

58 STS and Outer Space: Extending the Gaze

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Introduction: The Social Studies of Outer Space

As spaceflight activities increasingly aim to (re-)establish a new ‘frontier’ for exploration and exploitation in outer space, a diverse array of scholars from various disciplines is turning their attention to the intricate entanglements between Earth and outer space. Within this context, this entry seeks to invigorate the field of Science and Technology Studies (STS) by introducing the burgeoning domain of Social Studies of Outer Space (SSOS). Bringing together researchers from STS, anthropology, sociology, geography, political science, and many more, SSOS explores the cultural and social meanings, economics, materialities, infrastructures, and politics of human activities in outer space (Valentine, 2012; Battaglia, Valentine and Olson, 2015; Vertesi, 2015;). It offers crucial insights into the cultural, economic, political, and imaginative dimensions of space endeavours and how these shape and are shaped by social orders on Earth (Dickens and Ormrod, 2016; Messeri, 2016; Tutton, 2020). As will be shown exemplarily in this entry, much of the research in SSOS speaks to critical concerns in STS. STS has a long trajectory of engagements with space science and technology, particularly earlier work that focused on techno-scientific practices in astronomy and space science and the controversies surrounding these. Edge and Mulkay (1976) traced the evolution of Radio Astronomy in Britain, while Lynch and Edgerton (1987) scrutinized the production of astronomical images from a social studies of science perspective. Vaughan's (1996) influential study of the Challenger disaster (data) provided a sociological lens to examine the role of bureaucracy, statecraft, knowledge, and technology, shedding light on the intricate complexities and challenges inherent in scientific organizations such as NASA. However, outer space merely provided the backdrop for studying scientific practices in different contexts rather than being a specific, dynamic site of academic engagements and methodological challenges replete with its own complexities.

This entry suggests that a focus on outer space can extend the reach of STS frameworks and sensitivities to critically interrogate how outer space technoscience is not only a contested site

of innovation, investment, and imagined sociotechnical futures (cf. Alvarez et al., 2019) but a conjuncture (Salazar and Gorman, 2023) that opens up and refracts multiple conversations at the core of STS. In the following, I highlight four key dimensions of engagements with space that speak to broader debates in STS: *Modes of Knowing and Place-Making*, *Imaginaries and the NewSpace Age*, *Orbital Geopolitics and (Post)colonial Trajectories of Space Infrastructures*, *Care and Responsibility for Outer Space Environments*. These dimensions are not exhaustive, as the multifaceted nature of engagements with outer space transcends the confines of these classifications (and the scope of a short entry). Yet, what these diverse strands of interest and empirical sites have in common is that they treat outer space as a ‘sphere of the social’ (MacDonald, 2008: 614) and offer fruitful avenues for STS research on the cultural and social meanings, economics, and politics and controversies of human activities in and engagement with outer space.

Modes of Knowing and Place-making

As practices of knowing space are closely entangled with place-making practices, outer space requires us to rethink how we conceptualize extraterrestrial actions and sites (Praet and Salazar, 2017: 311). In her seminal book *Placing Outer Space* Messeri (2016: 190) states that space “is not just a passive canvas on which action occurs, but an active way of knowing worlds (...) even when place is not self-evident, as perhaps with invisible exoplanets, it is nonetheless invoked and created in order to generate scientific knowledge”. A growing body of work at the intersection of STS, anthropology, and sociology is now concerned with how outer space can be known, identified, studied, and understood – how people derive meaning from outer space (Dunnett et al., 2019). Research in this realm often links empirical work on space science, engineering, and scientific experiments to longstanding concerns in STS about the social construction of (scientific) knowledge and its visual representations. Interested in how the distinctions between outer space and Earth are (de)stabilized and shifting, work has, for example, explored how planetary sciences contribute to new place-making practices (Messeri, 2016), how exoplanets become places to be known and explored (Webb, 2021), and how meanings and valuations of scientific research are done in space science experiments and practices.. An excellent example of the entanglements between science, politics, and place (-making) is Merron’s (2020) work on the South Africa Square Kilometre Array telescope used by astronomers to analyse hyperobjects as vast as the centre of the Milky Way galaxy. While of high value to the scientific community, it causes controversies that expose the contextual relations surrounding all space infrastructures and space science (cf. Hobart, 2019). For the case

