

SPACE-BASED DATA CENTERS ROADMAP: THE CASE FOR CAUTION

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OPENING ESSAY:

Growing Momentum Towards Space-Based Data Centers

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Putting data centers in space once seemed fanciful. Today, a growing number of companies are seriously exploring doing so. This activity is concentrated in the United States but spread across at least a dozen countries globally. The number of data centers launched to space will likely grow in the years ahead.

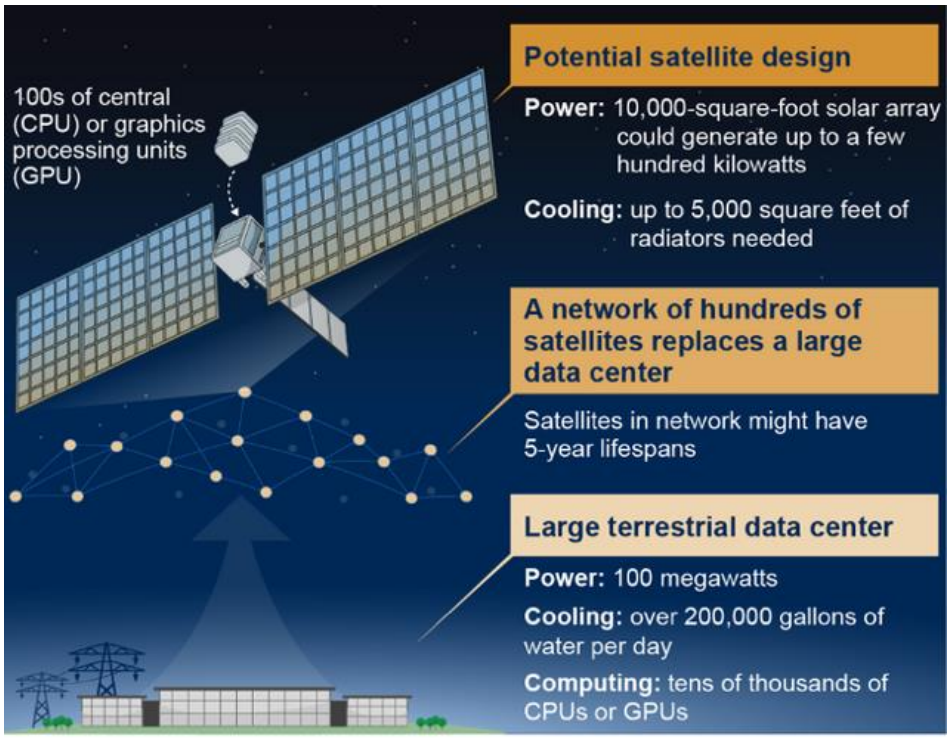
SpaceX is by far the largest player in this market. Founded and led by Elon Musk, the company has a track record of significant accomplishments in the space economy. SpaceX technology has been the main force behind a dramatic drop in launch costs in the past 15 years (in the range of 70–95%, depending on the rockets used for comparison).[1,2] The Starlink network of communications satellites, owned by SpaceX, now operates roughly 2/3rds of the satellites in the sky.[3]

In January 2026, SpaceX sought permission from the US Federal Communications Commission (FCC) to operate one million space-based data centers (SBDCs). To date, four other companies have followed, with applications that propose to put several hundred thousand more data centers in low Earth orbit (LEO). These companies include Blue Origin, led by Amazon founder Jeff Bezos, and Starcloud, a venture-backed company that has already trained artificial intelligence (AI) models in space. Several other companies have indicated interest in operating SBDCs, using existing FCC licenses to pursue initial deployments.

