# AFF – Cosmic Quarry Colonialism

## 1AC

### AC – Advocacy

#### Thus, resolved: The appropriation of outer space by private entities is unjust.

### 1AC – Detritus

#### Advantage 2 is Detritus

#### Asteroid mining spikes the risk of satellite-dust collisions

Scoles 15 ~~[(Sarah Scoles, freelance science writer, contributor at Wired and Popular Science, author of the books Making Contact and They Are Already Here) "Dust from asteroid mining spells danger for satellites," New Scientist, May 27, 2015, <https://www.newscientist.com/article/mg22630235-100-dust-from-asteroid-mining-spells-danger-for-satellites/>~~] TDI

* Study this is citing – Javier Roa, Space Dynamic Group, Applied Physics Department, Technical University of Madrid. Casey J Handmer, Theoretical Astrophysics, California Institute of Technology. Both PhD Candidates. "Quantifying hazards: asteroid disruption in lunar distant retrograde orbits," arXiv, Cornell University, May 14, 2015, <https://arxiv.org/pdf/1505.03800.pdf>

NASA chose the second option for its [Asteroid Redirect Mission](http://www.nasa.gov/content/what-is-nasa-s-asteroid-redirect-mission/), which aims to [pluck a boulder from an asteroid’s surface](https://www.newscientist.com/article/dn27243-rock-grab-from-asteroid-will-aid-human-mission-to-mars) and relocate it to a stable orbit around the moon. But an asteroid’s gravity is so weak that it’s not hard for surface particles to escape into space. Now a new model warns that debris shed by such transplanted rocks could intrude where many defence and communication satellites live – in geosynchronous orbit.

According to [Casey Handmer](http://www.caseyhandmer.com/) of the California Institute of Technology in Pasadena and Javier Roa of the Technical University of Madrid in Spain, 5 per cent of the escaped debris will end up in regions traversed by satellites. Over 10 years, it would cross geosynchronous orbit 63 times on average. A satellite in the wrong spot at the wrong time will suffer a damaging high-speed collision with that dust.

The study also looks at the "catastrophic disruption" of an asteroid 5 metres across or bigger. Its total break-up into a pile of rubble would increase the risk to satellites by more than 30 per cent ([arxiv.org/abs/1505.03800](http://arxiv.org/abs/1505.03800)).

#### Commercial rocket launches produce space clutter—increased debris could reach a tipping point. AND private companies are impossible to control – only space decolonization solves

Thompson 20 [(Clive, author of Coders: The Making of a New Tribe and the Remaking of the World, a columnist for Wired magazine, and a contributing writer to The New York Times Magazine) “Monetizing the Final Frontier The strange new push for space privatization,” December 3, 2020 <https://newrepublic.com/article/160303/monetizing-final-frontier>] TDI

“Physics tells us that two things can’t occupy the same space at the same time or else bad things happen,” Jah said dryly. Indeed, there’s already been one collision that produced sprawling orbital pollution. In 2009, a satellite owned by the U.S. firm Iridium slammed into a decommissioned Russian government satellite at more than 26,000 mph. The crash produced 2,300 pieces of debris, spraying off in all directions. And debris is a particularly gnarly problem in space, because when it’s traveling at thousands of miles an hour, even a marble-size chunk is like a bullet, capable of rendering a damaged satellite inoperable and unsteerable—the owner can no longer fire its boosters to guide it into a higher or lower orbit. There are currently an estimated 500,000 marble-size chunks up there. Decades of space travel by governments left plenty of refuse, ranging from parts of rocket boosters to stray bits of scientific experiments. One particularly grim vision of the future that haunts astronomers is the “Kessler syndrome,” proposed by the astrophysicist Donald Kessler in 1978. Kessler hypothesized that space clutter could reach a tipping point: One really bad collision could produce so much junk that it would trigger a chain reaction of collisions. This disaster scenario would leave hundreds of satellites eventually destroyed, and create a ring of debris that would make launching any new satellites impossible, forever. “Near space is finite—it’s a finite resource,” Jah said. “So now you have this growing trash problem that isn’t being remediated.... And if we exceed the capacity of the environment to carry all this traffic safely, then it becomes unusable.” That’s why a growing chorus of critics are already making the case that space is the next major environmental area to protect, after the oceans and land on Earth. “People seem to really treat resources in space as being infinite,” said Erika Nesvold, an astrophysicist who’s the cofounder of The JustSpace Alliance. “As we’ve seen, people don’t really intuitively understand exponential growth.” That’s the dilemma in a nutshell: The available room in the sky is limited, but the plans for growth are exponential. SpaceX isn’t the only New Space firm looking to toss up satellites. Satellite and rocket start-ups are now lining up en masse, atop new waves of investment. There are satellites geared up to connect to “the internet of things” so companies can communicate among proprietary networks of household devices. There are floating cameras pointing down—so as to gather “geospatial intelligence,” which is to say data streamed from “the vantage point you get from satellites looking down on Earth and giving us information about our planet,” as the venture capitalist Anderson told me. And new forms of satellite vision are emerging all the time, such as cameras that can see at night, or are specially designed to see agriculture. Experiments abound, and so satellite launches will inevitably multiply in their wake. Part of what makes near-Earth orbit so chaotic is that it is, at the moment, remarkably unregulated—not unlike the internet of the early ’90s. An American firm has to get permission from the Federal Communications Commission to launch a satellite, but once it’s in orbit, there’s no federal agency that can compel it to move out of the path of a collision. Satellite owners generally don’t like to move if they can avoid it, because their satellites have a limited amount of fuel; any movement decreases their usable lifespan. On top of that, there are dozens of nations shooting satellites into low-Earth orbit—but no international body coordinating their flight paths. Last fall, the European Space Agency realized one of SpaceX’s new Starlink satellites was on a dangerously close path to an ESA satellite. SpaceX said it had no plans to move the satellite; so the ESA decided to fire its thrusters and get clear. This high-stakes negotiation was conducted via email. What’s more, space debris is extremely hard to source. If a British satellite slams into yours, you can probably figure out who hit you. But if your satellite is wrecked by a random piece of junk, nobody has any clue where that debris came from. It is, in this way, a neat parallel to the problem of C02, where a ceaseless barrage of tiny commercial decisions creates a sprawling problem—one that’s all but designed to ensure that everyone who caused it can deny responsibility. And damage is asymmetric: A company with a small $60,000 satellite could smash into a wildly expensive one paid for by U.S. taxpayers. “A National Reconnaissance Office satellite is at least a billion dollars, if not more, so they have a lot more to lose if something hits a satellite,” Bhavya Lal, a researcher at the IDA Science and Technology Policy Institute, noted. “As more private activity starts to happen, there’s more chances of that loss of control, too.” One might dismiss all this anxiety as a sort of sci-fi version of hippie environmentalism—except that even the administrator of NASA is deeply worried about the chaos and destruction likely to be sown by commercial activity in near-Earth orbit. Jim Bridenstine, the Trump-appointed head of NASA, is as pro-market as one can be. He praises SpaceX every chance he gets; he talks about privatizing the space station. But when I asked him about the looming danger of space debris, during a press-conference call, he conceded that it’s a huge, unresolved issue.

“More satellites mean more risk,” he said. “And we as a nation have not yet caught up to the risk that currently exists in space.” In September, a few months after Bridenstine and I spoke, the space station had to fire its thrusters for 150 seconds to [move out of the way](https://blogs.nasa.gov/spacestation/2020/09/22/station-boosts-orbit-to-avoid-space-debris/) of dangerously approaching space junk, while the crew huddled in a Soyuz capsule in case the station’s hull was breached and they had to flee to Earth.

Apart from the fate of the station, one could ask who cares if a commercial stampede blights Earth’s orbit, and wrecks anyone’s ability to keep satellites aloft? Maybe it’ll just hurt a bunch of investors. And maybe we need less surveillance from deathless orbiting eyes, not more.

There are, though, plenty of civically significant reasons to keep low-Earth orbit usable. Satellite monitoring isn’t solely a spy activity—these days, it has become a powerful tool for climate scientists to figure out how the oceans are warming, and to puzzle out our adaptations to climate change. Other nonprofit concerns use satellites to monitor injustices on Earth: Global Forest Watch, for example, takes data from the 140-satellite array of the firm Planet and uses it to help [bust illegal deforestation](https://www.planet.com/pulse/planet-ksat-and-airbus-awarded-first-ever-global-contract-to-combat-deforestation/).

So it’d certainly be good to keep low-Earth orbit from becoming a junkyard. But there’s no ready consensus on how to do that. Some government regulation could help: Bridenstine wants Congress to pass a bill funding a department in charge of “compelling somebody to maneuver if it’s necessary.” Moriba Jah would like a federal law requiring space firms to openly publish the location of their satellites. (Some, like Planet, already do, but most, as Jah has found, make it very difficult for others to pin down the exact locations of their satellites.) “You can’t enforce anything unless you know what’s happening,” Jah said, and a name-and-shame system could help: “Once people can assign a first and last name, it’s like, OK, these assholes aren’t complying.” Better tech might also assist; the U.S. firm [LeoLabs](https://www.leolabs.space/" \t "_blank) is building a radar-dish array that can track pieces of space junk as small as a few centimeters. Others are working on as-yet-untested ways of actually cleaning up orbital junk, possibly by pushing it down to burn up on reentry.

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New Space firms themselves, however, want to be left alone to deal with this problem. Most I spoke to argued—quite against the weight of industrial history—that the free market would self-regulate, since each firm wants orbits clean enough to make money in. But even some ardent champions of the new commercial boom worry things may get worse before anyone snaps to attention. “Sometimes I think that we might need to have some terrible collision event happening for the world to kind of come together and take it seriously,” Lal told me.

Satellites are the big commercial opportunity in space right now, though there are plenty of others in various states of gestation. Each one raises a handful of intriguing possibilities for a commercial boom, and its own blizzard of questions for earthbound society. One rough rule of thumb for sizing them up might go something like this: The farther out you go from Earth, the weirder the questions become.

