JIMO DELIVERY AND SUPPORT OF A JUPITER DEEP ENTRY PROBE. T. R. Spilker[1] and R. E. Young[2], and Participants of the April 21-22, 2003 Entry Probe Workshop, [1]Jet Propulsion Laboratory (4800 Oak Grove Drive, M/S: 301-165, Pasadena, CA 91109, e-mail: Thomas.R.Spilker@jpl.nasa.gov), [2]NASA Ames Research Center (Mail Stop 245-3, Moffett Field, CA 94035, e-mail: Richard.E.Young@nasa.gov).

The 2003 Solar System Exploration Decadal Survey ("SSEDS") emphasizes the significant science available from Jupiter deep entry probes. Studies performed at JPL this year identified a mission design that would allow JIMO to deliver and support one or more entry probes that reach the 100-bar level in Jupiter's atmosphere, with relatively minor modifications to JIMO's preliminary mission design. Notably, the icy moon tour mission design, beginning with Callisto approach, is unaffected. This proposed mission design would offer the option of adding a rich new set of high-priority SSEDS science objectives to the planned JIMO mission for a relatively small investment.

Currently JIMO's preliminary mission design has the spacecraft approach Jupiter under power from its ion thrusters, gently nudging its speed upward over time to nearly match Jupiter's heliocentric speed [1]. This sets the stage for capture into (an initially distant) Jupiter orbit with those same ion thrusters. Early in the Jupiter approach, the spacecraft's "B-plane" aimpoint is more than ten million km from Jupiter [1] to yield roughly circular initial orbits that most efficiently use the engines to spiral down to Callisto. Large deviations from this type of trajectory impact that efficiency and are thus undesirable, increasing both the propellant required and time elapsed from capture to orbit insertion at Callisto.

By altering the initial approach aimpoint very early in the approach phase, the JIMO spacecraft can deliver payloads to precise Jupiter-impact and moderate-altitude (a few Rj) flyby trajectories, and then return to the originally planned trajectory during the rest of the approach phase. Moving the aimpoint much nearer Jupiter establishes the probe's impact trajectory, with release about half a year before capture [1]. Then a maneuver of a few tens of m/s, which requires a few days of ion thrusting, places JIMO on a mid-altitude equatorial flyby trajectory, where it releases a simple probe data relay subsatellite. At that point, still months away from Jupiter capture, the probe mission and the JIMO mission become entirely independent. Orbit calculations at JPL [1] show that with such an architecture, the modified approach trajectory for the JIMO spacecraft closely follows the original spiral-in trajectory after half of the first jovian orbit, and matches exactly after the second orbit, long before approaching Callisto.

This approach yields a probe entry geometry very similar to that of the highly successful Galileo Probe. The entry trajectory is similar, but there is flexibility with probe targeting. The simplest, most direct targeting delivers the probe to within a few degrees of Jupiter's equator. Modest additional ΔV from JIMO can target higher latitudes and aim for either a belt or zone, though significantly higher latitudes increase the entry speed. It can also adjust the jovicentric entry longitude, with the caveat that predictions of System III longitudes of atmospheric features six months in advance are imperfect.

The probe envisioned here shares many characteristics with the Galileo Probe but takes advantage of many technological advances since Galileo. The instrumentation is very Galileo-like in measurement strategy, with a few modifications such as adding a gas chromatograph to the mass spec, deleting the Helium abundance detector, etc. New instrument technologies offer a lighter payload with lower power demands, yet better performance. Better batteries promise a data relay link with higher transmitter power for higher data rates. Use of a pressure vessel and phase-change cooling, instead of a vented vessel of the Galileo probe type, allows operation to at least the 100-bar level, where temperatures are expected to be 650-670 K. Recent studies at JPL suggest the probe would be considerably less massive than the Galileo probe. Detailed studies soon to start at NASA Ames Research Center will reduce the uncertainties from previous estimates.

Implementing the probe's entry heat shield requires some resource investment. Certain materials used in fabricating the Galileo probe heat shield may no longer be available; using substitutes requires qualification of the new materials, and that requires resurrecting Ames' Giant Planet Facility. If the GPF is available and CFD codes are upgraded based on the Galileo experience, the tools would be available to design and test heat shields with new materials and better-optimized geometries, yielding higher payload mass fractions. This work can be done on a schedule commensurate with the JIMO Project schedule. The facilities and CFD codes would then be available for design testing and validation of heat shields for entry vehicles at other SSEDS high-priority destinations.

The relay subsatellite (RS) flies a trajectory similar to that of the Galileo Orbiter before orbit insertion, without the Ganymede flyby. It has a low inclination and a near-equatorial perijove, in the 3-5 Rj range, to be determined by telecomm rate vs view-period trades. Since the RS can downlink data from heliocentric orbit, no orbit insertion maneuver is needed.

Requirements for the RS indicate a very simple spacecraft. Like the probe it needs no primary propulsion system, it can be spin-stabilized, and with relatively wide-beamwidth telecomm antennas it needs only coarse sun-sensors for attitude sensing. It might be possible to use primary batteries for electrical power (redundant, with margin for multiple downlinks), but if the mass is available modest solar arrays can charge secondary batteries that meet all recording and downlink requirements.

We anticipate that JIMO delivery of a deep entry probe to Jupiter offers significant savings from the cost of a dedicated probe mission. Studies will show the level of cost savings and more accurately define the resource requirements. If resource requirements and JIMO resources available allow, there is nothing in this architecture that prevents delivering multiple probes, each to different latitudes, instead

of a single probe, supporting them via the single relay sub-satellite.

[1] Balint, T, M. Noca, G. Whiffen, T. Spilker, et al. (2003) JPL internal publication.

This work was performed at the Jet Propulsion Laboratory, California Inst. of Technology, under contract to NASA.