Activity is hardly limited to the United States:

- The Chinese company ADA Space has proposed to build a 2800-satellite "Star Compute" constellation, also known as Three-Body Computing. ADA Space launched the first 12 satellites in May 2025.[4,5]
- In December 2025, China Aerospace Science and Technology Corporation (CASC) announced plans to deploy gigawatt-scale SBDCs by 2030.[6]
- The European Commission is funding the ASCEND (Advanced Space Cloud for European Net zero emission and Data sovereignty) feasibility study, coordinated by Thales Alenia Space, to determine if SBDCs can help meet the EU Green Deal's net-zero carbon objectives and other goals.[7,8]
- India's Neev Cloud has announced plans for a pilot launch by the end of 2026 and 600 more SBDCs in the next three years.[9]

- Madari Space, a UAE company, has also announced plans for a pilot launch of SBDCs in 2026.[10]
- Activity on SBDCs is underway in Japan, Israel, Singapore and other countries as well.[11-13]



Source: U.S. Government Accountability Office 2026

What's behind the growing momentum toward operating data centers in outer space?

First, the exploding demand for AI compute on Earth.

Demand for AI compute is rising at extraordinary speed. AI data center capacity has more than tripled globally in the past two years. The International Energy Agency (IEA) estimates that electricity consumption by AI-focused data centers grew 50% globally in 2025. BloombergNEF projects capital expenditures of more than $750 billion by the 14 largest publicly owned data center operators in 2026. The capital expenditure of leading technology companies is now larger than global investment in oil and natural gas production.[14,15]

These trends are expected to continue. The IEA projects that data centers' global electricity consumption will roughly double by 2030. McKinsey projects that technology companies are projected to spend more than $5 trillion on data centers in the same period. Although many analysts believe current technology company valuations are characteristic of a bubble, demand for AI compute is generally expected to keep growing. Companies with interests in SBDCs are committing significant capital on the assumption that demand for AI compute will remain strong through at least the medium term.[14-17]



High-voltage electricity transmission infrastructure. Source: Shutterstock

Second, challenges in finding sufficient electric power for data centers on Earth.

Many AI data centers require power supplies on the scale of medium to large cities, with high degrees of reliability. The power demand for training frontier AI models is especially high. In many parts of the world, the lack of electric power is a binding constraint on data center growth. The problem is especially acute in the United States, but it is an important factor in many other jurisdictions as well.[18-20]

Building new power generation facilities and connecting them to electric grids can be a very slow process. Wait times for transformers, cables and gas turbines for combined-cycle plants stretch out over many years. New transmission lines can take a decade or more to site and build. Data center construction can collide with important public policy goals including low power prices and decarbonization, slowing permitting processes. Data centers can often be built much faster than the power infrastructure needed to operate them—a fact unlikely to change in the years ahead.[14,18]

Third, the abundance of solar power in space.

Space offers the potential for generating a large amount of solar power. In some LEOs, satellites can receive sunlight almost continuously, without interference from clouds or particles in the atmosphere and with only brief periods of eclipse (when satellites pass into Earth's shadow). However, specialized solar photovoltaic (PV) panels are needed in LEO to avoid rapid degradation. Google researchers estimate that, under perfect conditions, solar panels in LEO could be eight times more productive than solar panels on Earth.[21-23]



Sun rise in space. Source: Shutterstock

Elon Musk discusses this topic in civilizational terms, invoking the Kardashev scale. In 1964, Soviet astronomer Nikolai Kardashev proposed classifying a civilization by the energy it uses. A Type I civilization commands the energy resources of its

planet, a Type II civilization taps the total output of its star, and a Type III civilization uses the energy of its galaxy. Musk calls SBDC constellations an important step toward Type II status for humanity because they would increase use of the Sun's power.[24] (Some people may differ on whether the pursuit of Type II status should be a priority goal for humanity.)

Fourth, rapidly growing opposition to data centers from local communities on Earth.

