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The Decision to Act: Political, Legal, Social, and Economic Aspects

**Stressors on International Cooperation and Coordination in NEO Threat
Mitigation and Response**

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INTRODUCTION

Cataclysmic asteroid strikes have jeopardized life on Earth before, and will do so again. These naturally-occurring cosmic hazards are troublingly difficult for societies to collectively anticipate and plan responses for. This is perhaps because they are natural phenomena so devastating they seem beyond humanity's power to respond to effectively. Like other naturally-occurring disasters – whether earthquakes, volcanic eruptions, tornados, cyclones, tsunamis, droughts, or plagues – one might assume that humanity is simply helpless in the face of these threats. According to this way of thinking, we should just take our chances and suffer what we must: perhaps to perish, or perhaps to survive. Others believe that coordination and preparation against an asteroid or comet strike is possible – and even necessary – if we want our civilization to survive.

Planetary defense is the activity and actions to predict and mitigate a potential impact by an asteroid or comet on the Earth.¹ Beyond technical challenges of threat detection, prediction, and response, planetary defense against Near Earth Objects² (NEOs) involves intimidatingly large and uncertain social, cultural, and geopolitical challenges. Nevertheless, effective planetary

¹ SMPAG Terms of Reference, https://www.cosmos.esa.int/web/smpag/terms_of_reference_v2#_ftnref1

² A Near-Earth Object (NEO) is “an asteroid of periodic comet having an orbit that brings it within 1.3 astronomical units of the Sun.” Report of the Near-Earth Object Science Definition Team, *Update to Determine The Feasibility of Enhancing the Search and Characterization of NEOs*, September 2017, NASA.

defense requires that we rationally and thoroughly understand and address each element of a NEO threat, and the challenges to effective responses to it.

The idea of local, regional, or even global devastation from a natural (but rare and uncertain) phenomena, whether suffered collectively or individually by a state or group of states, obviously gives rise to social and political tensions, the possibility of slow and uncoordinated responses between actors, including national emergency planners, political leaders, legislative bodies, national space agencies, and national security and military structures. There is also the possibility of uncoordinated international responses. Geopolitically, the risks of misperceptions and miscommunications in NEO response forecast tensions between states.

OVERVIEW

This paper is an attempt to think through the security implications of planetary defense, including why governments and societies face challenges in planning and acting when the threat is real and an Earthstrike is likely and/or imminent. It will offer predictions on how governments and populaces might react to concrete NEO threats. It will then discuss actions and steps that decision makers could and should take action on now before a real, live, NEO threat is discovered.

The legal aspects of planetary defense have been discussed comprehensively and authoritatively elsewhere, including in the report of the Ad-Hoc Working Group on Legal Issues to SMPAG entitled *Planetary Defense: Legal Overview and Assessment*, as well as publications by scholars such as *Legal Aspects of Planetary Defense*, edited by Irmgard Marboe and published in 2021. However, international law and space law only provides a set of ‘guardrails’ for planetary defense, telling actors what behavior is lawful, what behavior is unlawful, compelling some actions, or forbidding other actions. But in concrete terms, in regards to planetary defense, as with other areas of space law, the law (such as it is) is quite modest. Armed with the knowledge of the *content* of the law, including its gaps and shortcomings, how can States take steps now to clarify their roles and responsibilities? Doing so would beneficially augment planetary defense activities – both in anticipation of a NEO threat, and upon the discovery of a real NEO threat. In distinct to legal aspects of planetary defense, there are political, cultural and even behavioral and mental aspects of planetary defense. This paper is a

discussion of the stressors, including time pressures and cognitive biases that will degrade effective planetary defense.

1 Anticipating Disasters

The threats posed by NEOs are sufficiently understood for planners to discuss and deliberate on their consequences, and take specific actions before a theoretical potential threat becomes a real threat.

The Torino scale categories NEO threats between 0 and 10, with 0 least severe and 10 most severe. Threats increase on the torino scale depending on their likelihood of occurring, the threat they pose, and the nearness in time posed by the threat. These elements (probability, severity, imminence) increase up the Torino scale, as do recommended planetary defense actions.