The most proximal market, according to investors, is probably the development of [manufacturing in near-Earth orbit](https://www.space.com/40552-space-based-manufacturing-just-getting-started.html), on space stations. Microgravity, it turns out, makes it possible to create materials that can’t easily be pulled together on Earth. The range of product lines for off-planet factories runs from specially shaped contact lenses (designed to correct deep vision problems) to optical fibers capable of carrying more data than cables made on Earth. One firm, [Nanoracks](https://nanoracks.com/" \t "_blank), currently contracts out room for commercial start-ups on the International Space Station. Its early client list boasts a diverse array of for-profit activities—everything from running science experiments to launching small, inexpensive “[Cubesats](https://www.nasa.gov/mission_pages/cubesats/overview" \t "_blank)” that can fit in your hand and mostly do remote sensing (like monitoring the atmosphere) for research or industry. In the long run, Nanoracks aims to launch its own space station to offer complex manufacturing capabilities that wouldn’t currently fit in the International Space Station’s limited confines.

“There’s a lot of work you can do, a lot of research and a lot of exciting things when you’re not connected to a gigantic, humongous modular space station that has different gravity tensions, different forces acting on it, disturbing the microgravity,” Nanoracks CEO Jeffrey Manber noted.

The next generation of space stations will probably be built—like Manber’s hoped-for one—mostly by private interests. Such installations will continue to do plenty of work for governments. Manber would rather make a fully robotic space station—it’s far more profitable for New Space moguls not to shoulder the, ahem, astronomical costs of keeping people alive in outer space—but he anticipates that a major early customer would likely be NASA, and one of NASA’s main scientific areas of study is how humans react to living in space. Any for-profit space station NASA’s contracting agents would bring on would thus likely need to host a crew.

Beyond the space station beckons another old NASA stomping ground—the moon, which has become newly lucrative. After the last Apollo visit in 1972, NASA and Congress abandoned the moon; reaching it had been a quest to beat the Soviets, and, that race won, public support for the incredible expense evaporated. But over the last decade, moon activity has rebooted. Trump [announced](https://www.theatlantic.com/science/archive/2019/03/trump-nasa-moon-2024/585880/) the goal of returning NASA astronauts to the lunar surface; India [tried and failed](https://www.npr.org/2019/11/26/782890646/2-months-after-failed-moon-landing-india-admits-its-craft-crashed) to put a lander down; and last year, [China succeeded](https://www.space.com/42981-china-moon-far-side-panorama-chang-e-4.html). NASA is currently planning to build a lunar [Gateway](https://www.nasa.gov/gateway), a space station orbiting the moon, to assist in regular traffic back and forth; SpaceX has a $7 billion contract for launching its components.

What, exactly, made the moon sexy again? The [discovery of water](http://news.bbc.co.uk/2/hi/science/nature/8544635.stm). Beginning in the late aughts, moon probes have found that craters in the lunar poles contain water ice—some 600 million tons of it, according to one estimate. This instantly changed the moon’s geopolitical and economic import, because water is an enormously precious commodity in space. It’s crucial for life—not just as a fluid, but broken into its constituent molecular parts: oxygen that lets you breathe, and hydrogen for fuel. One scientist’s rough estimate found that the amount of water on the moon could power one space shuttle launch every day for 2,200 years. Several companies announced their eventual goal would be to create landing craft that could reach the moon and mine the water. One such concern, [the Moon Express](https://www.theverge.com/2017/7/12/15958164/moon-express-robot-landers-private-mining-outpost), pitches its mission in a heady compound of colonialist new frontier rhetoric—equal parts Star Trek and Rudyard Kipling: “The Moon is Earth’s 8th continent,” the firm announces on its website.

But even assuming the wet new lunar frontier can be tamed—for all the space-booster rhetoric, it’s still a very spec-ulative prospect, both logistically and economically—there’s a whole host of untested questions about property rights in the great beyond. Space law, it turns out, is very ambiguous about who’s empowered to exploit space resources, and to what geopolitical-cum-commercial ends. There’s an [Outer Space Treaty](https://2009-2017.state.gov/t/isn/5181.htm), signed in 1967 by most major industrial countries, which seeks to establish space as a shared resource for humanity. It lets corporations engage in commercial activities on other celestial bodies—but neither they nor countries can claim property rights; and whatever a corporation does in space, its host country is on the hook for. There is also a Moon Treaty, created in 1979, that bans property rights on the moon and requires equitable use of lunar resources by all nations. But the Moon Treaty is [mostly toothless](https://www.thespacereview.com/article/1954/1); no country that has launched humans into space ever signed it.

The force of those treaties was never certain. But now that there’s possible money at hand, individual countries are openly defying the treaties—writing laws under their own steam to allow property rights in the heavens. In 2015, Obama signed the [SPACE Act](https://psmag.com/social-justice/outer-space-treaties-didnt-anticipate-the-privatization-of-space-travel-can-they-be-enforced), which explicitly gives U.S. firms the rights to any resources they mine from a celestial body. The Trump administration is [actively pushing](https://www.theguardian.com/science/2020/may/05/trump-mining-moon-us-artemis-accords) for firms to mine the moon. Other countries courting New Space firms—[hello, Luxembourg](https://www.technologyreview.com/2019/11/26/131822/why-its-now-the-perfect-time-to-start-a-small-space-agency/)—are following suit.

History, of course, would suggest that treaties crumble when serious money comes into play. Western settlers signed treaties with indigenous people in the Americas, then ignored them, as Lucianne Walkowicz, an astronomer at the [Adler Planetarium](https://www.adlerplanetarium.org/) and another cofounder of the JustSpace Alliance, noted.

“In many cases,” she told me, “treaties are good until somebody discovers something that they want.” She’s a fan of the Outer Space Treaty, finding it “a very, like, hopeful, peaceful, almost Star Trek-esque view of what space is.” She hopes it proves stronger than it looks.

Historically, however, law tends to follow the facts on the ground rather than shape them. When a new geography for commerce opens, whoever shows up first to exploit the resources sets the norm—and then law is written to validate the first movers. “‘First come, first serve’ is essentially what’s going to happen when people start to do things on the moon,” Peter Ward, author of [The Consequential Frontier](https://www.penguinrandomhouse.com/books/610858/the-consequential-frontier-by-peter-ward/), said.

Yet before the great water rush on the moon starts in earnest, one key point is worth pausing over: The supply of ice on the moon is limited. The estimated water reserves up there may be eye-popping at first glance, but they’re not that big. They likely add up to “three to five cubic kilometers of water, based on the studies that have come up,” said James Schwartz, a philosopher who also studies the ethics of space exploration. “Not a lot of water compared to even moderate- or small-size lakes on Earth.” It wouldn’t be that hard for a concerted explosion of commercial activity to chew through it all.

That may sound far-fetched, but, as all these space ethicists note, to the eyes of nineteenth-century explorers and industrialists, our planet seemed limitless, too—and it only took another century-plus of rapid commercial activity to tear through a diminishing store of finite resources. The environmental implications of exhausting the moon seem ludicrously sci-fi and far-off right now, and they’ll remain so for a long time—until, abruptly, they’re not. As with low-Earth orbit, outer space becomes much smaller and more cramped when you start thinking at commercial scale.

In any event, the moon is chiefly envisioned as a way-station project among the most ambitious cohort of space privatizers. A settled moon colony would serve as the push-off point for the main event, commercially speaking, for New Space entrepreneurs: mining the asteroid belt.

Asteroids are almost comically rich in precious materials. The asteroid Ryugu, for example, has about $82 billion in nickel and iron, according to the “[Asterank](https://www.asterank.com/" \t "_blank)” asteroid-value–ranking project. Another, Bennu, boasts a cool $669 million worth of iron and hydrogen. “You could totally collapse the gold and platinum market on Earth by mining asteroids,” joked Jacob Haqq Misra, a senior research investigator with the [Blue Marble Space Institute of Science](https://www.bmsis.org/), a nonprofit that encourages space exploration.

But there’s a hitch: Nobody has much of an idea how you’d actually mine an asteroid. Despite what you’ve seen in lumbering sci-fi epics like Armageddon, merely grabbing hold of a comparatively small, city-block–size object in microgravity is a forbidding physics puzzle—to say nothing of actually refining whatever you find.

One thing’s clear, however: In order to reach an asteroid, you’d need a lot of fuel for robotic probes. (Oxygen, too, if you’re bringing along a human crew.) This would likely be too expensive to do from Earth, given its gravity. The moon, on the other hand, is a sweet spot to base one’s commercial mining endeavors: enough gravity so humans can live in a base and assemble a rotating corps of mining robots, but sufficiently little gravity that launching mining probes at asteroids is easy.

“It takes so much energy to escape Earth’s orbit, by the time you do that, you’re basically halfway to anywhere in the universe,” Anderson said. “The moon as a launchpad—there’s a lot of commercial value there.”

Some New Space firms harbor still greater plans, in line with the classic “civilizing mission” that animated so many colonial land rushes in recent terrestrial history. Jeff Bezos wants to build space stations that rotate fast enough to simulate Earth gravity—and large enough to host entire cities full of residents. It’s a vision he built from a youth steeped in sci-fi. At Princeton, he took a class with Gerard O’Neill, a physicist who’d been [arguing since the 1960s](https://www.bloomberg.com/news/articles/2019-05-13/why-jeff-bezos-s-space-habitats-already-feel-stale) that humanity had to slip the surly bonds of Earth in order to survive over the long haul. O’Neill argued that living in space and mining asteroids represented the only path forward for the human race to continue growing and prospering without laying waste to planet Earth. He laid it out as a simple proposition of geology: If you were to mine the entire Earth down half a mile, leaving it a honeycombed crater, you’d still only get 1 percent of the metals and substances from the three biggest asteroids.

Bezos has eagerly endorsed the space-colony vision. In the short term, Bezos’s plans are the standard-issue vision for the New Space entrepreneur: building rockets and spacecraft that NASA will hire in order to resume landing astronauts on the moon. But in the long run—decades hence—building space colonies is, as he has argued, the only mission he can find big enough to devote his life and riches toward. “The only way that I can see to deploy this much financial resource,” Bezos [told Business Insider](https://www.businessinsider.com/jeff-bezos-interview-axel-springer-ceo-amazon-trump-blue-origin-family-regulation-washington-post-2018-4), “is by converting my Amazon winnings into space travel.”

The unexpected costs of Bezos-style space exploitation are, as yet, a little distant—decades, at least. But if there’s one thing we’ve learned from observing the human and environmental wreckage of the industrial era, it’s that history is like space travel: The path you set at the beginning is critical. Changing course later on is much harder. So it behooves us to plan now. Are there ways to avoid the worst possible outcomes in space? How is commercial life in space going to unfold?

