The Dawn of the Age of DART

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Posted to The World Orders Forum: 5 July 2023

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This article was originally published in *The Space Review* on 22 May 2023. It is republished here with the permission of the editor of *The Space Review*.

Within the cascade of wondrous–sometimes astounding–space discoveries and activities, the recent successful NASA DART mission can plausibly make claim to marking a new threshold of epochal historical magnitude, not just for the often painfully slow human movement into outer space, but to the larger prospects for the survival of the human species.

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DART (for Double Asteroid Redirection Test) is, as its advocates and commentators have proclaimed, a landmark because this mission marks the first time humans have conducted an actual test of "planetary defense" technology. The DART mission slammed a small (1.3 meters on a side) satellite at high velocity (22,000 kilometers per hour) into a small (160 meters across) asteroid, Dimorphos, in order to slightly alter its speed and direction. DART is thus a very small, but critical, first proof-of-concept test of the measures that will someday be needed to prevent natural celestial bodies (asteroids or comets) from colliding with the Earth.

Prior to DART, the planetary defense project consisted of only astronomical observations, computer simulations, and paper studies. The DART mission marks the debut of a major new technology, called Asteroid Redirection Technology (ART). There are good reasons to view the passing of this technological threshold as having first order historical significance. If it is further developed and employed, this new ART will, slowly but surely, profoundly alter the overall human prospect and path.

The recent DART mission is potentially a pivotal juncture because ART technology has three broad streams of application. In keeping with the technosphere custom of naming with snappy acronyms, these three streams can be labelled PART (Protective Asteroid Redirection Technology), CART (Constructive Asteroid Redirection Technology), and DART (Destructive Asteroid Redirection Technology). In thinking about scenarios of ART applications for protection, construction, and destruction, there is one fundamental fact: the technology of asteroid redirection is basic to all three possibilities. To a first approximation, the main difference between these very different paths is simply the intents and purposes of the actors employing ART. As such, ART is yet another leap in human superempowerment. And like so many previous such leaps, ART is very much a double-edged sword, capable of bringing both vast benefit and terrible destruction.

PART, the Earth-protective application of ART, is clearly first in line for real development. The DART mission took place because of the growing recognition of the need for planetary defense measures to protect the Earth, and the human civilizations which have sprung up on it, from the massive destruction produced by the collision of the Earth with an asteroid or comet.

Over the last half-century, the broad contours of the threat requiring planetary defense have become clear. The history of the Earth, and of many other celestial bodies, is punctuated with collisions, some of enormous violence and lasting influence. Best well known is the Chicxulub event of some 66 million years ago, when an object roughly the size of Manhattan and traveling many kilometers per second struck near today's Yucatan Peninsula, releasing some 100 million megatons of energy, vastly more than an explosion of all the nuclear weapons ever built. This collision caused massive earthquakes, set most of North America on fire, generated tsunamis hundreds of meters high, and darkened the sky with sun-blocking soot. This massive shock wiped out wide swaths of life, most famously the dinosaurs, clearing the way for the rise of mammals and, eventually, humans.

The largest strike in historic times occurred in 1907, in the remote Tunguska region of Siberia, when an object with roughly diameter of a half football field released the energy equivalent of some 15-30 million tons of TNT, devastating an area roughly equal to New York City and Washington, DC, combined.

As this has come to be scientifically understood and widely accepted, a variety of surveys and searches for potential colliders have, slowly but surely, gained a roughly realistic profile of this threat. The good news is that larger planet-altering collisions are much less frequent than smaller ones. But the bad news is that further strikes are inevitable unless deflection technology is developed and deployed.

Cosmic collision is a low-probability but high-impact threat, thus posing the question: how lucky do we, as a species, think we are? The random contingency of such events reminds of just how different the course of history, natural and human, might easily have been. What if the Tunguska rock had arrived a few hours later, and obliterated, say, a big part of Belgium? Or landed in the North Atlantic, creating a widely damaging tsunami? Might such a startling event have triggered an urgent effort, perhaps cooperatively, by the leading states to understand the full dimensions of this threat, develop rockets to enable interception, and perhaps even nuclear explosives? Or what if the Chicxulub mega-rock had passed harmlessly by the Earth, leaving the dinosaurs masters of the planet? It is a simple fact of nature that the fate of the Earth and its myriad inhabitants hinges on the dumb, brute, and ever shifting motions and pathways of a vast cloud of debris stretching to the distant edges of the solar system and beyond, and containing hundreds of billions or even trillions of lumps of primordial matter moving at astronomical speeds.

