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RENDEZVOUS MISSION DESIGN AND DEFLECTION OF ASTEROID 2023 PDC

Objective

To analyze the rendezvous nuclear deflection of 2023 PDC from a scientific and socio-political point of view

Introduction

The present research analyses the rendezvous deflection mission that uses a series of nuclear detonations to change the course of the hypothetical asteroid 2023 PDC and avoid an Earth impact.
Nuclear explosive devices (NEDs) present many risks even though they provide sufficient kinetic energy for deflection of the asteroid. These risks could be political, technological as well as biological. An asteroid impact is a global event that would impact billions across various countries, thus, coordination between various space agencies and organizations, both private and governmental is needed.

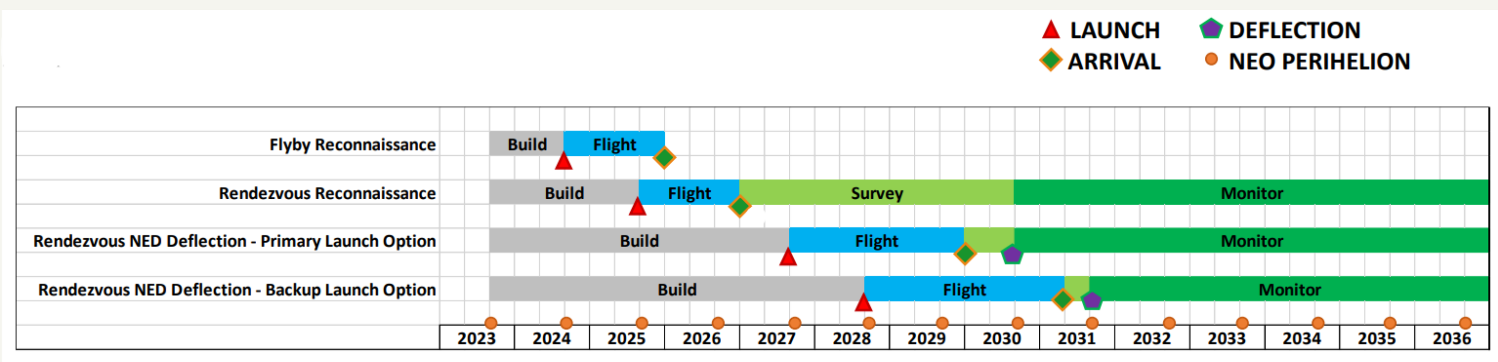
Current State-of-the-Art

- No decision making international body exclusively for planetary defense and hazardous asteroid deflection
- UN Security Council - includes major players but not accessible to many stakeholders. Vetoes and rigid system may hamper mission planning due to time constraint

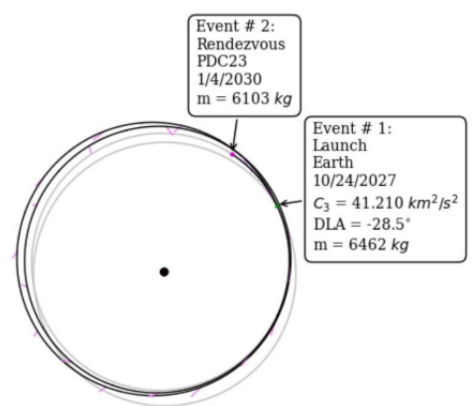
Results

The porkchop plots constructed show similar launch date options as in the figure. Kinetic impactor missions for the deflection of the asteroid is highly impractical considering the ΔV required (24.4 mm/s). NEDs to be used as they can provide enough energy for deflection with just one launch.

LAUNCH DATES FOR VARIOUS MISSION OPTIONS

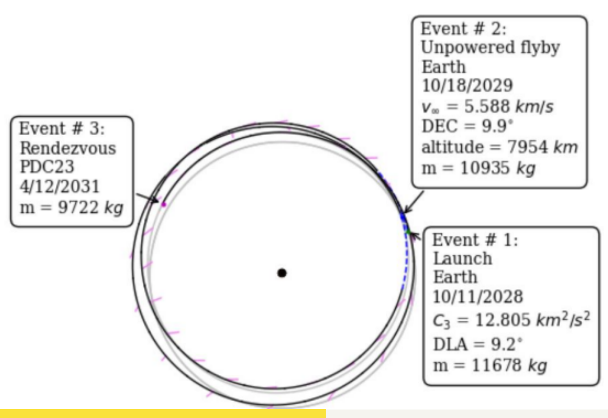


LV: Falcon Heavy Expendable
Launch: 10/24/2027
Arrive: 1/4/2030
EOL power at 1 AU: 8 kW
Thrusters: 1 active NEXT-C thruster
Prop mass: 394 kg (includes 10% margin)
Delivered mass: 6067 kg (margined prop not included)



