**Reconnaissance and Mitigation Mission Options for Asteroid 2024 YR4**

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Near-Earth asteroid 2024 YR4 was discovered by the Asteroid Terrestrial-impact Last Alert System (ATLAS) on 2024-12-27. Tracking showed a probability of Earth impact on 2032-12-22, peaking at 3.1% on 2025-02-18. By 2025-02-23, observations ruled out Earth impact, but the probability of lunar impact rose. Final observations during the discovery apparition were made by JWST on 2025-05-11. The probability of lunar impact is currently ~4.3%. The asteroid won't be visible from the ground again until June 2028 but may be detected by JWST again in early 2026. Wiegert et al (arXiv:2506.11217 [astro-ph.EP] 2025) estimate lunar impact debris could cause meteoroid flux in low Earth orbit reaching up to 1000 times background meteoroid flux (~10 years of exposure) over just a few days, at sizes potentially hazardous to astronauts and spacecraft (> 0.1mm). Particles > 1 cm could lead to spacecraft disruption, creating more orbital debris.

In this work, we present options for space missions to 2024 YR4 that could be utilized to prevent a lunar impact, covering flyby & rendezvous reconnaissance, deflection, and robust disruption of the asteroid. We assess deflection requirements and compare them to current heuristics for onset of asteroid fragmentation. For robust disruption, we assess launch options for nuclear detonations and kinetic impactors, considering multiple heuristics for sizing missions to provide confidence of robust disruption. We evaluate chemical and solar electric propulsion (SEP) options, various launch vehicles, and optimized deep space maneuvers and gravity assists. Re-tasking of extant spacecraft and usage of built spacecraft not yet launched are also considered.

Though we find viable reconnaissance and mitigation trajectory options via our exhaustive search, the ~7 yr timeline is stressing. Viable responses either require reconnaissance mission development start prior to lunar impact probability reaching 100%, or require mitigation development start without the benefit of reconnaissance data. This is driven by 2024 YR4’s ~4 yr orbit period, which constrains spacecraft encounters to roughly 2028 and 2032. The use of large maneuvers or SEP can expand these windows at the expense of spacecraft complexity. We describe this trade space and present candidate responses that address constraints.