

**PDC2025**  
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**A 2025 Update to the Asteroid Mitigation Response Plot**

**P. Chodas<sup>(1)</sup>, M. T. Burkey<sup>(2)</sup>, and K. M. Kumamoto<sup>(2)</sup>**

<sup>(1)</sup>*Jet Propulsion Laboratory, 4800 Oak Grove Dr, La Cañada Flintridge, CA 91011*

<sup>(2)</sup>*Lawrence Livermore National Laboratory, 7000 East Ave, Livermore, CA 94550*

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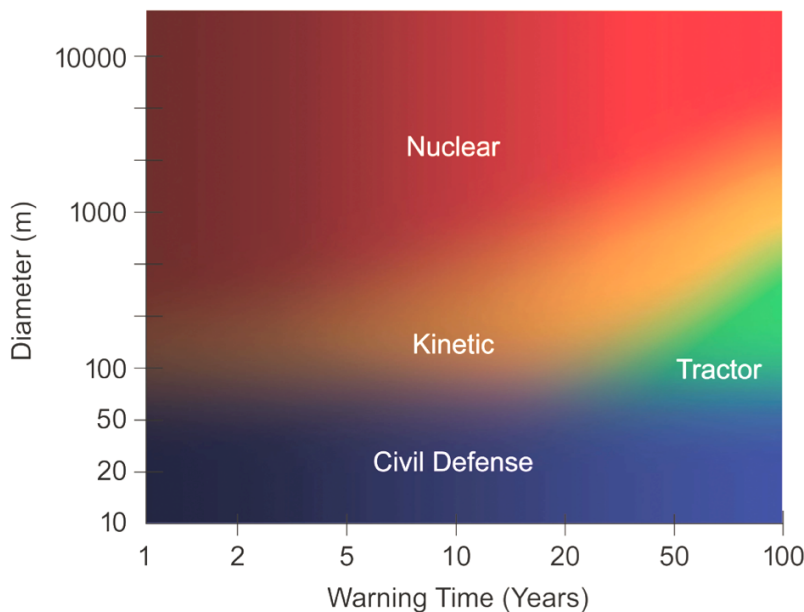
Asteroid impacts, though infrequent, have the potential for catastrophic consequences. Space missions offer the possibility of averting such disasters, provided there is adequate warning time and decisive action. Successfully mitigating a potential asteroid impact relies on decision-makers swiftly comprehending the complex mission space and committing to a course of action with enough time for the mission to be fully executed. The Asteroid Mitigation Response plot, sometimes referred to as Dearborn Plot (Figure 1), is a widely referenced figure that has served as a longstanding guide on deciding which mission strategies might best mitigate an impact based on asteroid size and warning time. It was first published in the National Research Council 2010 report on Planetary Defense[1] and later updated in 2015[2]. Since then, there have been substantial advancements in the field, notably with the establishment of the U.S. Planetary Defense Coordination Office and the Double Asteroid Redirection Test.

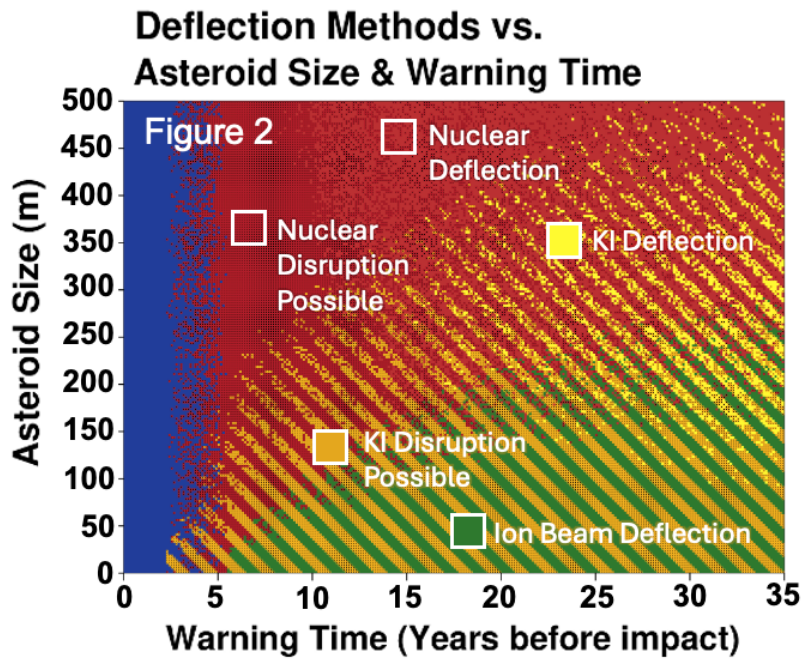
We present a timely revision of the Asteroid Mitigation Response plot that reflects current mission-design thinking. It incorporates a broader statistical analysis of mission options and asteroid trajectories, reflecting the latest technological and strategic

developments. The scenarios are sampled from a suite of realistic, Earth-impacting orbits, excluding those with significant pre-impact encounters with Earth (such as those with keyholes) which inject a degree of chaos into deflection modeling. The potential impact locations are randomly generated along the risk corridor. A mission scenario is considered “successful” if a single mission launched by a Falcon Heavy 1) can deflect the asteroid off Earth from 90% of the potential impact locations without even a weak disruption that would result in a hazardous debris field or 2) robustly disrupt the asteroid into small, fast-moving fragments that pose no threat. The plot will explore deflection through kinetic impactors (KI), deflection using an ion beam, and deflection or disruption via a nuclear explosive device (NED). The KI missions are informed by realistic ballistic trajectories and incoming velocities while sampling from a range of likely  $\beta$  values. The NED deflection missions are selected for feasibility based on recently updated deflection velocity ( $\Delta V$ ) analytic models and the disruption likelihood will be informed by simulations. The ion-beam deflection calculations assume the deployment of 20 kW NEXIS thrusters and a highly controlled  $\Delta V$ . The methodology will build on analysis presented at the 2024 IEEE Aerospace Conference by Paul Chodas in support of further developing/testing the ion-beam mission type (as seen in Figure 2).[3]

By updating the Asteroid Mitigation Response plot based on recent insights, we hope to better guide decision-makers to immediately focus on effective mitigation strategies, thereby maximizing the odds of successful mission, should one be needed.

Figure 1





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- [1] National Research Council. 2010, Defending Planet Earth: Near-Earth-Object Surveys and Hazard Mitigation Strategies (Washington, DC: The National Academies Press), doi: 10.17226/12842
- [2] Dearborn, D. P. S., & Miller, P. L. 2015, Defending Against Asteroids and Comets, ed. J. N. Pelton & F. Allahdadi (Cham: Springer International Publishing), 733–754, doi: 10.1007/978-3-319-03952-7\_59
- [3] Frazier, William, *et al.* (2024). Comparison of Planetary Defense Deflection Methods. 1-17. 10.1109/AERO58975.2024.10521323.

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**Comments:**

*If possible, an oral presentation would be preferred*