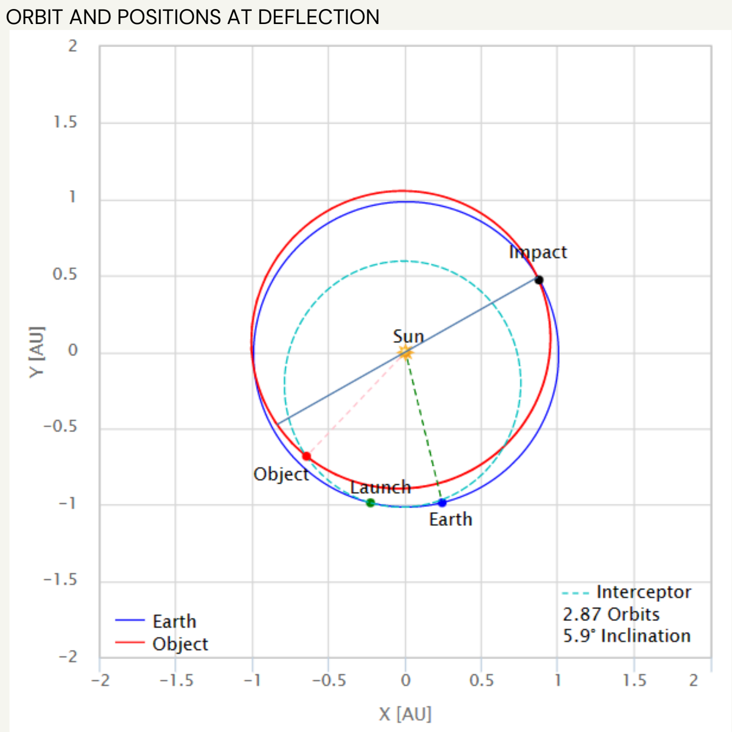
Primary Launch Option

LV: Falcon Heavy Expendable
Launch: 10/11/2028
Arrive: 4/1/2031
EOL power at 1 AU: 15 kW (can likely be lower)
Thrusters: 2 active BPT-4000 thrusters
Prop mass: 2153 kg (includes 10% margin)
Delivered mass: 9526 kg (margined prop not included)