The world’s small community of space ethicists has, in recent years, been increasingly pondering this, and they’ve come to some unsettling conclusions. First off, they note, the big winners in space will likely be ... the big winners on Earth. “I think it’s going to benefit the wealthy people that are running these mining firms,” Schwartz said bluntly. There are, as New Space investors today will tell you, winner-take-all dynamics. Bezos built a supply chain that is helping Amazon gradually dominate the world. Space will probably have room for only a few winners. So in order to envision the future contours of space conquest, it’s probably a safe bet to take all the harms of monopoly we see on this planet and project them on to a literally cosmic scale.

And that leads, in turn, to a corollary prophecy: Human rights in space are likely to be execrable, if they’re left up to the private sector.

Consider that anyone working in space will be reliant upon their employer for the most basic stuff of life. That’s not just food and water, but breathable oxygen, on a minute-by-minute basis. Plenty of science fiction has, over the years, war-gamed the bleak implications of these precarious situations. In Ridley Scott’s [Alien](https://www.imdb.com/title/tt0078748/) (1979), the employees of “The Company” are sent unwittingly to encounter a vicious alien life-form, with The Company hoping it would get a profitable specimen out of this. More recently, the TV show [The Expanse](https://www.imdb.com/title/tt3230854/) depicts the lives of asteroid miners as an outright form of slavery. One could, again, regard this as the typical pessimism of left-wing creative types—until one ponders workers’ rights on Earth as they exist now. Employees in Amazon’s warehouses are already [peeing into bottles](https://www.theverge.com/2018/4/16/17243026/amazon-warehouse-jobs-worker-conditions-bathroom-breaks) and [collapsing from heat exhaustion](https://www.businessinsider.com/amazon-warehouse-2011-9) in their attempt to satisfy their employer’s relentless work quotas; imagine if the company also controlled their breathable air.

Charles Cockell is a professor of astrobiology at the University of Edinburgh who’s written at length about the question of freedom in space settlements. He’s generally a libertarian, so he’s concerned about concentrations of power in both governments and private-sector firms in space.

“The controls on freedom of movement on the moon or Mars are worse than in North Korea,” he told me. “You can’t just walk out of a settlement.” Control of oxygen, he predicted, will empower the worst instincts of authoritarians of any stripe. “It will attract the coercively inclined and petty officialdom like all these things do…. It will attract people who crave power. You have to assume that that will lead to tyranny.”

These thought experiments don’t all conclude in grim dead-ends, however. There’s a whole arm of space ethics and philosophy devoted to asking the questions: Could the prospect of settling space positively serve society and justice? Could it offer up new ways of thinking about how we organize civic relations?

Coping with scarcity in space might impel settlers to reconsider some of the basic tent­poles of Western society. One is prison: On Mars, jailing someone would cost billions. A settlement would, as the astrophysicist and ethicist Nesvold noted, wonder, “Is it even worth it?” They’d be far more liable to consider styles of justice that don’t involve locking people up. The same goes for environmental thinking. Water and air will be so precious to space settlers that “the people who are living in space are going to be much more concerned about resource conservation,” Schwartz said. “It could be the attitudes that we get there are ones that are helpful to send back [to Earth].”

The idea of space as a fresh slate for political thinking is enticing. But it’s hemmed in by the very nature of the market forces currently reaching for the skies. Would any private-sector firms heading to space agree to limit their power when they’re beyond Earth’s grasp? Nesvold and Lucianne Walkowicz think it’s possible. There is, they believe, a window of opportunity right now, while commercial space activity is still ramping up, to convince everyone in New Space—from the firms to their early (and crucial) governmental clients—to take space ethics seriously. They’ve been pursuing two tracks of inquiry along these lines: first, talking directly to New Space companies about the political, social, and environmental aspects of space exploitation. (The smaller firms, Nesvold noted, are often eager to talk; the big ones—the SpaceXs and Blue Origins—not so much.) Walkowicz has also been holding public events to get everyday citizens to discuss, as she put it, “becoming interplanetary.”

“I think making the infrastructure of getting to spaceflight cheaper and more sustainable, reusable, all of that stuff is great—I love watching rocket launches as much as the next person,” Walkowicz told me. But she wants a much broader cross-section of the public to have a voice on how space is used. As she frames things, it’s a simple matter of public accountability: For all the self-mythologizing among New Space titans about the new, scrappy, and libertarian cast of modern space exploration, it’s still NASA—and by extension, the people’s treasury—that’s projected to supply the biggest revenue stream for much New Space activity today, and in the near future. In other words, we the people are paying for many of these rocket launches, and the huge outlays that will help bankroll the hard stuff, like future human colonies on the moon.

So the public ought to have more input on how the projected settlement and exploitation of outer space actually happens. Walkowicz and Nesvold want to create a bigger sample of people informed about the stakes in the new space race, people who’d lobby Congress to help lay down the new American road rules for space—from keeping orbits clean to the question of who gets to ride on those taxpayer-funded rockets in the first place.

Space, in other words, needs to be “decolonized.” That’s a coinage gaining currency among some space thinkers, including Lindy Elkins-Tanton. She’s a planetary scientist with one foot in the world of New Space, and another in the world of space ethics. She’s the head of the NASA [“Psyche” project](https://www.jpl.nasa.gov/missions/psyche/), which is launching a probe next year to explore the metallic asteroid Psyche. On the one hand, she is herself benefiting directly from the lower costs that New Space has created, so she’s generally a fan of commercial interests making space more viable. Her probe will launch on a SpaceX rocket, and it’s so much cheaper than NASA’s older launches that it makes her science far more affordable. (“I’m sure I’m not supposed to tell you, but I’ll tell you: It’s a lot of money,” she said.)

Yet as Elkins-Tanton noted, the story of new frontiers being settled is the history of colonization, fueled by moneyed interests. Whether it was Europeans heading to North America or Africa or parts of Asia, it was generally huge state interests putting up the money for risk-taking explorers—with the explorers getting rich, the states amassing power, the new frontiers becoming gradually stripped of resources, and their indigenous populations either killed or impoverished.

“Decolonization,” as she and other New Space ethicists put it, would be a different route. It’d be the act of exploring space with that history in mind, and working deliberately in concert to avoid its brutalities. What would that mean? Elkins-Tanton argued, like Walkowicz and Nesvold, that any voyages to space need to have much greater democratic participation. For years, she’s been organizing annual projects that bring together a disparate array of thinkers—astrophysicists, artists, indigenous scholars—to plan for things such as how a Mars colony might exist without becoming a human rights nightmare.

#### Private space companies vastly outpace the public sector and avoid regulation which makes it a uniquely dangerous industry

**Rauenzahn et al, 20** (The Regulatory Review, 6-6-2020, accessed on 1-14-2022, The Regulatory Review, "Regulating Commercial Space Activity | The Regulatory Review", https://www.theregreview.org/2020/06/06/saturday-seminar-regulating-commercial-space-activity/)azhang

Scholars address possible strategies to regulate an emerging commercial space industry. After much anticipation, the United States launched a manned rocket ship for the first time in almost a decade. The launch marked a new era of space travel as Elon Musk’s SpaceX became the first private company to transport astronauts to space. But the transformation of spaceflight from a public endeavor to a commercial industry raises questions about how to regulate the activities of private entities in space. In 2014, the National Aeronautics and Space Administration (NASA) outsourced the task of transporting its astronauts, granting billion-dollar contracts to SpaceX and Boeing in a program called Commercial Crew. NASA astronauts Doug Hurley and Bob Behnken became the first crew to enter space under this public-private program. Over the next few decades, NASA plans to rely on this commercial partnership to pursue even more ambitious goals: returning to the moon and sending astronauts to Mars. But private companies have their own aspirations for outer space. Musk hopes to use SpaceX to start a human colony on Mars. Amazon’s Jeff Bezos also has his sights set on space colonization, and firms such as Bigelow Aerospace and Axiom Space plan to develop their own space stations. Some investors see opportunities in space tourism and mining. But these for-profit goals raise serious concerns about who can claim ownership of space resources and what law will govern private activity in uncharted frontiers. International space law is governed by a 1967 agreement known as the Outer Space Treaty⁠. The treaty allows all nations to use and explore the moon and celestial bodies, prohibits claims of sovereignty, and it requires nations to oversee the activities of private space companies. But existing space law has not kept up with the growth in the private sector, and the United States lacks a comprehensive regulatory regime. In anticipation of a growing commercial space industry, some experts and scholars call for more robust regulation. This week’s Saturday Seminar focuses on possible legal frameworks for governing commercial activity in outer space.

#### Space dust wrecks satellites and debris exponentially spirals

Intagliata 17 ~~[(Christopher Intagliata, MA Journalism from NYU, Editor for NPRs All Things Considered, Reporter/Host for Scientific American’s 60 Second Science) "The Sneaky Danger of Space Dust," Scientific American, May 11, 2017, <https://www.scientificamerican.com/podcast/episode/the-sneaky-danger-of-space-dust/>~~] TDI

When tiny particles of space debris slam into satellites, the collision could cause the emission of hardware-frying radiation, Christopher Intagliata reports.

Aside from all the satellites, and the space station orbiting the Earth, there's a lot of trash circling the planet, too. Twenty-one thousand [baseball-sized chunks](https://www.scientificamerican.com/article/orbital-debris-space-fence/) of debris, [according to NASA](https://www.orbitaldebris.jsc.nasa.gov/faq.html). But that number's dwarfed by the number of small particles. There's hundreds of millions of those.

"And those smaller particles tend to be going fast. Think of picking up a grain of sand at the beach, and that would be on the large side. But they're going 60 kilometers per second."

Sigrid Close, an applied physicist and astronautical engineer at Stanford University. Close says that whereas mechanical damage—like punctures—is the worry with the bigger chunks, the dust-sized stuff might leave more insidious, invisible marks on satellites—by causing electrical damage.

"We also think this phenomenon can be attributed to some of the failures and anomalies we see on orbit, that right now are basically tagged as 'unknown cause.'"

Close and her colleague Alex Fletcher modeled this phenomenon mathematically, based on plasma physics behavior. And here's what they think happens. First, the dust slams into the spacecraft. Incredibly fast. It vaporizes and ionizes a bit of the ship—and itself. Which generates a cloud of ions and electrons, traveling at different speeds. And then: "It's like a spring action, the electrons are pulled back to the ions, ions are being pushed ahead a little bit. And then the electrons overshoot the ions, so they oscillate, and then they go back out again."

