



Monetizing the Final Frontier

The strange new push for space privatization

ILLUSTRATIONS BY JUSTIN WOOD

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On May 30, in the midst of a world-threatening pandemic and a surge of protests for racial justice, President Donald Trump arranged a photo op that harked back to the confident heyday of the Cold War American consensus. He flew down to Florida to gaze at the heavens.

The skies were blue over the storied NASA launch-ground of Cape Canaveral in mid-eastern Florida when, at 3:22 p.m., Trump peered from a nearby platform. Two astronauts—Bob Behnken and Doug Hurley—hurtled up from the launchpad, on a rocket roaring toward the International Space Station.

For longtime enthusiasts of NASA's human spacefaring, it was a singularly auspicious moment. Ever since NASA's space shuttles were mothballed in 2011, the agency had no American-owned way of getting people into space. It had been paying the Russian government to fly U.S. astronauts up and back, on Russia's Soyuz spacecraft. But this flight was different. It was the first time humans had flown in a rocket and a capsule made by a private-sector company: SpaceX, the creation of the billionaire Elon Musk.

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The launch was also a SpaceX branding bonanza. The astronauts rode up to the rocket in a Tesla, Musk's fabled luxury electric car; when they'd reached orbit, they broadcast a live video in which they thanked SpaceX for making the flight happen, and showed off the sleek capsule—a genuine marvel of engineering, with huge touch screen control panels that looked rather like the ones inside a Tesla itself. Over the



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For the feds, this price tag is remarkably cheaper than the space shuttle, which cost over \$1 billion per flight. In his speech after the launch, Trump lauded the cost savings that SpaceX had realized on the government's behalf. SpaceX, he announced, "embodies the American ethos of big thinking and risk-taking.... Congratulations, Elon."

For Musk, though, the launch was more than just a technical success, and is bigger even than the \$2.6 billion contract. It cements him as a leading player in what might seem the unlikeliest stage of the final frontier's exploration—the privatization of space.

Private-sector activity in space travel is accelerating dramatically—rocketing, one might say. For decades, ever since people first headed for orbit in the 1960s, spaceflight had been mostly the preserve of governments. States were the only actors with the money and technical acumen to blast things into the vacuum and get them safely down again. The private sector didn't have NASA's know-how, nor—more important—a business plan that could rationalize the massive outlay of capital required to operate in space.

In the last few years, that calculus has changed dramatically. A generation of “New Space” entrepreneurs has begun launching rockets and satellites. Some seek to flood the planet with fast, cheap mobile-phone signals; others want to manufacture new products in zero gravity, harnessing the novel physics of such conditions to engineer substances that can't be made in Earth's gravity. Further afield, they're aiming to harvest water on the moon and even mine asteroids. Backing this burst of entrepreneurial fervor are many billionaires who made their money in the early Wild West of the internet, including Amazon's Jeff Bezos, with dreams of building space colonies, and Musk, the former PayPal titan who hopes to personally make it to Mars.

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Texas GOP senator Ted Cruz said in 2018, “I predict the first trillionaire will be made in space.”

Barack Obama’s administration made the first major overtures to the space privatizers, signing legislation that paved the way for today’s space boom. But the real land rush has occurred under Trump, via a flurry of executive orders designed to give private firms greater access to “low-Earth orbit.” Trump officials have even touted the idea of privatizing the \$100 billion space station itself—the last signature NASA-sponsored human spacecraft project still aloft. When Trump’s transition team in 2017 pondered the handoff of low-Earth orbit to the private sector, it concluded: “This may be the biggest and most public privatization effort America has ever conducted.” Or as Texas GOP Senator Ted Cruz—at the time the chairman of the Space, Science, and Competitiveness Subcommittee—put it in 2018: “I predict the first trillionaire will be made in space.”