Community opposition is emerging as a significant constraint on data center construction.[25,26] Opposition is especially strong in the United States, where public sentiment has shifted dramatically against data centers in the past year. In a May 2026 nationwide Gallup poll, 71% of respondents said they opposed construction of an AI data center in their local area.[27] The governors of New York and Texas have each imposed moratoria on data center construction in recent months, and more than 100 moratoria have been proposed at the local, county, state and national levels in the United States.[28]

Community opposition to data centers is strong in other countries including Ireland, the Netherlands and Chile, as well. In Ireland, a proposed €1 billion data center was stalled after local protests over traffic, noise, light pollution, infrastructure pressure, climate impacts and changes to the character of the rural area.[29] In the Netherlands, Meta cancelled plans for a giant data center after a Dutch Senate motion asking the government to block the project.[30] In Chile, residents and local officials challenged a proposed Google data center's water use and aquifer impacts, leading an environmental court to partially reverse the project's permit.[31]

Fifth, concerns about data center water use on Earth.

Historically, cooling technologies at some data centers consumed large volumes of water. Evaporative cooling was the major culprit. In evaporative cooling systems, an estimated 80% of the water withdrawn is lost to evaporation. A single large hyperscale data center can withdraw up to 1.8 billion gallons annually, equivalent to the needs of a town of 10,000 to 50,000 people.[32] Although modern data centers increasingly use closed-loop cooling technologies that consume very small amounts of water, concerns remain about data center water use among many stakeholders.[33]



Hyperscaler data center in Eemshaven, Groningen, The Netherlands, 2025.
Source: Shutterstock

In addition, power supplied to data centers by coal plants and nuclear power plants can result in significant water consumption for cooling at the power plant. This "Scope 2" water use by data centers can be very large, even if the data centers receiving the power use closed-loop cooling technologies with very little water use on-site.[33]



SpaceX Falcon 9 launch from Cape Canaveral, Florida. December 2024. Source: Shutterstock

Sixth, falling launch costs.

Launch costs have fallen dramatically in recent years. Launch cost to LEO for the Falcon 9 is now approximately $2600/kg for the Falcon 9 and $1500/kg for the Falcon Heavy.[1,34] These falling costs have changed the economics of putting computing hardware into orbit. The cost declines are not sufficient to make SBDC constellations cost-competitive today but suggest the potential for significant further cost reductions. Some analysts have noted that the cost of terrestrial data centers may rise while launch costs fall, so the cost curves for SBDCs and terrestrial data centers could cross.[28] (See Chapter 1.1(C)-Launch Costs for more detail on this topic.)

Several industry leaders are bullish about further launch cost reductions and their implications. Elon Musk has said that rapidly reusable rockets could reduce "the cost of access to orbit and beyond" by "a factor of 100 or more."[35] Jeff Bezos has made a similar argument, saying that rocket reusability creates "a path to lowering the cost of access to space by a factor of 100."[36] Google's Suncatcher program projects launch costs falling to $200/kg by 2035, and Google CEO Sundar Pichai has said of SBDCs, "There's no doubt to me that a decade or so away we'll be viewing it as a more normal way to build data centers."[37]

Seventh, the capacity of leading SBDC companies to sustain financial losses.

SBDCs are unlikely to be profitable or compete with terrestrial data centers on cost in the short-term. High costs for launches, radiation-hardened electronics, specialized thermal radiators and other equipment are barriers. The inability to physically service hardware in orbit will increase life-cycle system costs, as well. Google experts found that launch costs must reach roughly $200/kg—far below current levels—for SBDCs to reach cost targets achieved by terrestrial data centers.[21,38,39]

However, the lack of short-term cost-competitiveness or profitability are unlikely to be barriers to launching thousands of SBDCs into orbit. With the supply of compute constrained on Earth and access to compute essential for developing frontier AI models, hyperscalers may be willing to accept high costs for AI compute in space. Furthermore, several leading SBDC companies have the capacity and, very likely, the willingness to sustain financial losses for many years to achieve market position in this sector:

- SpaceX founder and CEO Elon Musk has enormous financial resources and access to capital markets. He operated Tesla for more than a decade before its first full year of profitability in 2020.[40]
- Blue Origin owner Jeff Bezos is one of the world's richest men, with enormous financial resources.
- CASC is a state-owned company of the kind that often receives significant financial support from the Chinese government, independent of short-term profitability.[41]

The growing momentum towards SBDCs could have far-ranging impacts—in orbit, in the atmosphere and on Earth.

