

SPACE-BASED DATA CENTERS ROADMAP: THE CASE FOR CAUTION

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Text Box 1-1:

Reference Space-Based Data Centers (SBDC)

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WORKING PAPER

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To help analyze several topics in this Roadmap, we have defined a "Reference space-based data center (SBDC)." Our Reference SBDC represents an individual satellite carrying artificial intelligence (AI) compute within a larger constellation and has the characteristics set forth below. We chose these characteristics to reflect common design choices by commercially relevant SBDC developers, and they underpin quantitative estimates in this Roadmap. Other design parameters are possible, of course. Our goal in defining this Reference SBDC is to provide a consistent starting point for analysis, not definitive conclusions or results.

Parameter	Value	Notes
Orbit inclination	Sun-synchronous, at or near "terminator" orbit	This allows maximum solar power generation with minimum eclipse duration.
Orbit altitude	500–800 km	This roughly optimizes launch cost, radiation exposure and debris exposure.
Average information technology (IT) equipment power consumption	100 kW	This is the average power consumption of the IT equipment on board the satellite. The full satellite will consume perhaps 20% more than this because of additional "housekeeping" power demand.
Satellite power system	Solar photovoltaic (PV) array, battery, and power conditioning and distribution unit	The PV arrays and battery will be sized to provide sufficient power for the entire satellite, including serving the full load during eclipses.

Cooling system	Flat-panel radiators and mechanically pumped coolant	This provides sufficient cooling to maintain the IT equipment and other systems at a safe operating temperature.
Individual satellite lifetime	5 years	This roughly matches the graphics processing unit (GPU) obsolescence period. It assumes no on-orbit replacements or servicing.
Communications	Optical data links (intra-satellite) plus radio (ground-to-orbit)	This allows fast data transfer within the constellation and sustained ground-to-orbit communications.
Maneuvering	Sufficient propulsion for collision avoidance and end-of-life deorbiting	This may include Hall Effect thrusters or other relevant systems.
Individual satellite mass	2.5 tonnes	This is roughly based on developer claims.

A SBDC developer seeking to put 1 GW of AI compute into orbit would therefore need to always have 10,000 independent satellites (reference SBDCs) in operation, each with the characteristics listed above. The satellites would need to be placed in orbits that are close enough to allow them to communicate (to share data during computations) but far apart enough to allow for safe maneuvering to avoid orbital debris and other satellites.

Since each individual satellite would last for only 5 years, they would need to be regularly replaced to maintain the 1-GW compute capacity. If launched by SpaceX Starship or similar rockets once per week, this would imply a continuous 5-year cycle of refreshment/replacement of the 10,000 satellites, with 2000 launched and 2000 de-orbited per year, or roughly 38 per week.

We further assume that SBDC operators would follow all relevant regulations from Federal Communications Commission (FCC) and other authorities on orbital safety, deorbit and communications.