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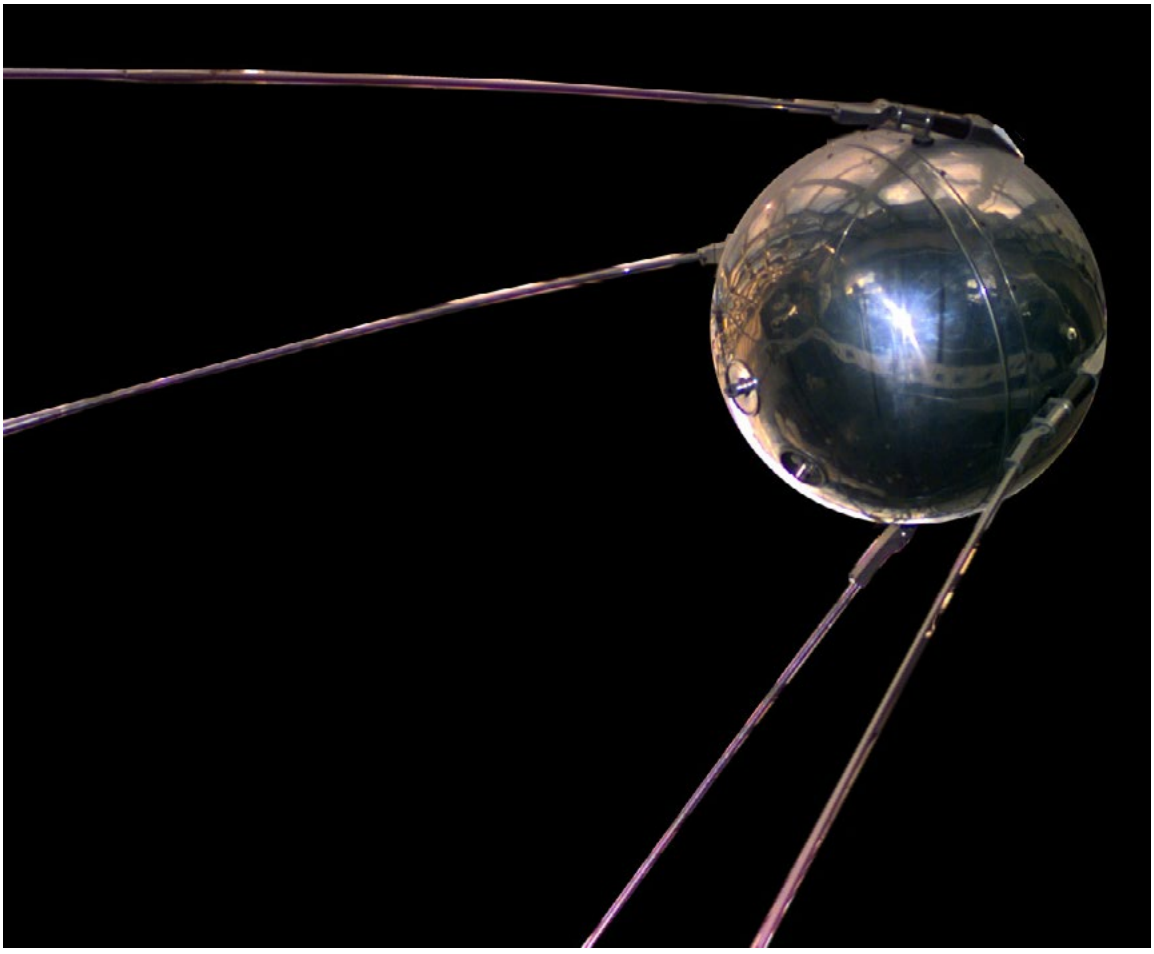
Introduction:
Infrastructure on/off Earth

Christine Bichsel

"Interrogate the slash!" *Roadsides*' edited collection no. 003 examines the meanings embedded in the slash between "on" and "off" for the infrastructure of space exploration and outer space. This slash implies simultaneity, but also distinction. It both connects and separates (Friedman 2010: 475). "On/off" alludes to a switch that has two positions, but also refers to a process that is not continuous, one that repeatedly starts and stops. These ideas serve as an entry point to think through the relationships between the states of "on Earth" and "off Earth." At first sight, these two states appear self-evident, representing separate geographical domains with a more or less defined boundary. As the atmosphere fades away, "on Earth" is phasing out and "off Earth" begins. However, this edited collection argues that there are many nuances in these two states and in the relations between them. We address the following question: How does a conceptual and empirical focus on infrastructure advance our understanding of the cultural, political and economic relationalities of outer space?