That movement of electrons creates a pulse of electromagnetic radiation, which Close says could be the culprit for some of that electrical damage to satellites. The study is in the journal Physics of Plasmas. ~~[Alex C. Fletcher and Sigrid Close, [Particle-in-cell simulations of an RF emission mechanism associated with hypervelocity impact plasmas](http://aip.scitation.org/doi/full/10.1063/1.4980833)~~]

#### Early warning satellites going dark signals attacks – causes miscalc and goes nuclear

Orwig 16 ~~[(Jessica, MS in science and tech journalism from Texas A&M, BS in astronomy and physics from Ohio State) "Russia says a growing problem in space could be enough to spark a war," Insider,’ January 26, 2016, <https://www.businessinsider.com/russia-says-space-junk-could-spark-war-2016-1>~~] TDI

NASA has already warned that the large amount of space junk around our planet is growing beyond our control, but now a team of Russian scientists has cited another potentially unforeseen consequence of that debris: War.

Scientists estimate that anywhere from 500,000 to 600,000 pieces of human-made space debris between 0.4 and 4 inches in size are currently orbiting the Earth and traveling at speeds over 17,000 miles per hour.

If one of those pieces smashed into a military satellite it "may provoke political or even armed conflict between space-faring nations," Vitaly Adushkin, a researcher for the Institute of Geosphere Dynamics at the Russian Academy of Sciences, reported in a paper set to be published in the peer-reviewed journal Acta Astronautica, which is sponsored by the International Academy of Astronautics.

Say, for example, that a satellite was destroyed or significantly damaged in orbit — something that a 4-inch hunk of space junk could easily do traveling at speeds of 17,500 miles per hour, Adushkin reported. (Even smaller pieces no bigger than size of a pea could cause enough damage to the satellite that it would no longer operate correctly, he notes.)

It would be difficult for anyone to determine whether the event was accidental or deliberate.

This lack of immediate proof could lead to false accusations, heated arguments and, eventually, war, according to Adushkin and his colleagues.

A politically dangerous dilemma

In the report, the Adushkin said that there have already been repeated "sudden failures" of military spacecraft in the last two decades that cannot be explained.

"So, there are two possible explanations," he wrote. The first is "unregistered collisions with space objects." The second is "machinations" ~~[deliberate action~~] of the space adversary.

"This is a politically dangerous dilemma," he added.

But these mysterious failures in the past aren't what concerns Adushkin most.

It's a future threat of what experts call the cascade effect that has Adushkin and other scientists around the world extremely concerned.

The Kessler Syndrome

In 1978, American astrophysicist Donald Kessler predicted that the amount of space debris around Earth would begin to grow exponentially after the turn of the millennium.

Kessler 's predictions rely on the fact that over time, space junk accumulates. We leave most of our defunct satellites in space, and when meteors and other man-made space debris slam into them, you get a cascade of debris.

The cascade effect — also known as the Kessler Syndrome — refers to a critical point wherein the density of space junk grows so large that a single collision could set off a domino effect of increasingly more collisions.

For Kessler, this is a problem because it would "create small debris faster than it can be removed," Kessler said last year. And this cloud of junk could eventually make missions to space too dangerous.

For Adushkin, this would exacerbate the issue of identifying what, or who, could be behind broken satellites.

The future

So far, the US and Russian Space Surveillance Systems have catalogued 170,000 pieces of large space debris (between 4 and 8 inches wide) and are currently tracking them to prevent anymore dilemmas like the ones Adushkin and his colleagues cite in their paper.

But it's not just the large objects that concern Adushkin, who reported that even small objects (less than 1/3 of an inch) could damage satellites to the point they can't function properly.

Using mathematical models, Adushkin and his colleagues calculated what the situtation will be like in 200 years if we continue to leave satellites in space and make no effort to clean up the mess. They estimate we'll have:

1.5 times more fragments greater than 8 inches across

3.2 times more fragments between 4 and 8 inches across

13-20 times more smaller-sized fragments less than 4 inches across

"The number of small-size, non-catalogued objects will grow exponentially in mutual collisions," the researchers reported.

#### Anti-Satellite Weapons and Space Debris Collisions Lead to Arms Race and War – extinction

**Blatt 20** Talia M. Blatt [I am a rising sophomore at Harvard, considering a joint concentration in Social Studies and Integrative Biology with a citation in Chinese. I specialize in East Asian geopolitics and security issues]., 26.MAY.2020, "Anti-Satellite Weapons and the Emerging Space Arms Race," Harvard International Review, https://hir.harvard.edu/anti-satellite-weapons-and-the-emerging-space-arms-race/

Despite their deterrent functions, ASATs are more likely to provoke or exacerbate conflicts than dampen them, especially given the risk they pose to early warning satellites. These satellites are a crucial element of US ballistic missile defense, capable of detecting missiles immediately after launch and tracking their paths. Suppose a US early warning satellite goes dark, or is shut down. Going dark could signal a glitch, but in a world in which other countries have ASATs, it could also signal the beginning of an attack. Without early warning satellites, the United States is much more susceptible to nuclear missiles. Given the strategy of counterforcing—targeting nuclear silos rather than populous cities to prevent a nuclear counterattack—the Americans might believe their nuclear weapons are imminently at risk. It could be twelve hours before the United States regains satellite function, which is too long to wait to put together a nuclear counterattack. The United States, therefore, might move to mobilize a nuclear attack against Russia or China over what might just be a piece of debris shutting off a satellite. Additionally, accidental warfare, or strategic miscalculation, is uniquely likely in space. It is much easier to hold an adversary’s space systems in jeopardy with destructive ASATs than it is to sustainably defend a system, which is expensive and in some cases not technologically feasible because of limitations on satellite movement. Space is therefore considered offense-dominant; offensive tactics like weapons development are prioritized over defensive measures, such as improving GPS or making satellites more resistant to jamming. As a result, countries are left with poorly defended space systems and rely on offensive posturing, which increases the risk that their actions are perceived as aggressive and incentivizes rapid, risky counterattacks because militaries cannot rely on their spaced-based systems after first strikes. There are several hotspots in which ASATs and offensive-dominant systems are particularly relevant. Early warning satellites play a central role in US readiness in the event of a conflict involving North Korea. News of North Korean missile launches comes from these satellites. Given North Korea’s history of nuclear provocations, unflinchingly hostile rhetoric towards the United States and South Korea, and diplomatic opacity, North Korea is always a threatening, unknowable adversary, but recent developments have magnified the risk. With the health of Kim Jong-un potentially in jeopardy, a succession battle or even civil war on the peninsula raises the chances of loose nukes. If the regime is terminal, traditional MAD risk calculus will become moot; with nothing to lose, North Korea would have no reason to hold back its nuclear arsenal. Or China might decide to seize military assets and infrastructure of the regime. If the US does not have its early warning satellites because they have been taken out in an ASAT attack, the US, South Korea, and Japan are all in imminent nuclear peril, while China could be in a position to fundamentally reshape East Asian geopolitics. The South China Sea is another hotspot in which ASATs could risk escalation. China is developing Anti-Access Area Denial (A2/AD) in the South China Sea, a combination of long range radar with air and maritime defense meant to deny US freedom of navigation in the region. Given the disputed nature of territory in the South China Sea, the United States and its allies do not want China to successfully close off the region. But the most effective way to break an A2/AD system would be with anti-satellite weapons. ASATs could neutralize the maritime surveillance China relies upon to deny access to the region and guide cruise missiles. Thus, China is extremely wary of US ASAT development: risks to Beijing’s South China Sea strategy are seen as threats to China itself because of territorial sovereignty claims that are deeply important to the regime and have only become more pronounced under President Xi Jinping. If a Chinese satellite went dark, Beijing might perceive it as a US ASAT designed to undermine the A2/AD approach, and escalate with conventional force. Many of these conflict scenarios start with the loss of satellite function, which may seem unlikely. But ASATs threaten satellites through more than just direct attack. ASAT testing, rather than deployment, risks the exponential accumulation of debris, which endangers satellites and creates a host of other problems. KE-ASATs rely on smashing satellites into thousands of pieces, so each test adds tremendous amounts of space debris. The 2007 Chinese KE-ASAT test alone increased the number of objects in orbit by 20 percent, producing more than two thousand pieces of debris large enough to be tracked and likely thousands more too small to be counted that will remain in orbit for centuries. Even the smallest pieces of debris can do great damage; traveling at more than 15,000 miles per hour, they can crash into other debris in a proliferation known as the Kessler Syndrome. The situation in space could approach a critical mass in which collision cascading occurs even if all launches were halted, choking orbits with debris until all satellites are destroyed and spaceflight rendered impossible. Compared to the negligible debris created during commercial launches, ASAT tests—especially if the arms race continues to escalate and countries with less developed space programs join with cruder designs—may accelerate the debris in space closer and closer to this critical mass. If debris knocks out a satellite, an increasingly likely possibility in a world with ASAT tests, then the aforementioned conflict scenarios become more likely. Conflict aside, ASAT-based debris clouds are terrifying in their own right. Public health, transportation, climate science, and a litany of other crucial infrastructures are dependent on satellites that are now at risk. Satellite GPS is a cornerstone of the modern economy; some pundits believe that the slightest glitch in GPS satellites could shock the stock market and further destabilize an unstable global economy. During the pandemic, satellites are playing a crucial role in geospatial data collection for infectious disease modeling. Essentially, it is hard to imagine a world without satellites, but that is a possible outcome given that there are no reliable methods of withdrawing debris from space.

#### Nuke war causes extinction – it won’t stay limited

Edwards 17 ~~[(Paul N. Edwards, CISAC’s William J. Perry Fellow in International Security at Stanford’s Freeman Spogli Institute for International Studies. Being interviewed by EarthSky/card is only parts of the interview directly from Paul Edwards.) "How nuclear war would affect Earth’s climate," EarthSky, September 8, 2017, earthsky.org/human-world/how-nuclear-war-would-affect-earths-climate~~] TDI

We are not talking enough about the climatic effects of nuclear war.

The "nuclear winter" theory of the mid-1980s played a significant role in the arms reductions of that period. But with the collapse of the Soviet Union and the reduction of U.S. and Russian nuclear arsenals, this aspect of nuclear war has faded from view. That’s not good. In the mid-2000s, climate scientists such as Alan Robock (Rutgers) took another look at nuclear winter theory. This time around, they used much-improved and much more detailed climate models than those available 20 years earlier. They also tested the potential effects of smaller nuclear exchanges.

