Ice & Fire: Missions to the Most Difficult Solar System Destinations... on a Budget

Robert L. Staehle, John B. Carraway, Karla B. Clark, Richard J. Doyle, Paul K. Henry, Torrence V. Johnson, Jan Ludwinski, Jack E. Mondt, Hoppy Price, James E. Randolph, Richard J. Terrile, Bruce T. Tsurutani

Jet Propulsion Laboratory, California Institute of Technology

and Elaine Hansen, University of Colorado

Three radii from the surface of the Sun... more natural radiation around Jupiter than would be encountered immediately following a nuclear war...to the farthest planet and beyond;...these challenges are faced by the three "Ice & Fire" missions: Solar Probe, Europa Orbiter, and Pluto-Kuiper Express. These three missions will be beneficiaries of the X2000 and related advanced technology development programs. Technology developments now in progress make these missions achievable at costs recently thought adequate only for missions of relatively short durations to "nearby" destinations.

The next mission to Europa after *Galileo* will determine whether a global subsurface liquid water ocean is currently present, and will identify locations where the ocean, if it exists, may be most accessible to future missions. Pluto Kuiper Express will complete the reconnaissance of the known planets in our Solar System with geological, compositional, and atmospheric mapping of Pluto and Charon while Pluto remains relatively near the Sun during its 248 year orbit. An extended mission to a Kuiper Disk object may be possible, depending on remaining spacecraft resources. Using a unique combination of Sun shield/high gain antenna and quadrature encounter trajectory, Solar Probe will deeply penetrate our nearest star's atmosphere to make local measurements of the birth of solar wind, and to remotely image features as small as 60 kilometers across on the photosphere.

Avionics technology, leading to integration of functions among a set of multichip modules with standard interfaces, will enable lower production costs, lower power and mass, and the ability to package with modest shielding to enable survival in orbit around Europa inside Jupiter's intense radiation belts. The same avionics and the software can be utilized on the other Ice & Fire missions. Each mission is characterized by a long cruise to its destination, which is sometimes interrupted by planetary flybys. To reduce operations and tracking costs, spacecraft will be more autonomous. They will self monitor and self-command, while sending a continuous beacon alerting inexpensive ground receivers to general spacecraft health and any need for immediate attention. Where solar power proves impractical for achieving mission goals, an advanced radioisotope power source may be utilized with much smaller heat sources. The dynamic range of solar power generation will be extended for less demanding applications from the orbit of Jupiter to about one-tenth of an astronomical unit from the Sun.

The three missions described are to begin the Outer Planets/Solar Probe exploration program, as first proposed in the FY1998 Federal Budget. Spacecraft, launch systems and mission operations must all fit within a single program, encouraging system- and program-wide tradeoffs to minimize costs. Some of the system and technological solutions utilized by these missions may find application in a variety of other science-driven missions.