Getting to Orbit: Launch Vehicles

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The LUVOIR mission has the potential to enable revolutionary scientific breakthroughs with the largest telescope aperture ever deployed in space. While in the distant future, telescopes might be assembled in space, the most economical and immediate path forward is to put a large aperture in space with a single launch. In the mid-2020s and 2030s when LUVOIR is expected to fly, the launch vehicle industry will not be exactly the same as it is now. Here we summarize our understanding of the current and future launch capabilities.

A strong candidate for the orbit of the LUVOIR observatory will be at Sun-Earth L2, which provides a stable thermal environment and excellent field of regard. Constraints on the size of the telescope aperture and the instrument suite include the mass-to-orbit and the size of the fairing that the launcher can provide. A mission with the ambitious goals of LUVOIR will surely need a heavy lift launch vehicle; however, as with all technology, the near-term landscape for launch vehicle options includes some mature options with well-known characteristics and some less-mature options whose characteristics are still somewhat in flux and therefore are more difficult to evaluate with certainty. In order to mitigate the risk (and its associated costs) inherent in each different launch vehicle option, it is prudent to adopt telescope designs with the flexibility to use a variety of different launch vehicles and fairings.

Below we outline the current options for heavy-lift vehicles, and describe their various attributes. Figure 1 depicts representative values of lift capabilities for a variety of launch vehicle configurations to achieve Sun-Earth L2 orbit. Figure 2 depicts the outer diameters of the associated fairings; this dimension of the cylindrical volume is the most restrictive to the overall architecture (the lengths of the fairings are more than sufficient). Not all of this space will be available to the payload; margins of roughly 0.5 to 1 m around the edges are needed to allow for payload motions during launch. These launch vehicles range in maturity from existing vehicles with proven flight records to vehicles that are undergoing development. Below we highlight a few of the larger vehicles most relevant for LUVOIR.

Delta IV Heavy is an existing heavy lift launch vehicle with a proven track record. It supports a fairing with a 5-m outer diameter and a 4.6-m inner diameter. United Launch Alliance (ULA) has stated that they will continue to manufacture the Delta IV Heavy for as long as the US Air Force wants it. ULA indicates that they intend to build a heavy lift successor to the Delta IV Heavy that will compete with the Falcon Heavy discussed below.

Falcon Heavy is in development by Space X; it will offer lift capability in excess of the Delta IV Heavy. Its payload fairing is currently in development and indicated as having a 5.2-m outer diameter. The inner diameter of the fairing is not currently specified, but it is reasonable to assume it will similar to that of other 5-m-class fairings. The Falcon Heavy is expected to be relatively economical (launch cost of order $100M).

Space Launch System (SLS) is currently in development in a variety of versions. Options are under study for fairings with 5-m, 8.4-m, and 10-m outer diameters. GSFC and the SLS Program Office at MSFC have instituted engineer-to-engineer working group meetings to develop conceptual interfaces between large aperture telescope observatory concepts and the SLS launch vehicle. The unsurpassed mass-to-orbit and fairing volume of SLS provide obvious advantages for a large aperture space telescope, but this must be balanced with the cost and risk associated with a technology development program of the complexity and magnitude of the SLS system.