The result: an exchange involving just 50 nuclear weapons — the kind of thing we might see in an India-Pakistan war, for example — could loft 5 billion kilograms of smoke, soot and dust high into the stratosphere. That’s enough to cool the entire planet by about 2 degrees Fahrenheit (1.25 degrees Celsius) — about where we were during the Little Ice Age of the 17th century. Growing seasons could be shortened enough to create really significant food shortages. So the climatic effects of even a relatively small nuclear war would be planet-wide.

What about a larger-scale conflict?

A U.S.-Russia war currently seems unlikely, but if it were to occur, hundreds or even thousands of nuclear weapons might be launched. The climatic consequences would be catastrophic: global average temperatures would drop as much as 12 degrees Fahrenheit (7 degrees Celsius) for up to several years — temperatures last seen during the great ice ages. Meanwhile, smoke and dust circulating in the stratosphere would darken the atmosphere enough to inhibit photosynthesis, causing disastrous crop failures, widespread famine and massive ecological disruption.

The effect would be similar to that of the giant meteor believed to be responsible for the extinction of the dinosaurs. This time, we would be the dinosaurs.

Many people are concerned about North Korea’s advancing missile capabilities. Is nuclear war likely in your opinion?

At this writing, I think we are closer to a nuclear war than we have been since the early 1960s. In the North Korea case, both Kim Jong-un and President Trump are bullies inclined to escalate confrontations. President Trump lacks impulse control, and there are precious few checks on his ability to initiate a nuclear strike. We have to hope that our generals, both inside and outside the White House, can rein him in.

North Korea would most certainly "lose" a nuclear war with the United States. But many millions would die, including hundreds of thousands of Americans currently living in South Korea and Japan (probable North Korean targets). Such vast damage would be wrought in Korea, Japan and Pacific island territories (such as Guam) that any "victory" wouldn’t deserve the name. Not only would that region be left with horrible suffering amongst the survivors; it would also immediately face famine and rampant disease. Radioactive fallout from such a war would spread around the world, including to the U.S.

It has been more than 70 years since the last time a nuclear bomb was used in warfare. What would be the effects on the environment and on human health today?

To my knowledge, most of the changes in nuclear weapons technology since the 1950s have focused on making them smaller and lighter, and making delivery systems more accurate, rather than on changing their effects on the environment or on human health. So-called "battlefield" weapons with lower explosive yields are part of some arsenals now — but it’s quite unlikely that any exchange between two nuclear powers would stay limited to these smaller, less destructive bombs.

#### Privatization drive rivalries and exponentially increases debris.

BERNAT 20. Pawel @ Military University of Aviation. 11/4/20. [SAFETY ENGINEERING OF ANTHROPOGENIC OBJECTS, “ORBITAL SATELLITE CONSTELLATIONS AND THE GROWING THREAT OF KESSLER SYNDROME IN THE LOWER EARTH ORBIT,” Volume 4, PDF] Justin

5. Orbital satellite constellations and the growing threat of the Kessler syndrome

Space 2.0 – the new era of space exploration that we witness now in the 21st century means, in words of Buzz Aldrin, “moving human enterprise into space” (Pyle, 2019, p. xiv). The process of commercialization of outer space has already begun and is not limited to private companies providing technologies and services for national or international space agencies, as it was in the past. On the contrary, private companies from the space sector have now matured to carry out their own independent projects.

As for 2020, SpaceX is a company that serves as the best example – it launches satellites to the orbit, both for state and private contractors, it successfully realized two crew missions to the International Space Station, and is in the process of constructing Starlink satellite constellation that will provide high-speed internet access across the planet.

Each satellite weighs around 260 kg, is equipped with an ion propulsion system, autonomous collision avoidance system, and orbits Earth at approximately 540-560 km altitude (Starlink, 2020). At the beginning of November 2020, more than 860 Starlink satellites were orbiting the Earth (Jewett, 2020). Immediate plans include launching 12,000 satellites, but they assume a potential later extension to 42,000 (Henry, 2019a). Of course, SpaceX has employed, at least declaratively, all necessary measures to keep the space clean – the satellites are equipped with the deorbiting system, and in the event of inoperability of the propulsion system (Starlink, 2020). The orbital collisions are, however, inevitable. As it was shown before, the possibility of collisions grows with the number of orbital objects. Bastida Virgili with the team compared (2016, p. 154-155) orbital debris environment development without and with a large hypothetical constellation consisting of merely 1080 satellites, distributed across 20 orbital planes at 1,100 km altitude (Fig. 5).

Chart, line chart

Description automatically generated

Figure 5. Comparison of long term evolution of the number of objects in LEO with and without the constellation (Virgili et al., 2016, p. 155)

It has to be noted that although SpaceX’s Starlink is the only constellation that is being built in orbit, it is not the only one planned. There are at least a few initiatives aiming at the same goal – to construct internet infrastructure at the Earth’s orbit. The planned Kuiper Systems LLC, which is a subsidiary of Amazon and intends to place 3,236 broadband satellites in the LEO, is one of Starlink’s biggest competitors (Henry, 2019b). Now, there is even a rivalry between the two companies because Kuiper’s lowest orbital shell is planned to be 590 km, with a tolerance of 9 km either above or below (Cao, 2020), which is the altitude of Starlink satellites. Moreover, the race for space in orbit is now at the beginning.

The outer space is vast. It increasingly becomes more cluttered with both operational satellites and space debris. The threat of collisions increases and no institution or body has enough power to license, coordinate and regulate what is sent to the orbit. The UNOOSA has not such power. National states decide what the companies from the space industry can launch to space. In the United States, which is most advanced in the area of private constellations, it is the Federal Aviation Administration (FAA) that issues the appropriate approvals. The race to put broadband internet satellites bears similarities to the gold rush – there are no rules, at the global level, apart from first-come, first-served.

#### Models are rigorous—inserted below.

Virgili et al. 16. Bastida, J.C. Dolado, H.G. Lewis, J. Radtke, H. Krag, B. Revelin, C. Cazaux b , C. Colombo, R. Crowther, M. Metz. 4/26/16. [Act Astranautica “Risk to space sustainability from large constellations of satellites,” <https://sci-hub.se/10.1016/j.actaastro.2016.03.034>.] Justin

1.3. Simulation approach and result analysis A Monte Carlo (MC) approach was used to simulate the evolution of the object population over a period of 200 years under different post-mission disposal requirements, with four different tools (MEDEE – Modelling the Evolution of Debris on Earth's Environment [9], LUCA – Long Term Utility for Collision Analysis [10], DAMAGE – Debris Analysis and Monitoring Architecture to the Geosynchronous Environment [11] and DELTA – Debris Environment Long Term Analysis [12]). For analysis purposes, the effective number of objects was used where the contribution to the population by each object was weighted by the proportion of the orbital period spent in LEO. In a first step, four different evolutionary models performed an analysis of two reference scenarios. One scenario considered only the evolution of the background population and non-constellation traffic. The second scenario augmented the first with the addition of the representative constellation, with the requirement that 90% of the constellation satellites achieved post-mission disposal to orbits with remaining lifetimes of 25 years. The manoeuvres performed at the mission end to meet the disposal requirement are assumed to be impulsive (i.e. instantaneous) and result in an eccentric orbit with the apogee near the original (constellation) altitude and the perigee at an altitude such that the effects of atmospheric drag would cause the orbit to decay within 25 years. Two of the models considered an apogee remaining at the operational constellation altitude, while the other two reduced the apogee by 50 km. The purpose of these scenarios is to provide a cross-comparison of the models in terms of their predictions of the total object population, which take into account the effects of the constellation. As the distribution of the MC results for the models is of the same nature and the results are independent, a bootstrapping [20] approach is used to derive the mean, the standard deviation and the confidence levels at 95% of the combined results of all the MC runs from the four models (cf. Fig. 1), although not all the models performed the same number of MC runs (see Table 1). The main source of variation inside a particular model's MC runs included the randomness in collision activity, while the different models used their own solar activity forecast.

#### Aff solves better.

David 21 – Leonard, 4/14/21, Leonard David is author of Moon Rush: The New Space Race (National Geographic, 2019) and Mars: Our Future on the Red Planet (National Geographic, 2016). He has been reporting on the space industry for more than five decades, [“Space Junk Removal Is Not Going Smoothly,” Scientific American, <https://www.scientificamerican.com/article/space-junk-removal-is-not-going-smoothly/>] Justin

“From my perspective, the best solution to dealing with space debris is not to generate it in the first place,” says T. S. Kelso, a scientist at CelesTrak, an analytic group that keeps an eye on Earth-orbiting objects. “Like any environmental issue, it is easier and far less expensive to prevent pollution than to clean it up later. Stop leaving things in orbit after they have completed their mission.” There simply is no “one-size-fits-all solution” to the problem of space junk, Kelso says. Removing large rocket bodies is a significantly different task than removing the equivalent mass of a lot more smaller objects, which are in a wide range of orbits, he observes. Meanwhile innovations by companies such as SpaceX are dramatically lowering launch costs, opening the floodgates for far more satellites to reach low-Earth orbit, where some will inevitably fail and become drifting, debris-generating hazards (unless they are removed by ELSA-d-like space tugs). “Many of these operators are starting to understand the difficulty and complexity of continuing to dodge the growing number of debris.” Space junk ranges from nanoparticles to whole spacecraft such as the European Space Agency’s Envisat, which is the size of a double-decker bus and at the top of everyone's removal hit list, says Alice Gorman, a space archaeologist and space junk expert at Flinders University in Australia. There are also objects such as despin weights, which are solid lumps of metal, and thermal blankets, which are paper-thin. “They’ll cause different types of damage and may need different strategies to remove. There is no way that a one-size-fits-all approach is going to do it,” Gorman says. The most serious risks, she says, come from debris particles between one and 10 centimeters in size. “There’s far more of them than whole defunct spacecraft, and there is a far greater probability of collision,” Gorman says. “While debris this size might not cause a catastrophic breakup, collision with it can certainly damage working satellites and create new debris particles.” Turning her attention to satellite mega constellations, Gorman worries about their effects in a low-Earth orbital environment that is already congested. “We also know that orbital dynamics can be unpredictable,” she says. “I want to see some of these mega constellation operators releasing their long-term modeling for collisions as more and more satellites are launched.” There is no doubt that active orbital debris removal is technically challenging, Gorman says. “However, the big issue is that any successful technology that can remove an existing piece of debris can also be used as an antisatellite weapon,” she says. “This is a whole other can of worms that requires diplomacy and negotiation and, most importantly, trust at the international level.” Indeed, the ability to cozy up to spacecraft in orbit and perform servicing or sabotage has spurred considerable interest from military planners in recent years, says Mariel Borowitz, an associate professor at the Georgia Institute of Technology’s Sam Nunn School of International Affairs. “These rapidly advancing technologies have the potential to be used for peaceful space activities or for warfare in space,” she says. “Given the dual-use nature of their capabilities, it’s impossible to know for sure in advance how they’ll be used on any given day.” TAKING UP SPACE For now, according to Moriba Jah, an orbital debris expert at the University of Texas at Austin, the business case for space debris removal is not monetizable and is more a “PowerPoint talk” than a real marketplace. “I think people are hoping that government basically comes to some common sense to help create and establish a marketplace for industries to engage in these sorts of activities,” Jah says. In order for that to happen, he believes that spacefaring nations have to agree that near-Earth space is an ecosystem like land, air and the ocean. “It’s not infinite, so we need environmental protection,” he says.

