First in Line/First in Time

Article · January 2018

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CASEY LANCE BROWN

FIRST IN TIME/FIRST IN LINE

2025

770,000,000 mi

TROJANS Government

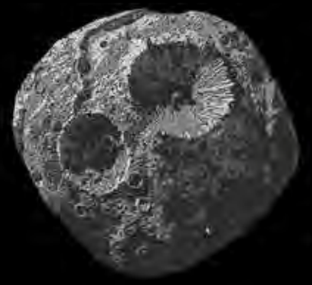
Lucy

NASA

Diameter: Var.
Material: 7 asteroids (C-, P-, D-types)
Est. Value: $???

2026

450,000,000 km



16 PSYCHE Government

Psyche

NASA

Diameter: 250 km
Material: Iron-Nickel Protoplanet (M-type)
Est. Value: $8-10 Quadrillion

2020?

(Unknown)

UNKNOWN Private Sector

Prospector-X and Prospector-1

DSI (Deep Space Industries)

Diameter: Unknown
Material: Unknown
Est. Value: Unknown

101955 BENNU Government 2023*

2018

160,000,000 km

OSIRIS-REx

NASA

Diameter: 0.5 km
Material: Carbon-rich (B-type)
Est. Value: ~$50 Billion

2018

160,000,000 km

162173 RYUGU Government 2026*

Hayabusa-2

JAXA

Diameter: 1 km
Material: Carbon-rich (Cg-type)
Est. Value: ~$95 Billion

1 2 3 4

Hayabusa-2 (Japan)

Psyche Spacecraft (Universal)

OSIRIS-REx (USA)

Prospector-X (Space)

Casey Lance Brown is the research director at P-REX, an interdisciplinary think tank at MIT, and a 2011 fellow of the American Academy in Rome. Independently, Brown conducts long-term research on the geologic selection of land uses, securitization of borderlands, and the ramifying effects of land speculation. The large-format photographs that accompany those projects have been collected and exhibited globally, most recently at THE FENCE national exhibit in Atlanta, USA.

✚ TECHNOLOGY: ASTROBIOLOGY: FUTUROLOGY

In 1890, the US Census Bureau declared the western frontier to be closed. This conceptual closure was based solely on a threshold of population density (two persons per square mile) that had already been surpassed in the American West.[1] Gold-rushers, homesteaders, and frontiersmen had staked claim to land plots from the plains to the West Coast, establishing San Francisco as the tenth largest city by 1870. Unsurprisingly, it is the technology pioneers of the San Francisco Bay Area that have opened the newest wave of frontier exploration – Mars expeditions, asteroid mining, and space tourism. One hundred and thirty years after the western frontier closed, the rush is on...again.

While the aerospace engineering and technological wizardry required to launch these space forays are remarkably advanced, the conceptual and ideological motivations behind the initiatives are more antiquated. This newest wave of expeditionary zeal is rooted in the original frontier mindset of early America. Natural resource extraction drove the formation of the early American colonies and the subsequent westward expansion of the nation. Gold, silver, and a bounty of unknown precious materials drove American settlers and European explorers alike toward new frontiers at a pace limited solely by the wind- and animal-powered transportation technologies of the discovery era.

Like an internet-era replica, the tech-industry entities involved in space exploration have expressed clear interest in mining as an early mission directive. Two companies—Planetary Resources and Deep Space Industries—have exclusively focused on launching, fueling, and equipping the first foray into extra-terrestrial mining. In 2016, Planetary Resources secured funding from Luxembourg to help jumpstart asteroid mining missions as planned by its team of former NASA engineers. Deep Space Industries intends to build the earliest space gas stations and factories, supplying orbital fuels and materials for in-space manufacturing by tapping asteroids for metals and water. In addition to mining-focused companies, the desire to establish transport infrastructure to launch a space civilization and commercial space ventures is at the top of the modern tech-industrialists wish list: Jeff Bezos started Blue Origin, Paul Allen launched Vulcan Aerospace, Richard Branson founded Virgin Galactic, and Elon Musk formed SpaceX. Each company has major West Coast hubs and various space development strategies focused on transportation. The tech titans likely see clear parallels with the shipping moguls of the colonial era, as well as the railroad, coal, and oil barons of American industrial expansion. With fortunes built from the internet's tentacled infrastructure, the industrialists of this generation are merely extending their infrastructural arms outside Earth's atmosphere.

However, this space-age manifest destiny retains an unstated subplot: to support actual, biotic explorers and tourists from Earth, the companies and their missions will have to find a supportive source of water. Water has the unique trifecta of properties of sustaining life processes, producing hydrogen for fuel and oxygen for respiration when broken down chemically, and serving as a vehicle propellant. Thus, water trapped in the moon, Mars, or asteroids would become like the fossil fuel of the galaxy. Investors have already begun to process this galactic investment opportunity. Goldman Sachs has issued research briefs broaching the subject while the United Arab Emirates has funded a new Space Research Centre – the first of its kind in the Middle East. Given the estimated supply of 25,000+ near-Earth asteroids, and potentially trillions of US dollars in mineral resources, there will be plenty to go around.

