, at 4; Brooks, *supra* note 12, at 242, 252; Koplow, *supra* note 17, at 284.
375. Fasan, *supra* note 11, at 2346.
376. Seamone, *Wishing on a Star*, *supra* note 8, at 4.
377. Tronchetti, *supra* note 12, at 1040.

multilateral decision-making framework,[378] incorporating sufficient safeguards,[379] surely would be important to try to protect against abuse.[380]

Resorting to the UN Security Council's Chapter VII powers thus may seem more desirable than withdrawal or necessity, as this would entail at least a degree of communal decision-making and multilateralism.[381] However, as discussed,[382] there exist uncertainties as to the scope of the Council's legal power to sanction nuclear planetary defense, and the sin of inaction in the face of human disaster has remained a common element of the Council's practice despite post-Cold War optimism.[383] Perhaps the most preferable option amongst those explored in section VI would therefore be the temporary suspension of the relevant treaties through the agreement of the parties.[384] This would constitute a response that could truly, if a little reductively, be said to come from "humanity." Desirable as that might be, however, whether the required universal agreement for suspension would be realistically achievable remains another matter.

The existing legal restrictions of the OST and LTBT were not designed to apply to NEO impact scenarios, but with other Cold War concerns in mind.[385] The same is true for much newer (not binding, or at least not directly binding) provisions of the CTBT, TPNW, and PPWT, in that they too were developed without considering their implications for planetary defense. Both the relevant prohibitions (whether hard or soft) and the possible defenses to them discussed in this article inherently are focused on inter-state rather than collective planetary security, and therefore arguably are not fit for purpose in the NEO context.[386]

As such, one might look beyond the current law and its myriad of uncertainties. This article ultimately takes the view that the most desirable option of all would be to carve out a bespoke legal exception to the existing prohibitions. It is proposed that this should be restricted to "on-world" missions only, in cases where a large collision-course NEO *was identified and verified* (never before), and where the balance of independent scientific

378. Gerrard & Barber, *supra* note 12, at 20, 39.

379. *Id.* at 19.

380. Sweet, *supra* note 12, at 228.

381. *supra* notes 318-319 and accompanying text; *see also supra* notes 374-380 and accompanying text.

382. *See* discussion *supra* Section VI.*D*.

383. *See, generally*, SABINE HASSLER, REFORMING THE UN SECURITY COUNCIL MEMBERSHIP: THE ILLUSION OF REPRESENTATIVENESS 22-28 (2013).

384. *See* discussion *supra* Section VI.*B*.

385. Gerrard & Barber, *supra* note 12, at 39; Brooks, *supra* note 12, at 246; Tronchetti, *supra* note 12, at 1029.

386. Su, *Measures Proposed for Planetary Defence*, *supra* note 12, at 4.

option clearly supported a nuclear response. The testing of the "nuclear option" and resort to pre-emptive measures such as stationing nuclear weapons in space *just in case* an NEO appears would remain prohibited.[387] Such restrictions to the proposed "exception" may decrease the chances of a response action being successful if the threat manifests, but the costs of allowing for testing and "off-world" preparatory nuclear measures (the need for which being scientifically disputed)[388] simply are too high in the abstract.

A bespoke and limited exception for an "on-world, actual peril" response would come with its own set of concerns, such as who would determine when it was triggered, who would action it (e.g., what if both the U.S. and Russia insisted on launching independent interception missions?), and who would oversee the resulting mission and assess its conformity with this legal exception.[389] To promote certainty, protect against abuse and increase the chances of success through the pooling of expertise and resources, it therefore would be desirable for a legal multilateral decision-making and oversight framework to be created.[390] Ideally, this would amount to a bespoke body composed of all states (or as many states as possible), which also included direct input from independently appointed scientific experts/organizations.

As this article proposes, situating NEO response decision-making in a body composed of most (or all) states is concerning because this could have the potential terminally to slow down or block a response once an NEO has been identified.[391] The "deadlock" problem inherent in turning to the Security Council or attempting to gain universal consent for treaty suspension would not disappear, but would be transferred to the proposed new decision-making and over-sight body.

The difference, however, is that debate in the Security Council, or attempts to gain universal consent for treaty suspension, only would begin once we knew an NEO was on the way: the clock would already be ticking.

387. Koplow, *supra* note 17, at 306 (similarly suggesting that an unequivocal renouncement by the nuclear powers of the possibility of nuclear weapons being pre-emptively stationed "off-world" for NEO response purposes may alleviate fears that other states may harbor and increase the likelihood of agreement over "on-world" nuclear options).

388. *See supra* notes 83-84 and accompanying text.

389. *See* Seamone, *The Precautionary Principle*, *supra* note 8, at 8-9; Seamone, *The Duty to "Expect the Unexpected"*, *supra* note 8, at 787; Brooks, *supra* note 12, at 248; Koplow, *supra* note 17, at 305.

390. *See* Su, *Measures Proposed for Planetary Defence*, *supra* note 12, at 4; Sweet, *supra* note 12, at 229; Fasan, *supra* note 11, at 2352 (all suggesting that some form of supranational body may be desirable, without giving much more detail).

391. *See supra* note 280 and accompanying text.