This collection brings into conversation two fields of the social sciences: the emerging social studies of outer space (Messeri 2016: 16) and recent social science research on infrastructure. First, it provides insights into how social science scholarship of space-

related activities can contribute to infrastructure studies. The contributions demonstrate that a focus on space infrastructure helps to unpack the terracentric assumptions and boundaries currently informing infrastructure studies, such as the prevalence of gravity and air pressure, and fixity in space-time with its Cartesian coordinates. Second, the collection shows how insights from the "infrastructural turn" in the social sciences can advance social studies of outer space. To date, infrastructure has figured in these studies as the "hardware" or "backdrop" for analyzing the social relations of outer space. However, this collection suggests that infrastructure may be a key entry point for unravelling the relationalities of Earth and outer space (Battaglia et al. 2015; Valentine 2016). Infrastructure studies offer the conceptual tools for such an analysis.



The model of Sputnik 1. Credit: https://nssdc.gsfc.nasa.gov.

In physical terms, the boundary between "on Earth" and "off Earth" has always been porous. For example, Earth not only experiences atmospheric weather but also "space weather" – the latter designating conditions in the Sun and the solar wind that can affect instrumentation and human health on Earth (Taylor, this issue). The very idea of the boundary is culturally and historically contingent, too. Since antiquity, Western imagination has conceived and represented Earth as a globe (Cosgrove 2001), a

mental operation that requires defining Earth's boundaries and its relation to the "outside." Moreover, throughout history, the idea of a bounded Earth has acquired great epistemological and normative power. Terracentric boundaries inform philosophies of human existence and sociality (Lazier 2011), and are involved in constructing social theory more generally (Olson and Messeri 2015). The practice of humans going "off Earth" through space exploration since the mid-twentieth century has raised new questions about this boundary (Battaglia et al. 2015; Praet and Salazar 2017).

In interrogating the connections between "on Earth" and "off Earth" through the lens of infrastructure, this collection argues that the conceptual and empirical analysis of space infrastructure – that is, the infrastructure of space exploration and outer space – can further our understanding of how these two states relate to each other. Space exploration is a highly material and technology-intensive activity, as contributions to this collection demonstrate. To escape Earth's gravity, humans require engineered vessels and strong propulsion produced by launching facilities (Peldszus, this issue). Once in space, humans are fully dependent on a highly elaborate built environment which creates the necessary conditions for survival under extreme conditions (Damjanov and Crouch, Bichsel, this issue). In turn, most of outer space only becomes accessible to the senses when mediated through technology such as radio telescopes (Hoeppe, Merron, this issue). Contemporary society on Earth relies heavily on a dense network of satellites for telecommunication and navigation purposes (Luk and Wijeyeratne, this issue). Yet imaginaries become infrastructure too, as they enable and sustain aspirations for human expansion into outer space (Dunnett, Popper, this issue).