The coming decade will witness a significant uptick in asteroid missions, data-informed extraction plans, and corporate jockeying for initial rights. In just a few years, the first returning asteroid missions are due, bringing data and material to populate the investment forecasts. Hayabusa-2, from Japan's JAXA space agency, will return with samples from asteroid Ryugu in 2020 if the mission is successful. Meanwhile, NASA's OSIRIS-REx Mission plans to reach asteroid Bennu in 2018 and return with samples collected from nitrogen blasts in 2023. Next up will be NASA's Psyche mission, which is built to explore a nickel-iron asteroid between Mars and Jupiter (recently moved up to a 2022 launch with a 2026 asteroid arrival).

Simultaneously, nations and international institutions are rushing to formulate a legal framework. The 1967 Outer Space Treaty, which prohibits national appropriation of space property, remains untested. Conveniently, the treaty may not legally apply to private entities. Its vague language will almost certainly need to be revamped. Already, a 2015 US law and a copycat law from Luxembourg attempt to reassert the rights of future private space claims.[2] This nascent body of law emulates mineral rights laws that date back to at least Spanish colonial ordinances from the 16th century and even earlier medieval customs from Cornwall and Devonshire.[3] Broadly stated, the mining claim laws hinge on the concept of prior appropriation—more commonly known as "first in time is first in line." Prior appropriation ultimately formed much of the frontier's jurisdictional basis, distributing water, land, and mineral rights to the first occupants of each area or resource. In a lockstep corollary, space mining companies want to extend those rights to extraterrestrial objects.

If we want to avoid a repeat of the grab-bag of environmental destruction and resource conflicts that took place during westward expansion, nations and companies will have to form strategic and pre-emptive agreements. This is where groups like the Blue Marble Space Institute of Science come into play. Their scientists and engineers penned a tentative scheme to manage space resources, largely focused on Mars.[4] Broadly stated, colonies would follow a "bounded first possession" model that limits claims to exclusive economic rights rather than a kind of squatter-based sovereignty. Further, mandated planetary parks will set aside some Martian land for research and unknown future

uses. All entities will remain under the jurisdiction of their host nations, while a Mars secretariat comprised of representatives from each colony will manage communication and disputes. Such a distant, tentative bureaucracy will have to consider problematic precedents, like the all-too-easy violation of the UN's Law of the Sea by territorial claims derived from artificial island formation in the South China Sea and bathymetric uncertainty in the Arctic.

All this preliminary legal wrangling, focused primarily on resource development, stands apart from the most outspoken of the tech billionaires' approaches. Elon Musk, in his forthright ambition to establish humans as a multi-planetary species, has initiated the first constitutional plans to establish this extraterrestrial society. In public statements, Musk described a direct democracy on Mars, where laws could be enacted with a 60% majority, repealed with a 40% vote, and would contain a sunset clause to automate legislative updating.[5] While sensible enough as a governing framework, there is little to prevent Mars from adopting the privateer, monopolizing schemes that Earth experienced during colonization waves. For example, will the founding pioneer miners of Mars readily agree to incrementally debase their vote to later waves of Martian immigrants?

This burgeoning utopian hope for a new start on Mars parallels the missionary plans of New World colonial powers and conceptions of westward expansion in early America. In the colonial era, a unique combination of religiously motivated European monarchies and powerful orders of Franciscan, Dominican, and Jesuit monks, inspired by philosophical tropes of enlightening the noble savage, coalesced to push a utopian agenda on the new lands. Their agenda drove resources and people to colonize a newly opened frontier with new forms of spatial governance.[6]

Frederick Jackson Turner's frontier thesis, delivered soon after the Census declared the western US frontier closed, offers another version of the frontier approach. Turner described the cultural evolution that occurred across frontier space as a succession of dominant industries, evolving from fur trading pioneers to farmers to the full suite of professional trades and ownership systems that exist today. While not necessarily utopian in outlook, the Turnerian frontier is a positivistic realm that fostered new, democratic American systems through the frontier settlement process itself. Turner argued that the act of exploring, settling, and ultimately putting these new lands into production allowed the frontiersmen to shed older, hierarchical systems of European land ownership. It seems that Musk sees the Martian frontier similarly, as a kind of next stage for human civilization, launched from American shores but unburdened by its current political morass.

Both historical approaches to the frontier discount the tremendous damage inflicted to the native populations and ecological resources in the colonized regions. Although Mars, planetary moons, and asteroids may only have microbiological inhabitants to protect, we would do well to operate under the precautionary principle and attempt to do no harm, both to protect potential life, and to protect the discovery process and its fruits. One approach that could perhaps avoid some of the pitfalls of colonization would be to form an agreement that establishes robot colonies first. Tech billionaires could fund their robot avatars to conduct exploratory missions, assess resources, and perform experiments that have the lightest feasible footprint on environmental baselines. Naming rights would be theirs to command, but the frontier would remain squatter-free and unexploited for more advanced space colonies in the far future.

