Technical Memorandum
September 4, 2015

TO: LightSail Team

FROM: Sean Chait, SSDL GT

SUBJECT: LightSail-B Laser Ranging Operations Overview

Overview

In support of laser ranging activities, this document provides an overview of the LightSail-B corner cube hardware configuration, an initial assessment of changes in orbital parameters due to sailing activities, and representative time histories of corner cube offset angles.

Hardware Overview

LightSail-B has a total of 13 corner cubes. Drawings of cube locations relative to the spacecraft structure can be found in Appendix A. Cubes 1-4 are attached to LightSail's 4 deployable solar panels. All other corner cubes are mounted to the primary structure. While this spacecraft is in the stowed configuration, Cubes 8-13 will be visible. Cubes 1-4 are not visible until solar panels have been deployed and Cubes 5-7 are only visible after sail deployment. It is also important to note that Cubes 1-4 are aft of the sail and Cubes 5-13 are foreword. Depending on spacecraft attitude, not all cubes will be visible from ground stations due to the sail obstruction.

Orbit Raising Strategy

The LightSail-B spacecraft will be ejected from the host Prox-1 spacecraft into a 720 km circular orbit at an inclination of 24°. After systems checkout, the spacecraft will be commanded to deploy its solar sail and begin its sailing campaign. An "on-off" switching algorithm has been developed to utilize solar radiation pressure (SRP) to raise LightSail's apoapsis. This concept of operations calls for 90° slew maneuvers twice every orbit. While the spacecraft is heading towards the sun, the solar sail normal will be perpendicular to the sun line. While moving away from the sun, the solar sail normal will be parallel to the sun line. A visualization of this concept can be found in Figure 1. The resulting acceleration due to SRP will gradually cause the spacecraft's velocity to increase, resulting in the raising of apoapsis altitude. Although SRP dominates at this altitude, it is important to note that atmospheric drag still has a measurable effect which will cause LightSail's periapsis to decrease during the sailing campaign resulting in an increasingly elliptical orbit.

