Title

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Publication Date

2026-03-16

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Abstract: This paper examines the commercialization of Low Earth Orbit via satellite mega-constellations, analyzing technological, environmental, and governance impacts through Standpoint and Native Feminist frameworks, and proposes community-driven strategies for equitable, ethical, and sustainable orbital stewardship.

INTRODUCTION

Since the launch of the first artificial satellite, Sputnik 1, in 1957, Earth's orbit has hosted innovation in forms of state-funded research missions and telecommunications infrastructure [4]. However, the rise of the NewSpace era, characterized by the rapid commercialization and privatization of space, has fundamentally transformed orbital space. One major development of this era is the emergence of satellite mega-constellations: networks composed of thousands of satellites operating primarily in Low Earth Orbit (LEO) to deliver high-speed broadband internet.

One of the pioneers of the NewSpace era is SpaceX's Starlink system, which launched its first batch of 60 operational satellites in May 2019. As of early 2026, Starlink operates 10,000+ active satellites, accounting for more than 60% of all functional hardware currently in orbit [4]. This dominance has accelerated a new race to commercialize LEO. Competitors such as OneWeb (supported by Eutelsat), Amazon's Project Kuiper, and China's Guowang and Qianfan constellations are currently deploying or planning their own satellite networks, with projections exceeding 100,000 satellites within the next decade [4].

Advocates of satellite mega-constellations emphasize their potential to improve global connectivity and extend internet access to remote communities. These narratives often frame orbital commercialization as a natural and beneficial progression of technological innovation. However, such perspectives frequently overlook critical questions regarding environmental sustainability, governance, and global equity. As the number of satellites increases, the probability of orbital collisions and the accumulation of space debris grow, threatening critical infrastructure used for navigation, communication, and climate monitoring.

This paper argues that the commercialization of orbital space through satellite mega-constellations functions as a contemporary form of frontier expansion. Drawing on Native Feminist and Standpoint Theory frameworks, this analysis examines the narratives used by NewSpace corporations and international space governance institutions. By engaging global critiques of land dispossession and colonial expansion, this paper calls for a shift from models of private control toward a relational framework of stewardship that reimagines humanity's responsibility to orbital space. This work is in partial fulfillment of the ENGR184 course using the blueprint curriculum in Ref [1,2] and captured in a collection [3].

METHODS

This paper employs a qualitative critical discourse analysis situated within the interdisciplinary frameworks from science and technology studies. By examining the intersection of technological development, corporate power, and environmental ethics, this research investigates the socio-political implications of

satellite mega-constellations. The primary evidence for this study is drawn from a multi-vocal dataset designed to consider the dominant narratives from leaders of the NewSpace industry as well as the scientific and ethical critiques positioned against them. These sources include corporate promotional materials and mission statements from firms such as SpaceX, Amazon, and OneWeb; international governance documents; and peer-reviewed scientific literature regarding orbital debris, atmospheric chemistry, and astronomical interference.

Two primary frameworks guide the analysis and decomposition of the materials. First, Standpoint Theory, rooted in feminist epistemologies, is used to examine how knowledge claims and notions of technological "necessity" are shaped by individuals in positions of political and economic power. Through this lens, the paper analyzes how stakeholder-backed corporations and technologically competitive nations frame satellite expansion as a universal benefit to civilization. This approach enables a critique of whose voices are marginalized in these discussions, highlighting how the situated knowledge of astronomers, space-marginalized nations, and communities affected by satellite infrastructure is frequently excluded from decisions governing orbital space.

Second, the analysis draws upon Native feminist frameworks that interpret orbital commercialization not as a neutral technological frontier but as part of an ongoing process of colonial expansion and extractive governance. Within this perspective, the commercialization of Low Earth Orbit is critically examined through concepts such as the "logic of elimination" and territorial dispossession. These perspectives challenge narratives that frame orbital space as an empty void available for technological occupation, arguing instead that such framing mirrors historical patterns of land theft and resource extraction on Earth. This framework therefore shifts the analysis beyond purely technical critiques of satellite impacts and toward a model of relational responsibility, contrasting extractive ownership models of private industry with Indigenous-informed understandings of the sky as a site of kinship and collective stewardship.

Through the integration of these frameworks, the paper analyzes three major thematic areas. The first focuses on the narratives of technological progress and inevitability used by NewSpace companies to bypass the effects of ethical consequences. The second examines governance structures and how they currently enable private control over orbital space while offering limited mechanisms for collective accountability. Finally, the paper investigates the distribution of environmental risks, exploring how the long-term harms of orbital congestion and atmospheric pollution are externalized to the global community, disproportionately affecting those who have the least power to influence space policy.

RESULTS AND INTERPRETATION

Technological Development

Satellite technologies have rapidly transitioned from communication systems to foundational infrastructure for modern society. As Danielle Wood, director of the Space Enabled research group at the MIT Media Lab, explains that satellite observation and communication are "vital to our daily life" [5]. This framing positions orbital infrastructure as an inevitable technological necessity supporting navigation, climate monitoring, telecommunications, and global logistics. However, the Standpoint Theory perspective suggests that the claims of necessity reflect the perspective of those who benefit most from these systems: governments, technology companies, and industry leaders. It masks how technological "necessity" is socially constructed. The priorities of high-frequency data processing and communication reflect the interests of corporations with significant economic resources, rather than the needs of the global population as a whole.

