

SPACE-BASED DATA CENTERS ROADMAP: THE CASE FOR CAUTION

November 2026

CHAPTER 1.5:

Launch Capacity

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Innovation for Cool Earth Forum

WORKING PAPER

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MAIN MESSAGES

- Space-based data centers (SBDCs) would require launch activity far beyond historical norms, putting significant pressure on existing launch capacity.
- Even with cheaper and reusable rockets, infrastructure will struggle to keep pace with the launch rates needed for large SBDC constellations.
- SBDC launch demand would crowd out commercial, civil and national security missions.
- Expanding capacity will take time and may be constrained by permitting, geography and industrial capacity.

Space-based data centers (SBDCs) would depend on a global launch system capable of placing thousands to tens of thousands of large spacecraft into orbit and replacing them over time. Even if current launch costs fall substantially, deployment at scale will require launch cadences far above historical norms and place new demands on launch infrastructure. These pressures will affect commercial and government launch needs across multiple spacefaring states. The feasibility of SBDCs depends in part on whether launch infrastructure can expand quickly enough to accommodate the sustained high-cadence operations that delivering SBDC constellations will require.

A. Launch Requirements

The number of launches required for SBDCs to provide significant compute capacity will depend on several variables including spacecraft mass, compute capacity, operational lifetime and launch vehicle performance. However, under plausible assumptions, very high launch cadences will be required.

Consider a 1-GW constellation of the Reference SBDC used for analysis in this Roadmap (see Text Box 2-1). Such a constellation would require roughly one launch of a Starship-sized rocket each week for as long as the constellation is operational. To meet 25% of projected demand for artificial intelligence (AI) data centers in 2030 would require more than five launches per day of rockets with the Reference SBDCs in perpetuity.

These conclusions are based on the following:

- The Reference SBDC in this Roadmap has 100 kW of compute, weighs 2.5 tonnes and is operational for 5 years.
- A 1-GW constellation would require 10,000 Reference SBDCs (100 kW x 10,000 = 1 GW).
- 10,000 Reference SBDCs have a combined mass of 25,000 tonnes (2.5 tonnes per SBDC x 10,000 = 25,000 tonnes).
- Assuming each launch vehicle carries approximately 100 tonnes into orbit (the current estimate for Starship), initial deployment of the 1-GW constellation would require 250 launches (25,000 tonnes ÷ 100 tonnes per launch = 250 launches)
- If initial deployment of the constellation takes place at a steady pace of 50 launches per year over 5 years, roughly 1 launch per week will be required.
- In Year 6, the Reference SBDCs deployed in Year 1 will require replacement, so another 50 launches (roughly 1 launch per week) will be needed. The same will occur in every following year.
- As a result, deploying and maintaining a 1-GW constellation of Reference SBDCs will require roughly 1 launch per week until the constellation ceases to function.
- McKinsey projects 156 GW of AI data-center demand by 2030.[1] To meet 25% of that demand (39 GW) with Reference SBDCs would require 39 launches of Starship-sized rockets per week in perpetuity. That is more than 5 launches per day and roughly 2,000 launches per year.

For comparison, there were 329 rocket launches globally in 2025, across a range of rocket types.[2] In 2025, 109 rockets were launched from Florida's Space Coast (Cape Kennedy and Cape Canaveral).[3]

Different assumptions would change these results, of course. If Starship-sized rockets are not available or SBDCs weigh more than 2.5 tonnes each, for example, faster launch cadences would be required. If SBDCs have lifetimes longer than five years, slower launch cadences would be possible.

B. Launch Infrastructure and Capacity

The ability to support hundreds or thousands of launches for SBDC constellations will depend on physical infrastructure that enables frequent operations. This includes launch pads, payload processing facilities, propellant storage and distribution, transportation networks, electrical power and other shared services. With a high launch cadence, each of these systems can become a bottleneck.



