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Mixing Moons and Atmospheric Entry Probes: Challenges and Limitations of a Multi-Objective Science Mission to Jupiter

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The quest to better understand our solar system and life within it drives the exploration of Jupiter and its moons. Galileo, the most recent of our missions to the Jovian system, vastly improved understanding of that system but raised further questions that call for new science missions there. Some advanced mission concepts focus on Jupiter's satellites while others would study Jupiter itself; recently multi-objective mission concepts emerged, such as combining a Jovian satellite tour with atmospheric entry probes. The multi-billion-dollar NSI mission "Jupiter Icy Moon Orbiter" (JIMO) would orbit Callisto, Ganymede and Europa, using fission-based electric power for spacecraft systems, instruments, and Nuclear Electric Propulsion (NEP). As initially formulated this mission focuses on the icy satellites, so its architecture does not include Jupiter entry probes. At the same time potential investigators and mission implementers have discussed concepts for entry probe missions that might fit the ~$650M "New Frontiers" category. It was suggested that adding a Jupiter entry probe to the JIMO mission might achieve the scientific objectives of both missions, while costing less than the sum of the two missions implemented separately. Recently a small team at JPL studied five such combined-mission architecture options. In this paper we outline those architectures, highlighting the advantages and disadvantages of each. We also detail the issues that make the JIMO mission and a probe mission incompatible unless the original JIMO science objectives are descoped or modified, a compromise not likely acceptable to the JIMO science team. For instance, in all cases studied, telecommunications is a significant obstacle to supporting a probe from the nominal JIMO orbit. Without an unanticipated, clever new mission architecture, it appears that any feasible option adds significant complexity, cost, and risk to the original JIMO mission, so the value of such a mission merger is questionable. The well-designed JIMO mission architectures, optimized for a given set of objectives, used up the available degrees of freedom. As is often the case, adding new mission objectives to the optimized original mission adversely impacts the original objectives and architecture.