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Earth's best defense

If a dangerous meteoroid were discovered on a collision course with Earth, there would be no time for political correctness. What's the best defense? Michael J. Dunn makes the case for going nuclear.

I strongly disagree with Aerospace America's characterization of the nuclear option against dangerous near Earth objects as a "Hail Mary" that would have "little chance of averting disaster." The article "Course Correction" [October 2017] states that the kinetic impactor is preferred "because the technology for doing it is the most mature."

Let's subject the nuclear and kinetic impactor options to a comparison based on the history of technology and some back-of-the envelope calculations.

A credible threat: For sake of discussion, let's imagine that a body analogous to the meteoroid that formed the Barringer Crater in Arizona (1.2 kilometer diameter, 0.17 km deep) was detected 2 astronomical units from Earth, and its trajectory showed it to be on a collision course with Earth. That means our notional target would be a hunk of nickel-iron

50 meters in diameter with a volume of 65,450 cubic meters. Let us say that our approaching meteoroid has an average density of 8,400 kg/cubic meters, and therefore a mass of 549,780,000 kilograms, and a linear momentum of 3.421×10^{12} kg-m/sec.

Interceptor requirements: Let us first look at the interceptor that would be needed for either the nuclear or kinetic impactor option. Let's postulate that we have the means to intercept this meteoroid when it reaches 1 astronomical unit, a distance equivalent to that from the Earth to the sun or 149,597,870 kilometers. The escape velocity of this interceptor would need to be 11.186 km/sec, and it would need an additional 6.222 km/sec to reach the object at 1 au. This means the interceptor would need a total propulsive delta-velocity of 17.408 km/sec. Time to intercept (calculated by dividing 1 au by 6.222 km/sec) would be 278.3 days.

If the first engagement were a "miss," or some other kind of failure, we would have 139 days of flight time

for a second shot. (We now have warning at a distance of 1 au, so an intercept with the same closing velocity would occur at 0.5 A.U., for half the previous flight time.) If that failed, we would have 69 days of flight time for a third shot. This desire for multiple shots is one constraint on such an interceptor launch vehicle, which may strongly influence the practicality of the kinetic technique that I discuss next.

A kinetic impactor: In order to assure that the meteoroid would not hit Earth, it should have its trajectory deflected by at least Earth's radius of 6,378 km; let us say 10,000 km for a round number with some margin. Roughly speaking, this would convert to a transverse, or sideways, velocity perturbation of 0.416 m/sec. The kinetic impactor would, therefore, need to impart a momentum perturbation of 228,661,760 kg-m/sec. Even in the unlikely hope that this could be accomplished by a head-on collision, this would require an impactor (or flock of impactors) massing 36,750 kilograms. This (plus an end-game propulsion system) would need to be launched by a vehicle about the payload capacity of the Apollo-era's Saturn V rockets.

Also, there is no assurance that the kinetic impact would be transmitted to the entire mass of the meteoroid. It is possible that the impactor might simply split the meteoroid instead of perturbing its trajectory. And, if the meteoroid were only an agglomeration of material, the impactor might simply pass through with minor interaction.

A nuclear device: Let us suppose we could deliver a nuclear device like the Soviet-era Tsar Bomba hydrogen bomb of 100 megatons yield, weighing 27,000 kg, at a range of 0.1 to 1.0 km. Approximately half the yield would be available as radiation (X-ray photons) of sufficient energy to ionize the surface material of the meteoroid and form a thin plasma. (The other half of the yield is usually considered to comprise the kinetic energy of the bomb plasma. In space, this would have little effect.) The thin plasma would be inertially confined to a layer of maybe 1 mm thickness. Because of this confinement, the energy deposition would go into heat, temperature, and thus pressure across the surface of the meteoroid exposed to the nuclear blast. The direction of this force is therefore determined by the relative position of the nuclear device at detonation.

The exposed area of the meteoroid would be approximately 1,963.5 square meters, leading to a total force application between 3.229×10^{12} and 3.229×10^{10} newtons for 0.1 msec. This means the nuclear device can accomplish the momentum perturbation if detonated at a distance slightly greater than 0.1 km. In this case, because the "X-ray slap" is a whole body interaction, it would be effective even against an agglomerated meteoroid. The material facing the deto-

nation would be impelled into the material behind.

And, because the Barringer meteorite was vaporized by its impact, it stands as a logical conclusion that a 10-megaton nuclear warhead detonated on impact would likewise vaporize a similar meteoroid. As a reference point, the W53 warhead for the LGM-25C Titan II reportedly had a yield of 9 megatons and a weight of 2,800 kg.

It bears mentioning that we have had experience detonating high-yield warheads in outer space. The U.S. detonated the HARDTACK-Teak and Orange devices in 1958 (3.8 megatons each). In 1962, we detonated Starfish Prime (1.4 megatons). We have also shown the ability to deliver anti-ballistic missile warheads to orbital altitude, as when the LIM-49A Spartan missile in 1975 delivered a W71 nuclear warhead to a 560 km ceiling (though the warhead was not tested operationally).

A reasonable conclusion: Our notional meteoroid threat could, only in theory, be resolved by a massive kinetic impactor, requiring propulsive maneuvers in the end game to achieve the required transverse momentum perturbation, with unknown terminal effects. On the other hand, it could also be solved with a nuclear detonation at close range on a passing trajectory, using technology that is over half a century old. It is fair to say that the nuclear solution is the "most mature."

My overall concern is this: It is starkly apparent that the nuclear detonation approach has the most timely and most powerful prospect of achieving the desired end of repelling a true planetary threat. As an engineer conscious of the lives depending on the technical solution, I find the dismissal of nuclear detonations to be highly negligent. I will say candidly that a "politically correct" approach would invoke the Outer Space Treaty as a barrier to their use. This would be a suicidal denial of what is needed for the human race to survive. The treaty would need to be abandoned or changed to permit this defense. High-yield nuclear devices must be designed, fabricated and tested in space. Launch vehicles must be prepared and placed in readiness. Surveillance systems must be constructed and operating. It is not acceptable to waste time with solutions that have a low prospect of success. ★

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