### 1AC – Framing

#### Extinction first --- moral uncertainty.

Bostrom 12 [(Nick Bostrom, Faculty of Philosophy & Oxford Martin School University of Oxford) “Existential Risk Prevention as Global Priority.” Global Policy, 2012] TDI

These reflections on moral uncertainty suggest an alternative, complementary way of looking at existential risk; they also suggest a new way of thinking about the ideal of sustainability. Let me elaborate. Our present understanding of axiology might well be confused. We may not now know — at least not in concrete detail — what outcomes would count as a big win for humanity; we might not even yet be able to imagine the best ends of our journey. If we are indeed profoundly uncertain about our ultimate aims, then we should recognize that there is a great option value in preserving — and ideally improving — our ability to recognize value and to steer the future accordingly. Ensuring that there will be a future version of humanity with great powers and a propensity to use them wisely is plausibly the best way available to us to increase the probability that the future will contain a lot of value. To do this, we must prevent any existential catastrophe.

**Pleasure and pain are intrinsically valuable.**

Moen 16 [Ole Martin Moen, Research Fellow in Philosophy at University of Oslo “An Argument for Hedonism” Journal of Value Inquiry (Springer), 50 (2) 2016: 267–281] TDI

Let us start by observing, empirically, that a widely shared judgment about intrinsic value and disvalue is that pleasure is intrinsically valuable and pain is intrinsically disvaluable. On virtually any proposed list of intrinsic values and disvalues (we will look at some of them below), pleasure is included among the intrinsic values and pain among the intrinsic disvalues. This inclusion makes intuitive sense, moreover, for there is something undeniably good about the way pleasure feels and something undeniably bad about the way pain feels, and neither the goodness of pleasure nor the badness of pain seems to be exhausted by the further effects that these experiences might have. “Pleasure” and “pain” are here understood inclusively, as encompassing anything hedonically positive and anything hedonically negative.2 The special value statuses of pleasure and pain are manifested in how we treat these experiences in our everyday reasoning about values. If you tell me that you are heading for the convenience store, I might ask: “What for?” This is a reasonable question, for when you go to the convenience store you usually do so, not merely for the sake of going to the convenience store, but for the sake of achieving something further that you deem to be valuable. You might answer, for example: “To buy soda.” This answer makes sense, for soda is a nice thing and you can get it at the convenience store. I might further inquire, however: “What is buying the soda good for?” This further question can also be a reasonable one, for it need not be obvious why you want the soda. You might answer: “Well, I want it for the pleasure of drinking it.” If I then proceed by asking “But what is the pleasure of drinking the soda good for?” the discussion is likely to reach an awkward end. The reason is that the pleasure is not good for anything further; it is simply that for which going to the convenience store and buying the soda is good.3 As Aristotle observes: “We never ask [a man] what his end is in being pleased, because we assume that pleasure is choice worthy in itself.”4 Presumably, a similar story can be told in the case of pains, for if someone says “This is painful!” we never respond by asking: “And why is that a problem?” We take for granted that if something is painful, we have a sufficient explanation of why it is bad. If we are onto something in our everyday reasoning about values, it seems that pleasure and pain are both places where we reach the end of the line in matters of value.

#### Thus, the standard is maximizing expected well-being – prefer:

#### 1] Actor specificity – Governments must aggregate since every policy benefits some and harms others, which also means side constraints freeze action.

#### 2] **No act-omission distinction—governments are responsible for everything in the public sphere so inaction is implicit authorization of action: they have to yes/no bills, which means everything collapse to aggregation.**

### Other

#### 1] Indo Soft Power dead – GDP decline, Kashmir, foreign aid, Muslim policies, vaccine diplomacy, COVID

Mullen 6/29 Rani D. Mullen, associate professor of government at the College of William and Mary, East-West Center, "Covid’s Impact on India’s Soft Power in the Indo-Pacific | East-West Center | www.eastwestcenter.org", June 29, 2021, https://www.eastwestcenter.org/publications/covid%E2%80%99s-impact-india%E2%80%99s-soft-power-in-the-indo-pacific TDI

Signals of India’s global soft power include ancient Hindu temples in Bali and Angkor Wat, Gandhi’s nonviolent resistance influencing the US civil rights movement, the popularity of Bollywood movies, and the economic and social impact of Indian migrant workers in the Gulf states to Singapore. Indian soft power is also audible in the southern Indian language of Tamil being an official language of Sri Lanka and Singapore.

In the first decade of the 21st century, Indian soft power increased as its democracy deepened, its economy grew, and it became a role model for many countries in the region. Indian politics evolved into a competitive two-party system, and the economy doubled in purchasing power parity terms between 2000 and 2010. India also increased its foreign and humanitarian aid from just over $200 million annually at the turn of the century to $1.5 billion in 2015. By the second decade of the 21st century, India was becoming a country to emulate: a developing country that had a consolidated, competitive democracy, a rapidly growing economy, and a growing foreign aid program.

Yet even before the Covid pandemic’s disastrous impact on India, its soft power had been declining. Despite campaigning in 2014 on a platform of economic growth, under Prime Minister Modi’s government, India’s GDP growth rate dropped from around 8 percent in 2015 to 4 percent by 2019. During this period, eroding civil liberties also undermined India’s democratic character, as the state of Jammu and Kashmir was stripped of its constitutional special status, and parliament passed the 2019 Citizenship Act, which was widely regarded as “anti-Muslim.” Indian development assistance allocations, the majority of which went to neighboring countries, also declined to under $1 billion in 2020. Subsequently, at the beginning of 2020, India’s soft power was deteriorating as measured by the internationally recognized Brand Finance’s Global Soft Power Index.

Indian soft power during the Covid pandemic: Exacerbating an already declining trend

India, which in 2020 appeared to avoid the high infection and death rates experienced by richer countries like the United States, was devastated by a second wave of the pandemic starting in February 2021. By June 2021, India’s official numbers of Covid cases and deaths were among the world’s highest despite likely being severely undercounted. The catastrophic Covid situation in mid-2021 further undermined Indian soft power and influence in the Indo-Pacific region. As the country’s economy was battered, its democratic norms continued to be undermined, foreign aid decreased, and a vaccine diplomacy effort failed.

In 2020-21, India’s economy took a battering while other countries in its neighborhood were less affected, further denting its image as the South Asian economic powerhouse. According to the World Bank, India’s economy had a 4 percent growth rate in 2019, followed by a 7 percent contraction in the government’s fiscal year ending in March 2021. Given the ongoing impact of Covid, analysts have slashed India’s GDP growth forecast for 2021-22 from 11 percent to 8 percent. At the same time, India’s neighbor Bangladesh, which has been one of the largest recipients of Indian foreign aid, overtook India in GDP per capita.

India’s democracy also continued to deteriorate in 2020-21 as measured by all international rankings. Notably, Freedom House, which ranks countries on their level of political rights and civil liberties, downgraded India for the first time from “free” to “partly free,” largely due to discriminatory policies against the Muslim population and the squelching of dissenting civil society groups by the government. By contrast, democracy scores for India’s neighbors Bangladesh and Bhutan improved during 2021 in many rankings.

Arguably, India’s soft power appeal has been most visibly undermined by its declining foreign aid and its failed vaccine diplomacy. Indian aid to its neighbors had already declined during the five years before the pandemic in 2020. Yet India’s status as the world’s leading producer of pharmaceuticals led it to engage in vaccine diplomacy. As late as March 2021, when the pandemic’s second wave was already devastating India, Prime Minister Modi promised at a meeting of the security alliance known as the “Quad” that Indian-manufactured vaccines were going to help the world. By early 2021, India gifted over 3 million vaccine doses to Bangladesh, 1 million to Nepal, and 500,000 to Sri Lanka. It also had contracts with many countries in the Indo-Pacific and beyond to deliver millions more. Moreover, the Quad alliance announced a vaccine initiative by which American, Australian, and Japanese funds would be used to produce vaccines in India and distribute them throughout the Indo-Pacific.

Yet, instead of delivering vaccines, India instituted a vaccine export ban in April 2021 to deal with its own second wave of Covid, which saw the health care system collapse in many cities. Within India, criticism of Modi’s handling of the crisis grew, resulting in further government attempts to stifle dissent. At the same time, criticism of India also increased outside its borders as countries in Africa and Asia were left scrambling to find other sources of vaccines–a demand which China and Russia were particularly happy to fill.

India’s image as a regional economic powerhouse, a consolidated democracy, and a reliable regional leader and development partner–all factors contributing to its soft power–has been increasingly undermined over the past seven years, a trend exacerbated by the Covid crisis. While a 2021 Pew Survey found that a plurality of Americans had neutral views of India, the ISEAS 2021 Survey of Southeast Asia found that more than half of the respondents had little or no confidence in India as a major power in the region due to its preoccupation with domestic issues and lack of capacity on global leadership–a trust deficit only outdone by China. Brand Finance’s rankings of soft power saw India fall 9 places to 36th place in 2021. Soft power can be more difficult than hard power to build or orchestrate. Even as the country recovers from the Covid pandemic and the economy rebounds, India’s image as a model that others want to emulate and partner with will face a more difficult recovery..

