Legal and Policy Considerations for Multi-Action Deflection of Hazardous Near-Earth Objects

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Background & Motivation

- Earth impacts by near-Earth objects (NEOs)—asteroids and comets whose orbits closely approach that of Earth—have shaped life on our planet since the earliest days of the solar system and always will.
- The applied science of Planetary Defense is aimed at building our capability to defend ourselves against NEO impacts.
- A variety of techniques and strategies could be employed to deflect an incoming NEO, with either a single action, multiple actions, or a gradual method.
- In this paper, we present an analysis of issues associated with multi-action or gradual NEO deflection.
- **One of our primary aims is to help prevent those issues from becoming impediments to carrying out a successful NEO deflection mission during a time of need.**

NEO Deflection Techniques and Strategies

- **Kinetic Impactors (KIs)** and **Nuclear Explosive Devices (NEDs)** are examples of **fast or strong or impulsive techniques** that change the NEO's orbit essentially instantaneously.
- **Ion Beam Deflection (IBD)** spacecraft and **Gravity Tractor (GT)** spacecraft are examples of **slow or weak techniques** that change the NEO's orbit gradually over a long period of time.
- **We identify three kinds of planetary defense applications or scenarios:**
  - **Single-step operations (KI / NED)**, where only one intervention is necessary to alter the NEO's trajectory enough to cause it to miss Earth.
  - **Multi-step operations (KI / NED / IBD / GT)**, in which several discrete interventions are required, with some time gaps between the sequential applications.
  - **Continuous gradual operations (IBD / GT)**, in which the force exerted on the NEO is small but constant, with no gaps or pauses, over an extended period of time.

Elevated Risks as Basis for Objection

- **The possibility of a pause (or several pauses) in the multi-step scenario could have significant consequences.**
  - A particular state or states would experience heightened danger, sustained for a longer period of time, whenever there was a gap in the conduct of the planetary defense operation.
- **A particular state would also experience heightened danger for a longer period of time even during a truly continuous gradual deflection with no pauses at all.**
  - That approach still drags the NEO's impact location across individual nations one at a time.
  - There will be some (potentially long) amount of time from when the NEO's impact point enters a nation's borders to when the NEO's impact point eventually exits that nation's borders.
  - Throughout that time interval, that particular nation is at elevated risk, and that condition can persist for months, even with no pauses in the continuous deflection.
- **A state in such a situation would have a reasoned basis for objecting to the intervals in the multi-step process or the continuous gradual process.**

Potential Complaints of Affected States (1/2)

- Judgments about the timing of the several steps in the multi-step process are partly or mainly based on science and engineering.
- But those decisions may also be perceived as being partly political or economic in nature (e.g., asking which states should be exposed for how long, or how much would it cost to build and launch two IBD spacecraft instead of just one).
- A state that would be exposed to a heightened or prolonged risk is not being irrational or just selfish; it may have a basis for arguing that the better tactic is to intervene more/faster.
- Additionally, a state that was affected by a pause in the planetary defense mission would likely suffer some degree of immediate harm, long before any NEO impact.
    - If it were known that a particular state would be exposed for a lengthy time (and especially if there was any doubt about whether the next step in the multi-step process would actually be undertaken), there would be immediate social and economic repercussions.

Potential Complaints of Affected States (2/2)

- To be clear, the state is not objecting simply to being at risk of an NEO impact – that risk is inevitable, due simply to the unlucky geography of being located on the risk corridor.
- But the state could complain about having to endure an elevated risk for a sustained period of time, when its neighbors are not similarly exposed.
- The pause in the planetary defense mission, or the slow nature of the gradual deflection, causing the NEO to hover for some time on a trajectory that would impact a particular nation, is not due solely to astrodynamics, but also to the human decisions about when to undertake the multiple steps and when to pause them.
- A state could plausibly complain, for example, that:
  - The NEDs should be fired more rapidly, or more powerful NEDs should be used.
  - The KIs should be launched every week instead of every month.
- Or, a state could complain that:
  - Two (or several) IBD or GT spacecraft should be employed simultaneously, to speed up the deflection process.
  - That the IBD or GT system should be kept active for a longer time, even as the NEO leaves perihelion, because even though the process is less efficient at that point, it is still having at least having some positive effect.

Legal and Policy Questions

- During a multi-step or gradual deflection campaign, it would be predictable that:
  - People in the potential impact area would experience increased psychological stress.
  - People and corporations would decide to relocate away from the danger zone.
  - Property values in that location would decline.
  - The overall economy would suffer.
- The questions we therefore pose are:
  - Who should make decisions about what planetary defense method would be used, including about whether and when there would be pauses in the multi-step scenario?
  - Should the key choices be delegated entirely to the state(s) undertaking the PD mission?
  - Should the state(s) that would encounter heightened risks have a special voice in the decision-making?
  - How and under what authority would any associated protocols be enforced?

Some Undesirable Outcomes to Avoid

- If the state undertaking the planetary defense mission was seeking some sort of “waiver” of tort liability before undertaking the operation, then **a state facing the prospect of sustained risk might decline to sign – and that refusal might jeopardize the entire mission.**
- A state that was particularly agitated by being exposed during a pause might assert that the operators of the PD mission had deliberately selected that state as the location to be affected by a pause – it might assert that the judgments about when to pause and whom to jeopardize were made for political or hostile reasons, and **that such a motivation constitutes illegal aggression**.

Conclusions

- Deflection of an NEO to prevent Earth impact may be performed as single-action, multi-action, or gradual and continuous operation, using any of several candidate deflection techniques and technologies.
- The planned pauses and gradual motion of the NEO's impact location in a multi-action or gradual deflection result in particular nations along the impact risk corridor being placed at elevated risk for prolonged periods of time.
- That could significantly complicate the execution of such a deflection campaign in ways that are not fully treated by tort liability.
- This, raises difficult legal and political questions regarding:
    - How to handle the rights and complaints of those states.
    - The obligations of the launching state(s).
    - How protocols should be organized so as to facilitate prompt and effective action, to save lives and prevent infrastructure damage.
- Additional legal and political issues may be uncovered after further analysis; this paper is intended to be a starting point rather than a comprehensive treatment of the problem.
- We recommend that legal and policy issues surrounding multi-action and gradual NEO deflection be sufficiently studied to illuminate approaches to carrying out those types of planetary defense missions should the need arise.
- Unresolved legal and policy issues associated with multi-action or gradual deflection could significantly delay the execution of an NEO deflection mission.
- **Any such delays could severely compromise our ability to defend ourselves from cosmic impacts that are capable of doing us grave harm.**