of Hawaii, Maile (2021) shows how the development of the astronomy industry on Mauna Kea is shaped by technoscientific aspirations related to time, territory, and outer space, driven by a desire to uncover alien life and explore other worlds, often intersecting with settler colonialism on Earth. As techno-epistemic infrastructure, the telescope shapes how space on/off Earth is produced, organized, and experienced. Similarly, Sammler and Lynch (2021: 962) argued that debates about the ethics and politics of space science require a closer look at its infrastructures and apparatuses and “the ways they iteratively reshape the world”. Recent research in the field of SSOS explicitly addresses how non-Western modes of knowing space come to matter and explore the colonial trajectories of space science and its infrastructures (Treviño, 2023).

Vertesi's (2015) *Seeing Like a Rover* explores NASA's Mars Rover mission, highlighting how digital processing technologies have transformed space research. Scientists on the mission had to not only interpret Rover images but also develop new methods of interplanetary visualization, communication, and coordination. Similarly, Mirmalek (2020) demonstrates how the Mars Exploration Rover mission created unique temporal challenges, aligning time zones on Mars and Earth and revealing insights about technology-mediated work organization. From a different angle, Olson (2018) provides a rich account of NASA spaceflight programmes by moving across various speculative scientific projects, from haptic spacesuits to underwater human habitats and medical laboratories. Focusing on these experimental knowledge practices, Olson shows how these ‘extreme’ environments are used as proxies to provide clues about life in outer space and on other planets and explore the co-constitutive relationship between outer space (research) and contemporary US-American technoscientific visions of the future.

A third perspective on modes of knowing and place-making is how satellite technologies create novel forms of knowledge. Satellites generate data used for communication and navigation, environmental monitoring, crisis response, and surveillance and have radically changed our understanding of the nature-society relationship beyond Earth, producing novel ontological relations (Gärdebo et al., 2017). Yet, such technology-mediated forms of knowing the world as a global whole are far from offering a view from nowhere. Their ground stations and data centres are part of earthly (knowledge) infrastructures closely entangled with the geopolitics of data access, diplomacy, in/security and the shifting epistemologies that arise from having new tools for sensing the environment.

Imaginaries and the NewSpace Age

Studying Outer Space requires an engagement with the future and the questions that envisioned futures create for socio-political orders in the present. The following part gives an overview of STS literature and related fields about outer space as a prominent area of speculation and future-making (Kilgore, 2003). Outer space has always been a place of imagination and space programmes and technologies offer a vibrant narrative of possibilities and a ‘utopian future’ as they reflect changing ideologies of ordering the world, entangling technological choices and strategies to broader configurations of identity and statehood. As such, they urge us to attend to interplanetary and earthly spaces and infrastructures as intrinsically linked to each other (Clormann and Klimburg-Witjes, 2021). Work in SSOS and STS alike is increasingly concerned with how “claims and counter-claims about the future of humans in outer space also articulate competing visions of Earthly futures” (Tutton, 2020: 2), how these are made, performed, and contested and shape collective imaginaries of what the future of humans in outer space will be like. Many actors are developing and promoting bold, ambitious visions of human destinies in outer space that prominently feature in media accounts and public debate. So-called NewSpace companies like SpaceX or Blue Origin intend to build an entirely new economy in outer space, including space tourism and human settlements on the Moon and Mars in the next two decades. NewSpace refers to an increasing privatization of outer space, which at once spurs enthusiasm and critique. A new popular fascination with ‘colonizing’ Mars, new legislative practices and regulations empowering private enterprises to exploit outer space, and the channelling of funds to support the space industry have disrupted Cold War-era paradigms of national big science projects in outer space, previously led mainly by governments.