A whole host of questions would exist as to what criteria should be applied in assessing whether to sanction a nuclear response. Whereas, while the exception proposed by this author would not allow for nuclear planetary defense actions *to be taken* in the abstract, the process of *the creation of* that exception (and its oversight body) could begin now, at a point where no time pressures exist. Explicit criteria thus could be developed to clarify that only an "on-world" approach would be permissible, in circumstances where a qualified majority of appointed independent NEO experts *and* a qualified majority of state members approved it (mitigating the "universal problem" that would exist for treaty suspension), as well as setting out appropriate requirements of proportionality, temporariness, transparency through reporting/oversight, and so on.

All this would require either treaty amendment[392] (especially to the LTBT, given that if the exception were limited to "on-world" approaches it would not in fact engage the OST), or, at least, the development of an additional protocol. Alternatively, a bespoke new treaty setting out a carefully restricted nuclear NEO response exception could be drafted.[393] State agreement for the implementation of any of these legal measures (whether treaty amendment, additional protocols, or an entirely new treaty) would—even in a best-case scenario—require extensive negotiation, and may ultimately be impossible to achieve. However, recent developments at the UN, such as the creation of SMPAG and IWAN,[394] indicate that states increasingly are viewing a cooperative approach to NEO response as desirable,[395] as do other current inter-state initiatives such as the AIDA mission.[396] It is proposed that this spirit of cooperation be transferred to the legal level.

A balance must be struck between the threat of an unlikely but catastrophic NEO impact and the threat that nuclear weapons themselves pose. Any proposed approach to handling this "irresistible force/immovable object" problem at the heart of the nuclear planetary defense concept will never be entirely satisfactory, but it would seem prudent for the international community to explore options for best achieving this balance now, rather than having to try to do so with an asteroid on the way.

X. CONCLUSION

392. *See* Kunich, *supra* note 12, at 150; Brooks, *supra* note 12, at 234, 247, 251; Gerrard & Barber, *supra* note 12, at 49.

393. Tronchetti, *supra* note 12, at 1041; Gerrard & Barber, *supra* note 12, at 49.

394. For discussion of these bodies, see *supra* notes 69-72 and accompanying text.

395. Tronchetti, *supra* note 12, at 1030.

396. *See supra* notes 90-92 and accompanying text.

Catastrophic Near-Earth Object impact—especially on a regional level—represents a genuine threat to human good (potentially even survival), albeit a low probability threat. Developments over the last five years in politics, science and technology indicate that humanity is better placed than ever before to respond to a "killer asteroid" should one appear. Many experts and states now appear to support a nuclear approach to NEO response, at least in extreme circumstances. Yet any resort to nuclear weapons, of course, itself also represents a genuine threat to human good. This article has explored the question of nuclear planetary defense, and has particularly examined whether such an action would or could be undertaken in conformity with international law.

Despite the huge strides towards NEO preparedness recently witnessed at the political and scientific levels, at the legal level there still exists significant uncertainty. Were an incoming NEO requiring a nuclear response identified tomorrow, any state seeking to act would have to resort to contorted legal assessments of the LTBT, OST, and the various possible defenses to their breach, to be able to advance a claim that its interception mission was acceptable under existing international law.

Perhaps more likely, and more worryingly, would be for a state to assert, as it seems some already *have* in the abstract,[397] that the moral imperatives of planetary defense meant that any contradictory requirements of unclear, Cold War era international law simply should be ignored.[398] An extra-legal stance of that kind would have hugely damaging implications for the rule of law and integrity of the international legal system.[399] Such side-stepping of legal norms would also mean that the use of nuclear weapons in space against an NEO would be undertaken in a *de facto* lawless vacuum.

397. *See* Oliphant, *supra* note 111, at 115 (citing a statement made by the Central Scientific Research Institute of Machine Building, which forms part of Russia's federal space agency: "[i]f the asteroid threat becomes a matter of serious damage or even the very existence of life on Earth, [any legal] ban would naturally be lifted.").

398. Koplow, *supra* note 17, at 275 (suggesting that if a large collision-course NEO was identified, it is likely that humanity would act irrespective of the requirements of international law). *See also*, YEOMANS, *supra* note 3, at 146; Pop, *supra* note 12, at 677; Bucknam & Gold, *supra* note 80, at 152.

399. *See, e.g.*, Jeremy Waldron, *The Rule of International Law*, 30 HARV. J.L. & PUB. POL'Y 15 (2006) (in general, but especially at 26, arguing that the rule of law in the international legal context means that "[g]overnments are bound in the international arena, as in any arena, to show themselves devoted to the principle of legality in all of their dealings. They are not to think in terms of a sphere of executive discretion where they can act unconstrained and lawlessly.").

The international community should look to avoid this by taking steps towards legal preparedness. It has been proposed tentatively herein that it would be desirable for this to take the form of a limited, bespoke exception to the existing law and an associated multilateral decision-making and oversight body.[400] Whether this proposal itself is seen as the suitable or not, the crucial point is that steps towards legal preparedness should begin now, at a time when controversies and details can be debated, probed and hopefully resolved, free from the time pressure that would exist if a collision-course NEO ever was identified.

Any attempt at legal preparedness would be far from an easy or uncontroversial endeavor. Further research is needed to attempt to find the correct balance between protecting the planet from NEOs and protecting the planet from nuclear armaments. For good or ill, the political and scientific reality is that nuclear NEO response now exists as a genuine possibility. On the legal level, however, as things stand in relation to planetary defense, the maxim *fiat justitia ruat cælum* may apply too literally.[401]

400. *See* discussion *supra* Section VII.
401. Pop, *supra* note 12, at 677.