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MESSENGER AT MERCURY: FROM ORBIT INSERTION TO FIRST EXTENDED MISSION

Abstract

After more than 6.6 years in interplanetary cruise, NASA's MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) spacecraft entered orbit about Mercury on 18 March 2011. Operating from a highly eccentric, near-polar orbit designed to keep the spacecraft safe and to facilitate the required observations, MESSENGER is using its payload of seven instruments and its radio-frequency telecommunications system to characterize the planet's interior, surface, atmosphere, and magnetosphere. Because one Earth year spans two Mercury solar days, MESSENGER's science data-collection campaign includes two opportunities each calendar year to observe any location on Mercury with a given viewing geometry. The focus of the first solar day was on global map products, and the second solar day provided opportunities for targeted observations, to recover measurements missed during the first six months, and to acquire images complementary to those from the first solar day to form a global stereo map. The spacecraft's orbit has completed six local-time rotations and nine rotations in longitude, allowing spatial characterization of Mercury's magnetic field, construction of an elevation model from northern hemisphere altimetry, and global to regional measurements of surface abundances of major elements. Six orbit-correction maneuvers (OCMs) kept minimum altitude low and the orbit period near 12 hours during the first year after Mercury orbit insertion (MOI). Within one year of MOI, all MESSENGER full-mission success criteria were either met or exceeded. In mid-April 2012 two OCMs used most of the remaining

propellant to lower orbit period from 11.6 to 8.0 hours. The 8-hr orbit option for the yearlong extended mission originated with studies that addressed how reducing orbit period delays Mercury surface impact brought about by strong solar gravity perturbations. During the first two years after MOI, MESSENGER's minimum altitude drifted upward as the sub-spacecraft Mercury periapsis latitude drifted from 60N to 84N. Two years after MOI, periapsis will begin drifting southward and periapsis altitude will decrease until Mercury surface impact occurs. The 8-hr orbit will delay Mercury impact months longer than remaining in a 12-hr orbit for the second year at Mercury and using remaining propellant to raise periapsis altitude. Relative to the 12-hr orbit, the 8-hr orbit has 50% more low-altitude passes and a 32% lower apoapsis altitude for higher-resolution observations of Mercury's southern hemisphere. Certifying the 8-hrorbit extended mission option required extensive engineering and operational analysis to ensure that the spacecraft will be safe and that all scientific objectives will be met.