

A Realistic Interstellar Explorer

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For more than 20 years, an “Interstellar Precursor Mission” has been discussed as a high priority for our understanding (1) the interstellar medium and its implications for the origin and evolution of matter in the Galaxy, (2) the structure of the heliosphere and its interaction with the interstellar environment, and (3) fundamental astrophysical processes that can be sampled *in situ*. The chief difficulty with actually carrying out such a mission is the need for reaching significant penetration into the interstellar medium (~ 1000 Astronomical Units (AU)¹) within the working lifetime of the initiators (< 50 years). During the last three years there has been renewed interest in actually sending a probe to another star system - a “grand challenge” for NASA – and the idea of a precursor mission has been renewed as a beginning step in a roadmap to achieve this goal [Anderson, 1999].

In the Phase I work, we have completed an initial scooping of the system requirements and have identified system drivers for actually implementing such a mission. The proposed Phase II work takes these drivers and the initial architecture concept and further defines them. In particular, industrial partners have been identified for some of these tasks and proof-of-principle breadboarding tasks and experiments have been defined for others. It is important to note that although we will be studying the full system architecture for the mission, much of the proposed effort is devoted to the development of the spacecraft architecture required for long-term cruise in deep space, and is so largely independent of the mission design and propulsion implementation used to provide high-speed escape from the Sun's gravity.

In the Phase I study we began the task of looking seriously at the spacecraft mechanical, propulsion, and thermal constraints involved in escaping the solar system at high speed by executing a ΔV maneuver of ~ 10 to 15 km/s in the thermal environment of $\sim 4 R_s$ (from the center of the Sun) remains challenging. Two possible techniques we identified for achieving high thrust levels near the Sun are: (1) using solar heating of gas propellant, and (2) using a scaled-down Orion (nuclear external combustion) approach. We investigated architectures that combined with miniaturized avionics and miniaturized instruments, enable such a mission to be launched on a vehicle with characteristics not exceeding those of a Delta III.

We will examine a variety of propulsion means and their associated architectures including both solar flyby impulsive and low-thrust continuous concepts. We do not propose to consider any “breakthrough physics” propulsion schemes [Millis, 1999] as these are not in keeping with our self-imposed ground rules for considering “realistic” probe architectures.

We do propose to continue the cruise configuration architecture work [our NIAC Phase I Report and McNutt *et al.*, 1999] with an emphasis on long-lived, self-healing architectures and redundancies that will extend the probe lifetime to well over a century. Such a long-lived probe could be queried at random over decades of otherwise hands-off operations. Finally, we will also look at the various systems trades for cruise architectures/propulsion system combinations. This systems approach for such an Interstellar Explorer has not been previously used to address all of these relevant engineering questions and will also lead to (1) a probe concept that can be implemented following a successful Solar Probe mission (concluding around 2010), and (2) system components and approaches for autonomous operation of other deep-space probes within the solar system during the 2010 to 2050 time frame.

