THE DAVINCI PROBE DESCENT MODULE AND ENGINEERING DEVELOPMENT UNIT TESTING.
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Introduction:

Venus is our nearest neighbor and the closest in size to our home planet. Yet it remains largely unexplored, its runaway greenhouse atmosphere remains unexplained and it's geologic past unknown. The deep atmosphere of Venus remains largely unexplored and key details of its trace gas chemistry remain unmeasured. The history of key volatile reservoirs and surface-atmosphere-interior exchange processes is poorly established and based on limited data. Noble gases within the bulk Venus atmosphere, as well as isotopes of hydrogen, oxygen, and sulfur, are essentially unmeasured to the degree required to address fundamental questions about the evolution of the planet. The planet that is the most capable of teaching us about our own planet must not remain so mysterious. The gaps in deep atmosphere and surface ground truth must be closed. The value of past and future remote sensing at Venus is threatened by our lack of in-situ data and unanswered fundamental questions about the atmosphere and surface. Planetary probes capable of in-situ chemistry measurements within the atmosphere of Venus enable critical science measurements that are needed to answer unresolved science questions. There is critical science data that is not measureable from orbit or from other remote sensing approaches. Much of the needed constituent, chemical and dynamic information requires in situ measurements. Models for solar system formation and the evolution of atmospheres depend on measurements probes can deliver, as do comparisons between the Earth and planets like Venus.

DAVINCI Probe:

The Deep Atmosphere Venus Investigation of Noble gases, Chemistry, and Imaging (Davinci) Venus mission was recently selected for Phase A in the Discovery competition. It fills the fundamental voids that exist in critical Venus in situ knowledge that are crucial to understanding Venus, Earth and future Venus orbital remote measurements. Davinci employs a well instrumented deep atmosphere probe to fill these voids. Davinci's in situ probe allows the mission to address most of the key Decadal Survey New Frontiers "Venus In Situ Explorer" (VISE) science objectives. This includes atmosphere composition, noble gases, nitrogen isotopes, hydrologic cycles and many physical properties of the atmosphere, all crucial to origin and evolution objectives. Davinci's probe also enables resolving key surface atmosphere interaction and pursues radiative balance and surface physics and chemistry goals.

The Davinci probe is designed to enter the atmosphere and carry its instruments through the atmosphere as they carry out their measurements, to the surface where pressures and temperatures are challenging. Science objectives require state-of-the-art neutral mass spectrometer capabilities to achieve seminal measurements of noble gas isotopes while also allowing for high mass resolution and time rate sampling of trace gases. Instruments developed at NASA's Goddard Space flight Center, the world's most experienced space flight mass spectrometer instrument organization, are designed to achieve these pivotal observations. The mass spectrometer is linked to tunable laser spectrometer instrumentation, similar in capability to that which is part of SAM instrument on NASA's Mars Science Laboratory (MSL). The physical context for the atmospheric chemistry measurements is an essential part of the scientific measurement strategy and Davinci takes advantage of current state-of-the-art approaches in atmospheric structure instrumentation for pressure, temperature, and accelerations. The photometry of the atmosphere beneath the cloud deck, as well as imaging of surfaces in regions not explored by the many decades old Soviet Venera landers is enabled by a very capable descent imaging system. The design enables observations that were not possible during the decades old first era of *in situ* Venus reconnaissance (i.e., *PV, Venera*), and which go well beyond what orbital or flyby remote sensing can achieve.

These scientific measurement instruments have been combined into Davinci's optimized "descent sphere" within a probe flight system that includes an aero-entry capsule with a thermal protection system and parachutes. The instruments and thermal solutions lend themselves to probe descent module of reasonable size and power using proven approaches that are combined with updated approaches. The basic Davinci probe descent sphere is shown in Figure 1. Figure 2 shows the descent module in the heat shield.

Figure 1 - Davinci probe descent module layout.

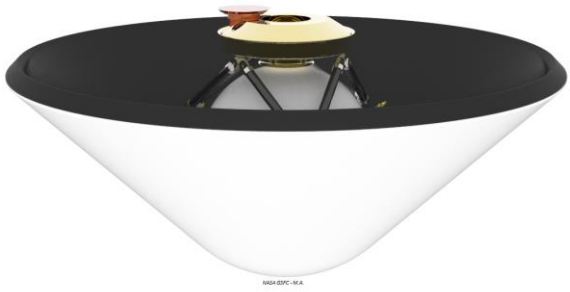

Figure 2 – Davinci Probe descent module and entry and descent system.

The Davinci concept is based upon Pioneer Venus designs and approaches, combined with over six years of NASA Goddard Space Flight Center investments, prototypes, engineering test units and tests. The instrument packaging and science requirements, combined with the high temperature and high pressure conditions near the surface, drive many design elements. Packaging, thermal control, seals, materials trades, aerodynamics, communication links, reliability, testing approaches and heat shield materials challenges drive design options and are also linked to higher level mission flight dymincs decisions. The analysis and prototype work being done by the team has rapidly advanced the design maturity to a level allowing low risk probe missions. The test work has also allowed us to solve, prove, hone, practice and test the key steps of designing building, and testing the Davinci probe. This includes Davinci probe manufacturing, Venus surface environment test procedures, integration and test, and thermal design implementations. NASA GSFC has built Davinci probe engineering development and test units (EDU) and tested them through multiple full Venus descent test conditions. Figure 3 shows one of the EDUs just after a full Venus surface conditions test.

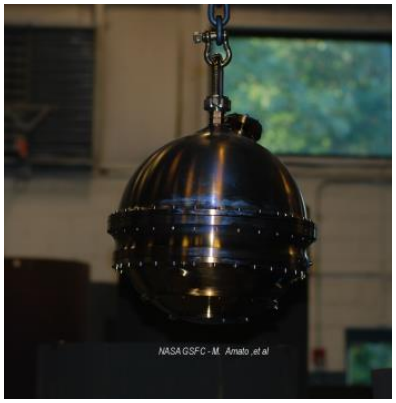

Figure 3 – Davinci Probe descent module EDU just after one of the Venus surface environment tests.

We believe the Davinci probe design approach is the lowest risk and most cost-effective approach to resolving key scientific issues for Venus within the context of competed mission programs at NASA.

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