A launch pad. Source: Shutterstock

Launch pads are a critical constraint. Each pad can support only a finite number of launches. Vehicles must be transported, integrated, fueled, checked

and launched. The site has to be inspected and prepared again before each mission. Reusable launch vehicles may reduce some of the time and cost associated with producing new hardware, but they do not eliminate the need for pad turnaround or range coordination. This bottleneck is already visible at some major launch sites. In June 2026, the US National Aeronautics and Space Administration's (NASA's) Office of the Inspector General found that launch activity at the Kennedy Space Center and Wallops Flight Facility had increased by 252% and 467%, respectively, between 2020 and 2025.[4] The report concluded that both facilities could approach operational capacity in the 2028–2029 timeframe even without substantial new demand from SBDCs.[4]

Launch capacity also depends on infrastructure that is shared across multiple launch pads. At the Kennedy Space Center, NASA's inspector general identified electrical power, gas supply and distribution, and transportation infrastructure as existing constraints to the number of launches possible at the center.[4] Most of this infrastructure is decades old and was not designed for the launch frequencies proposed SBDC constellations will require. Super-heavy launch vehicles also create operational constraints for neighboring users because their fueling and safety requirements temporarily restrict access to nearby facilities.[5] At high cadence, these shared-site effects could reduce overall spaceport throughput even if individual launch vehicles become more capable.

Launch-range capacity is another limiting factor for the amount of mass that can be launched. A launch site is the physical location where a rocket is prepared and launched, including its pads and associated ground infrastructure. A launch range is a network of personnel, tracking systems, safety infrastructure and procedures that supports launch operations from a launch site. Range operators monitor vehicles during flight, protect surrounding populations, establish hazard areas and coordinate restrictions on nearby airspace and maritime traffic. Each launch requires range resources and coordination before the vehicle ever leaves the ground. At low launch-cadence, these functions are scheduled around other missions, but high-cadence operations place greater demands on range personnel and infrastructure. Because major launch sites frequently support multiple commercial and government users, the launch range that provides airspace-management services may constrain launch cadence even when an individual operator's pad and vehicle are ready.[6]



European Space Agency's main launch site, Kourou, French Guiana. Source: ©European Space Agency - Stephane Corvaja.

Payload processing represents a less visible but important bottleneck. SBDC satellites need to be transported to launch sites, inspected, tested, integrated with deployment hardware and prepared for launch.[7] Some payloads may also require specialized clean rooms, hazardous-material handling, fueling or other processing facilities.[8] These activities can occur well before launch and may occupy facilities for extended periods. A launch system capable of flying weekly or even daily needs a corresponding pipeline of

payload-processing capacity. A shortage of processing facilities can limit cadence even if rockets and pads are otherwise available.

Major launch states worldwide rely on a limited number of high-capacity spaceports, many of which also support civil, military and commercial missions. Expanding launch activity will require new pads, upgrades to shared infrastructure, additional processing facilities and regulatory approvals. Some launch systems may benefit from newer infrastructure or vertically integrated operators, while others may face limited geographic options, aging facilities or competition among multiple users.[5] Globally, the practical capacity to support SBDCs will depend on the ability of launch infrastructure to expand alongside vehicle capability.

The number of launches a rocket can perform is different from the number of launches a spaceport can support. Failure to expand any one of the elements involved in space launch will constrain SBDC deployment even if launch vehicles are reusable and readily available.