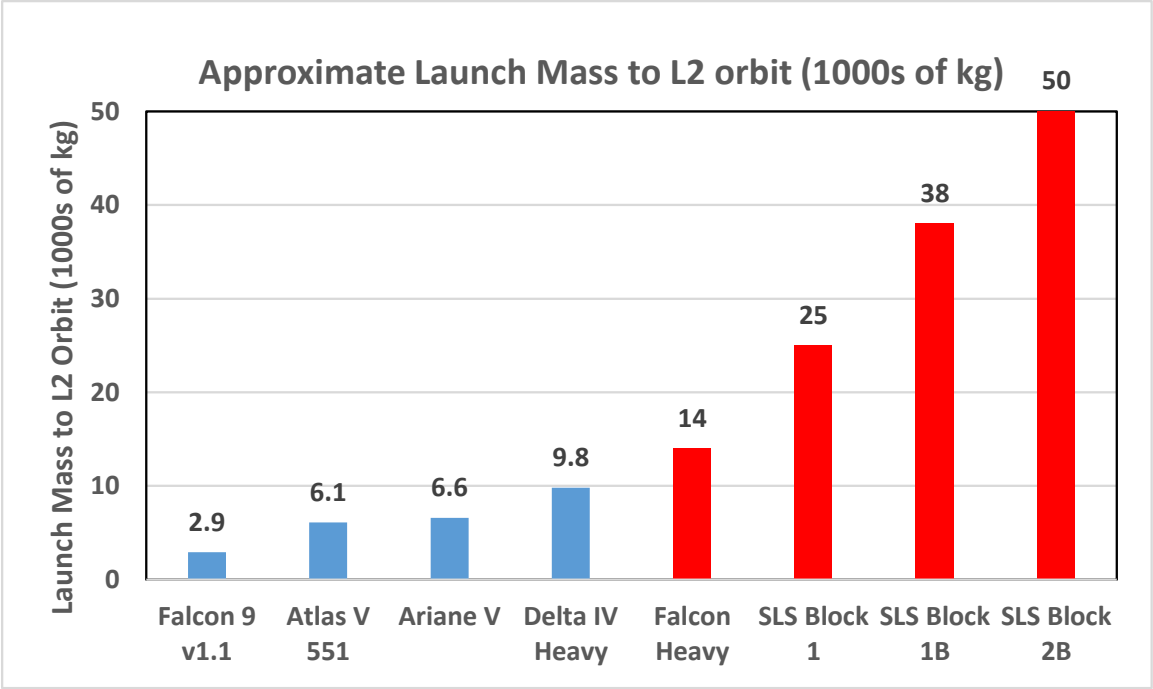

Figure 1 - Launch mass to Sun-Earth L2 orbit for a variety of current and future launch vehicles. Existing vehicles are in blue, ones in development are in red. These are representative values subject to refinement of designs in development and evolution of existing vehicles.

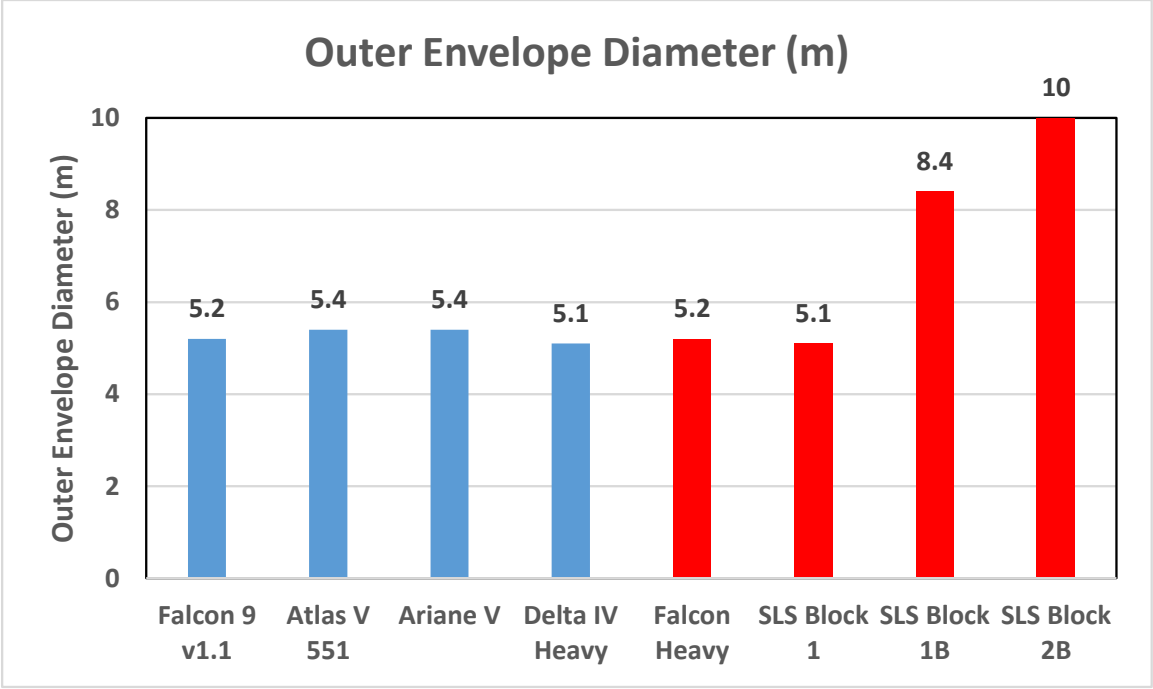

Figure 2 - Launch fairing diameters for a variety of current and future launch vehicles. Existing vehicles are in blue, ones in development are in red. These outer diameters correspond to the exterior physical extent of the fairing. Inner diameters are developed through coupled loads analyses with particular payloads and are roughly 0.5 to 1 m smaller. All these fairing diameters are representative values subject to evolution of existing vehicles and refinement of designs in development.