

## GALILEO NAVIGATION: LAUNCH TO JUPITER 01(111)'

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### Abstract

The Galileo spacecraft was launched on October 18, 1989. After a 3.7 billion kilometer journey lasting just over six years, the Galileo Orbiter and Probe arrived at Jupiter on December 7, 1995. The atmospheric Probe survived its atmospheric entry and successfully transmitted data to the Orbiter flying overhead for 58 minutes. The Orbiter, after a 900-kilometer gravity-assist flyby of Io, stored the data received from the Probe and then fired its main engine to enter a 203-day orbit about Jupiter. During the orbital phase of the mission, which lasts two years, the Orbiter will conduct a tour of the Jupiter system, including ten planned close encounters with the three Galilean satellites Europa, Ganymede and Callisto. To date, the Orbiter has successfully completed the first three of the ten planned satellite encounters. Navigation for the Galileo Mission has proved to be a unique and challenging task. Major factors that have had significant effects on the navigation strategy for Galileo include limited spacecraft propellant supply, Earth flyby navigation constraints, low-gain antenna operations, and spacecraft AV mechanization constraints. En route to Jupiter, navigation performance at the three planetary gravity-assist flybys (one with Venus and two with Earth) and the two main-belt asteroid flybys (951 Gaspra and 243 Ida) was excellent. The Jupiter Probe was delivered to its atmospheric entry target well within targeting requirements. The Io flyby and Jupiter orbit insertion burn were also completed flawlessly. An innovative contingency orbital tour strategy, developed about a month prior to Jupiter arrival, in conjunction with an early perfect Jupiter orbit insertion burn, enabled cancellation of five planned trajectory correction maneuvers - a truly remarkable outcome. Navigation performance continues to be excellent for the orbital tour satellite encounters; this has resulted in a significant increase in end-of-mission propellant margin. This excellent navigation performance is attributable in large part to the use of sophisticated gravity-assist trajectory optimization techniques and extensive use of optical navigation (enabled by new spacecraft software algorithms that reduce the amount of data returned for each optical navigation picture by a factor of 200). The challenges and results of navigating Galileo through the interplanetary transfer to Jupiter, delivery of the atmospheric entry Probe, Jupiter orbit insertion, and the

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orbital tour are presented in the paper. Data is included for trajectory correction maneuver results and delivery errors for the atmospheric Probe and for each planetary, asteroid, and Galilean satellite encounter. Propellant utilization since launch is summarized; the amount of propellant remaining (90% probability estimate) at the end of the baseline mission is currently 36 kilograms, including 13 kilograms of Project Manager Reserves.