As the threshold step in the development of a viable planetary defense system, DART may be the most consequential space technology, along with rockets and Earth-orbiting satellites. And looking at the possible magnitude of the planetary vulnerability it may help solve, DART may be one of the most, if not the most, important technological development in human history. “The dinosaurs became extinct because they did not have a space program,” space enthusiasts proclaim, but humanity can persist by having a space program. Under this perpetually looming cosmic threat, the development of space technology eventually, surely, defines human destiny.

If DART is followed up with the many further measures needed to construct a planetary defense capability, and if such a system were someday successfully employed to avert a civilization- or species-killing cosmic collision, the core DART mission technology of asteroid redirection will surely be heralded as a development, like the control of fire, agriculture, and the steam engine, as a defining moment in the overall human story. As such, we are justified in thinking of the small DART mission as the dawn of the age of ART.

The DART mission’s test of asteroid redirection is also an essential step in CART, a key technology to realizing the visions, widely discussed in science fiction and space circles, of mining asteroids. Initially asteroids would be mined for valuable metals, increasingly scarce on Earth, then for the fabrication of space infrastructures and eventually for large habitats.

The idea that large-scale human activities in space would be possible because asteroid material could be exploited was sketched at the very beginning of space thinking early in the 20th century by the great Russian visionary and scientist Konstantin Tsiolkovsky. Numerous schemes have been developed for exploiting the vast bounty of “the fertile stars,” and visions of routinely slinging cosmic masses about the solar system permeate space futurist thinking all across the political spectrum, from the techno-libertarian right to neo-Marxist advocates. A particular hotbed of support is Silicon Valley and its sprawling penumbra of futurist think tanks. The key point is that, for these mining and then fabrication activities to be viable, extremely precise asteroid redirection techniques will need to be conducted routinely, on a massive scale.

Techniques to alter the trajectories of large masses of celestial material are to the long-heralded "space industrial revolution" what the railroad and steamship were to the modern Industrial Revolution which has so profoundly altered all aspects of human life.

The technology first demonstrated by DART, if progressively expanded and deployed for construction, will thus enable the realization of the grand vision, widely shared and voiced in the global network of space advocates, of making humanity a "multiplanetary species" of expanding human habitat off the troubled and vulnerable terrestrial cradle of its birth, and of setting humanity on a path of cosmic expansion with mind-boggling dimensions. This vision of cosmic human expansion is typically coupled with "transhumanist" and "silicon successionist" scenarios of cyborgization, genetic enhancement, and evolution into supercomputers. This scenario is yet another legacy of fevered quasi-religious late modern Russian intellectuals. This path is now central to the expectation of "longtermist" thinkers that unimaginably large numbers of humans, or human descendants, could come into existence across distant futures—as long as humans do not now blunder into extinction. If such visions of significant human settlement across the solar system and beyond do come to be realized, historians of such distant days will likely look back at the DART mission as a critical step in the ascending pathway of our species to the stars.

Beyond these two species-salvation (even near apotheosis) scenarios lies a third, much less discussed, set of possibilities centered around the weaponization of ART, the path of DART. Humans have been trying–with uneven, but cumulatively astounding, success–to weaponize pretty much every natural principle discovered by science, every new civil technology, and every natural part of the terrestrial habitat, from fire and ballistics to chemistry and nuclear physics. Overall, and especially in the last century, humanity has been spectacularly successful in turning the fabric of nature into killing tools, into ever larger, faster and more accurate instrumentalities of destruction. During middle years of the 20th century, when the magnitude and ramifications of the weaponization of nuclear physics were being urgently explored and pondered (especially in Cold War America), pretty much every geophysical facet of the planet, from earthquakes and hurricanes to tsunamis and tornadoes, were explored for weaponization potentials, an exploratory assessment which largely—and fortunately— returned almost empty-handed.