The various scenarios used in past planetary defense conferences, as well the 2023 PDC, involved NEO threats which emerge and develop over the course of the conference. While a variety of different NEO threat scenarios exist, one of the clearest divisions between these scenarios is between the worse scenarios, threatening imminent global and civilisational devastation, to which only last-chance ditch efforts using nuclear explosive divisions, and all those other scenarios which are either more remote in time (say, more than a few weeks or months away), or which threaten serious, but not global, civilisational, planet-wide destruction. As NEO surveys have not yet spotted any NEO threats greater than 1 kilometer in size, these largest NEO threat scenarios can be put aside by the present paper. It remains useful to discuss the NEO threat posed by smaller (but still massive) NEOs. *Figure 1* displays the Near Earth Asteroid Survey Progress by the end of 2017. The blue line depicts the percentage of Near-Earth Asteroids discovered by the end of 2017, and shows asteroid sized between 1 meter to 25 meters in the green zone on the left side of the graph; from 25 meters to 80 meters in the yellow zone (and threatening citywide devastation); from 80 meters to 400 meters in the orange zone (threatening regional devastation), from 400 meters to 1,600 meters in the pink zone (threatening continent wide devastation), and finally, from 1,600 meters (1.6 kilometers) to 20 kilometers in the red zone (threatening global devastation).

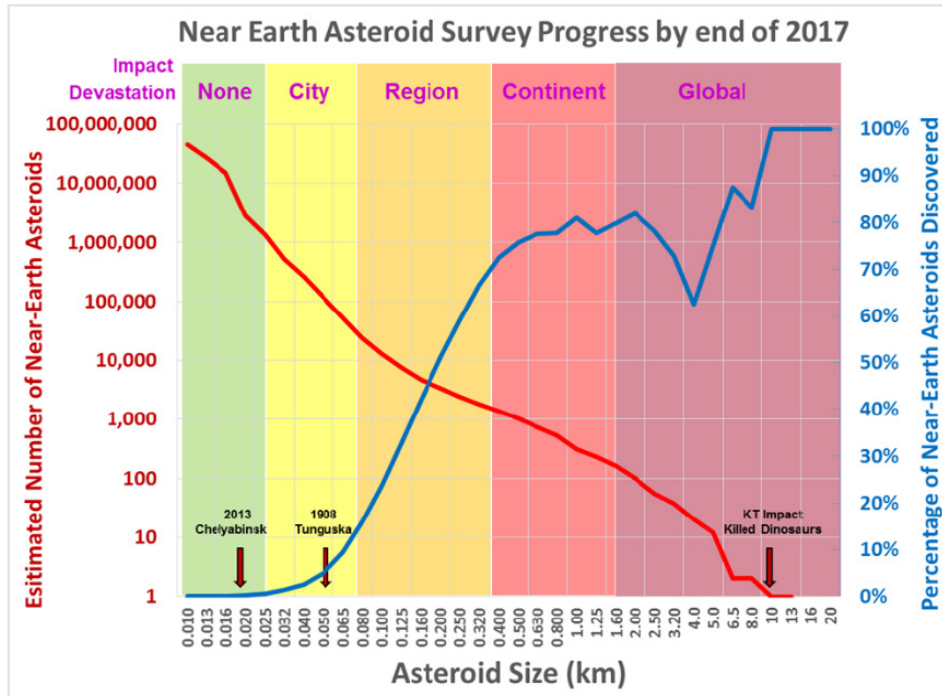


Figure 1 - Near-Earth Asteroid Survey Progress by end of 2017 (National Science Council/NASA PDCO).³

Looking at the percentages discovered, in descending order, we see that while 100% of NEOs in the predicted population 10 kilometers in size have already been discovered, the percentages drop off drastically the smaller in the asteroid size. For those asteroids in the yellow zone, and thus threatening citywide destruction, at most 10% of the predicted population of asteroids of this size has been discovered. For those in the orange zone, threatening regional destruction, the figure increases from around 10% of asteroids around 80 meters in size to 50% of those around 180 meters in size. While any of those numbers below 100% are worrying, the very low percentages of discovered asteroids threatening citywide, regional, or continent wide destruction illustrate that theoretical NEO threats may become real with further NEO threat detection. Until the blue line is at or near 100% across the entire graphic, there is every reason to be concerned, and to reflect on the fact that predicted threats may become real NEO threats.