The burst of activity and high-tech acumen thrills many space fans. But it is making many others quite nervous. Opening up space to a frenzy of private actors could, they agree, produce measurable benefits back on planet Earth—making crucial scientific research, environmental monitoring, and everyday communication cheaper. But the critics are quick to note as well that the history of privatization is spotty at best, with plenty of civically brutal knock-on effects: concentrations of monopolistic power, enfeebled democratic control, and widespread environmental degradation. We’ve seen all those problems appear on Earth as all manner of traditional social goods, from education and housing to pension plans and mass transit, have been targeted for private-sector control. Next up, it seems, is the great beyond.

Certainly, space has been profitable for American commercial firms for a long time. But for decades, NASA also kept a tight rein on each project’s planning phase.

The basic setup was simple, and familiar to any agency or tech executive who had

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the design was done, they'd hire a private-sector contractor to build components, or even a complete finished model. NASA's engineers and tech specialists would then test the components or finished models all over again, sometimes going so far as to disassemble and reassemble them, to be sure the job was done to their specs.

NASA's technical acumen was, back then, considered particularly elite. Young, ambitious aerospace engineers flocked to NASA for the opportunities that couldn't be had in private industry. Most project managers had insisted NASA continue to be at the helm of any spacecraft design as a basic quality-control measure. If all they did was buy rockets and capsules designed and made by the private sector, they'd become too reliant on contracting firms that were unaccountable to the public interest. Under an all-private model of space exploration, managers couldn't judge when work was done well, or fix things themselves if they went wrong. There was also the risk that greater rewards and research opportunities on the private side of space exploration would create a brain drain from NASA's Houston base of operations.

The arrangement suited private-sector firms fine; companies such as Northrop Grumman and Boeing made piles of dough assembling rockets for NASA. The contracts were "cost plus"; NASA would cover whatever the costs were, plus a profit margin. That type of arrangement—also common in military and spy contracting—is a gold mine, as well as a breeding ground for all sorts of perverse market incentives. Under a cost-plus contract, the firm doing the work can be as inefficient or as slow as it wants, and it'll still make a tidy profit. And in the heady run-up to the historic Apollo 13 moon shot, NASA was flush with cash; at its peak, NASA was 4.4 percent of the federal discretionary budget, with an annual budget line of \$135 billion in today's dollars. Because NASA was the only real player of note in the rush to outer space, the Boeings and Northrops of the world were a captive contracting base.

Things began to change in the 1970s. With the moon race won, NASA's budgets began to contract, and agency leaders gave up on pushing into new frontiers. They poured their budget into the space shuttle program. Even at the time, the shuttle was regarded as wildly expensive and curiously modest in scope: It could only fly as high as low-Earth orbit—a few hundred miles up—and go around the planet, in a kind of

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public let their attention drift elsewhere. Space began to look like just another expensive boondoggle.

Meanwhile, the private sector was beginning to see a host of nongovernmental business opportunities in satellite communications. In the 1980s, if you wanted to communicate around the world via satellite—say, for a long-distance call—there was only one company to buy data from: Intelsat, a satellite monopoly run by a consortium of governments. In 1988, however, an entrepreneur named Rene Anselmo broke that monopoly. He'd bought a cut-rate satellite, booked a cheap flight on a new rocket made by a European consortium, and convinced the United States to let him launch it. He didn't have a guarantee there'd be any viable business, but, as he told *The New York Times*, "My theory ... was that I couldn't imagine putting a satellite up there and offering all this technology without it being used." Sure enough, by the early 1990s he was selling vast quantities of data to companies that wanted to communicate more cheaply than they could under the Intelsat monopoly. A new sector was born: for-profit satellites, launched and owned by for-profit firms, helping companies communicate globally or doing "imaging"—pictures of the planet that, say, assess weather.