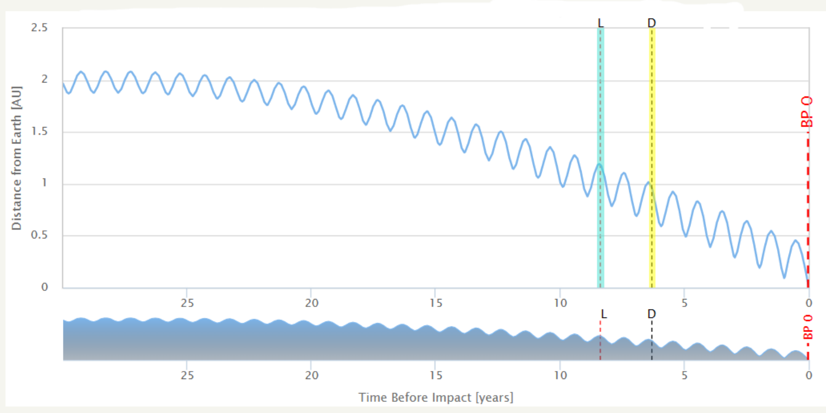


IBackup Launch Option

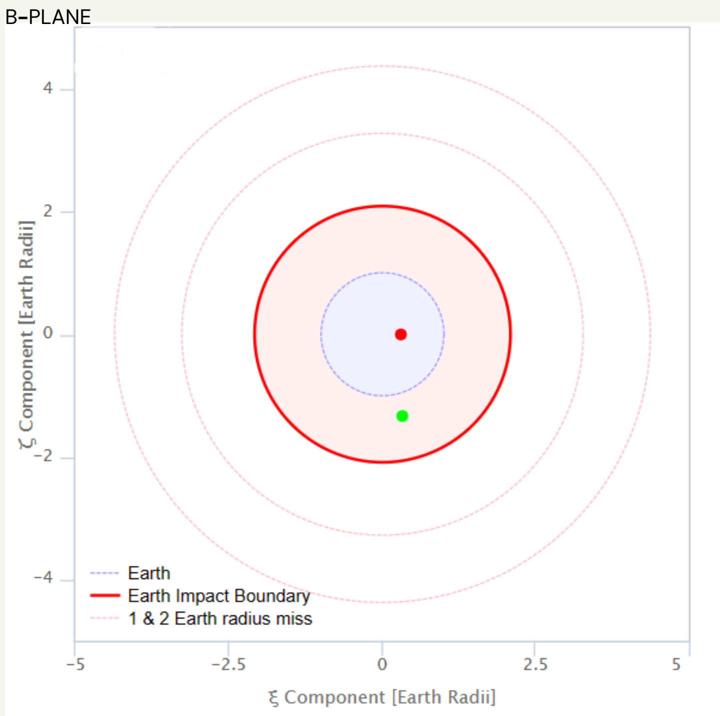
ORBIT AND POSITIONS AT DEFLECTION

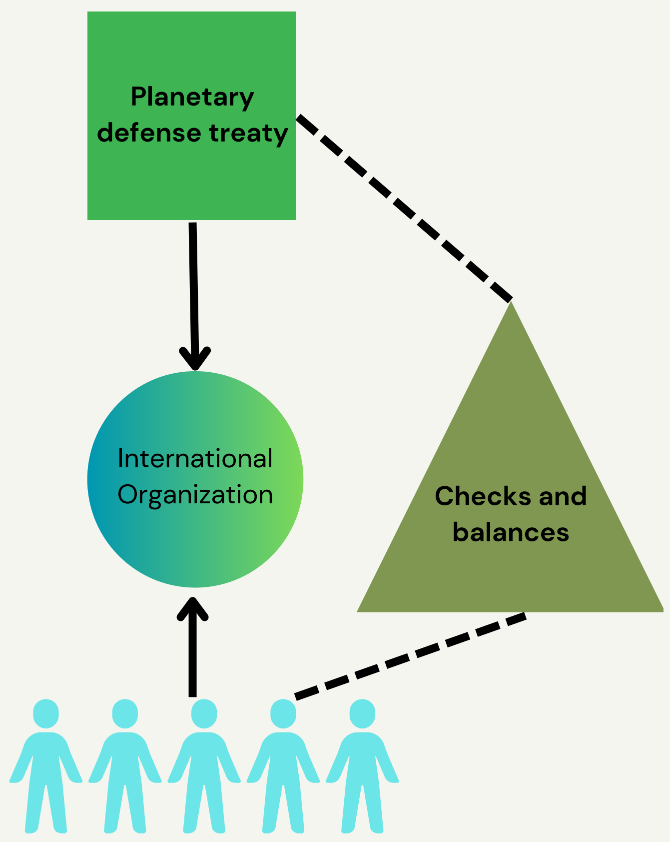


DISTANCE AND ΔV SENSITIVITY



B-PLANE





Points to note

The Space Mission Planning Advisory Group (SMPAG) is an example of coordination that can bring together representatives from different space agencies (currently 18) to discuss about planetary defense measures, but, it does not have any decision-making authority. The members of SMPAG also don't need to seek permission for building and launching their own missions. There is no system of checks and balances in case of this scenario.

The recent Artemis Accords also illustrate how hard it is to bring all nations together for a common goal with several countries vetoing the treaty due to distrust and political tension among countries.

Global coordination and cooperation become more crucial and multifaceted when NEDs are involved. Treaties need to be drafted carefully between all the parties based on their concerns and interests while also keeping the timeframe of the impact in mind. The testing and development of the nuclear detonation devices must be done on neutral and isolated ground with minimal risk to humans, flora and fauna.

It is equally important to ensure safety during the launch of the mission with the vehicle having proper shielding and the ability to contain a detonation in case of a misfire. The launch site must also be chosen meticulously such that it poses minimal threat to the biodiversity while also providing an advantage to the trajectory of the spacecraft.

Conclusion

A total deflection of the asteroid is preferred to avoid any collision impact with the Earth and is achieved by using NEDs. However, preparation must also be done for scenarios that are unfavorable and not nominal. In case of any failure in the detonation devices, the required ΔV for deflection - 24.4 mm/s for the worst-case (mid-chord) impact location may not be achievable, in which case the backup launch option might have been used if the faults were detected early. However, if they were identified only when the sequence of detonations in the period of August to September 2030 were taking place, it would be hard to send another launch vehicle to the asteroid. In this worst-case scenario, the detonations can be timed and planned in such a way that the impact point is changed towards a sparsely populated and easy-to-evacuate region.

Even in this case, the threat to biodiversity and nature is quite significant and only multiplies because there may be a risk of contamination by nuclear substance sticking to the asteroid debris. This can affect the atmosphere as well as land and water sources, causing widespread damage.

Thus, technologies that can minimize the contamination must be deployed in and around the impact region. Proper planning and countermeasure development by an international organization with representatives from all national and private entities that implements the checks and balances system for every scenario, irrespective of whether the scenario contains the asteroid impact is very vital.

Related Literature

Aaron C. Boley , Michael Byers, "Precautionary Planetary Defence", PDC 2021.