SBDCs could provide substantial compute capacity, serving a range of commercial interests and human needs. They could relieve pressures on terrestrial power systems, many of which are straining under rapidly increasing demand from data centers. They could help respond to growing opposition to data center siting in communities around the world.

At the same time, large constellations of SBDCs would have a range of risks and negative impacts. SBDCs could transform night skies, so that more satellites than stars are visible each night in much of the world. They could create cascades of space debris, rendering parts of LEO unusable for decades. They could lead to uncontrolled space debris falling to Earth. They could deplete the stratospheric ozone layer. They could accelerate global warming. They could dramatically interfere with professional astronomy, significantly reducing the value of billions of dollars invested in astronomical observatories around the world.

SBDC constellations as proposed by leading companies would be vastly larger than anything humanity has ever deployed in space. This scale alone means the risk of "unknown unknowns" (unforeseen risks and impacts) could be significant.

This Roadmap explores the technical feasibility of SBDCs, risks and impacts of SBDCs, and governance regimes for managing SBDCs.

A. References

1 Thomas G. Roberts. Space Launch to Low Earth Orbit: How Much Does It Cost?; Center for Strategic and International Studies (CSIS) Aerospace Security Project (ASP), Washington, D.C., https://aerospace.csis.org/data/space-launch-to-low-earth-orbit-how-much-does-it-cost/ (2022).

2 Bao Tran. Reusable Rockets vs. Disposable Rockets: Market Trends and Cost Reduction Stats; PatentPC, Santa Clara, California, https://patentpc.com/blog/reusable-rockets-vs-disposable-rockets-market-trends-and-cost-reduction-stats (2025).

3 azmth. How many satellites are in orbit right now?; https://azmth.space/stats (Accessed August 2026).

4 Curt Hall. On-Orbit Data Centers: Mapping the Leaders in Space-Based AI Computing; Cutter Consortium (an Arthur D. Little community), Boston, Massachusetts, https://www.cutter.com/article/orbit-data-centers-mapping-leaders-space-ai-computing (2025).

5 Xinhua. From ground to orbit: China eyes computing in space; The Global Times English Edition, Beijing, China, https://www.globaltimes.cn/page/202604/1359778.shtml (2026).

6 Andrew Jones. China eyes space resources, space tourism and on-orbit digital infrastructure; SpaceNews, Alexandria, Virginia, https://spacenews.com/china-eyes-space-resources-space-tourism-and-on-orbit-digital-infrastructure/ (2026).

7 European Commission. EU Orbital Data Centers Workshop; European Union, Bruxelles, Belgium, https://defence-industry-space.ec.europa.eu/eu-orbital-data-centers-workshop-2026-05-13_en (

8 Thales. Thales Alenia Space reveals results of ASCEND feasibility study on space data centers (Press Release); Thales, Paris, France, https://www.thalesgroup.com/en/news-centre/press-releases/thales-alenia-space-reveals-results-ascend-feasibility-study-space-data (2024).

9 Pratima Harigunani. India aims for the stars with orbital datacentres; Computer Weekly (Informa TechTarget), London, United Kingdom, https://www.computerweekly.com/news/366642407/India-aims-for-the-stars-with-orbital-datacentres (2026).

10 Jason Ma. UAE's Madari Space to pilot sending data centers into space in 2026; Data Centre Dynamics Ltd (DCD), London, United Kingdom, https://www.datacenterdynamics.com/en/news/uaes-madari-space-to-pilot-sending-data-centers-into-space-in-2026/ (2025).

11 Space Compass Corporation. Beyond the Edge; Space Compass Corporation, Tokyo, Japan, https://space-compass.com/ (Accessed August 2026).

12 Tereza Pultarova. Ramon.Space, Ingrasys Aim To Fly Prototype Orbital Data Center In 2027; Payload, Santa Monica, California, https://payloadspace.com/ramon-space-ingrasys-aim-to-fly-prototype-orbital-data-center-in-2027/ (2026).