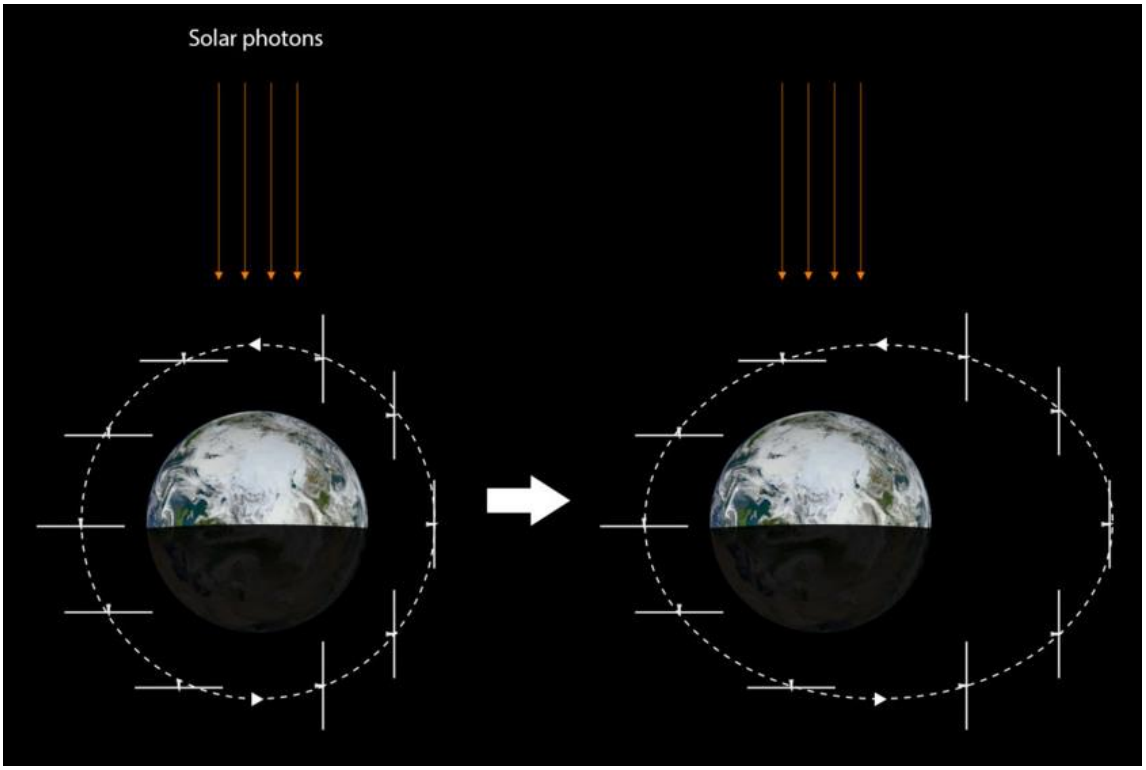

Figure 1: Sailing Campaign Concept of Operations

Initial analyses of LightSail's control algorithm predict an estimated increase of approximately 1 km per day in apoapsis altitude. A preliminary 14 day analysis is shown in Figure 2.

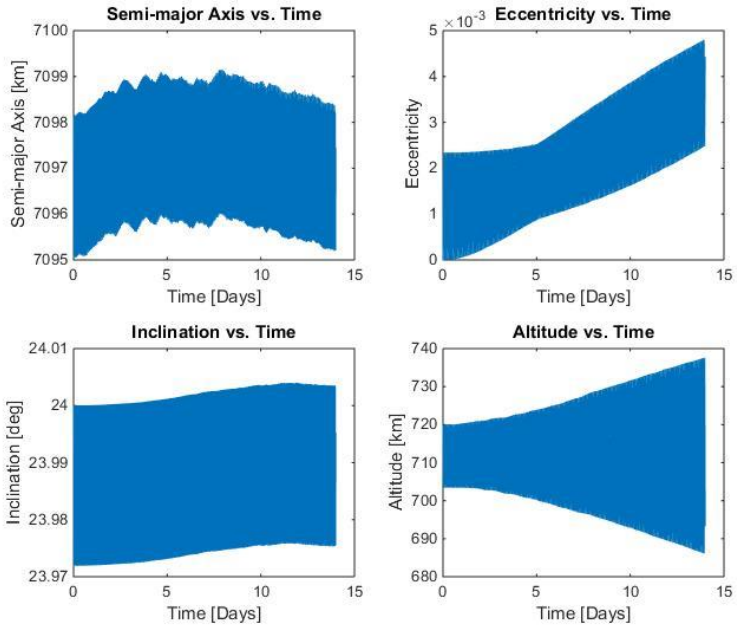

Figure 2: 14 Day Estimated Performance

Pointing Assessment

Offset Angle Definition

For the purposes of this analysis, a corner cube offset angle is defined such that the angle equals 0º when the corner cube normal is parallel to the nadir direction, i.e. pointing towards Earth, and equal to 90º when the corner cube normal is perpendicular to nadir. If the offset angle is greater than 90º then the corner cube normal is pointing away from Earth. These angles are further defined in Figures 3 and 4.