As Valentine (2012: 1047) argues, NewSpacers are drafting specific space futures that build on libertarian ideas and speculative fiction that envisions the flourishing of humanity to be found ‘elsewhere’, e.g., in human settlements beyond Earth. Outer space, as Popper (2023: 70) writes, becomes “a place of opportunity, pioneering, and progress; of modern men, in the image of Robinson Crusoe, confronting and taming nature with technical ingenuity.” Through narratives, visualizations, and technological demonstrations, such collectively performed and rehearsed visions of becoming multi-planetary by space entrepreneurs and investors offer crucial insights into how these are “animated by political and cultural claims about Earthly societies and their problems” (Tutton, 2020: 2) and often informed by Silicon Valley innovation cultures.

At the same time, to its proponents, NewSpace promises more than economic gains but an exit strategy from the multiple crises on and constraints of Earth – from resource depletion to global

warming and wars (Valentine, 2012). For research in STS and related fields, the ‘reinvigoration’ of space activities in the new space age opens novel areas to explore how forms of technoscientific capitalism emerge and stabilize in outer space.

Orbital Geopolitics and (Post)colonial Trajectories of Space Infrastructures

Since the launch of the very first satellite in 1957, it was apparent that space travel would not leave politics and nationalism behind but that they would effectively be taken to orbit, providing a new dimension for competing geopolitical interests (Dickens and Ormrod, 2007; Beery, 2016; Klimburg-Witjes, 2023). As different actors with competing territorial agendas are co-producing the spaces of outer space (Dunnett, 2023), questions of outer space are “inextricably linked by the spatial politics of privilege and the imposition of sacrifice—among people, places, and institutions” (Klinger, 2019: 667). Work that engages with outer space from the perspectives of critical geography, feminist technoscience, and postcolonial studies has challenged narratives of frontier expansionism and settlement (Macdonald, 2008; Siddiqi, 2010; Gal and Armstrong 2023). Sage (2014) has shown how the idea of space as a frontier still draws on geographical imaginations of America’s ‘Manifest destiny’ and evokes colonial logic to legitimize expansion and exploitation. Gorman (2009) has highlighted material-discursive parallels between practices of terrestrial colonialism and expansion to outer space, in which “both interplanetary space and the lands of ‘primitive’ people are [considered] terra nullius, empty wildernesses, or moral vacuums, into which civilized sea-faring or space-faring nations moral order inserts itself” (2005: 99). Work in SSOS and related fields aims to re-situate outer space against the ground and attend to the different spatial and temporal frames within which ‘the local’ takes shape (Redfield, 2000) and how the placement of space infrastructure shaped colonial geographies of extraction, sacrifice, and risk (Trevino, 2023).

In *Space in the Tropics*, Redfield (2000) gives a rich account of how space infrastructures affect and transform places on Earth. This study has been foundational for social science engagements with space and place and how space technologies, expertise, and ambitions are always also grounded in geographies of power. Recounting the history of Kourou in French Guiana, from being a penal colony for the French to becoming the European Space Port still in use today, Redfield traces the colonizing impulse of European space exploration overseas and the “particular locale in order to describe the shifting cultural topographies of people passing through it” (2000: 18). Mitchell (2017), in turn, provides a detailed empirical account of how the Brazilian Air Force built a satellite launch facility on the Alcântara peninsula, one of

Brazil's poorest regions. A technopolitical mega-project, the base displaced many Afro-Brazilians from coastal land to inland villages, spurred decades of conflict and controversy, and amplified existing socio-political inequalities. Both accounts show how the differences in accessing space are a metaphor for the global disparities in technological modernization projects and uneven labour geographies of the space industry.

As any environment shaping and shaped by human relations, practices, and materialities, outer space is crowded with the leftovers and residues of scientific-technological projects and infrastructures. The following section attends to research on the environmental consequences of increasing outer space engagements and the long-neglected questions of sustainability of and responsibility for outer space environments.