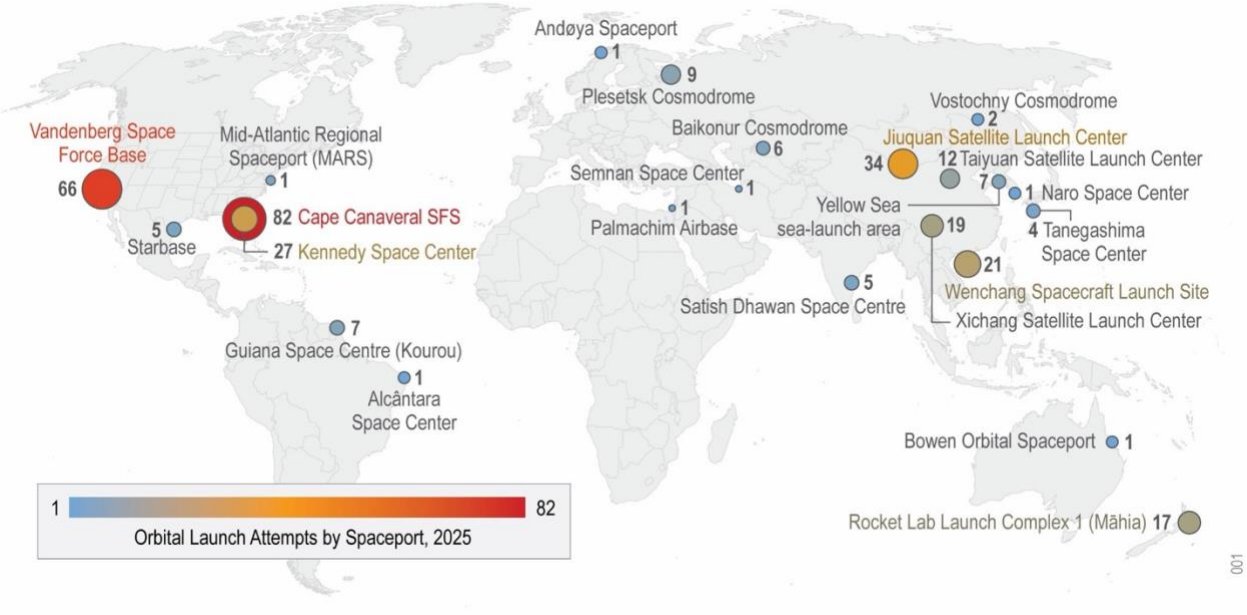
C. Competition for Launch Capacity

Large-scale SBDC deployment would add to growing demand for launch services from civil, commercial and national security customers. Launch infrastructure is often shared among these users, so sustained SBDC launch campaigns could compete for access to launch pads, ranges, payload-processing facilities and launch windows. At high cadence, allocating capacity to one operator or mission could delay or constrain others, particularly at spaceports supporting multiple providers.

This challenge is exacerbated by the launch activity occurring at a small number of sites. In the United States, much of the country's orbital launch activity is concentrated at Cape Canaveral Space Force Station and the Kennedy Space Center in Florida and the Vandenberg Space Force Base in California. In response to limited launch capacity available in the United States, SpaceX is considering constructing a new launch facility on Louisiana's Gulf Coast as it seeks additional locations to support a higher Starship launch cadence. However, this proposal has already drawn opposition from residents and environmental groups.[9] Similar concentrations of launch sites exist elsewhere. Europe relies on the Guiana Space Centre in French Guiana for Ariane 6 launches, concentrating a significant share of its civil, commercial and national-security launch activity at a single spaceport.

Reliance on a small number of high-capacity spaceports creates capacity and resilience concerns: congestion, infrastructure failures, accidents or natural disasters at a major site can affect multiple launch providers and missions simultaneously.

SBDC demand will create allocation and capacity challenges. Governments may need to consider how commercial SBDC launches interact with requirements for national security missions, civil space programs, communications constellations and other commercial activity, particularly if SBDCs begin consuming a significant share of available launch capacity.



Source: Author visualization based on data from Wikipedia, "2025 in spaceflight," section "By spaceport."

D. Geography and Orbital Access

Launch capacity is also orbit specific. Many proposed SBDC architectures may favor sun-synchronous or near-terminator orbits because these trajectories can provide relatively consistent solar illumination, reducing periods when spacecraft must rely on batteries.[10] Sun-synchronous orbits are nearly polar and require particular orbital inclinations, which means not every launch site is equally well positioned to reach them efficiently.[11] Vandenberg Space Force Base is preferred for US missions requiring north-south or polar orbits, making it particularly important for spacecraft destined for sun-synchronous trajectories.[12]

As a result, aggregate national or global launch capacity can overstate the capacity actually available for SBDCs. If SBDC concepts require polar or sun-synchronous trajectories, launch demand would become concentrated at a smaller subset of geographically suitable spaceports. In the United States, this could place additional pressure on Vandenberg.[13] In China polar and sun-synchronous missions launch from Taiyuan and Jiuquan, while other launch sites in the country are optimized for different trajectories.[14-16] Large SBDC deployments seeking sun-synchronous or near-polar orbits will concentrate demand at particular launch sites even if a country has substantial launch capacity available at other launch sites.

E. Environmental Permitting and Spaceport Expansion

Expanding launch capacity can require lengthy environmental and regulatory review, particularly when new pads, spaceports or substantially higher launch cadences are proposed. In the United States, these reviews occur under the National Environmental Policy Act (NEPA) and are headed by the Federal Aviation Administration (FAA).[17,18] Other launch countries use different legal frameworks

but impose similar requirements. In the United Kingdom, launch and spaceport license applicants must submit an Assessment of Environmental Effects to the UK Civil Aviation Authority.[19] In Australia, launch facilities are licensed by the Australian Space Agency, while environmental approvals may also be required under federal, state and territorial environmental laws.[20-22]



Launch of Shenzhou 22 from Jiuqian Launch Area 4, China (2025). Source: China News Service (https://www.youtube.com/watch?v=HpvSTS7WJNE) Licensed under CC BY 4.0.