Planetary defense activities, missions, and technologies will be different for NEO threats at the right side of the graph, or in truly imminent emergencies, than they will be on the left side

³ National Plan. For a 2018 update, see Planetary Defense Coordination Office, slide 12, https://science.nasa.gov/science-red/s3fs-public/atoms/files/LJohnson%20PDCO%20NEOO%20Brief%20to%20PAC%20Feb%202018_TAGGED_v2.pdf

of the graph. For NEO threats on the left side of the graph, the time element (immanence) will be a major discriminating factor in how actors respond. The majority of this paper will consider scenarios on the left side of the graph, where something less than continent-wide or global devastation is threatened. This is because the consequences of NEO threats on the further right side of the graph, with overwhelming immanence having the largest of NEOs, have different qualities that almost completely obviate the findings and recommendations for smaller and less imminent NEO threats. However, for all those NEOs which we, as a society, may hope to respond to, and to these threats which appear and threaten Earth-impact far enough into the future that some meaningful planetary defense actions can be mounted, it is well worth planning specifically for those contingencies.

Stressors on NEO Threat Decision-Making

There will be numerous stressors which will degrade the effectiveness and success of decision makers responding to a NEO threat. On the one hand, the science and technology assisting planetary defence will continue to advance. This means that the detection and characterization of potentially hazardous NEOs will continue to develop, and the catalogue of NEO objects will be continually refined, updated, and eventually near completion. NEO threat response, such as Earth-based and even space-based technologies for NEO redirect may also come online in the years to come, especially with the NASA DART mission and its successors. However, for the foreseeable future, these technological developments will not ease a number of stressors placed on planners and decision makers.

Public Perceptions

It is not inconceivable that many actors (the public, commentators, pundits, authorities, the media, etc.,) will react with conspiracy theories, spin, fear, “fake news”, propaganda, and blaming others. Misinformation and disinformation will likely run rampant. From a basic view, if your country is predicted to be the target of an asteroid strike while other countries will be missed, a human reaction along the lines that “surely, someone somewhere is responsible for this”, as well as the feeling that the devastation threatened is unfair, unfairly distributed, and undeserved are all understandable human reactions. Blaming others for their inaction, wrong

action, and even their malice might serve as a venting mechanism for those suffering but surviving a NEO strike.

In many ways, the COVID-19 global pandemic is an example of how populaces, national decision makers, intergovernmental organisations, and various institutions and authorities react and respond to uncertain and indiscriminate natural risks for which no entity is to blame.

Who is in Charge?

The first stressor that will degrade NEO response is organisational in nature, in that there will likely be no single authority or organisation which is clearly tasked with NEO response, either on a national or an international level. Some international coordination has already occurred on planetary defence but its effectiveness will be sorely tested in a real scenario.

Additional to this, there will also likely be no predetermined rubric for specific actions, with clear thresholds triggering specific responses. Married to this, when faced with a real and credible threat, there will likely be bureaucratic infighting between different agencies with different mandates and authorities. Absent a clear, pre-existing agency with a specific mandate, funding, and capability to respond to a NEO strike, there will certainly be time wasted in infighting, and in competency and jurisdictional feuds. This confusion will likely be polycentric, i.e., spanning international as well as a variety of national fora – including civil and military divides – and this could quickly lead to politically-charged differences in opinion on how to proceed, which will further waste time. Is space-based NEO redirect a task for civil space agencies, or for the military? If for the military, how to reassure the international community of the peaceful nature of these capabilities? Is just one national military sufficient, or will multiple militaries - including traditional adversaries - be required?

On the national level, can a government act as a coordinated whole, with a “one government” approach, or will there be battles over competency and jurisdiction to act. Can a single government mobilise its population, including potentially evacuating entire areas threatened by a potential NEO strike? Would laws have to be in place beforehand, akin to Marshall law, for governmental authorities to effectively evacuate entire cities, states, or regions? If the NEO strike is predicted to threaten multiple states, these become international questions with additional layers of complexity.