13 Tan Rui, Wen Yonggang, Yang Ze & Fei Shengkang. Space-Based Data Centre Research – NTU–BC Space Collaboration; Nanyang Technological University, Singapore, https://www.ntu.edu.sg/computing/news-events/news/detail/space-based-data-centre-research---ntu-bc-space-collaboration (2026).

14 International Energy Agency (IEA). Executive Summary in Key Questions on Energy and AI (IEA, Paris, France, 2026, https://www.iea.org/reports/key-questions-on-energy-and-ai/executive-summary).

15 Lloyd Arnold. AI Data Center Build Advances at Full Speed: Five Things to Know; BloombergNEF (Bloomberg Finance L.P.), London, United Kingdom, https://about.bnef.com/insights/data-centers/ai-data-center-build-advances-at-full-speed-five-things-to-know/ (2026).

16 Jesse Noffsinger, Mark Patel, Pankaj Sachdeva, Arjita Bhan, Haley Chang & Maria Goodpaster. The cost of compute: A $7 trillion race to scale data centers; McKinsey & Company: Technology, Media & Telecommunications, New York, New York, https://www.mckinsey.com/industries/technology-media-and-telecommunications/our-insights/the-cost-of-compute-a-7-trillion-dollar-race-to-scale-data-centers (2025).

17 Centre for the New Economy and Society. Chief Economists' Outlook (Insight Report); World Economic Forum (WEF), Geneva, Switzerland, https://reports.weforum.org/docs/WEF_Chief_Economists_Outlook_January_2026.pdf (2026).

18 Ryne Friedman. Data Centers and the Grid: How Hyperscale Computing Is Reshaping Power Infrastructure; POWER (Access Intelligence, LLC), Rockville, Maryland, https://www.powermag.com/data-centers-and-the-grid-how-hyperscale-computing-is-reshaping-power-infrastructure/ (2026).

19 Charlotte Trueman. Microsoft has AI GPUs "sitting in inventory" because it lacks the power necessary to install them; Data Centre Dynamics Ltd (DCD), https://www.datacenterdynamics.com/en/news/microsoft-has-ai-gpus-sitting-in-inventory-because-it-lacks-the-power-necessary-to-install-them/ (2025).

20 Ambia Staley. America's power grid can't keep up with AI demand; Quartz Media, Inc., New York, New York, https://qz.com/us-power-grid-ai-data-center-demand-constraints-051326 (2026).

21 Travis Beals. Exploring a space-based, scalable AI infrastructure system design; Google Research, Google Research, https://research.google/blog/exploring-a-space-based-scalable-ai-infrastructure-system-design/ (2025).

22 Government Accountability Office (GAO). Science & Tech Spotlight: Data Centers in Space (GAO-26-109012); GAO, Washington, D.C., https://www.gao.gov/products/gao-26-109012 (2026).

23 Jeremy Hsu. Data Centers in Space Aren't as Wild as They Sound; Scientific American, Inc., Wilmington, Delaware, https://www.scientificamerican.com/article/data-centers-in-space/ (2025).

24 Dealroom.co. Musk's space AI data centres: SpaceX unveils the AI-1 satellite and a path to terawatt-scale orbital compute; Dealroom.co, Amsterdam, The Netherlands, https://app.dealroom.co/news/note/musk-s-space-ai-data-centres-spacex-unveils-the-ai-1-satellite-and-a-path-to-terawatt-scale-orbital-compute (2026).

25 Anthony F. Pipa & Adam Aley. The local implications of data centers for rural communities in the US; The Brookings Institution, Washington, D.C., https://www.brookings.edu/articles/local-implications-data-centers-rural-communities-us/ (2026).

26 Jim VandeHei & Mike Allen. Behind the Curtain: The new existential threat to AI; Axios Media, Inc., Arlington, Virginia, https://www.axios.com/2026/08/19/data-centers-ai-political-opinion (2026).