#### 2] Soft power not enough – India misplaces focus and fails to create hard solutions

Sushant Sareen, Sushant Sareen is Senior Fellow at Observer Research Foundation. MA Economics, Delhi School of Economics, University of Delhi, 10-11-2018, "When soft power is not enough," ORF, https://www.orfonline.org/research/when-soft-power-not-enough-44889/ TDI

That soft power is an extremely important component of foreign policy is a no-brainer. But it is, at best, one of the necessary conditions or components of foreign policy. Without hard power (both military and economic) and the ability to exercise “smart power” — a term first coined by the US diplomat Joseph Nye Jr. — soft power alone itself will never be sufficient enough to achieve foreign policy objectives. In India, however, the focus is more on projecting and leveraging soft power i.e. music, films, sports, art, culture, ancient wisdom, civilisational values etc, so as to occupy a place on the global high table. The latest example of this is the production of music videos of Mahatma Gandhi’s favourite bhajan — Vaishnao Janato. Indian missions across the world were instructed to rope in top stars from their respective countries and get them to sing the bhajan as a part of the commemoration of Gandhiji’s 150th birth anniversary. While there is nothing intrinsically wrong with such a project, given the security, strategic and economic challenges that confront Indian foreign policy, should be getting this bhajan sung by foreign stars have been a priority for Indian diplomats? Was the expense this would have incurred — monetary as well as in terms of time and energy of diplomats — justified? What are the takeaways of this somewhat batty idea in terms of even projecting soft power? How many people around the world, and I don’t even mean influential persons, were influenced or swayed by the rendition of this bhajan by foreign singers? How many people other than Indians had even heard this bhajan? How does the bhajan advance any of India’s important or vital interests in other countries? The current dispensation led by Prime Minister Narendra Modi has managed to engage rest of the world and advance India’s relations with almost all the important countries in the world. Where necessary, it has shown steely resolve in upholding Indian interests. To the Prime Minister’s credit, he hasn’t allowed personal slights or ego clashes to distract him or deflect him from pursuing India’s interests. He has ignored Trump mimicking him or other Western countries unfairly denying him a visa before he became Prime Minister. He has certainly injected energy and confidence in how India interacts and engages other countries. And yet, the obsession with soft power and reclaiming India’s stature as a “vishwa guru” (what does that mean anyway?) has frittered away or at least expended energies that could be better utilised elsewhere. The ruling party’s reverence for Deen Dayal Upadhyay is understandable. But let’s face it, there is nothing pathbreaking or revolutionary in what he said. What did he say, other than the typical confused socialistic mumbo-jumbo of his times? Will holding international symposiums, seminars, conferences to propagate D.D. Upadhyay’s thoughts really make any difference? Isn’t it a colossal waste of resources? Similarly, with Yoga, the world recognises and practises yoga not because the Modi government is promoting it or because there is an international Yoga Day, but because it is truly an exceptional form of exercise. Should the government then needlessly be going bonkers in celebrating Yoga Day all over the world? While every government must be permitted or forgiven, its peculiarities and peccadilloes, the Congress party apparatchiks cannot open their mouth without first singing paeans of their first family, and pretentious socialists must take Ram Manohar Lohia or J.P. Narayan’s name to justify their whacky policies and politics. The problem is that overtly focusing on these “events” and the need for showing performance in organising these events has become an end in itself for civil servants. Thus, it is that the High Commissioner in Islamabad, unlike his counterparts from other countries, doesn’t feel that merely meeting a newly (s)elected Prime Minister of Pakistan is enough; he must create a splash by doing the most cliched thing possible — presenting a cricket bat with signatures of the current Indian team. This gesture was apparently supposed to soften the nominee of the Pakistan Army. Seriously? There exists a number of examples of this dumbing down of diplomacy where form has taken precedence and priority over substance. While it is important that India and Indians take pride in their astounding accomplishments in ancient times, it is even more critical to recognise that India today cannot rest on its laurels from the past. India might have been a “vishwa guru” a millennia or more ago, but today, it has more to learn from both, its friends, as well as its enemies and adversaries. And it (India) has very little to teach them. By overdoing soft power, India isn’t going to be able to fix the challenges of today, nor will it be able to exploit and benefit from the opportunities of today and tomorrow. For more than four decades after independence, India exercised soft power but had very little heft in terms of hard power, or in some cases, lesser economic power. India was the defender of all lost causes, an irritant on the international stage that pontificated, moralised, even hectored others. Sure, India was the toast of all the countries that didn’t matter — a bit like Venezuela on steroids (okay, that’s a bit over the top, but you get the drift) which today is the toast of rootless, clueless and even brainless Left-Liberal types who saw Hugo Chavez, the man who ruined his country, as a revolutionary and anti-imperialist icon. India really started being noticed after the economic reforms of 1990-91, the architect of which wasn’t Manmohan Singh, but his boss, P.V. Narasimha Rao. Suddenly the world rediscovered India’s potential. It was the Indian techies and scholars in Western universities and companies that made people in other parts of the world sit up and take notice of this awakening giant. While Pakistan was being noticed for its jihadist policies (a number of Hollywood films had a Pakistani character involved in terrorism or making sinister plans for a WMD attack), India was being feted for its geeks, the industriousness of its people, their commitment to family and education, and their adherence to laws of the lands in which they lived. All this wasn’t the outcome of some publicity campaign or some bureaucracy-driven scheme to promote India. It happened organically and was the result of hard work, perseverance and investment in things that matter, education being the most important one of them. Packaging is important, even necessary, in making an impression in the world. But it is grossly insufficient if the product being sold isn’t good enough, or for that matter useful. Instead of frittering away the gains we have made over the years by behaving as though we have arrived or even acting as a ‘vishwa guru’ and world leader, India (and its leaders) need to realise that it has an enormous distance to travel, many mountains to climb, many seas to traverse, many storms and minefields to avoid and confront before it can claim to be a genuine ‘vishwa guru’. And when that stage comes, India will not need to announce its arrival, other will do it for India. Until then, Indians need to get serious, hunker down and do the hard work needed to rebuild India — fixing our education system, fixing our legal and judicial system, making governance more effective, responsive, sensitive, giving impetus to productive agents in the economy (the entrepreneur, industrialist, farmer), fixing our infrastructure, fixing our crumbling, overstretched cities, its an endless list. Neither bhajans, nor yoga days will do this for India. If anything, shifting focus from the important and urgent things to the cosmetic and perceptual stuff will only make it more difficult for India to make its tryst with its destiny.

#### 3] Modi translates soft power into aggressive hard power over Pakistan – nuclear war

Mohydin 19 Ravale Mohydin, TRT World Research Centre, Lahore University of Managament Sciences, TRT World, "The rise and decay of India's soft power", 5 SEP 2019, https://www.trtworld.com/opinion/the-rise-and-decay-of-india-s-soft-power-29554 TDI

According to Joseph Nye, "the soft power of a country rests primarily on three resources: its culture in places where it is attractive to others; its political value when it lives up to them at home and abroad; and its foreign politics when they are seen as legitimate and having moral authority."

This is what Tharoor highlighted: India’s formidable soft power. With Bollywood and Tikka Masala taking the world by storm, India became more than a far-away curiosity. It became your doctor, your software engineer, your cool Netflix show host. That, along with yoga and Gandhian non-violent movements, India became potentially the greatest soft power after the US and Japan.

Almost at the same time, India’s ‘sticky power’ grew. Describing sticky power, Walter Mead gives the example of a carnivorous sundew plant: "it attracts its prey with a kind of soft power, a pleasing scent that lures insects toward its sap. But once the victim has touched the sap, it is stuck; it can't get away."

That is sticky power or economic power. The Indian economy is considered the third-largest in the world by purchasing power parity. Recently the United Arab Emirates awarded Prime Minister Narendra Modi its highest civilian honour, even as Kashmiris suffered. Unsurprising though, as the UAE's exports to India surged by 37 percent to reach almost $30 billion in the last year alone.

Unfortunately, the BJP is busy translating India’s soft and sticky power into hard power. Indian economic influence landed India a plum Financial Action Task Force (FATF) membership which has been, according to Pakistani Prime Minister Imran Khan, leveraged to create economic pressure for an already cash-strapped Pakistan desperately trying to exit the FATF grey list and not end up on its dreaded blacklist.

With India snugly on the FATF panel, the BJP has chosen now to ‘correct a past mistake’ in Kashmir. On the other hand, velvet-gloved Priyanka Chopra-Jonas, a renowned Bollywood actor and a United Nations goodwill ambassador usually championing feminist causes—whose wedding was attended by Narendra Modi himself—did not flinch when the mic was yanked away from a Pakistani-American woman who asked her to clarify her apparent support for war.

With more than 700,000 soldiers stationed in the Kashmir Valley to thwart any protest, the Indian defence minister warned Pakistan (and the world) that the ‘No First Use’ nuclear policy could change ‘given the circumstances’.

Nuclear war is now a serious threat in South Asia. India’s attempts at hard power cannot get more dangerous.

The Narendra Modi-led BJP has overridden much of India’s goodwill earned over decades. The Hindutva ideology is alive and kicking, even if it is the one that murdered Mahatma Gandhi.

#### 4] Sino-Indian war goes nuclear – great power draw-in.

Lockett 20 - Senior Journalist @ The Sun Daily Star. Journalist with more than 30 years’ experience (Jon Lockett, “How nuclear World War 3 is serious threat if India and China ‘fist fights’ escalate conflict and allies get dragged in,” *The Sun*, June 18th, <https://www.thesun.co.uk/news/11893725/nuclear-world-war-3-india-and-china/>) TDI

Now there are genuine concerns the regional dispute between the two rival nuclear powers could erupt into a **global conflict**. And that could see **America** - which has just signed a £3bn arms deal with ally India - dragged into the bloodshed. New Delhi has grown closer to the US in recent years and Washington now calls India a "major defence partner". The warm welcome afforded to President Trump in India also reflects the extent to which he has found new friends in the region. Meanwhile, US-China relations have been are reaching an all-time low in the wake of a trade war and the coronavirus pandemic. China, on the other hand, can count India's long-time enemy **Pakistan** as a very close friend and military partner. Beijing - which calls Pakistan its "iron brother" - has become its largest supplier of arms and its third-largest trading partner. The pair are curently involved in several military projects including the development of JF-17 Thunder fighter plane. Chinese and Pakistani troops also conduct joint regular training sessions in the mountainous region. Tensions have been growing along the border since the spring when China deployed thousands of troops as well as artillery and vehicles. Analysts say the soldiers were sent there in an attempt to stop India increasing its own military presence in the area. Then China moved scores of nukes to Mongolia and leaked images of the weapons just to let the world know they were there. "Given China knows the location of India's bases, it could launch a **pre-emptive first strike**," warned Mark Almond, director of the Crisis Research Institute, Oxford, in the Daily Mail. "Even if the bombers got airborne, they could be shot down by Chinese air defences in a war. "China has more than double the number of India's warheads - around 300 - and its strategy is based on the **destruction of key urban centres** which, it believes, would terrify an opponent into passive, appeasing mode." So it seems Beijing now has the ability to strike anywhere in India and India has no effective defence from attack. To make things worse, China has nuclear-armed Pakistan ready and waiting on India's doorstep.This also increases the risk **India might feel pressured to strike first** before its bases can be knocked out by either China and Pakistan. That would then almost definitely trigger a massive retaliatory strike from the nuclear-armed Chinese military. And it could **void Beijing's "no first use" policy** in which it pledges only to use nukes in retaliation to a similar attack on them. Not only would such an all-out conflict devastate billions of people in Asia it could force **Russia** - which has close ties to both - to choose sides.