Additional to this is the question of recourse to nuclear explosive devices, which may be required if the NEO threat is so large, and/or so imminent, that no other NEO response would be adequate. With the clock ticking and perhaps little time for international coordination, can one nation launch a nuclear explosive device – a device substantially similar to a nuclear weapon – into space to destroy an incoming NEO? What nuclear power state would take this risk? Will there be time to reassure other nations, including other nuclear powers? Is such an action in contravention of international law, or does international law even directly regulate such a scenario?⁴

The Clock is Ticking

There will be time pressure to make decisions, which will further put pressure on potential actors to act. The NEO is getting closer to Earth, and effective NEO responses might become less effective if they are delayed. Some NEOs may be spotted years, even decades, before their closest approach or potential impact. Other NEOs may be spotted only months, weeks, days, or even hours before their impact. Planning for emergency NEO decision making will be negatively affected by this wide discrepancy, as a NEO threat of a few months may allow for different planning procedures than a NEO threat only days or hours away, and these different scenarios may likely require different protocols for response. Regardless, there is an inherent cognitive bias to take action, rather than refrain from acting.

Regardless of how soon the strike is, time will remain of the essence. However, this stress will be sharply contrasted to a desire to wait for more data and evidence to refine one's understanding and predictions of the NEO threat. In decision-making, this is known as the closing problem, where there is a desire to continue to amass and ingest further information and data before making a decision, lest an opportunity for a better-informed later decision is missed.

There is also something akin to the “fog of war” affecting decision makers, whereby information about the NEO is changing, and will likely continue to change, and there remains information about the NEO which will never be known but which might be crucial to a response, and the fact

⁴ See Koplou, David A., "Exoatmospheric Plowshares: Using a Nuclear Explosive Device for Planetary Defense Against an Incoming Asteroid" (2019). *Georgetown Law Faculty Publications and Other Works*. 2197. <https://scholarship.law.georgetown.edu/facpub/2197>

that different actors in a NEO response will be differently informed or likely have access to different data about the NEO threat.

The Perfect is the Enemy of the Good

In the early days of the COVID-19 pandemic, officials from the World Health Organization stressed that time was of the essence, preparedness was crucial, and that it is better to act and make mistakes than to fail to act. Dr. Michael Ryan of the WHO summarised his lessons in emergency preparedness as “act fast, and have no regrets”, “the greatest error is not to move” and “speed trumps perfection.”⁵ He also stated, in the context of emergency preparedness, “if you need to be right before you move, you will never win.” These pearls of wisdom apply to planetary defence.

The need to know with certainty the consequences of your actions can be paralysing. Henry Kissinger has written about the hazards faced by governmental decision makers, stressing that, despite imperfect knowledge (ala the “fog of war”), emergencies require that decisions must be made. Therefore, decisions must be taken based on imperfect knowledge. Adding further uncertainty, and time only runs in one direction, outcomes often cannot be strongly tied to particular decisions, and as each situation is unique, past experience only provides so much guidance.⁶

From the perspective of decision makers faced with a NEO threat, it will be wise to contemplate serious and catastrophic outcomes, take all actions possible to avoid those outcomes, and if and when the catastrophe is avoided, it is better to deal with the consequences of over-reacting than to face the consequences of insufficient action.

Conclusion

Having gone over the various challenges of planetary defence, including the immensity of the threat posed by NEOs and the stressors on taking effective decisions and actions to plan in

⁵ Michael Ryan (WHO Health Emergencies Programme) at daily press briefing on COVID 19 March 13th 2020, Available at: <https://youtu.be/AqRHH6e-y6I>

⁶ Niall Ferguson, HENRY KISSINGER –1923-1968: THE IDEALIST, pgs. 871-874, 872 “The key point for Kissinger was the uncertainty that must inevitably surround all strategic decisions.... Unlike the intellectual, the policy maker ‘is part of a historical process and is making irreversible decisions that becomes the factual basis for the next decision’.... Just as the policy maker can never know, once Option A has been selected, what would have happened had he chosen Option B, so the historian cannot know.”

advance or respond in a timely and effective manner, the following sections will go through a number of scenarios which might play out, and discuss their legal and political context and implications.

Scenario 1. After an Earthstrike

Some asteroids are only spotted after their closest approach to the Earth, speeding away on their lengthy orbits before returning Earthward again someday. Other times, meteorites are found here on Earth, the result of Earth strikes that went unspotted in the sky. In both cases, we did not see it coming. Perhaps a great many of the smaller asteroids go undetected as they burn up in the atmosphere or strike Earth without consequences important enough to notice. While the NEO objects catalogue maintained by the scientific community continues to grow, the strong possibility remains that an previously-unnoticed NEO might strike the Earth and cause some level of damage and destruction without advance warning.