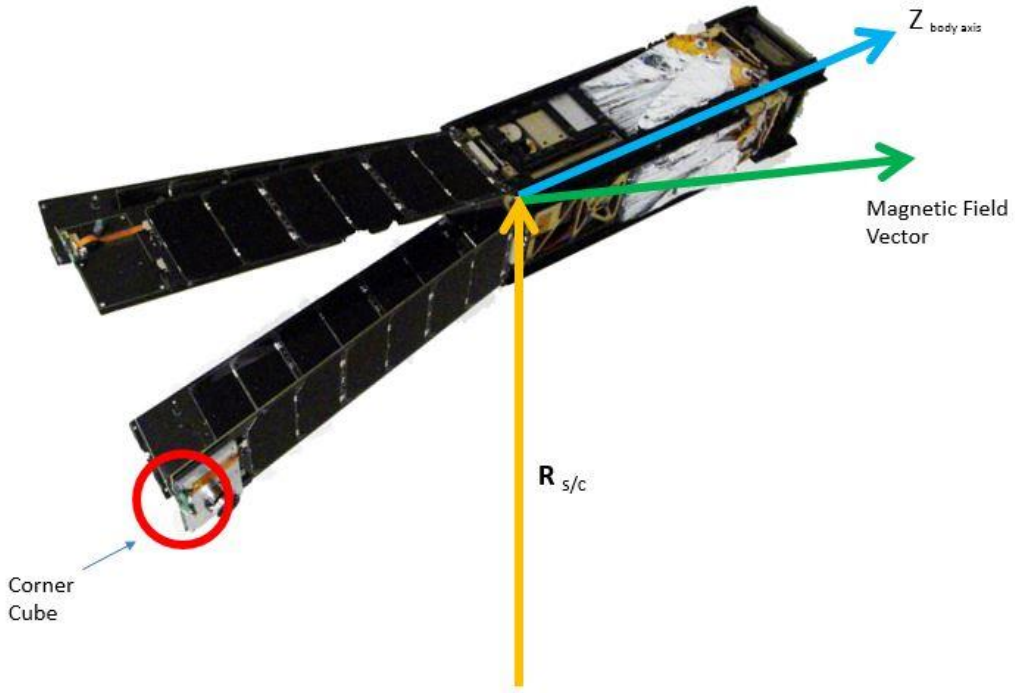

Figure 3: LightSail Vector Definition

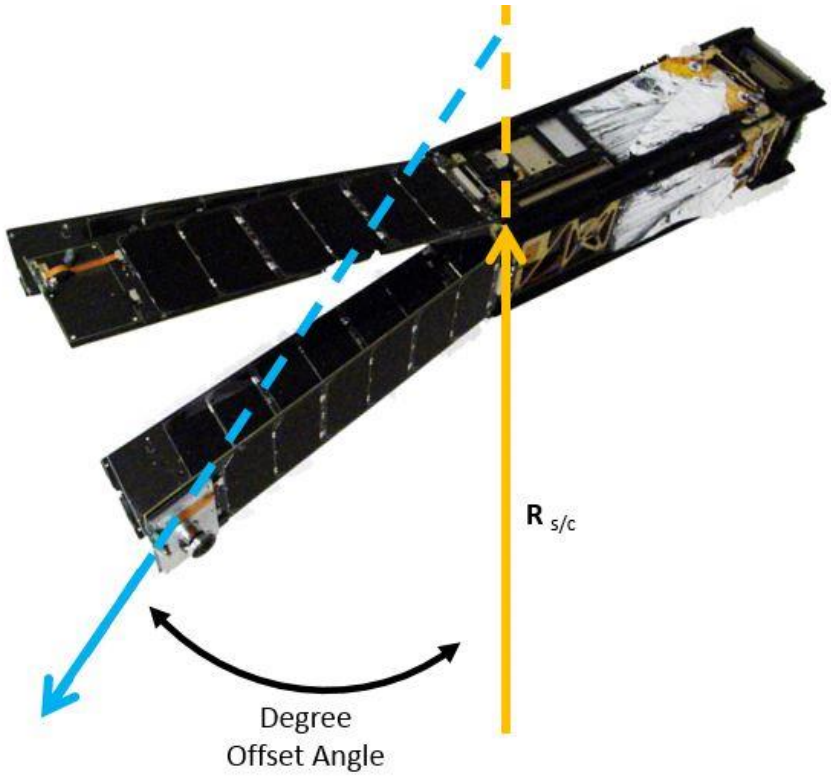

Figure 4: Corner Cube Offset Angle Definition

Corner Cube Time Histories

Figures 5 and 6 present representative time histories of each corner cube offset angle during 6 hours of nominal sailing operations. Throughout the initial campaign of solar sailing, the angle histories with respect to nadir are expected to be fairly repeatable.

