**Launch Capabilities and Costs**

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**1 Current Launch Systems**

A geosynchronous orbit (GEO) would be advantageous for space-based solar power (as opposed to low-Earth orbit and Sun-synchronous orbit). There are two ways of launching payload into space into a geosynchronous orbit: launching payload directly into this orbit or launching payload into a geostationary transfer orbit (GTO) [1].

1. **GEO, GTO, and other Orbits**

Not many aerospace companies in the U.S. currently launch payload directly into geosynchronous orbit. The table below shows the different launch vehicles currently being employed and developed for different orbits; the \* symbol denotes launch systems that are currently being developed. Data about payload capabilities were taken from the websites of the manufacturers of these launching systems (links on the last page).

Other launch systems (e.g., SLS from NASA, etc.) are capable of orbits even further from Earth than a GTO or a GEO, such as a trans-lunar injection (TLI) and a trans-Mars injection (TMI). Based on these launch systems’ capacity for launching payloads further into space (even as far as deep space), I assume that they are also capable of launching payloads into GTO or GEO.

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**2 Launch Costs**

As of today, the two biggest competitors (in terms of reliability and cost) for launching

are ULA and SpaceX.

1. **SpaceX**

Space Intel Report noted in 2019 that the base cost for launches starting in 2021 for SpaceX was to be $52 million per launch for the Falcon 9, putting the price of launching payload at **$6265/kg**. Launches with the Falcon Heavy are reported to now cost $316 million\*[2], putting the price of launching with the Heavy at **$11835/kg**. Right now, SpaceX’s biggest selling point is that their rockets are reusable (e.g., their boosters), which, over time, will bring launch costs down over time.

\*This $316 million-dollar figure comes from the contract SpaceX just procured with the U.S. Air Force; SpaceX will be paid $316m for one launch with the Falcon Heavy sometime in 2022.

In addition, SpaceX is continuing to push their rideshare program for sending payload into space. As of right now, the only orbits they offer in this rideshare program include LEO, SSO (sun-synchronous orbit), and Polar. All of these orbits would not be appropriate for space-based solar power, as they are much lower than a geosynchronous orbit. (100 – 1000 km vs. 36000 km needed for GEO). Their website does estimate that the maximum **830 kg** payload going into LEO or SSO orbit sometime in 2021 would cost **$4.15 million**, putting their cost at **$5000/kg.**

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Elon Musk has stated that he hopes for launches with SpaceX’s Starship to cost around $2,000,000 dollars; with a payload capacity of 21,000 kg to GTO, that makes the cost **$95.23/kg**.

1. **United Launch Alliance (ULA)**

ULA was just awarded $169 million for two launches by the U.S. Air Force in early August. They are still developing their Vulcan Centaur line of rockets, but the Vulcan Centaur Heavy is expected to be able to carry 14,400 kg, putting their launch price at **$11,736/kg**. Vulcan Centaur is meant to replace their other launch systems (Atlas and Delta), as Atlas and Delta use Russian engines, and are very expensive in comparison to SpaceX’s Falcon 9. The Atlas launch systems currently cost between $109m (401) to $153m (551) [3].

**Sources**

[1]: <https://www.esa.int/ESA_Multimedia/Images/2020/03/Geostationary_transfer_orbit>

[2]: <https://www.forbes.com/sites/lorenthompson/2020/09/17/when-it-comes-to-military-launches-spacex-may-no-longer-be-the-low-cost-provider/#3e2c74914c3b>

[3]: <https://www.rocketbuilder.com/#thirdPage>

**Additional Information:**

*Technical Summary of ULA’s Launch Capabilities (Atlas, Delta, and Vulcan Centaur)*

<https://www.ulalaunch.com/docs/default-source/rockets/atlas-v-and-delta-iv-technical-summary.pdf>

*Technical Summary of NASA’s new Space Launch System (SLS)*

<https://www.nasa.gov/sites/default/files/atoms/files/sls_lift_capabilities_configurations_04292020_woleo.pdf>

*Blue Origin User Guide for New Glenn Launch System*

<https://yellowdragonblogdotcom.files.wordpress.com/2019/01/new_glenn_payload_users_guide_rev_c.pdf>

*SpaceX Starship’s User Guide (with Payload Capacity)*

<https://www.spacex.com/media/starship_users_guide_v1.pdf>

*SpaceX Launching Costs through Rideshare*

<https://rideshare.spacex.com/search?orbitClassification=1&launchDate=2021-01-27&payloadMass=830>