Furthermore, robot colonies would allow us to collectively benefit from the technological advances derived from space exploration without bumbling into a galactic gold rush and its inherently damaging mining claims. With a co-evolving set of artificial intelligence (AI) protocols, we could safely test our most-advanced AI as a proto-civilization. Each of the robot colonies could run a different civilization-testing simulation. By varying initial parameters for each robot colony, the simulations could simultaneously advance mineral extraction, interplanetary communication, space governance, and technology.

Because these benefits are global in scale, governments should continue to both underwrite and restrain the acts of private companies in space. The Planetary Resources website notes that a single metal-rich asteroid could have more platinum-group metals than have been ever extracted here on Earth. If the resource assessments confirm a vast supply of rare metals, the commodity economy here on Earth could collapse. Costs for products that depend on these rare materials, which includes everything from rechargeable batteries to wind turbines and lighting, would decline. Mining, and its knotty pollution problems, could be moved to asteroids. Land reserved for mining on Earth could be opened for less-destructive land uses.

Alternatively, the techno-extractive approach could be subordinated to a biological dispersal imperative. Freeman Dyson, the physicist and generally subversive space theorist from the Institute of Advanced Study, has postulated that unforeseen biotech methods could enable the design of colonization "eggs" capable of spreading entire ecological communities in small packages throughout space.[7] These Noah's Ark seeds would evolve in unpredictable ways, spreading via asteroids, comets, and interstellar dust. Dyson argues this astrobiological approach takes dispersal advantage of the vast surface area of thousands of small objects rather than limiting it to the "planetary cage" of gravity from large masses. However, considering the recent discovery that flatworms returned from space with a tendency to produce two heads, Dyson's approach would have to proceed with the understanding that space will fundamentally alter whatever we originate from this gravity-based, oxygenated atmosphere.

There may be an operating space where the AI-robot colonies and the astrobiological seeding could work in tandem to extend complex life into space. The viability of space mining will ultimately fuel, oxygenate, and physically assemble the foundation of any future human colonies in space. For this reason, the legal and techno-scientific pathways used to establish the earliest claims must be very strategically crafted and sufficiently visionary to support future biological colonization. Historical versions of frontier colonization fostered a vicious cycle of exploitation, violent resource grabs, and toxic legacies of abandonment, despite their oft-utopian ambitions. To initiate a virtuous cycle, space mining and colonization efforts need to be properly vetted for unintended consequences and collective benefits, not just for private profitability. Towards this goal, a new space colonization directive might require dual functions for each mission to help form habitable life conditions and provide new technological means of travel and economic viability.

None of these proposed checks and balances is meant to suppress the race for space colonization. Indeed, the endeavor is the next apparent advancement for our species and bears the promise of extensive technologies, biological advancements, and resources that will be useful here on Earth. Musk shows clear intent and resolve to retire on Mars.[8] And if your idea of a solid retirement is braving a three- to six-month trek to a barren land in an exploding cylinder, where you must live underground to endure the raining radiation, unbreathable air, and unlivable temperatures, then mining-based frontier Mars colonization may be your ticket. I, for one, am more eager to let my asteroid robot avatar test that frontier first, to terraform and atmospherically design it into habitability. This techno-bio dilemma will remain an important chicken-and-egg question for decades. Should we first house our most advanced lifeform on other space objects, or should we pioneer new space with our most advanced, technological creations?

1 US Census Bureau, "Following the Frontier Line, 1790–1890," https://www.census.gov/dataviz/visualizations/001/ (accessed June 22, 2017).

2 Jeff Foust, "New Luxembourg Space Agency to Support Luxembourg's Space Resources Ambitions," SpaceNews, June 6, 2017, http://spacenews.com/new-luxembourg-space-agency-to-support-luxembourgs-space-resources-ambitions/ (accessed June 22, 2017).

3 John C. Lacy, "The Historic Origins of the US Mining Laws and Proposals for Change," *Natural Resources, Energy and Environmental Law* 10, no. 1 (1995): 13–20.

4 [illegible], "A Responsive Approach to Sovereignty on Mars," *Space Policy* 38 (2016): 57–61.

5 Kurt Wagner, "Here's How Government Will Work on Mars, According to Elon Musk," *Recode*, June 2, 2016, https://www.recode.net/2016/6/2/11845148/elon-musk-mars-government-direct-democracy (accessed June 22, 2017).

6 [illegible], *The Myth of the Savage: A History of Invention* (Waterloo: Wilfrid Laurier University Press, 1990).

7 Freeman Dyson, "The Green Universe: A Vision," *The New York Review of Books* (October 13, 2016), http://www.nybooks.com/articles/2016/10/13/green-universe-a-vision/ (accessed June 22, 2017).

8 Elon Musk, "Making Humans a Multi-Planetary Species," *New Space* 5, no. 2 (2017): 46–61.

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Editorial

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