

SPACE-BASED DATA CENTERS ROADMAP: THE CASE FOR CAUTION

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Preface

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Innovation for Cool Earth Forum

WORKING PAPER

PREFACE

Science fiction writers have imagined computing power in space for many years. In 1978, the great Isaac Asimov published a story about two technicians sent to repair a large computer orbiting the Earth.[1] In 1968, Arthur C. Clarke released 2001: *A Space Odyssey*, in which a computer tries to take control of a spaceship.[2] In 1966, Robert Heinlein's *The Moon Is a Harsh Mistress* imagined a self-aware supercomputer helping plan a revolt in a lunar colony.[3]

Today computing in space is a reality. Many of the roughly 19,000 satellites currently in orbit have small amounts of computing power on board to support core functions such as Earth observation and communications, and a significant expansion of space-based computing capacity may be on the horizon. In the past 18 months, more than a dozen satellites have been launched to develop and demonstrate technologies for large-scale data processing in space. Driven by huge demand for compute, constraints on building that capacity on Earth and falling launch costs, several companies have announced plans to deploy hundreds of thousands of satellites for data processing, principally to train and run artificial intelligence (AI) models.

These plans raise many questions. Are data centers in space technically feasible? If so, will high costs be a barrier to their deployment? What are the risks and impacts of deploying vast constellations of space-based data centers? What treaties, laws and regulations would govern?

This year's ICEF Roadmap explores these questions. In this Roadmap, 10 coauthors set forth their initial views and analysis on a range of technical and policy questions related to space-based data centers. Our goal is to provide a useful resource for experts and non-experts alike.

The analysis in this Roadmap is primarily based on documentary research conducted during the summer of 2026. The text was prepared under a tight deadline and has not been subjected to peer review. As such, we consider it to be a "working paper."[4,5] We welcome comments and corrections, which can be sent to SBDCRoadmap@gmail.com. Some or all of the Roadmap will be updated to reflect comments, corrections and further research as opportunity permits.

In the past several years, AI models have become powerful research and writing tools. In preparing this Roadmap, we used AI models, including Claude, ChatGPT and Gemini for background research, fact-checking and suggestions with respect to writing clarity. We found those models to be very useful for these purposes, while of course recognizing that AI models can make errors and that statements made by AI models require careful review and verification.

This Roadmap builds on the body of literature produced annually in connection with the ICEF conference. Previous roadmaps have addressed the following topics:

- Sustainable Data Centers Roadmap (2025)
- Artificial Intelligence for Climate Change Mitigation (Second Edition) (2024)
- Artificial Intelligence for Climate Change Mitigation (2023)
- Low-Carbon Ammonia (2022)
- Blue Carbon (2022)
- Carbon Mineralization (2021)
- Biomass Carbon Removal and Storage (BiCRS) (2020)
- Industrial Heat Decarbonization (2019)
- Direct Air Capture (2018)
- Carbon Dioxide Utilization (2017 and 2016)
- Energy Storage (2017)
- Zero Energy Buildings (2016)
- Solar and Storage (2015)

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The ICEF Innovation Roadmap Project aims to contribute to the global dialogue about innovative solutions to energy and climate change challenges. We welcome your thoughts, reactions and suggestions.

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Please send comments and corrections to SBDCRoadmap@gmail.com.

References

1 Isaac Asimov. Found! OMNI Magazine No. 1, 62-63 (1978). https://archive.org/details/omni-archive/OMNI_1978_10/page/n63/mode/2up.

2 Arthur C. Clarke. 2001: A Space Odyssey. (New American Library, New York, New York, 1968).

3 Robert Heinlein. The Moon Is a Harsh Mistress. (G. P. Putnam's Sons, New York, New York, 1966).

4 CASRAI Editorial Board. Working paper in CASRAI Dictionary v2026.2 (2026, https://casrai.org/dictionary/term/working-paper).

5 Massachusetts Institute of Technology (MIT) Libraries. Working Papers in the MIT Libraries: Home: What are working papers?; Cambridge, Massachusetts, https://libguides.mit.edu/working-papers (Accessed August 2026).