A REVIEW OF THE DEEP SPACE 1 MISSION: IMPORTANT RESULTS IN SPACECRAFT ENGINEERING AND SPACE SCIENCE

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Conceived in 1995, Deep Space 1 (DS1) was the first mission of NASA's New Millennium program. Its purpose was to test high-risk, advanced technologies important for space and Earth science missions. DS1's payload included ion propulsion, solar concentrator arrays, autonomous navigation and other autonomous systems, miniaturized telecommunications and microelectronic systems, and two highly integrated, compact science instruments. DS1 was launched in October 1998, only 39 months after the initial concept study began, and during its 11-month primary mission it exceeded its requirements. All technologies were rigorously exercised and characterized, thus reducing the cost and risk of subsequent science missions that could consider taking advantage of the capabilities offered by these new systems. Missions that will benefit from DS1's testing include Dawn, planned to rendezvous with 4 Vesta and 1 Ceres, and Deep Impact, designed to encounter comet 9P/Tempel 1. Following its primary mission, DS1 embarked on an extended mission devoted to comet science, although it had not been designed for a comet encounter. The spacecraft suffered a critical failure, with the loss of its star tracker, its only source of 3-axis attitude knowledge. Although this was initially considered to be a catastrophic failure, the project completed an ambitious two-phase, seven-month recovery that included the development of extensive new software and new operations procedures. In September 2001, the spacecraft flawlessly completed a high-risk encounter with comet 19P/Borrelly. Using the two instruments included on the flight as technology tests as well as reprogrammed sensors originally intended for monitoring the effects of the ion propulsion system on the space environment, DS1 returned a rich harvest of data, with panchromatic images, infrared spectra, energy and angular distributions of electron and ion fluxes, the composition of ions, and magnetic field and plasma wave measurements. These data constitute the most detailed view of a comet and offer surprising and exciting insights. In addition to the direct scientific return, the comet encounter is of value to other missions planning comet encounters. As one example, Stardust's encounter with comet 81P/Wild 2 will rely on the software DS1 used to located and track the nucleus for its remote sensing observations. With the successful conclusion of its extended mission, DS1 undertook a hyperextended mission. This phase of its flight was dedicated to final testing of the advanced technologies on board. With the mission at more than three times its planned lifetime, this offered an excellent opportunity to obtain unplanned data on the effects of long-term operation in space. All nine of the hardware technologies were used during the hyperextended mission, with a focus on the ion propulsion system. Following this period of extremely aggressive testing, with no further technology or science objectives, the mission was terminated on December 18, 2001, with the powering off of the spacecraft's transmitter, although the receiver was left on. By the end of its mission, DS1 had returned a wealth of important science data and engineering data for future missions. It did so following the shortest time from pre-phase A through launch of any NASA interplanetary mission in the modern era and the lowest cost of any NASA interplanetary mission ever conducted (measured in same year dollars, including the launch cost). This paper will describe the

encounter with comet Borrelly, the hyperextended mission, and summarize the overall results of the Deep Space 1 project.

The Successful Conclusion of the Deep Space 1 Mission: Important Results without a Flashy Title

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