9th IAA Planetary Defense Conference – PDC 2025
5-9 May 2025, Stellenbosch, Cape Town, South Africa

IAA-PDC-25-07-216

STARGRIND & ARMORY PRACTICE – USING EARTH'S BEST BAD HABITS AS A LAST DITCH STAND AGAINST SHORT WARNING TIME NEO IMPACTS

Jan Thimo Grundmann[(1)#*], Laura Borella[(2)], Ross Centers[(2)(3)#], Dirk Plettemeier[(4)], and Fabienne Seibert[(5)]

[(1)]*DLR German Aerospace Center, Institute of Space Systems, Robert-Hooke-Strasse 7, 28359 Bremen, Germany*

**corresponding coauthor +49-(0)421-24420-1107, jan.grundmann@dlr.de*

[(2)]*Consultants to DLR Institute of Space Systems*

[#]*Planetary Sunshade Foundation, Golden, Colorado, United States*

[(3)]*Ethos Space, Los Angeles, United States*

[(4)]*Dresden University of Technology, Chair for RF Engineering, Dresden, Germany*

[(5)]*Faculty of Aerospace Engineering, FH Aachen University of Applied Sciences, Hohenstaufenallee 6, 52064 Aachen, Germany*

Keywords: *NEO deflection, short warning time NEO impact, ad-hoc re-use in space, massively parallel spaceflight, space industrialization*

Abstract

This time, we have time. 2024 PDC_{25} takes 16 years, 10 months, 2 weeks, and 6 days from its fictitious discovery to its fictitious impact on Wednesday, April 24th, 2041 – *and it will*, because *this is an exercise*! 2021 PDC was not so kind, leaving us only 6 months to play with it. The coming close encounter of (99942) Apophis on Friday, April 13th, 2029, when it will get to within 31650 km altitude over the North Atlantic at 21:46 UT in the night sky of more than a billion people, reminds us that, if it had not been for an exceptional discovery at very low solar elongation – 56° – and very long range – 1.1 AU – for a 370 m object in a midsummer night in 2004, we might well have gotten a shocking Friday 13th naked-eye surprise below geostationary altitude 4¼ years from now instead of an impact probability peaking at 2.7% for Christmas 20 years ago. With 6 months to go, or even 6 years considering from the perspective of a surprise in 2029 the possible 2036 impact of Apophis that took 9 years to rule out completely, who knows what, when a NEO should approach this globe to destroy it, as it often has been and will be destroyed, we could tear from its foundations by means of ingenuity and improvisation, to hurl masses, as Deep Impact and DART have done, against the piled rubble? Well, for starters, we are good at churning out the same stuff all over again and again from assembly lines – known as armory practice before it came to Detroit. Nearly a century after the Springfield Rifle, the U.S. alone built over 300,000 airplanes during the 6 years of World War II. Today, the world builds more than 85 million cars *a year*, and more than 1.4 billion mobile phones. One company alone built over 7500 satellites and put them into orbit with over 215 launches, within 6 years, and thousands more are planned, also by other space service providers. Although the detailed design of these spacecraft is proprietary, sufficient public information exists to derive their approximate properties and capabilities, and to lay out a feasibility study of last-ditch attempts to save Earth from a near-term large impact on the scale of the PDC Exercise targets or their notorious leftovers aimed at the participating civil defense and disaster management communities, and a location conveniently close to the conference center. With lead times ranging from several months to a few years to impact, the adaptation and development potential spans the range from shoot and hope straight off production lines accelerated to the very limit, to largely mission-specific redesign based on the now-term technology of the day, in global synergy of planetary science and planetary industry working hand in hand to grind down an approaching asteroid in space by a long series of somewhat DART-like impacts. And then we shall have traditions of tycoons and telescopes again, and of wars with rocks.

Introduction

The progress of the design and building of dedicated missions to Apophis in the >20 years since its discovery and 4 years before its closest approach for a marvelous one-in-a-hundred-lifetimes opportunity should be a sobering realization for the planetary defense community: So far, only one mission that has been in space, already, is definitely going – OSIRIS-APEX, NASA's re-purposed OSIRIS-REx mission that previously brought samples from Bennu to Earth heads out again after a swing-by, in extended mission not just beyond Earth but also beyond its design life. Fortunately, spacecraft of its kind are built

with margins to spare, and not only in this are they similar to one or the other kindly neglected piece of infrastructure on the ground. Many a sophisticated and once expensive civil defense facility has fallen into disrepair, and exercises are few and far between; in fact, the planetary defense community may well be way ahead in this, considering the bi-annual PDC Exercises held since 2013 with additional interleaved exercises on the national and international level. [1]

Who knows whether, when…

Our knowledge of dangerous asteroids has improved vastly since the threat was recognized as real and substantial in the 1980s by the few to whom the many owe much, and moved out of the once feared giggle factor zone by the sweat and toil of a worldwide community still smaller than the staff of a high-street McDonalds, in the 1990s. [2] But not only nature's surprises like the very real 2024 YR_4 which has meanwhile nearly played out a possible and fortunately much more likely course of this PDC 2025's exercise revolving around the fictitious 2024 PDC_{25} tend to catch us off guard. Even unique events that we do know of decades in advance, such as Apophis' close encounter with Earth on Friday April 13th, 2029, at 21:46 UT, seem to approach placidly without giving much power to those who could exploit them for the benefit of all inhabitants of this planet. For those following the progress in dealing with climate change, and vice-versa, it all sounds too familiar: a complex problem with complex solutions which take long to study to eliminate all uncertainties and even longer to implement. (cf. e.g. [3])