A state suffering a significantly large impact, but without being able to verify that it was a naturally occurring event, might conceivably fall under the impression that it was being attacked. This might particularly be the case with an airburst, where the NEO strikes the atmosphere with such force that no piece of material is found on the ground, and no impact crater is created. The Tunguska event of 1908 is notable for its lack of impact crater, and only microscopic remains of the impactor itself, which is thought to have burned up somewhere between 15,000 and 30,000 feet in the air.⁷ Were such an event to happen today, under the right circumstance, it could be initially perceived as the use of a weapon. This would potentially be the case if the state suffering the damage lacked the knowhow to spot an incoming asteroid, or could otherwise confirm the naturally-occurring quality of the event. That state might not share, or trust, NEO data and conclusions by other states. Such a scenario could spiral into the injured state believing that it has been attacked. If other states were to subsequently seek to disprove this suspicion, other difficult questions may arise – such as why no warning was given to the injured state, or even asking why no action was taken.

⁷ Encyclopedia Britannica, *What Is Known (and Not Known) About the Tunguska Event*, <https://www.britannica.com/story/what-is-known-and-not-known-about-the-tunguska-event>

Scenario 2. They Don't See it Coming

The corollary to Scenario 1, where the injured state presumes that a NEO strike on its territory was actually an attack, there is a possible situation where a state or other entity performing NEO surveillance detects a hazardous NEO but does not disseminate that information, or warn the threatened state or states. Are there security implications of not warning?

Here, international law, including the principles of international space law as found in the UN treaties on outer space, inform a discussion on the legal context and consequences of this behaviour. The 1967 Outer Space Treaty is the most important source of norms applicable to the exploration and use of outer space, and if a duty to share NEO hazard information exists, its basis should be found in the Outer Space Treaty.⁸ Various articles of the treaty could be interpreted as encouraging the sharing of NEO hazard information, although there is no explicit wording anywhere in this treaty or any other of the UN treaties on space that explicitly create this obligation.

Article IX requires that states which are party to the treaty adhere to the principles of cooperation and mutual assistance in their exploration of outer space.

In the exploration and use of outer space, including the Moon and other celestial bodies, States Parties to the Treaty shall be guided by the principle of cooperation and mutual assistance and shall conduct all their activities in outer space, including the Moon and other celestial bodies, with due regard to the corresponding interests of all other States Parties to the Treaty. (emphasis mine)

Whether earth-based or space-based, telescopes and other NEO detecting instruments comprise “space exploration” as envisioned in the treaties. Consequently, a NEO-detecting state is obliged to observe these principles of cooperation and mutual assistance. However, information sharing about hazards from space is not specifically found in the text of this article.

Article IX also requires states to show due regard to the corresponding interest of all other states which are also party to the Outer Space Treaty. However, this obligation to show due regard is limited merely to their activities in outer space, rather than all of their space exploration activities

⁸ Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, opened for signature on 27 January 1967, entered into force on 10 October 1967. As of 2022, 111 countries are parties to the Outer Space Treaty (herein Outer Space Treaty).

– which may comprise earth-based space observation and exploration. It is therefore difficult to see this due regard obligation as a basis for a duty to warn other states about NEO threats.

Article XI of the Outer Space Treaty is also an information sharing obligation. It requires states to inform the UN Secretary-General, as well as the public and the international scientific community, of the nature, conduct and results of their activities in space.

In order to promote international cooperation in the peaceful exploration and use of outer space, **States Parties** to the Treaty **conducting activities in outer space**, including the Moon and other celestial bodies, **agree to inform** the Secretary-General of the United Nations as well as **the public and the international scientific community, to the greatest extent feasible and practicable, of the nature, conduct, locations and results of such activities**. On receiving the said information, the Secretary-General of the United Nations should be prepared to disseminate it immediately and effectively. (**emphasis mine**)

However, and like Article IX, this obligation is limited to those states “conducting activities in outer space” and is further restricted by the phrase that such information sharing is only required “to the greatest extent feasible and practicable”. Both limitations could arguably further restrict whether a state sees itself under a duty to inform.

