NAVIGATION DESIGN FOR THE GALILEO EXTENDED MISSIONS

C.A. Halsell

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California, 91109 USA

The original Galileo orbiter mission was designed to orbit Jupiter eleven times, encountering a Galilean satellite (Io, Europa, Ganymede, and Callisto) on ten of those orbits. This nominal mission lasted for two years, from Jupiter orbit insertion on December 7, 1995 to December 1997. As this tour progressed, it became clear that an extended mission might be possible. On-board resources such as propellant had not been exhausted as rapidly as expected, and radiation damage to the orbiter was surprisingly low. Observations to test for the existence of a global ocean on Europa priorities were a high priority, as were high-resolution images of Io, which had been visited only briefly during the primary mission. To meet these objectives the Galileo Europa Mission (GEM) was developed. GEM added fourteen orbits and two years to the original mission, visiting Europa eight times, Callisto four times, and Io twice. GEM successfully augmented the nominal tour by offering many attractive additional opportunities for remote sensing.

The continued success of the GEM tour prompted the design of an additional mission extension, constrained by the desire to coordinate observations with the Jupiter closest approach of the Cassini spacecraft in December 2000. The Galileo Millennium Mission (GMM) allowed Galileo to record measurements within the magnetotail of Jupiter simultaneously with Cassini observations beyond the magnetotail. In keeping with this goal the main focus for the extension was *in situ* fields and particles measurements rather than remote sensing. A third and final extension to the Galileo mission was designed to add remote sensing and fields and particles observations of Io as well as establishing an orbit which would not threaten Europa with potential biological contamination by accidental impact. This planetary protection requirement was met by allowing the orbiter to impact Jupiter in September 2003.

The Galileo navigation team developed strategies to accommodate these challenging extended missions, always with the need to conserve the limited propellant in mind. These techniques included frequent trajectory re-optimization, robust orbit determination processes and repeated satellite ephemeris reconstruction. Some of these methods have been adopted by other projects and will be described.