JWST Orbit

JWST will orbit *around* the Sun-Earth L2 Lagrange point, located about 1.5 million km from Earth.

Introduction

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JWST will be placed in an orbit about the Sun-Earth L2 Lagrange point located about 1.5 million km from Earth, which is four times the distance between the Earth and the Moon.

It is incorrect to say that JWST "will be at L2." Rather, *JWST will orbit around L2*.

The distance of JWST from the L2 point varies between 250,000 to 832,000 km, as shown in Figure 1. The period of the orbit is about six months. The maximum excursion above or below the ecliptic plane is 520,000 km. The maximum distance from the Earth is 1.8 million km, and the maximum Earth-Sun angle is <33°.

L2 is a saddle point in the gravitational potential of the Solar System. Because saddle points are not stable, JWST will need to regularly fire onboard thrusters to maintain its orbit around L2. These station-keeping maneuvers will be performed every 21 days.

To maintain solar power, the orbit is designed such that JWST is never in the shadow of the Earth or the Moon during the mission.

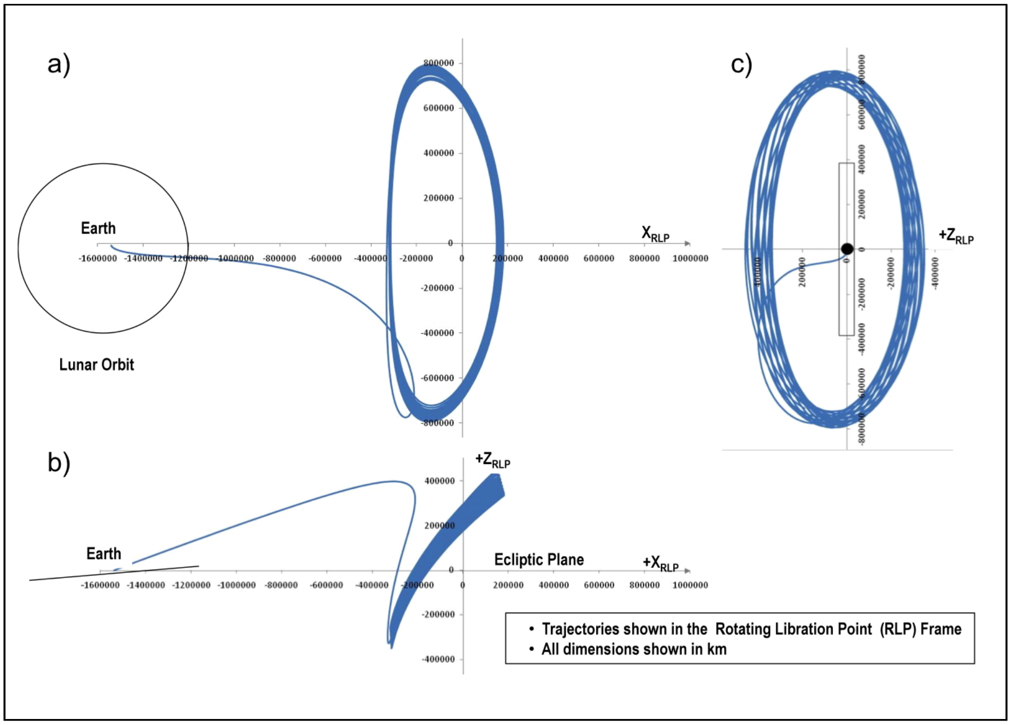
Rationale for the orbit dimensions

A larger orbit makes it easier to get the spacecraft to L2, as well as maintain its orbit. However, larger orbits can also permit stray light from the Earth or Moon to get past the sun shield and strike the primary or secondary mirrors. In addition, a larger orbit reduces communication contact opportunities.

Because JWST is solar powered, it cannot pass through the Earth's shadow during the mission. Orbits are selected that avoid shadow crossings, by selecting the launch time for a given launch day.

The L2 orbit shape is not constrained, so torus orbits, halo orbits, or Lissajous orbits are acceptable and are determined primarily by the launch's time of day and day of year. This freedom in the L2 orbit design allows for multiple launch opportunities for most months and minimizes the velocity needed to get to orbit. A trajectory can be fashioned so that JWST ‘falls into orbit’ about L2 rather than having to forcibly inject itself into a set orbit using its propulsion subsystem; this saves propellant and makes for simpler orbit maintenance.

Figure 1. JWST trajectory and orbit



A representative example of a valid JWST trajectory and orbit. Panel a is the view of the orbit projected onto the ecliptic plane; panel b is the view in the ecliptic plane, and panel c is the view along the Earth-Sun line.

Orbit maintenance

The L2 orbit has an orbit period of six months. While orbits about the L2 point are inherently unstable, the orbit size is large and the orbital velocity is low (~1 km/s), so the orbit "decays" slowly. However, JWST's large sun shield, roughly the size of a tennis court, is subject to significant solar radiation pressure which results in both a force and a torque. The direction of solar force varies as the observatory's attitude changes from observation to observation. The solar torque is balanced by reaction wheels, but periodically, the accumulated momentum is dumped by firing thrusters. Because JWST operations are event-driven, the observatory attitude profile and momentum dumping cannot be accurately predicted months in advance. These two perturbations increase the acceleration of JWST from its orbit about L2, and necessitates more frequent orbit maintenance (station keeping) maneuvers than other Lagrange orbit missions (which are typically 3–4 times per year). Accurate orbit determination will require daily tracking measurements over a period of 19 days, so station keeping will be performed every 21 days.

Orbit perturbations along the Sun-L2 axis have the greatest impact on-orbit stability. Thrusters are mounted on the spacecraft bus on the side of the sun shield facing the Sun; those used for orbit correction are oriented as far away from the sun shield as possible, and the sun shield can support a larger sun-pitch angle[1] for orbit correction than is allowed for science operations. This architecture allows thruster firing at angles up to 90° from the Sun consistent with Sun avoidance restrictions, which is sufficient to provide orbit correction in all cases.

The orbit will be biased to compensate for mean outward forces associated with gravitation of the planets and radiation pressure on the sun shield.

[1] The angle between the pointing direction and the satellite-Sun line. The "pointing direction" is the "boresight" of the telescope, also called the V1 axis of the observatory.