Care and responsibility for Outer Space Environments

“Despite being often imagined as an empty vessel (...) awaiting purposeful inscription by the human species” (Kearnes and van Dooren, 2017: 182) outer space is deeply affected by technopolitical endeavours beyond the stratosphere, spurring debates in SSOS on outer space as an environment in the Anthropocene. As Marino (2023) states, critiques of the Anthropocene have proven essential yet insufficient in addressing environmental concerns extending beyond Earth. While the Anthropocene, as a geological epoch, inscribes itself deep within Earth's strata, it reveals a notable limitation—it fails to encompass the reach of pollution and exploitation beyond our planet, exemplified by phenomena like space debris. Decades of spaceflight activities have left an ever-growing pile of junk in the Earth's orbits – from rocket components, defunct satellites, and propellant residues to paint chips and tools lost by astronauts. These debris fragments can lead to orbital congestion (like a traffic jam on the highway) and already complicate present and future uses of outer space. As Rand (2019: 4) has argued, “Contrary to triumphal spaceflight narratives, (...) the Space Age became truly global not solely through acts of innovation but also in moments of decay”. Once an accepted by-product of technological progress, economic interests, and geopolitics, the junk in space highlights the sociotechnical vulnerability of relying on space infrastructures for our daily lives on Earth (Clormann and Klimburg-Witjes, 2021). The worst-case scenarios predict a future in which the orbits become permanently impenetrable to astronomical observation and space exploration, a human-made barrier that would end all dreams (or dystopias) of becoming ‘multi-planetary’. Attending to the interplanetary space as a “cultural landscape forged by the organic interaction of the space environment and human material culture,” as Gorman (2005: 86) suggests, allows

considering junk in space not as a distant outer space phenomenon but rather, in many ways, closely bound to planetary concerns (Hunter and Nelson, 2021: 229; Praet and Salazar 2017). Like other forms of debris in terrestrial environments (e.g., nuclear waste, microplastic), space debris prompts questions about how to live with the material remains of technological endeavours as these are “imbricated in the management of the future as a material force” (Damjanov, 2017: 180), prompting us to rethink issues of sustainability and responsibility for beyond-planetary environments (Gärdebo et al., 2017). Given the increase in space activities, as is evident in the unprecedented number of planned satellites to be launched by private companies, space debris demands fundamental developments in ideas about ethico-political practices, the life and death of technologies, and the status of what is shared (cf. Damjanov, 2017). Research on space debris can draw on longstanding engagements in STS with waste, residues, and technological leftovers and on work concerned with responsible innovation to understand how space debris is slowly becoming a matter of concern and, eventually, care. Future work at the intersections of STS and SSOS will be well-prepared to explore the material enactment of orbital-planetary infrastructures as a means to understand sustainability discourses in technosocieties at large (Clormann and Klimburg-Witjes, 2021).

Conclusion and Outlook: Engaging Outer Space

Earth's spatialized socioeconomic and political relations will likely extend into space in the future (Beery, 2016), and envisioned space futures are already materializing in the present. It is thus vital to progress beyond disciplinary comfort zones as —paraphrasing Armstrong and Gal’s (2023) work on feminist approaches to outer space— as how we think about science, technology, politics, and the environment, shapes the way we research the past, understand the present, or speculate about the future. Insights, interests, and interventions from SSOS will contribute to research in STS on how outer space is not simply ‘out there’ but intimately bound up in Earth-based assemblages, concerns, and power relations and imaginations. As a ‘friendly alien’ (Vidmar, 2019) to STS, SSOS can contribute much to an engaged conversation about the consequences of past, current, and future visions and practices related to outer space. Research in STS, in turn, is well suited to address discourses, artifacts, politics, and temporalities that reach beyond ‘our’ planet, the practices that constitute outer space as a place, and how outer space is envisioned and enacted as a place of techno-scientific and political possibilities and struggles.

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