Spaceport expansion affects nearby communities and ecosystems through noise, construction, hazardous operations, air and water pollution, and habitat disruption and creates restrictions on surrounding land, airspace and maritime areas.[23] The constraints for launch pads are highly location-specific, but they can limit where new launch infrastructure is built and how quickly existing sites can increase cadence. For SBDCs, this means that growing launch demand cannot necessarily be met by adding pads or opening new spaceports. Regulatory approval and community acceptance may become important factors in how quickly global launch capacity can expand, similar to the backlash terrestrial data centers currently receive.[24]

F. Manufacturing, Supply Chains and Export Controls

Large-scale SBDC deployment would require a manufacturing base capable of producing both launch vehicles and spacecraft at sustained high cadence. Reusable launch systems can reduce the number of new rockets required for each mission. However, operations still depend on steady production of the components necessary to manufacture the launch vehicles and payloads. The same is true for the SBDCs themselves. For a 1-GW Reference case, 10,000 satellites would require 25,000 metric tonnes of compute electronics, solar arrays, radiators, batteries, propulsion systems, communications equipment and structural materials.

These requirements expose SBDCs to the supply-chain constraints that already affect advanced manufacturing. Batteries, solar technologies and aerospace systems depend on minerals such as lithium, graphite, cobalt, gallium, germanium, rare earth elements and titanium. The International Energy Agency (IEA) found critical-mineral processing remains highly concentrated. China is the leading refiner for 19 of the 20 strategic minerals tracked by the IEA, with a market share of nearly 70%. China holds especially dominant positions in graphite, rare earth elements and gallium.[25] Recent Chinese export controls show that concentrated supply chains within singular countries can severely impact global manufacturing capability. Restrictions on minerals and heavy rare earth elements have affected materials essential to numerous industries.[26] The 2025 rare-earth controls caused shortages that forced some manufacturers to reduce or temporarily suspend production.[27]

Replacement cadence makes these demands never ending. Maintaining a 1-GW SBDC requires manufacturing roughly 2000 replacement satellites every year in addition to launch vehicles and supporting hardware. Larger constellations increase these material needs. SBDC deployment is

dependent on the ability of global manufacturing capacity and supply chains to support continuous production at the required scale without creating new bottlenecks elsewhere in the supply chain.

G. National Security Impacts

Increased launch demand affects access to launch infrastructure used for national security missions. Governments, particularly the United States, rely on commercial providers to place military and intelligence spacecraft into orbit. The United States seeks to diversify these providers to improve resilience. The US Space Force's National Security Space Launch program is designed to assure access to orbit for critical military capabilities. It expanded the number of eligible providers in part to strengthen launch resilience. Large commercial SBDC campaigns will compete with these missions if infrastructure does not expand at a similar pace.

Export controls add another layer of complexity for who can launch critical technologies and where they can launch from. SBDCs would place some of the world's most advanced computing hardware aboard spacecraft capable of serving customers across national borders. Export controls on advanced computing and space technologies are coordinated across several major technology-producing economies. The United States restricts certain advanced chips, semiconductor manufacturing technologies and related software based on destination, end user and intended use.[28] The European Union maintains its own dual-use export-control regime, while certain countries, including Japan and the Netherlands, have imposed national licensing requirements on advanced semiconductor manufacturing equipment.[29-31] Similar controls apply to propulsion, communications, sensing and other dual-use technologies. As a result, SBDC developers will face overlapping national rules dictating where hardware can be manufactured, launched, operated or made available to foreign customers. Governments need to contend with how existing controls apply when sensitive computing hardware is physically located in orbit but provides computing services to users in multiple jurisdictions.

The national-security challenge created by SBDCs is broader than just protecting SBDCs themselves. Policymakers need to consider whether SBDC growth competes with assured access to space, deepens dependence on a small number of commercial providers or creates new pathways for transferring strategically sensitive computing capability across borders.

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