CASSINI SOLSTICE MISSION MANEUVER EXPERIENCE: YEAR THREE

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The Cassini spacecraft is now in its second Saturn tour extension, the Solstice Mission. By emphasizing propellant preservation over minimizing maneuver cycles, the Cassini Project is meeting the challenge of mission completion in 2017. Since June 2012, 18 of 21 maneuvers were performed to closely maintain the prescribed trajectory, saving downstream propellant. These and other maneuvers during the third year of the Solstice Mission (June 2012 to August 2013) are highlighted in this paper: 31 planned maneuvers targeted to 11 Titan flybys and the last planned Rhea encounter. An assessment of the updated maneuver execution-error models will also be presented.

EXTENDED ABSTRACT

In July 2004, the Cassini-Huygens spacecraft began a four-year tour of Saturn and its moons. Following the four-year Prime Mission, two subsequent extended missions were approved: the two-year Equinox Mission, from September 2008 through September 2010, and the seven-year Solstice Mission, which began in September 2010 and is planned to conclude in September 2017. The Solstice Mission extends the mission lifetime past Saturn's northern summer solstice in May 2017 in order to augment the temporal baseline observable to two Saturnian seasons.[1] To increase the likelihood of reaching the end of mission (EOM) in 2017, the Cassini Project now emphasizes propellant preservation over saving maneuver cycles. From June 2012 to March 2013, 18 of 21 maneuvers were performed by Cassini to closely maintain the prescribed trajectory. This maneuver approach yielded a propellant savings by minimizing the ΔV cost across several downstream maneuvers. In contrast, the propellant savings by canceling a maneuver may add ΔV to future maneuvers. This paper focuses on the maneuver activities of the Cassini spacecraft from June 21, 2012 through August 7, 2013, comprising the third year of the Solstice Mission and included 31 planned Orbit Trim Maneuvers (OTMs), and how the Project's EOM outlook affected the decisions for these particular maneuvers.

Maneuvers are performed by using Cassini's Main Engine Assembly (MEA) or Reaction Control Subsystem (RCS). The nominal navigation strategy is to employ three propulsive maneuvers between each encounter. The maneuvers are generally targeted to three B-plane flyby conditions of the upcoming encounter; the spatial components $\mathbf{B} \cdot \mathbf{R}$ and $\mathbf{B} \cdot \mathbf{T}$ and time-of-flight. Earlier papers from the Cassini Navigation Team reported on the OTMs during the Prime Mission,[2,3,4,5]

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the Equinox Mission,[6,7] and the first two years of the Solstice Mission.[8,9] The planned maneuvers in the third year of the Solstice Mission, OTM-327 through OTM-357, were used to achieve 11 targeted flybys of Titan (T85–T94) and one encounter of Rhea (R4). These 12 encounters were part of the first half of the second inclined phase of the Solstice Mission. From July 2012 through April 2013, a series of short-period resonant Titan-to-Titan transfers (T85–T90), targeted by OTMs 327–346, increased the inclination from near zero to 61.7°. The majority of ring and high latitude Saturn atmospheric occultations in the Solstice Mission occurred during this phase, including the last planned targeted encounter of Rhea. From May 2013 through May 2014, a series of resonant and generally longer period orbits (most > 32 days) reduces inclination from 61.7° to 40.7°. This phase was designed to provide both northern and southern hemisphere, low phase Titan surface coverage and multiple inclined passages through Saturn's magnetotail region.[1] The first four Titan flybys in this phase, T91–T94, were targeted by OTMs 347–357 and are discussed in this paper.

Other than RCS burns, hydrazine is used when orienting Cassini for main engine burns, attitude control, and pointing the spacecraft's high-gain antenna to Earth for communication. To save hydrazine consumption and throughput, the RCS to main engine threshold has been lowered from 0.3 m/s to 0.25 m/s. This ΔV threshold for main engine burns was determined by the one second limitation on burn times, where 0.25 m/s main engine burns are currently between 1.2–1.3 seconds in duration. This new threshold for main engine burns was established in April 2012 with the implementation of OTM-318, and revisited with the recent burns OTM-335 and OTM-342.

One of the long-term tasks of the Cassini Maneuver Team is to monitor and assess the performance of the main engine and RCS burns by modeling the execution errors.[10] New execution-error models for Cassini's main engine and RCS maneuvers were developed and used in maneuver operations beginning in August 2012.[11,12] Magnitude biases were identified in the modeling process and have been removed either through a flight software change or within the maneuver design process. RCS and main engine burns that have been performed since these software and design changes appear to follow the predicted zero-mean magnitude-error models.

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