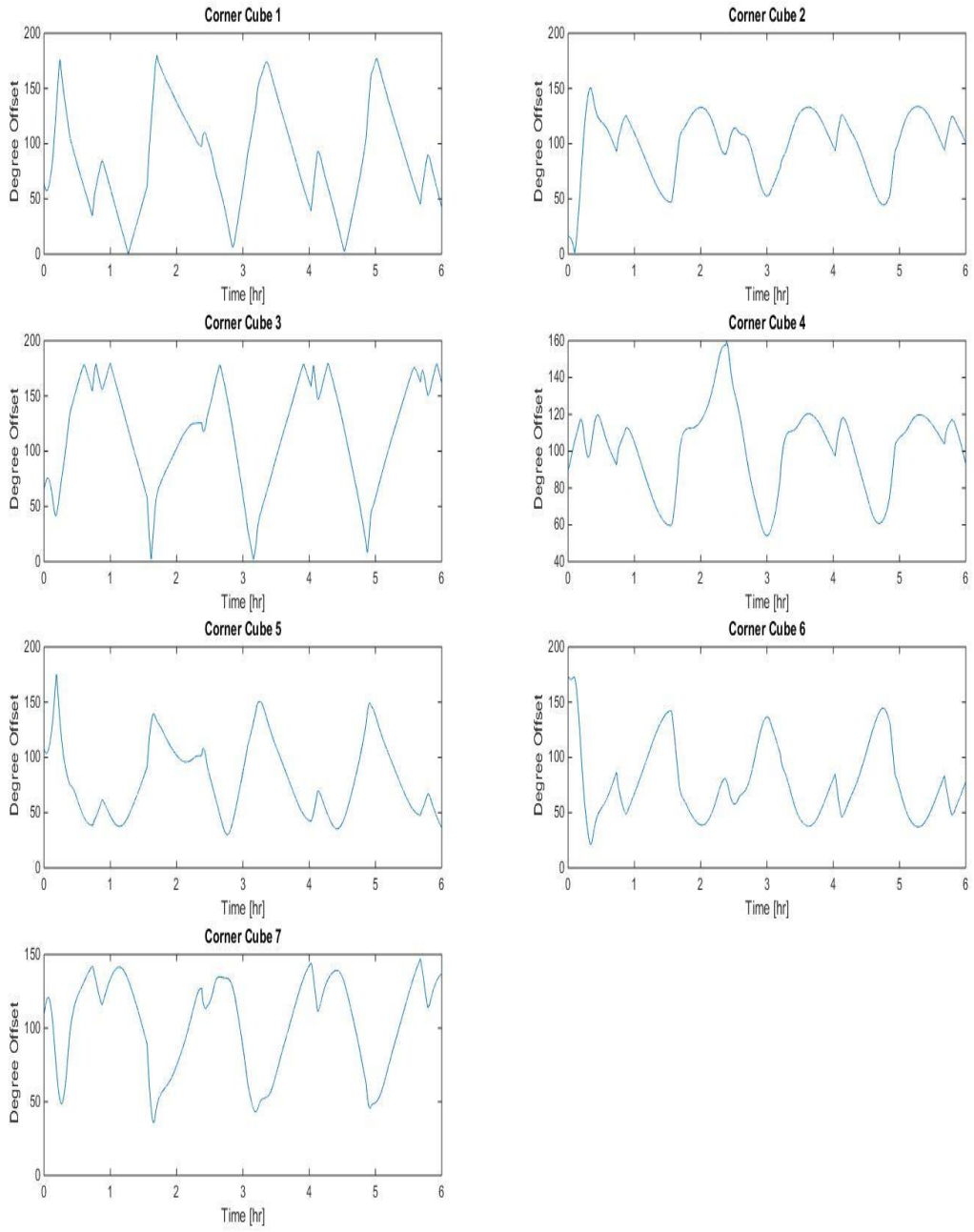

Figure 5: Corner Cube 1-7 Angle History

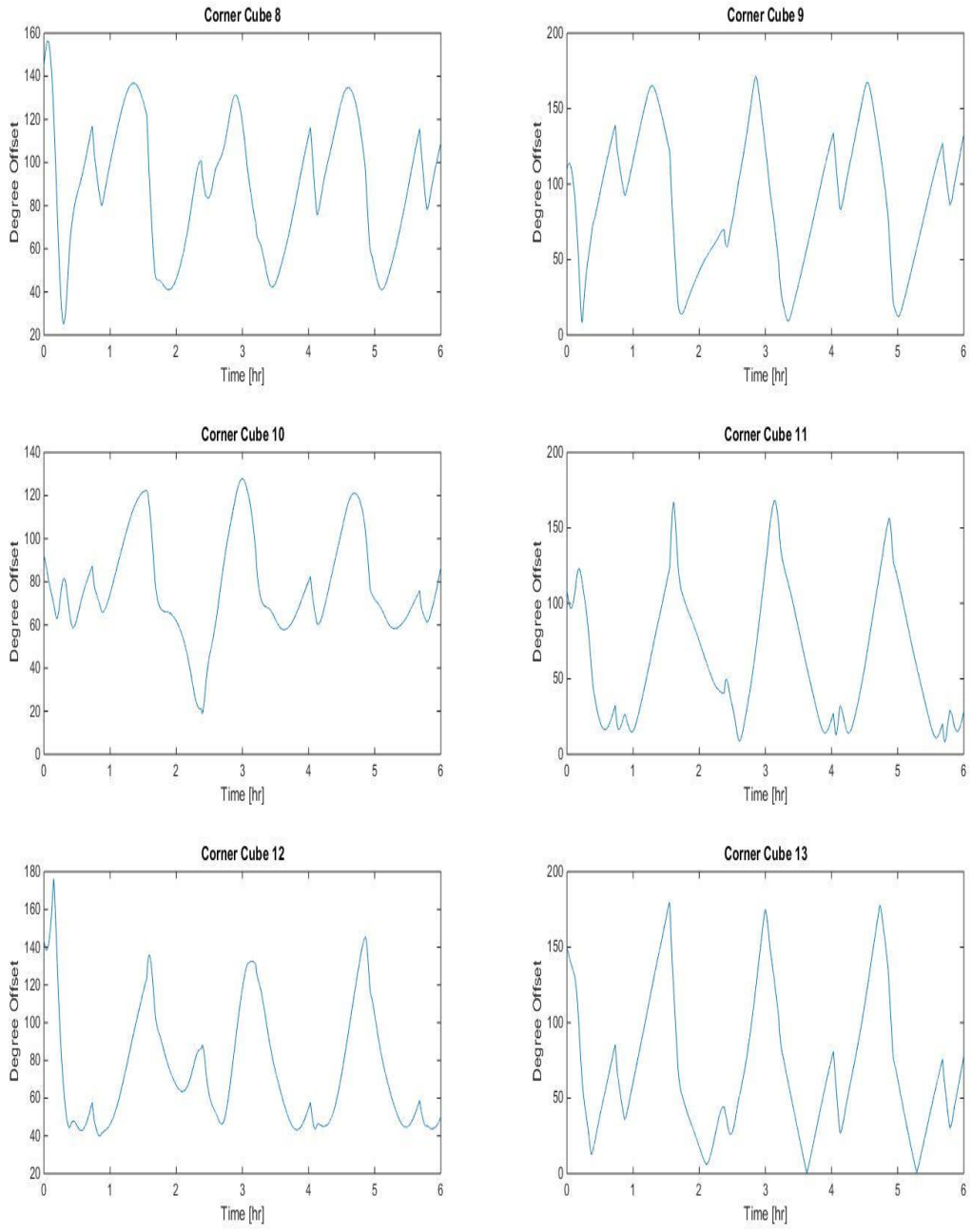

Figure 6: Corner Cube 8-13 Angle History