Among these Strangelovian investigations, the space visionaries Dandridge Cole and Donald Cox in the early 1960s proposed what they called "planetoid bombs": the redirection of asteroids (which they called "planetoids") to strike enemy targets, thus providing a truly "ultimate deterrent" against attack. This possibility of intentional bombardment of the Earth with celestial objects was also seriously considered by the protean cosmic thinker, space scientist, and science popularizer Carl Sagan and his student Stephen Ostro. They urged delay in ART testing, deployment, and even surveying, due to what they termed the "deflection dilemma." They argued that the probability of intentional misuse of ART will exceed the probability of its use against Earth-smashing natural objects. In making their case for the dangerous probability of intentional use, they spun out a wide range of scenarios in which such weapons might be used, essentially replicating all the familiar terrestrial scenarios of rivalrous rulers, deranged dictators, or terrorists initiating, or stumbling into, nuclear war.

In retrospect, the military appeal of one group based on Earth attacking another with large space rocks is probably quite low, for much the same reason that large-scale nuclear war has come to be seen as essentially insane: the fact, imposed on all terrestrial actors by the raw features of the planet, makes such an attack an indirect form of suicide due to biospheric collapse and severe nuclear winter climate alterations.

In thinking about the volumes of violence potentially tapped by ART, a very large sky is the limit. Any precise calculation of even the violence potential of just the NEOs, the inner solar system objects with orbits potentially intersecting with the Earth's path, is impossible. But making reasonable guesses about their collision speeds and composition, a 'back-of-theenvelope calculation puts their destructive potential at some seven or eight orders of magnitude greater than all nuclear weapons. This is a jump in available violence roughly analogous, in orders of magnitude increase, to the leap from chemical high explosives to thermonuclear weapons. But some 97% of the solar system's asteroids are in what astronomers call the Main Belt, located between Mars and Jupiter, where around a million objects, some gigantic, have been detected. Even this is just the tip of the proverbial iceberg, because the far outer reaches of the solar system are thought by astronomers to contain hundreds of billions to trillions of comets. These objects are in deep freeze and long-term orbits far distant from Earth, but all are potentially available for advanced ART to re-route, for better or worse. In the face of this staggering destruction potential, the notion that nuclear weapons are the "absolute weapon" is a provincial conceit.

While DART can potentially tap into a vast natural reservoir of destructive potential, is it realistic to expect, and worry, about humans actually redirecting space rocks for large-scale destruction? The most plausible scenarios assume the existence of viable colonies of humans on other celestial bodies in the inner solar system (most likely Mars and the asteroids). This colonization project is viewed by many as being vital for long term human survival, and as the ultimate point of the entire space enterprise. "All of our eggs are in one basket," as the great physicist Stephen Hawking said, but the future of humanity as a multi-planetary species will be assured.

What could go wrong? Advocates of space settlement widely assume that colonies will, and should, become politically interdependent. Once this happens, a list of all-too-familiar reasons for violent conflict and mass destruction will potentially come into play. The ancient, and most pedestrian, root of violent rivalry, competition for valuable resources and favorable geographic positions, seems quite likely. Indeed, space war analysts are already gaming conflict scenarios with China over scarce, icebearing, permanently shadowed craters on the Moon.

Adding greatly to the mix of potential conflict scenarios, colonization advocates assume and advocate that the human species will biologically radiate in off-worlds. Great differences of circumstances in alien environments will naturally stimulate the biological diversification of humans, and this branching might be aided and greatly accelerated by maturing technologies of genetic manipulation. Over time, our solar system will come to be populated with alien intelligent species with advanced technology, not from the vast interstellar beyond, but with our descendants. As interplanetary warfare evolves into interspecies warfare, DART is likely to be highly valued and employed. All of our eggs will no longer be in one basket, but egg-smashing with large rocks will be widely available—and likely.

Given these multiple and entangled empowerment possibilities, the fateful historical technological threshold most resembling the recent DART mission is the experimental accomplishment of the first controlled nuclear fission. Conducted in the early days of the Manhattan Project under the stadium bleachers at the University of Chicago in 1942 under the direction of Enrico Fermi, the controlled fission experiment was a critical proof-of-concept test whose success opened the path to the development of nuclear explosives.

Both the planetary protection project and atom bomb project are driven by a similar objective—to avoid mass destruction—but are different in another very important way, at least so far: the pattern of human agency. The path from Fermi's controlled fission test in 1942 to a potent workable military device in 1945 was extremely rapid. The pace was so quick because the project was force-fed with vast economic and material resources. In contrast, the progress of planetary protection is resource-starved and very slow. That controlled nuclear fission would lead to weapons capable of vastly increased destructiveness was, of course, the reason the experiment was conducted. Fear that others – particularly Nazi Germany – would successfully weaponize the recent advances in nuclear physics to produce a war-winning superweapon supercharged this technological advance.