By the '90s, there were signs that the private and public sectors might shift positions. NASA was becoming less relevant; the commercial world, more so. The 1986 explosion of the Challenger shuttle showed that NASA's internal engineering and safety culture had slipped. (Tellingly, it was a group of engineers at a contractor who warned the NASA brass that a crucial part they'd created might fail, and it was the NASA brass, following the myopic ethos of margin-driven management in the private sector, who hoped to jam the project through, and refused to stop the launch.) NASA's star dimmed even further with the second shuttle explosion in 2003. Its funding had dwindled year by year; by the time of the second shuttle disaster, the agency's budget was just 0.68 percent of the federal government's overall spending. In 2011, NASA permanently shut down all shuttle flights. No American firm was making rockets capable of getting humans aloft, so NASA's manned-space operations now had to rely on Russia, which had maintained its rocket program at par under the watch of former KGB strongman Vladimir Putin. It made for a distinctly deflating gloss on the superpower rivalry that prompted President John F. Kennedy to

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Other historical ironies crowded the scene—beginning with the libertarian worldview of the cohort of New Space firms that emerged during NASA's long shuttle boondoggle. NASA was originally envisioned as the height of public-private collaboration in the postwar economy: a stirring example of just how ambitious a government-led initiative could be with the world's biggest economic players working alongside it—provided, of course, that the whole undertaking was lubricated by a mammoth outlay of R&D funding from taxpayers.

But the space entrepreneurs emerging in the '90s had soured on this postwar social contract. They'd grown up dreaming of spaceflight, but thought the federal government was too slow, too risk-averse, and—throwing cost-plus money at giants like Boeing—grossly inefficient in its spending. The only way to accelerate access to space would be for private-sector firms to tackle it, and pursue the main chance on their own terms. They'd create firms that sold launches to NASA, but also to any other companies looking to get into orbit.

Meanwhile, the federal government was itself actively encouraging the growth of a for-profit space industry. In 2005, Congress passed a law creating the “Commercial Orbital Transportation Services” program. It set up hundreds of millions—eventually billions—to pay new American firms that could launch NASA payloads into orbit. The goal was to encourage companies that would avoid the clotted and lumbering M.O. associated with the worst excesses of the cost-plus regime; picking up on the new spirit of laissez-faire globalism taking root in the centers of American power, NASA declared that it would be entirely content to be but one customer among many in a profit-driven model of space exploration. NASA's money would prime the pump, as with most infant industries, but eventually the New Space sector would take on a life of its own.

That, at any rate, is the dream of for-profit space conquest that Musk and the other New Space firms signed on for. In 2002, Musk took some of the many millions he'd made taking PayPal public and founded SpaceX. By 2008, his engineers had launched their first successful rocket. Over the next few years, he began a brisk business selling rockets to the federal government, which was eager to have non-Russian ways to get satellites in orbit or supplies to the space station.

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each rocket launch. And in a remarkable feat of engineering, SpaceX's techies mastered the ability to land a rocket stage back on the ground after it had propelled its payload into orbit, which drove the cost of space travel still lower. If you don't need to build a new rocket each time, prices drop.

Musk was joined by Amazon CEO Jeff Bezos, who'd dreamed of going into space since his *Star Trek*-addled boyhood. In 2000, Bezos founded his own spaceflight firm, Blue Origin. But Bezos's view wasn't quite the sunny New Frontier ethos of Gene Roddenberry; it had a distinctly Malthusian cast. Humanity, he argued, needed to escape the planet in order to save it from utter devastation; he envisioned one day building mammoth space stations complete with farms and trains. By 2018, Bezos was—like Musk—landing lucrative government contracts, such as \$500 million from the Air Force to create a rocket.

By the 2010s, the boom in New Space was in full swing. Arriviste space executives were brashly proclaiming their superiority to the old, slow twentieth-century model of government-controlled space travel. Heeding the siren song of the space privatizers, venture capital swung into action. In 2019 alone, investors poured a cool \$5.8 billion into companies pursuing rocket and satellite developments.

"There's a ton of promise here," Chad Anderson, CEO of the venture capital firm Space Angels, said. "We're just scratching the surface. This wave of entrepreneurship and innovation over the last 10 years is something that we've never seen before."