This perspective becomes even more visible in emerging proposals for orbital computing infrastructure. Corporate filings from SpaceX suggest that future orbital data centers could host artificial intelligence systems "freed from the constraints of terrestrial deployment," transforming Low Earth Orbit into a site of computational production [6]. While presented as a technical solution to terrestrial limits such as energy consumption and cooling, this view implicitly treats orbital space as an open environment available for technological expansion. Such assumptions echo the colonial frontier narratives critiqued in Native Feminist perspectives, where territories were historically described as empty or underutilized in order to justify development and extraction. When orbit is framed as the next logical site of technological infrastructure, the question becomes not simply whether the technology is possible, but who defines the boundaries of development in shared environments and whose priorities shape that decision.

Corporate Power

A second key finding is the increasing alignment between commercial space companies and national strategic priorities. Interviews and policy statements from space industry leaders reveal that government contracts and defense partnerships are becoming central drivers of NewSpace development. Jamie Morin, Vice President of Defense Strategic Space at The Aerospace Corporation, notes that private companies have significant opportunities to "gain significant government revenue" through partnerships related to defense and national security [7]. This alignment is reinforced by recent national policy directives emphasizing the strategic importance of commercial space leadership. The 2025 U.S. Trump Administration executive directive on "Enabling Competition" explicitly states that emerging space-based industries should be "pioneered in America rather than by our adversaries" [8]. Such policies frame orbital space not as a shared global common but as a competitive domain in which technological leadership contributes directly to geopolitical influence.

Applying Standpoint Theory highlights how this governance structure reflects the standpoint of state security institutions and the military–industrial complex. Within this framework, space becomes primarily defined through strategic competition and national security concerns. This perspective privileges military readiness and economic dominance while marginalizing alternative viewpoints, including those of the international scientific community and non-spacefaring nations that rely on orbital infrastructure but have limited influence over its governance. From a Native Feminist framework, this rhetoric of "pioneering" space closely mirrors historical language associated with colonial expansion and Imperialism. Terms such as exploration, conquest, and pioneering historically justified territorial expansion under the assumption that frontier lands were open for ownership and control. When applied to orbital space, this discourse similarly frames it as territory to be claimed through technological capability and political power, replacing models of collective stewardship with systems of private and national dominion.

Environmental Ethics

The rapid expansion of satellite mega-constellations introduces significant environmental risks. Heavy-lift rocket launches required to deploy these systems generate large emissions; a single launch of SpaceX Starship produces roughly 76,000 metric tons of CO_2 equivalent while also creating noise pollution and ecological disruption near launch sites [9]. Satellite reentry introduces additional hazards as well. Research from the University of British Columbia estimates a 40% cumulative probability of ground casualties if satellites fail to fully burn up during atmospheric reentry [10]. Even when destruction is complete, metallic particulates released into the upper atmosphere raise concerns about long-term atmospheric chemistry. Meanwhile, the growing number of satellites increasingly interferes with astronomical observations conducted by major space instruments such as the Hubble Space Telescope [11].

Despite these risks, environmental impacts are often framed as acceptable trade-offs for technological progress. Standpoint Theory helps explain this framing: the actors making decisions about satellite deployment (corporations, policymakers, and investors) are largely insulated from many of the consequences. Communities living near launch sites, regions where debris may fall, and astronomers whose research is disrupted have comparatively little influence over orbital policy. This uneven distribution of power reflects a broader pattern that Native Feminist scholars associate with frontier expansion, where environments beyond immediate centers of authority are treated as spaces where ecological limits can be ignored. When applied to orbital commercialization, this logic effectively transforms the atmosphere and near-Earth space into industrial zones where pollution and risk are externalized to the global commons. Such dynamics raise an unresolved ethical question: if orbital space is an interconnected environment shared by the entire planet, what forms of stewardship or governance should guide its technological use?

CONCLUSIONS

This research demonstrates that the rapid commercialization of orbital space is often framed as an inevitable technological progression, yet Standpoint Theory and Native Feminist frameworks reveal that this narrative reflects the priorities of governments, defense institutions, and private corporations, while marginalizing communities most affected by orbital activity. Satellite mega-constellations disrupt local environments near launch sites, interfere with astronomical observation, and impose risks on non-spacefaring nations that lack meaningful governance representation. These inequities are exacerbated by an outdated legal framework: the 1967 Outer Space Treaty and related conventions were designed for a Cold War era and fail to address private operators, mega-constellations, or orbital debris liability [12]. National regulators like the FAA, FCC, and NOAA have limited authority, leaving gaps in oversight for on-orbit activities, multi-actor accountability, and debris mitigation, creating a "tragedy of the commons" in low-Earth orbit [13, 14].

To address these challenges, this research proposes concrete, community-integrated actions. Locally, universities could partner with observatories and amateur astronomy clubs to organize satellite interference monitoring programs, where students and residents track satellite passes, light pollution, and debris using telescopes or smartphone apps. Data could be compiled into annual public reports submitted to local governments, regulators, and NGOs. Community workshops could train participants in software that models orbital debris or satellite trajectories, giving residents a direct role in monitoring impacts. Press releases and local STEM publications could raise awareness of environmental and cultural consequences.

At the national level, researchers could draft policy briefs advocating stricter licensing, mandatory environmental impact assessments, and formal representation of astronomers and non-spacefaring nations in FCC and FAA decisions. These briefs could be submitted to congressional hearings, agency workshops, or published in STEM outlets such as *Scientific American*. Globally, international workshops and collaborative reports could propose an Orbital Stewardship Framework codifying debris mitigation standard, transparency for satellite lifecycles, and liability rules for collisions. A public-access global database could allow volunteers worldwide to log satellite observations and interference events, amplifying community voices in orbital governance.

By combining citizen science, targeted communication, and policy advocacy, these initiatives create a pathway toward equitable, enforceable, and community-informed orbital governance. As satellite networks expand and legal frameworks lag, the challenge is no longer technical feasibility, but who has the authority and tools to shape orbit according to shared environmental, scientific, and ethical principles.

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