However, fear of cosmic collision is like the fear of a catastrophic 500-year flood, easily discounted as an impetus for present, let alone urgent, action. The sleepy pace of the planetary defense effort is, however, inherently subject to sudden and radical change in the wake of a significantly destructive or visible strike. Since there are an estimated 300,000 Tunguska-sized rocks in the inner solar system, almost all undiscovered and untracked, there are plenty of possibilities for such a course-altering strike.

Scenarios of mega-destruction from human space activities have a curiously split-screen presence in contemporary space thinking. On one side, science fiction, widely recognized and celebrated as the seedbed of so many major visions of space activity, from the rocket and satellite to space stations and colonies, is brimming with scenarios of epic violence and total war. But one looks in vain through the plentiful, often rousingly inspirational, advocacy books, studies, and blogs of space enthusiasts for more than minor hints of violent conflict and epic-scale destruction. In the contemporary advocate mindset, space promises an escape from the many woes of our species and planet, not their enlargement. The unspoken assumption seems to be that as technology leaps upward, so too will human capacities to peacefully resolve conflict and avoid the patterns of large-scale violence so prevalent across the political history of humanity. But barring some major alteration of human beings and their basic social capacities, this "elevationist" ethical and political assumption of space thinking is clearly utopian. Indeed, it is in many ways the purist and most high stakes incarnation of the utopianism at the core of scientifictechnological modernity itself: the belief that, as the double-edged swords of technological empowerment become larger and sharper, human capacity to wield them wisely will keep pace.

Thinking about the larger horizon of violence possibilities in space can help underscore a key feature of all space activities, including the baby steps of today's Earth orbital activities, that remains stubbornly underappreciated. That the space environment is radically different from humanity's terrestrial habitats is widely grasped. The space medium—the vast, almost completely empty void stretching from the upper edge of the Earth's atmosphere to the edge of the observable universe billions of light years away—is washed by potent radiation and extreme temperatures, and is a near vacuum, conditions all potentially lethal to human bodies, and all requiring elaborate and extensive countermeasures.

It is also widely recognized that access to space has been so difficult because of the extreme speeds which are necessary to reach and stay there. Simple physics dictates that for an object with the mass of our planet, orbital velocity is some 25,000 kilometers per hour, some 34 times faster than commercial aircraft and much faster than bullets fired from our familiar guns. Simple physics further dictates that collisions between objects travelling at such velocities will be extremely violent, with the energy released being equal to the mass multiplied by the square of the velocity. Thus, even tiny objects—a metal shard, an errant bolt, or even a paint fleck—are potent darts, able to disable or destroy any satellite that happens to be in their path.

This means the space environment is naturally violent in ways radically alien from our terrestrial experiences. Yes, earthquakes, tsunamis, and volcanoes are natural and release enormous quantities of destructive energy. But, fortunately for humanity, such violence occurs infrequently and in particular places. In contrast, the enormous kinetic energies of space are continuously present wherever objects in space are present. "This New Ocean" that John Kennedy poetically evoked in launching the Apollo missions to the Moon is a realm of extreme natural violence, quite unlike the familiar watery realms of Earth.

There is no guarantee that ART will be further developed, and many of the most consequential deployments are not likely to occur very soon. Given this, what should be done differently now? Perhaps most important is a clear recognition of the inherently vast violence potential of this newborn technology, and indeed of almost all space activities. It is unrealistic to think that what we now do, or do not do, will decisively shape or restrain the truly big choices further ahead on the road of space development. But we can help tilt things in the right direction now by making sure that space activities are minimally military and maximally cooperative. This means strengthening, not weakening, the "common heritage of mankind" provisions of the Outer Space

Treaty of 1967. This means striving to ensure that outer space is not yet another domain for war and interstate competition. This means cooperatively building lunar science bases for exploration and resource assessment. This means avoiding a competitive resource scramble for the asteroids by buccaneering corporations and expansionist states. And perhaps most importantly, all tests of redirection technology should be conducted cooperatively by all the leading spacefaring states.

Compared to where we are now headed, these seem like big changes. But they are tiny in comparison to the steps our descendants will need to take to survive in our violence-saturated cosmos.