This commercial boom may be heretofore unseen, but it's rapidly leaving its imprint across the heavens. What, exactly, does an outer-space land rush *look* like?

Moriba Jah got a sobering glimpse of this last year, when he watched SpaceX launch 60 satellites on a single rocket. Jah is an astrodynamist, devoted to the study of how objects move in space, and when his colleagues trained their telescopes on the SpaceX rocket releasing the satellites into orbit, they fixed on a colossal stream of bright points of light.

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internet access anywhere on the planet, letting subscribers “watch high-def movies, play video games and do all the things they want to do without noticing speed,” as Musk promised. But to blanket the planet in bandwidth, SpaceX needs a lot of satellites. Musk shot another 60 up in January 2020, and another 120 in March and April. He aims to have almost 12,000 circling Earth by 2027, and 30,000 more after that.

Prior to the SpaceX launch-binge, by contrast, there were only about 2,000 satellites in orbit. “Elon has a green light to just put a *dump truck* of satellites in Earth orbit,” Jah told me.

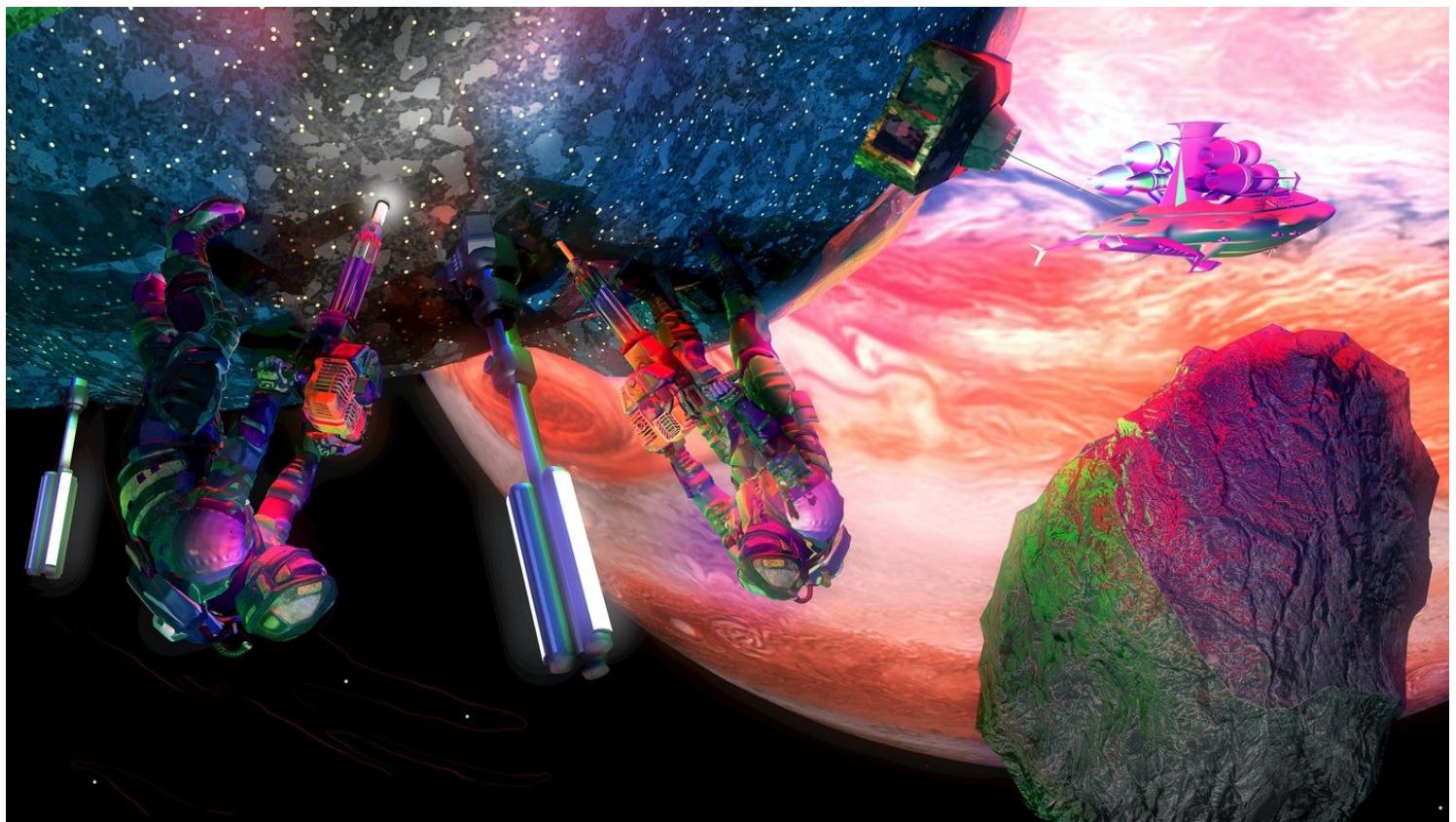
What worries him is congestion, and—in a weird, futuristic way—environmental devastation. Jah is an expert on the problem of space debris, the littering of space. If companies keep tossing up satellites this rapidly, he fears, we could soon create an irrecoverable mess. Having blighted the Earth’s environment, commercial activity seems poised to wreck the next frontier: low-Earth orbit.