Appendix A

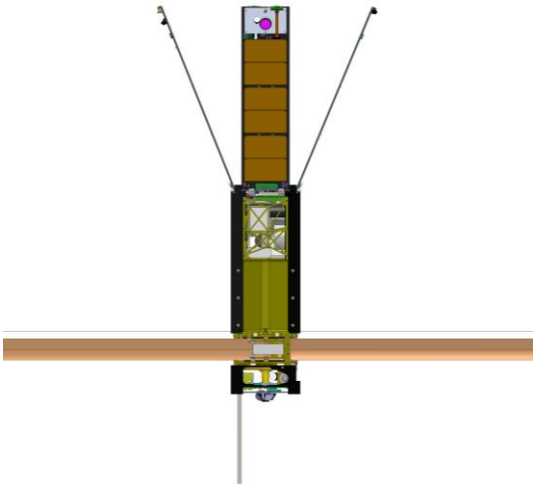

Figure 7: LightSail-B Deployed Configuration Side View -Y

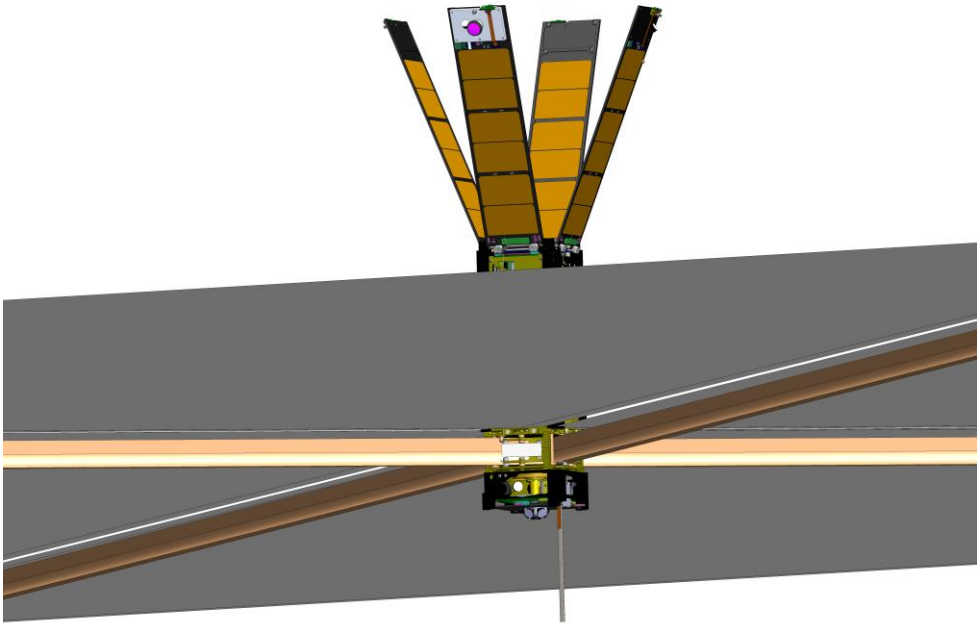