International law also speaks about elementary considerations of humanity, and this might be the only source of law to find, or develop, a duty to warn others about potentially hazardous NEOs. A case before the International Court of Justice (ICJ) decided in 1949 that one of the states before them was under an obligation to inform foreign sea vessels about a minefield in its territorial waters, due to the “general and well-recognized principles” of elementary considerations of humanity.⁹

While the SMPAG Ad-hoc Working Group on Legal Issues discuss these principles as a potential basis for an obligation to warn of NEO threats,¹⁰ the extension of this principle to phenomena in space, rather than territorial waters, and to the threat of naturally-occurring threats rather than human-made threats, seems tentative and subjective. Other scholars agree, finding that, at

⁹ Corfu Channel, Judgement of April 9th, 1949: ICJ Reports 1949, p.4, p.22.

¹⁰ Ad-Hoc Working Group on Legal Issues to SMPAG, *Planetary Defense: Legal Overview and Assessment – Report by the Space Mission Planning Advisory Group (SMPAG) Ad-Hoc Working Group on Legal Issues to SMPAG*, 2020. (herein Ad-Hoc Working Group).

present, there is no formal international obligation placed upon states, or any other actor, to warn others about such threats.¹¹ There are at least a few instances of states providing warning to other states that an asteroid will enter that state's territory as a meteor, and hopefully this practice can become more frequent.¹²

The security implications of a lack of a duty to warn other states of NEO threats warn of tension and mistrust between states, perhaps akin to state's having other intelligence that could be of use to a state, but demurring from sharing that data and findings. Typically, intelligence data concerns human-related threats, such as intelligence regarding international terrorism. However, some intelligence and findings might be related to naturally-occurring threats.

Scenario 3. Taking the Hit

Additional to the above scenarios is a situation where a state discovers a NEO which threatens its own territory and/or people.

Both the SMPAG Ad-Hoc Legal Working group and scholars have discussed whether a State's duty to act exists, either to protect its own territory and citizens, or the territory and citizens of other states. Looking at sources of international law, including international space law, the SMPAG Ad-hoc working group found that a state has "a right and an obligation to try to protect its territory and its population, but there is no obligation under international law to assist other States in any particular way or to any particular agree."¹³ However, their analysis looked for inspiration to a host of general instruments, such as the UN Charter and various human rights covenants, including those which speak about a general responsibility to protect in the case of natural catastrophes. These seem plausible as a basis, but could and should certainly be clarified and strengthened.

It seems equally clear that there is no clear indication that a state must undertake planetary defence actions, whether planetary defence actions on Earth or in space – such as NEO redirection or other space-based measures. As mentioned above, some elementary considerations of humanity might be viewed as a source of law for the development in the future of some duty to undertaking planetary defence, but at present there appears to be no clear international

¹¹ Lyall & Larsen, *SPACE LAW – A TREATISE*, 258.

¹² Yeomans, pgs 177-178.

¹³ Ad-hoc Working Group, Page 3.

obligation to act either to protect your own state, or to protect other states, from hazardous NEOs.

On a national level, the situation seems different for states (including the US) which have space agencies legally tasked with planetary defence. National space agencies might be tasked with surveying for NEOs, predicting NEO strikes on the surface of the Earth, and even of developing means for space-based planetary defence measures. For these states, the obligation to act stems from national policies and plans, rather than any international commitment.

Common sense seems to dictate that one of the most basic functions of a state is to work toward the health and safety of its citizens, and to safeguard its territory and people from threats, including naturally occurring and even space-borne threats such as NEOs. That rationale seems to serve as the basis for national planetary defence programs and activities. It does not presently extend to other states and populations.

The security implications of deciding not to act are complex to forecast beforehand. Deciding not to take Earth-based NEO responses, such as warning the public and mobilising emergency response capabilities may also include the evacuation of large areas, perhaps entire states and regions. If the NEO impact is not predicted for many years or months, this may be feasible. However, accurate NEO Earthstrike predictions that far in advance may be currently impossible. Earthstrike ground predictions may not be refined enough until months or weeks in advance of the collision, so national planners might have to be able to act quickly. Public sentiment and compliance will be a major concern, and there would be significant negative sentiment if evacuation turns out to be unnecessary. Imagine the politician who orders a city to be evacuated, only for the NEO to miss. States with vast territories, and therefore exposed to greater NEO risks than smaller states, will obviously face different decision making situations than smaller states, or states with concentrated populations, or those on coasts.