Rocks from their foundations

Consider this: a 2 million km² infrastructure in space to be built over 2 million km away from Earth within 25 years, starting 25 years from now. [4] Sounds phantastic? Yes, it is – in detail. In bulk, it is mundane. The world today builds 85 million automotive vehicles, each on average weighs just under 2 t. Whether built from steel or from aluminium, rolled out to ≈40 g/m², half the area density of the sheet of paper that you might print this abstract on, these cars would cover twice that area – *a year*. Taking the phantastic detail cue, you might then want to point out that a membrane the 2-dimensional size of Greenland will astrodynamically collapse and be torn apart at the same time, it should therefore be broken down into, say, football-field-sized elements that are within reach of now-term technologies, [5] and therefore >200 million spacecraft would be in need their own suite of avionics and controlled operations. Well, we also build >1.4 billion mobile devices – increasingly including entire cars – *a year*, and currently operate >16 billion of them in a controlled way *all the time*. Each of them contains several tens to a few thousand of integrated circuits (IC), rather more and of higher complexity and performance than those found in your average spacecraft. All but one of these things are built in large numbers using the same general concept of processes, though at vastly varying scales of size – cars, mobiles, chips. Spacecraft still aren't built in the millions, *yet*. We could expect that at one point they will be because we are good at this because we have been doing this for more than 1½ centuries [6] and since then, mass production has been the decisive winner of many things in the end, [7] though with not insignificant side effects.

…and hurl mountains

When Dimorphos, the small moonlet of the (65803) Didymos binary asteroid system similar in size to this PDC's fictitious exercise asteroid 2024 PDC_{25} (at least as far as we know now) was hit by the 579 kg DART spacecraft travelling at 6.1 km/s, the impact produced 1–6 × 10^7 kg of ejecta which is roughly 1% of Dimorphos' mass of 1–6 × 10^9 kg; [8] i.e., neglecting advantageous side effects of a shrinking residual impact target such as complete fragmentation, of order 100 DART-like impacts would suffice to completely grind down an incoming impactor of this size *even if no effective deflection were to occur*.

Against the flaming mass

Considering the cadence of e.g. StarLink spacecraft launches, hundreds of spacecraft of a similar or slightly larger size than DART can be built and launched into low Earth orbit *per year*. Re-use is limited to the 1st stages of their launch vehicles, Falcon-9, which carries stacks of more than 20 such spacecraft per launch. Considering the higher capability Falcon Heavy launch vehicle, it appears likely that similar payload stacks can be launched to escape Earth. Also, equipped with solar-electric orbit maintenance propulsion, ample photovoltaic power generation, and some extensive radio communication equipment, it is conceivable that this hardware, with some minor hardware and quite substantial software defined radio modifications, can be used to guide such re-purposed off-the-production line requisitioned spacecraft into collision course with an approaching asteroid at least relatively near Earth. This opens a perspective to deal with extremely short warning impactors akin to the fictitious 2021 PDC, by leveraging currently running series production of spacecraft and currently operated launch faclities. The preparations and ramp-up duration and total output of presently operating constellation satellite and launcher production lines suggests that these could be leveraged for deflection also against much more massive impactors with a longer lead time like the fictitious 2023 PDC which we presently still consider to force an early nuclear deflection decision. After all the dinosaurs might have perished not just due to the lack of a planetary science or space program or the absence of nuclear

devices, but maybe also due to the lack of affordable and popular mobile satellite phones in their hands.

Conclusion

While we have to leave the study of the details and limits of ad-hoc off-the-production line asteroid down-grinding and deflection in a hurry to a future journal paper, and can leave the far more elegant approach of leveraging a few of the very many solar sails of a planetary sunshade for tolerable centuries of climate recovery also for asteroid deflection now and then to the PhD thesis of one of us (Seibert), we can leave the last word to a voice from the beginning of the space age who was instrumental in getting silicon semiconductors into mass production and keeping unwanted vibrations off the ever more delicate production line shop floors, and yet like everyone of us day by day ended up in the same fateful fix as dedicated missions to Apophis, now and then:

> "As we skidded around a turn and were accelerating down the straight, still a mile from the Geologic Survey property, Tom looked at his watch and said calmly, "The nuke just went off. The seismic wave is on its way." … Tom and I were out of the car and into the cave at a dead run. We flipped switches on at an alarming rate … and then we saw the jerk of the recorder needle as the first nuclear blast shock wave hit. The system had been running maybe fifteen seconds when it arrived. We decided that evening over a beer that we had cut it a bit thin." [9]

At the time, they also only ever had one such system available to hand-operate as a capricious lab curiosity.

References

[1] https://cneos.jpl.nasa.gov/pd/cs/

[2] https://archive.org/download/BBCHorizonCollection512Episodes/BBC%20Horizon%20-%20s1995e17%20-%20Hunt%20for%20the%20Doomsday%20Asteroid%20%28Update%29.mp4

[3] https://www.ipcc.ch/reports/

[4] https://www.planetarysunshade.org/publications

[5] Spietz et al., (2021), https://elib.dlr.de/141755/

[6] https://www.bbc.co.uk/programmes/b01cnwq3/episodes/guide , S2E3 Lock, Stock and Barrel: The Springfield Rifle

[7] = [6], S2E1 cf. S1E6

[8] Adams et al., Final Technical Report to the National Aeronautics and Space Administration for the Double Asteroid Redirection Test (DART) Mission October 2023, APL_COMM-23-04772

[9] Ed Millis, 'TI, the Transistor, and Me', Chapter Six – 1963, ©2000 Ed Millis Books, Dallas, Texas, USA.