Low-Earth orbit—roughly, anything that’s whizzing around the planet no more than 1,200 miles high—is the zone where SpaceX and many other New Space firms seek to operate. And simple math—together with the history of virtually all new forms of transportation—tells us that the more things go up there, and without a clear fix on where objects are in space, the greater the odds are that those things are going to start slamming into one another by accident.

“Physics tells us that two things can’t occupy the same space at the same time or else bad things happen,” Jah said dryly.

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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.

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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

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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 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

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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 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.

"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."

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
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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, 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” 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 the goal of returning NASA astronauts to the lunar surface; India tried and failed to put a lander down; and last year, China succeeded. NASA is currently planning to build a lunar 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.

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—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](#), 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 speculative 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](#), 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](#); 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](#), which explicitly gives U.S. firms the rights to any resources they mine from a celestial body. The Trump administration is [actively pushing](#) for firms to mine the moon. Other countries courting New Space firms—[hello, Luxembourg](#)—are following suit.

History, of course, would suggest that treaties crumble when serious money comes

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“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*, 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.

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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](#), 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](#) 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

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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, “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* (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* depicts the lives of asteroid miners as an outright

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Employees in Amazon's warehouses are already peeing into bottles and collapsing from heat exhaustion 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

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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](#), 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

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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.

“We need artists and philosophers and sociologists, psychologists and every other kind of person thinking about how we do this thing,” she said. This can sound, she admitted, touchy-feely. But in her own work as an astronomer, the big-tent approach has paid off. When Elkins-Tanton initially pitched the Psyche mission to NASA, she was competing with 28 other pitches, and asking NASA to commit \$750 million. To build her proposal, she insisted her team members, down to the college interns, “speak up” about their concerns—how things could go wrong, and what unexpected outcomes of the project might be. “Our motto is, the best news is bad news brought early,” she said. “You need everybody to be able to speak up.” In her pitch to NASA, she touted her insistent culture of inclusion. When NASA heads approved her mission over the other ones, they cited it as a crucial reason why.

“To them, it was a success metric,” she said. “So now I can stand up and say: Culture is not for the weak. Culture is literally worth \$750 million.” It would be heartening if NASA seriously embraced this model. Decolonizing the way we explore space would actually honor the incredible unknowns and unexpected dangers the sustained commercial settlement of the heavens will bring. As John F. Kennedy said when he first argued for putting people on the moon: “The greater our knowledge increases,

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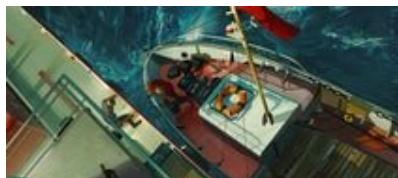
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