The nine contributions making up Roadsides 003 explore space infrastructure for its on/off Earth relations. **Katarina Damjanov** and **David Crouch** analyze the International Space Station (ISS) as a media infrastructure. They demonstrate how the specific configuration of modules, cables and wireless networks produces a closed system that is, at the same time, intimately linked to Earth through material and signal traffic, including live feeds. The essay by **Götz Hoeppe** engages with the sky as an infrastructural medium. He shows how the sky itself becomes a resource for infrastructuring practices in astronomy, the latter creating epistemic communities in science that form around methods of instrumentation. **Joseph Popper** considers imaginaries of private and commercial space exploration as infrastructure. He offers insights into how material and representational artefacts collapse the near and distant future, stabilizing aspirations for human expansion into outer space. **Regina Peldszus** focuses on space launch systems with a view to infrastructure resilience. She shows how disparate launch debris from the explosion of the Ariane 5 rocket epitomizes the ever more complex system-of-systems of space infrastructure, of which human actors can only grasp and act upon a microscopic section. **Oliver Dunnett** explores the space elevator as imaginary infrastructure in science fiction literature. He reveals how this literature anticipates the geographical, cultural and political ramifications of fast access from Earth to outer space by means of a tether linking a point on the equator to a point in geostationary orbit. **Christine Bichsel**'s paper looks at the former space station Mir as cinematographic infrastructure. She sheds light on how Mir as a representational object is closely interwoven with the political turmoil of Soviet disintegration in 1991. In their contribution, **Christine Luk** and **Subodhana Wijeyeratne** examine the satellite architecture for global positioning systems as geopolitical infrastructure. They elaborate

on how competing satellite systems are a means for and expression of claims to global control over terrestrial navigation. **A. R. E. Taylor** focuses on space weather to think through critical infrastructure. He demonstrates how public and political perceptions of solar conditions as a threat to ground-based terrestrial infrastructure reconfigure relations of connectivity between Earth and Sun, and redefine the scope of space infrastructure. **James Merron**'s essay investigates a radio astronomical observatory as ambient infrastructure. He reveals how the production of astronomical knowledge of the Universe bears the inscriptions of contemporary terrestrial life and local contestations from the surrounding space.

Let me draw attention to three cross-cutting themes that emerge in these contributions. First, there is the historical contingency of space infrastructure. This manifests in the ISS's interconnected American and Russian sections (Damjanov and Crouch), as the latter was originally meant to become space station Mir-2; in the conversion of an obsolete broadcasting dish into a radio telescope (Merron); the trajectory of the space elevator as "almost possible" infrastructure from Soviet space science to British and American science fiction (Dunnett), and in the adaptation of former NASA imagery by NewSpace actors for the projection of their business aspirations (Popper).

Second, we see the tension between humanist framing of and particular interests in space infrastructure. Labeled as "for all of humanity" in representations of future human habitation in space or scientific knowledge of the Universe, space infrastructure embodies geopolitical and ideological projects such as the Chinese Space Silk Road (Luk and Wijeyeratne) or pan-African aspirations (Merron), provides a nucleus for epistemic communities in science (Hoeppe), and creates complex multinational technological assemblages with unpredictable dynamics (Peldszus).

The third strand is the normative and epistemological centrality of "on Earth" against "off Earth." Even if humans escape Earth's gravity by dwelling on space stations (Damjanov and Crouch; Bichsel), they remain within the intellectual force field of Earthbound frames of reference (Clark 2013). Space exploration itself is defined by Earthbound epistemologies. As a project of knowledge production, it is driven by "on Earth" assumptions and purposes. "On Earth" and "off Earth" are thus not solely relational states, but mutually constitutive domains exposing a power asymmetry. "On Earth," so far, remains the singular and dominant framework within which space infrastructure's materiality and imaginaries take shape.

This introduction took as a starting point the slash in "on/off Earth", aiming to examine this apparent division and its embedded meanings. The slash, it has proved, reveals a complex set of relationships inviting us to question whether it makes sense to distinguish and separate those two states. Should we then do away with the slash in order to overcome the dichotomy of "on Earth" versus "off Earth," replacing it with a more encompassing and relational concept? The nine contributions show that thinking with and through the slash is productive. While they demonstrate that the separation and distinction between "on Earth" and "off Earth" is in many ways arbitrary and unhelpful for analyzing space infrastructure, they also show how terracentric boundaries powerfully shape scientific and popular thought. As such, the slash might be worth keeping for the time being. Undoing the "on/off Earth" distinction too early

risks losing sight of how it is continuously constructed and maintained in societies. The slash forces us to engage further with this very particular relationship.

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