A COMET NUCLEUS SAMPLE RETURN CONCEPT

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In cooperation with NASA's Solar System Exploration Subcommittee (SSES) the Jet Propulsion Laboratory (JPL) is conducting a series of studies to assess the feasibility of planetary science missions proposed for launch in the 2006-2010 time frame and to prioritize technology development steps that will enable these missions. This presentation describes the results of one of these studies, dealing with a concept for a Comet Nucleus Sample Return (CNSR) mission. Included are discussions of the science objectives, the major design trade-offs in planning a mission to satisfy these objectives, and the resulting mission concept.

One of the principal themes of NASA's Space Science Program is to develop an understanding of the origins of life on Earth. NASA's science planners have identified the return of pristine material from a comet as an important element of this understanding since it is widely believed that comets were the couriers for distribution of complex organic molecules in the early days of the Solar System. Examination of ancient comet nucleus material in laboratories on Earth will lead to significantly enhanced models of this process.

The principal science objective identified by the SSES is the return to Earth of comet nucleus material acquired and preserved so as to permit detailed chemical analysis of key organic species. This led to requirements for obtaining samples from one or more sites (three sites desired) at a depth of 10 meters or more and to preserve the samples at 150K or lower during the transit to Earth. Additional science requirements call for documentation of the sample context by remote and on-the-surface imaging and spectroscopy and by in-situ chemical analysis.

The major tradeoffs in the study dealt with propulsion methods and with methods for obtaining samples from multiple sites. These trades were strongly influenced by the assumed success of the DS4/Champollion mission, a major element of the New Millennium technology demonstration program. DS4 will demonstrate the use of an advanced solar electric propulsion (SEP) system, sending a lander vehicle to comet Tempel I arriving in late 2005. It will also demonstrate landing, anchoring, sample acquisition and analysis, and an ascent vehicle which will rendezvous and dock with an orbiting vehicle. (A proposed Earth-return segment of DS4 is not currently funded.)

The CNSR study developed a mission profile that would use SEP to propel a DS4-like lander/ascent vehicle combination to the subject comet. But instead of permanently anchoring as in the DS4 case, the lander would be capable of temporarily anchoring, releasing, and flying to additional sites before rendezvous with the SEP stage for return to Earth. After rendezvous the samples would be transferred to an Earth entry vehicle similar to that being developed for the Stardust mission but with enhanced thermal control capability. Conventional propulsion was considered but found to fall far short of SEP in performance for missions of this type. A more

interesting comparison was made with performance predictions for application of solar sails to CNSR missions. If development of solar sail capability lives up to current forecasts, it would become a strong competitor for missions of this type, although problems of operating a sail in close proximity to a comet would have to be investigated.

The estimated end-to-end cost of the CNSR mission as defined in the study (including launch vehicle and mission operations) would be consistent with NASA's existing Outer Planets Program, which plans to launch a mission in the $200-$300 million range every two years.

Substantial technology development will be needed to make the CNSR mission a reality. Keys to this mission include development of the anchor and release capability for the lander (or one of the other methods for obtaining samples at multiple sites) and development of deep drilling capability. The mass and power allocations in the study are based on a multi-segment drill but other mechanisms will also be considered. As a follow-on to the study, plans for development work in these areas are being drawn up with the NASA technology community.