#### 5] Indo-Pak war goes nuclear – simulations prove.

Toon et al. 19 — Owen B. Toon, Laboratory for Atmospheric and Space Physics, Department of Atmospheric and Oceanic Sciences, University of Colorado, Boulder; Charles G. Bardeen, Atmospheric Chemistry Observations and Modeling Laboratory, National Center for Atmospheric Research; Alan Robock, Department of Environmental Sciences, Rutgers University; Lili Xia, Department of Environmental Sciences, Rutgers University; Hans Kristensen, Federation of American Scientists; Matthew McKinzie, Natural Resources Defense Council; R. J. Peterson, Department of Physics, University of Colorado, Boulder; Cheryl S. Harrison, School of Earth, Environmental, and Marine Sciences, University of Texas Rio Grande Valley, Institute of Arctic and Alpine Research, University of Colorado, Boulder; Nicole S. Lovenduski, Department of Atmospheric and Oceanic Sciences, Institute of Arctic and Alpine Research, University of Colorado, Boulder; and Richard P. Turco, Department of Atmospheric and Oceanic Sciences, University of California, Los Angeles; October 2nd ("Rapidly expanding nuclear arsenals in Pakistan and India portend regional and global catastrophe", Science Advances, volume 5, number 10, https://advances.sciencemag.org/content/5/10/eaay5478, accessed 12-1-2019) TDI

To help evaluate the consequences of a nuclear conflict between India and Pakistan, table S1 provides a specific scenario for a war assumed to take place in 2025. Although this scenario has Pakistan first launching nuclear weapons, we do not mean to imply that they are more likely to do this than India. Because large numbers of weapons are assumed to be used by both sides, we would expect our results to be similar no matter how the war started. Moreover, we would expect the global outcomes projected here to apply equally well—with relevant recalibration for weapon sizes and targets and related smoke emissions—to any nuclear conflict between nuclear-armed states that involves a corresponding total yield detonated essentially in urban areas.

Many scenarios of an India-Pakistan conflict in 2025 are possible, ranging from no nuclear weapons deployed to as many as 500 nuclear weapons—many with yields above 100 kt—detonated. We chose the scenario outlined in table S1 as plausible following advice from a number of military and policy experts. In addition, the information presented in this paper and the Supplementary Materials can be used as a basis to compute the results for other scenarios. The main determinants of casualties and climate effects are the number of weapons used, the yield of the weapons, and the targets for the weapons, each of which is unknown in advance. The discussion in the following paragraphs exemplifies scenario factors that have been widely considered in the literature concerning conflicts between India and Pakistan, which might be varied in alternative scenarios including the role of the number of potential targets in choosing the sizes of arsenals; the characteristics, such as failure rates, of available weapons and delivery systems; the events that might lead to an escalating nuclear conflict; resolution of the Kashmir problem that might lessen the likelihood of a dangerous confrontation; the importance of urban targets in contributing to fatalities and climate effects owing to high population densities and fuel loadings; the difficulty of preventing a conflict from going nuclear because of the destabilizing effects of tactical nuclear weapons on both sides; the importance of Indian concerns about China in making it difficult for Pakistan and India to reduce their nuclear stockpiles; and the possible role of the disproportionate sizes of the countries, militaries, and populations of India and Pakistan in motivating the initial use of nuclear weapons.

In the scenario outlined in table S1, we assumed that each country would have 250 nuclear weapons in 2025 (5, 9). We also adopted a highly simplified scenario in which only urban targets are considered, and these are attacked using airbursts. Many military or strategic targets in rural areas are likely to be attacked as well, but these would involve smaller populations and lower fuel loading, which would not add significantly to the near-term fatalities or smoke emissions. Therefore, we do not specifically track them in our scenario. Likewise, some targets, such as buried military facilities, might attract ground bursts, which would produce significant radioactive fallout and many additional fatalities—effects that are not explicitly considered in this work.

India has one of the largest conventional militaries in the world, with about 1.4 million active duty personnel. India has not deployed tactical nuclear weapons. Indian nuclear strategy requires that a significant number of high-yield bombs be held back in case China joins a war on the side of Pakistan (10). Because Pakistan is a small country with only about 60 cities with more than 100,000 people, India would not need all of its 250 weapons to destroy Pakistan’s cities.

We assume that India will keep 100 nuclear weapons in its arsenal to deter China from entering the war. Chinese involvement would greatly amplify the destruction discussed below. As China expands its presence in Pakistan as part of the China-Pakistan Economic Corridor, which is an element of China’s broader “Belt and Road Initiative,” the odds of a Pakistani-Indian war spreading to China would appear to be increasing.

Of India’s 150 weapons that can be used against Pakistan, we assume that about 15% will fail. In this case, failure is primarily due to the weapons not being delivered or failing to explode. Most urban targets in Pakistan are so large that precise targeting is not needed to hit them. Therefore, our scenario suggests 125 weapons actually exploding. We further assume that there are 25 targets in Pakistan that are isolated military bases or industrial facilities located in regions with low populations and little combustible material. We do not include these in computing fatalities or environmental damage. Therefore, we assume that India has 100 strategic nuclear weapons to use on urban countervalue targets or military counterforce targets that are located within urban areas, such as military bases, industrial facilities, oil refineries, nuclear weapons facilities, and airports.

Pakistan also has one of the largest militaries in the world, with about half as many active duty personnel as India has. We assume that, in 2025, Pakistan will have 50 tactical weapons with yields of 5 kt to be used against an invading Indian army. We assume that 20% of these will fail or be overrun by the Indian Army. Many of these tactical weapons might be used in sparsely populated areas with little flammable material. Accordingly, we only consider the remaining 200 strategic weapons when computing fatalities or smoke created from fires. Of these 200 strategic weapons, we assume that 15% will fail to be delivered to the target but that the remaining 170 will be detonated over their targets. We further assume that 20 of these explosions will be over isolated military, nuclear, or industrial areas. The balance, 150 weapons, will thus be used against India’s urban countervalue targets and military counterforce targets located within urban areas.

The yields of modern Indian and Pakistani weapons are unknown and not easily constrained. India detonated a ~40-kt yield weapon in 1998, which, they claimed, was a two-stage bomb. Kanwal (10) suggests that this design could produce 200-kt yields. Pakistan claimed that its weapons tested in 1998 used boosted fission. Possibly, these could also produce yields of 200 kt. Given the lack of reliable information about yield, we will explore the consequences of using strategic weapons with yields of 15, 50, and 100 kt.

Our scenario, as outlined in table S1, begins with a terrorist attack on the Indian government, similar to the one that occurred on 13 December 2001, but with massive fatalities among members of India’s government. As happened in January 2002, we assume that India and Pakistan mobilize their troops within a few weeks of the terrorist attack. Indian troops would likely be dispersed along the border and in Kashmir. Skirmishes would break out, resulting in deaths on both sides. Similar skirmishes happened in 2002 and now occur with regularity, most recently with a conflict in the Kashmir region beginning with a terrorist event on 14 February 2019. In the 2002 confrontation, the United States, Russia, and other countries intervened, eventually convincing India and Pakistan to end the confrontation, which had continued into the summer of 2002 until Pakistan agreed to control terrorist groups within its borders.

A crisis simulation exercise in Sri Lanka during 2013 organized by the U.S. Naval Postgraduate School and involving retired senior military and civilian analysts from India and Pakistan found that “a limited war in South Asia will escalate rapidly into a full war with a high potential for nuclear exchange” (12). In our scenario, with the Indian government having been severely damaged, the Indian Army brings a number of tanks to the border and crosses into Pakistan and also crosses the Line of Control in Kashmir. On day 1 of the nuclear conflict, Pakistan uses 10 tactical atomic bombs with 5-kt yield inside its own borders with low air bursts against the Indian tanks (table S1).

The conflict continues on day 2 when Pakistan uses another 15 tactical weapons with 5-kt yield on the battlefield, whereas India detonates two air bursts against the Pakistani garrison in Bahawalpur and deploys 18 other weapons to attack Pakistani airfields and nuclear weapons depots, partially degrading Pakistani retaliatory capabilities. Nevertheless, on day 3, Pakistan responds with a barrage of nuclear ballistic and cruise missiles on garrisons, weapon depots, naval bases, and airfields in 30 locations in Indian cities (30 air bursts with 15- to 100-kt yield each) plus another 15 tactical bursts with 5-kt yield. India also uses 10 strategic weapons against Pakistani military bases on day 3. Because of panic, anger, miscommunication, and protocols, escalation cannot be stopped now. On days 4 to 7, cities in India are hit with 120 strategic weapons, and those in Pakistan are struck with 70 air bursts with 15- to 100-kt yield. In total, Pakistan’s urban areas are hit with 100 nuclear weapons using airbursts, and India’s urban areas are hit with 150 nuclear weapons using airbursts. In addition, Pakistan has used 40 tactical nuclear weapons successfully and 20 strategic weapons successfully on targets not in urban areas, whereas India has used 25 strategic weapons successfully on targets not in urban areas.

In previous simulations (13, 14), all of the smoke produced during the nuclear exchange (as described below) was initially distributed uniformly over a broad area of India and Pakistan in January 1. Here, the smoke is injected above individual targeted urban regions (at the grid scale of the climate model) on the day of the detonations. Hence, the smoke injection varies in location and time in accordance with the evolution of the specific war scenario (e.g., as illustrated in fig. S1 for the scenario with 50-kt weapons). Further, in the present climate simulations, the smoke injection is assumed to start on 15 May and extend over the duration of the exchange (e.g., 6 days for the case in fig. S1). We did not evaluate the sensitivity of the results to the time of year the war begins. In (14), it was found that a war initiated on 1 January or 15 May made little difference to the ultimate climatic effects. On the other hand, a war occurring in Northern Hemisphere summer might lead to enhanced impacts initially, as implied by earlier nuclear winter studies.