Figure 8: LightSail-B Deployed Configuration Isometric View

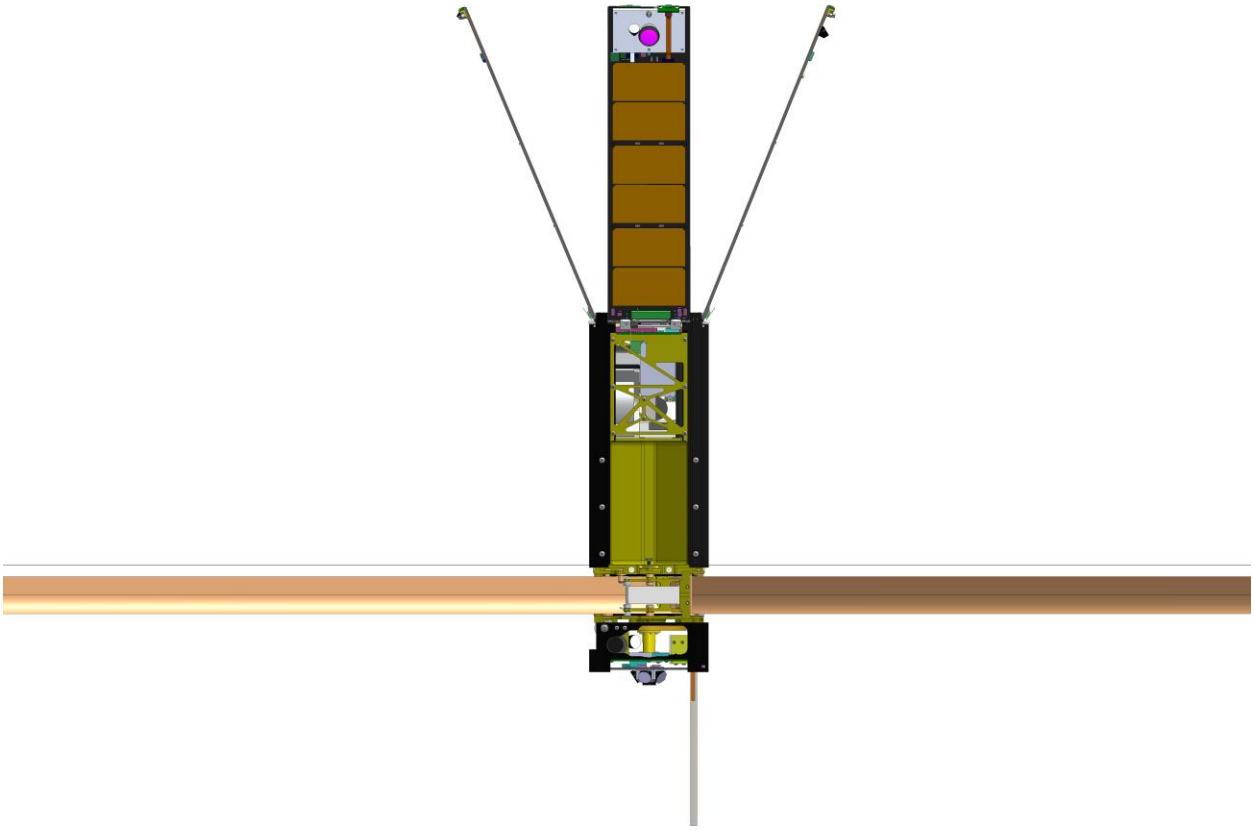

Figure 9: LightSail-B Deployed Configuration +X Side View