Space-based planetary defence actions are a different matter than Earth-based responses, and states subject to NEO strikes without space-based response are likewise subject to different decision making than those with space-based NEO response capabilities. However, space-based response is currently rudimentary, and while there have been missions to asteroids, such as the Japanese Hayabusa and Hayabusa-2 mission, NASA's mission to Bennu, only the NASA DART

(Double Asteroid Redirect Test) shows development of actual space-based NEO threat mitigation response. DART is an attempt to impact the smaller asteroid Dimorphos, around its larger parent asteroid, Didymos, at 4 miles per second in late September 2022, to test the feasibility of kinetic-impactor response.¹⁴ Space-based NEO threat mitigation will be the linchpin of any successful future planetary defence capability.

Scenario 4. Playing the Hero

There are a number of technologies which can be used to respond to a NEO threat, including responses to imminent threats where impact is days or weeks away, and other responses that have longer timelines. Potential responses including kinetic impactors, gravity tractors, and (in the most imminent and severe threats) nuclear explosive devices.¹⁵

Regardless of whether a state is under a duty to act (as discussed above) there are security considerations for any state that, indeed, decides to act. The UN treaties on space, chiefly the 1967 Outer Space Treaty and the 1972 Liability Convention, provide some context here. Firstly, they make states internationally responsible (answerable) for their national space activities, whether those activities are conducted by national agencies or private actors. A subset of international responsibility is liability. Liability is a duty to pay compensation, or be otherwise answerable for damage for which you are responsible. Liability is not a finding that an actor has violated the law, it is merely a finding that one is financially answerable for damage that has occurred. In space law, damage occurring in space is under a fault-based regime, where the space object of one state causes damage to the space object of another state. In space-based NEO threat response, this likely will not happen, as there will likely only be one (1) human-made space object involved, and the asteroid is not considered a “space object” under the terms of the applicable legal instruments.

In turn, space law creates a regime of absolute liability for damage occurring on the surface of the Earth, caused by the space object of a launching state (or joint launching states). The legal standard of absolute liability does not require a showing of intent, or fault, but merely that the damage occurred as a causal consequence of the actions or inactions of a defendant. This regime

¹⁴ NASA, *DART*, <https://www.nasa.gov/planetarydefense/dart/dart-news> and *DART Team Confirms Orbit of Targeted Asteroid*, (29 Aug. 2022), <https://www.nasa.gov/feature/dart-team-confirms-orbit-of-targeted-asteroid>

¹⁵ National Research Council 2010. *Defending Planet Earth: Near-Earth-Object Surveys and Hazard Mitigation Strategies*. Washington, DC: The National Academies Press. <https://doi.org/10.17226/12842>

for absolute liability for space objects causing surface damage was created in contemplation of re-entering launching vehicles and spaceships, or perhaps parts of those artificial vehicles. It was not created in contemplation of NEO redirect missions which fail to achieve their intended results. As such, while the law points towards absolute liability for a NEO mission gone awry which causes damage, it is hard to consider such a rigid application of the law plausible in any real scenario. However, the Liability Convention is a victim-oriented regime, and a plain reading of the rules of this regime would seem to give an outcome whereby actors conducting NEO response missions which result in damage on the Earth are internationally liable as a result of those damages. This appears as a serious legal and political problem, which may result in actors rethinking NEO response missions in light of their legal exposure to liability.

Regardless of the space law context and consequences, the security implication of NEO redirect missions requires consideration. Should a state take it upon themselves to redirect an incoming NEO, they should do so with a maximum understanding that their best efforts, likely being better than no efforts at all, should be seen by other actors in the most hopeful and needed light possible. A NEO threatening widespread destruction, for which a state responds to, should create conditions where the best efforts by that state are respected. To hold otherwise might disable a state from even attempting to redirect or mitigate the NEO threat. It does not seem workable to expose a state conducting planetary defence to liability should their mission fail. Absent actual negligence or malice, planetary defence missions can be seen as a service to the global community, a global public good, for which all benefit even though only some contribute. Those who contribute to such a planetary defence mission should not have to be unduly delayed by the spectre of absolute liability should their mission fail, in whole or in part. Legal and policy work to clarify these issues and foster, rather than suppress, NEO activities is needed.

