LAUNCH WINDOW TRADE ANALYSIS FOR THE JAMES WEBB SPACE TELESCOPE

Wayne H. Yu(1), **Karen Richon**(2)

(1) (2) *Code 595.0, NASA Goddard Space Flight Center, 8800 Greenbelt Road, Greenbelt MD, 20771. 301-286-1298. wayne.h.yu@nasa.gov.*

Keywords: *James Webb Space Telescope, Launch Window, Libration Point Orbits*

ABSTRACT

The James Webb Space Telescope (JWST) is a large-scale space telescope mission designed to study fundamental astrophysical questions ranging from the formation of the Universe to the origin of planetary systems and the origins of life. Succeeding the Hubble Space Telescope and the Spitzer Space Telescope, the spacecraft is an international collaboration between NASA, ESA and CSA.

JWST's orbit design is a libration point orbit around the Sun-Earth/Moon (SEM) L2 point for a planned mission lifetime of 11 years. The observatory will be launched on an Ariane 5 launch vehicle from the Guiana Space Centre in Kourou, New Guiana. The spacecraft will then perform three mid-course correction maneuvers (MCCs) at predetermined locations the transfer trajectory in order to reach the SEM L2 libration orbit, approximately 1,500,000 km 'behind' the Earth as viewed from the Sun. JWST will then perform station-keeping maneuvers to maintain the L2 orbit for the full mission lifetime.

The launch window analysis provides the daily, monthly and seasonal time ranges that the JWST vehicle can achieve its nominal orbit within design requirements. The current project launch readiness date is October 1st, 2018. The nominal required orbit requires a three dimensional box in the RLP frame to physically restrict the size of the SEM L2 orbit, the avoidance of all Earth and Moon penumbra and umbra shadows, an upper and lower restriction of the amount of fuel use during the mission, and finally the minimum lifetime of the mission itself. Derived from these requirements, typical concerns of the launch window analysis come from the physics, the engineering, and project specific challenges. The physics of the window is dominated by the third-body lunar perturbations and the Earth axis orientation at the time of launch. Thermal and communication subsystem requirements dominate the libration orbit geometry, as is common for a SEM libration point orbit. JWST-specific project challenges come from the fluidity of spacecraft project requirements, launch vehicle dispersions, the avoidance of stray light over the edges of the sunshield, and the pointing restriction of JWST thrusters to face away from Earth.

This paper presents the first launch window analysis for JWST using finite-burn modeling, setting propulsion hardware limitations to the MCC burns executed during simulations. It demonstrates the analysis process to accommodate JWST-specific project challenges and its subsequent results. A previous trade study used a single impulsive MCC burn for its orbit design. Using the results from the impulsive burn model data, the paper compares this information to the finite burn model to achieve two purposes: confirm accurate modeling of the natural dynamics of the system and compare engineering performance metrics. The data shows that the finite and

impulsive burns demonstrate expected physical behavior and also shows that the two models provide similar performance. The physical limitations of the propulsion system are countered effectively by the added degrees of freedom given with three burns occurring at different phases of the mission design.

Plans for further study will also be discussed.