27 Jeffrey M. Jones. Americans Oppose AI Data Centers in Their Area; Gallup, Inc., Washington, D.C., https://news.gallup.com/poll/709772/americans-oppose-data-centers-area.aspx (2026).

28 Bob Woods. No one wants AI data centers on Earth. Do they make sense in space?; CNBC (Versant Media, LLC.), Englewood Cliffs, New Jersey, https://www.cnbc.com/2026/06/21/do-space-based-ai-data-centers-make-economic-sense.html (2026).

29 Gordon Deegan. Plans for controversial €1bn data centre campus in Co Westmeath stalled after 10 appeals lodged; Journal Media, Ltd., Dublin, Ireland, https://www.thejournal.ie/westmeath-data-centre-stalled-7094643-Jul2026/ (2026).

30 Reuters. Facebook owner Meta puts plans to build Dutch data centre on ice; Reuters, Toronto, Canada, https://www.reuters.com/technology/facebook-owner-meta-puts-plans-build-dutch-data-centre-ice-2022-03-29/ (2022).

31 Sebastian Moss. Chile partially reverses Google data center permit over water use concerns; Data Centre Dynamics Ltd (DCD), London, United Kingdom, https://www.datacenterdynamics.com/en/news/chile-partially-reverses-google-data-center-permit-over-water-use-concerns/ (2024).

32 Miguel Yañez-Barnuevo. Data Centers and Water Consumption; Environmental and Energy Study Institute (EESI), Washington, D.C., https://www.eesi.org/articles/view/data-centers-and-water-consumption (2025).

33 Julio Friedmann, Angela Yuan & David Sandalow. Chapter 5: Data Center Water Use in Sustainable Data Centers Roadmap (ICEF Innovation Roadmap Project) (2025, https://icef.go.jp/wp-

content/themes/icef_new/pdf/roadmap/2025/13_CHAPTER%20%E2%85%A4%20%E2%80%93%20DATA%20CENTER%20WATER%20USE.pdf).

34 SpaceNexus Research. How Much Does It Cost to Launch a Satellite? Falcon 9 at $74M, Every Rocket's 2026 Price; SpaceNexus, LLC, Sheridan, Wyoming, https://spacenexus.us/guide/space-launch-cost-comparison (2026).

35 William Harwood. SpaceX launches four astronauts on Crew Dragon flight to space station; CBS News (CBS Interactive, Inc.), New York, New York, https://www.cbsnews.com/news/spacex-launch-nasa-astronauts-falcon-9-reused-rocket-international-space-station/ (2021).

36 Charles Fishman. Is Jeff Bezos' Blue Origin the Future of Space Exploration?; Smithsonian Magazine, Washington, D.C., https://www.smithsonianmag.com/innovation/rocketeer-jeff-bezos-winner-smithsonians-technology-ingenuity-award-180961119/ (2016).

37 Shannon Carroll. Google's data centers could actually be going to the moon; Quartz Media, Inc., New York, New York, https://qz.com/google-moon-data-centers-project-suncatcher-pichai (2025).

38 Mahmoud Al Ahmad, Qurban Memon & Michael Pecht. Reliability and Risk in Space-Based Data Centers: A Lifecycle Assessment of Orbital Cloud Infrastructure. Applied Sciences 16, 5247 (2026). https://doi.org/10.3390/app16115247.

39 Jon Sinclair. Data centers in space; Luminix AI, San Francisco, California, https://www.useluminix.com/reports/industry-analysis/data-centers-in-space (2026).

40 Motley Fool Transcribing. Tesla (TSLA) Q4 2020 Earnings Call Transcript; Motley Fool Transcribing, Alexandria, Virginia, https://www.fool.com/earnings/call-transcripts/2021/01/27/tesla-tsla-q4-2020-earnings-call-transcript/ (2020).

41 Jack Congram. China Seriously Backs Space-Based Compute With Over 57 Billion Yuan Financed; China in Space, https://www.china-in-space.com/p/china-seriously-backs-space-based (2026).