Conclusion: Planetary Defence Planning Priority Items

This article has attempted to lay out both the reality of NEO threats, policy and law contexts for NEO threat response, and some of the security implications that can be discerned with some minimum out of clarity in these hypothetical situations with vague legal and normative guidance.

Having surveyed a few potential scenarios and looked at the applicable laws, it appears that at present, there is no formal international obligation placed upon states, or any other actor, to

either track NEO threats, or to warn others about such threats, or to act to prevent or mitigate the effects of the threats posed by NEOs. Furthermore, the legal regime governing space-based planetary defence missions seems ill-suited to foster such potentially crucial activities. However, amidst this legal background that is murky at best, and which provides uncertain normative guidance, states will have to take decisions in light of imminent NEO threats, and planetary defence presents uncertain and unsettling security challenges.

Taking the advice of emergency planners in other domains, there is work to be done in preparedness and planning in advance of the day when an actual NEO threat becomes real. The stressors placed upon decision making, including the need to take decisions sooner rather than later, and the conflicting pressure to wait for ever-more refined data and projections, threaten to degrade the decision maker's effectiveness. Communication with the public, as well as public trust, will play a significant role in a variety of terrestrial responses to a NEO threat.

When the day arrives that a NEO threat demands positive and coordinated action, we will be better situated to respond to it if we have accomplished everything we can do beforehand to be prepared. This involves a number of security-related policy and legal steps that can be taken now.

Fund Planetary Defence

Planetary defence deserves to be considered a public service, akin to meteorology or emergency preparedness. As such, it is not planetary science similar to the other planetary science activities, and budgets for planetary sciences should be used for planetary defence activities, including NEO observation and characterization activities.

Make the Duty to Warn a Clear and Explicit Duty

First among these is making the duty to warn others about hazardous NEOs a clear, explicit obligation in international and national law. Rather than the vague duty that exists now, which requires subjective determination, and may be resisted, a clear and explicit duty to warn can be agreed upon, based on the more vague obligations found in Articles IX and XI of the Outer Space Treaty, as well as other general principles of international law.

Clarify the Duty to Protect

Clarifying that a state which possesses planetary defence capabilities must engage in planetary defence activities would be a step in the right direction. It seems clear that a state must act to protect its own citizens, but this can be made explicit on the national level through the creation of planetary defence policy and legislation.

Regarding other states, the duty to protect others with your own planetary defence capabilities seems more nebulous. Such a duty can and should be clarified. One way to assist this clarification would be to make it clear that states undertaking planetary defence are given deference, and that their valiant efforts would not expose them to the liability provisions of international space law.

Clarify Rights and the Legality of NEO Response Measures

A variety of space-based planetary defence capabilities have been posited, including gravity-tractors, kinetic impactors, and even nuclear explosive devices. The utility of these measures should vary with the NEO threat scenario, with some better suited for scenarios with longer lead times, and others to be held as “last ditch” “hail mary” efforts. Regardless of technology or method used, a state undertaking the planetary defence measure should not be dissuaded or have their efforts curbed by an exposure of liability provisions.

There also is the question of the legality of nuclear explosive devices, and whether they are violative of arms control provisions, including the prohibition on the placement of nuclear weapons or other weapons of mass destruction into space, one of the foundational pillars of the Outer Space Treaty.¹⁶ Clarifying that these devices, intended to save humanity but which appear technologically very similar to nuclear weapons (such as would be used in an international armed conflict, the legality of even this is disputed) is a task that can be accomplished long before we should ever have to use such a device. The security implications of these devices, and the mere mention of nuclear weapons or technology similar to them, has extreme security implications, which is why the lawfulness of their use, only in the most extreme cases, should be rationally discussed and planned for beforehand.

¹⁶ See Koplow; See also Ad-Hoc Working Group on Legal Issues to SMPAG, *Planetary Defense: Legal Overview and Assessment – Report by the Space Mission Planning Advisory Group (SMPAG) Ad-Hoc Working Group on Legal Issues to SMPAG*, 2020.

Further Reading

Ad-Hoc Working Group on Legal Issues to SMPAG, *Planetary Defense: Legal Overview and Assessment – Report by the Space Mission Planning Advisory Group (SMPAG) Ad-Hoc Working Group on Legal Issues to SMPAG*, 2020.

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