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Introduction: Lockheed Martin has a long history of developing and operating Mars spacecraft, starting with our designing and building the heat-sterilized landers for the Viking 76 mission. Building on that powered lander architecture, a smaller version was developed in the mid 90's that was eventually launched as the Mars Polar Lander (MPL). Even before MPL launched, development of the Mars Surveyor 2001 lander began. Using lessons learned from the MPL development, this larger lander would carry more than double the payload of MPL. When MPL was lost, work on the '01 lander was stopped, but resumed a few years later and launched as the Phoenix mission[1]. Phoenix delivered nearly 60 kg of payload to the Martian arctic and many science firsts, including the first confirmation of water ice in the regolith, and the discoveries of perchlorates and carbonates in the soil. The Phoenix platform payload fraction (kg science per kg launch mass) is the highest yet flown to Mars. Our heritage is the basis for this abstract in response to challenge Area 2: Safe and Accurate Landing Capabilities, Mars Ascent, and innovative Exploration Approaches.

The Phoenix architecture has been studied for a multitude of Mars missions for every Mars opportunity from 1998 to 2018 (Figure 1). The platform has been proposed for nearly a dozen Mars Scout and Discovery missions with total science payload ranging from 20 kg to 90 kg. The missions have included equatorial, mid-latitude and polar (north and south) landing sites, and altitudes ranging from -4 km to +6 km. Proposed and conceptual missions have included lander decks packaged with drills (conventional and melt), rovers, life detection payloads, and seismometers. Designs exist for incorporating the new Advanced Stirling Radioisotope Generator (ASRG) to enable long duration missions, especially at the poles..

In addition to many specific mission designs, the platform has been studied for use across opportunities and for scalability (Figure 2). An even larger version was the basis of the cancelled Mars Surveyor 03/05 lander for Mars Sample Return. The design changes

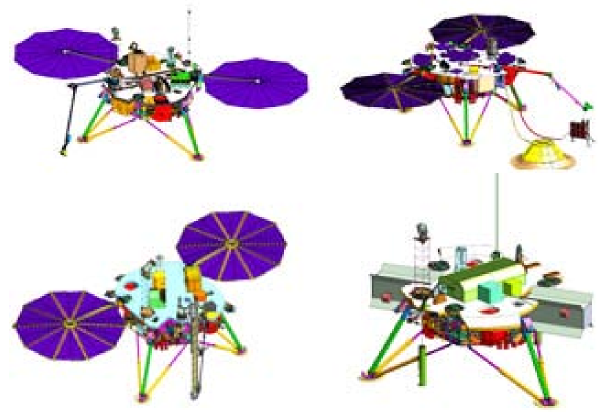

Figure 1. Phoenix and several recent Discovery/Scout proposal efforts based on the Phoenix design.

needed to continue to increase landed payloads have been studied and costed and the design scales well up to several hundred kilograms of payload, including large rovers and Mars ascent vehicles. The impact of the different opportunities on EDL design has been characterized, even down to the detail of the atmospheric changes experienced by arriving at different times of year. In addition to the blunt nose aeroshells from Lockheed Martin used on all successful U.S. landers to date; mid L/D aeroshells and lifting bodies have also been studied for use at Mars.

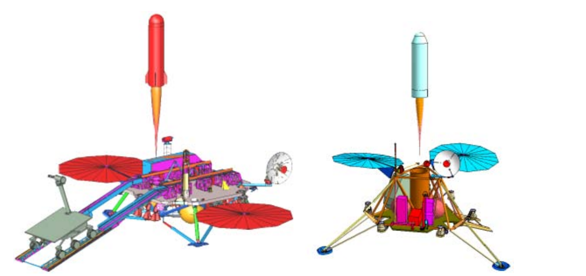

Figure 2. Larger versions of the soft lander design.

Specific upgrade capabilities, while not yet flown, have also had some development work. Spacecraft-to-spacecraft navigation (e.g., between Odyssey and Phoenix) was studied and a navigation algorithm developed that would provide sub hundred meter knowledge accuracy at entry interface (an order of magnitude or more improvement over current capabilities). Hypersonic guidance has been developed to steer out errors introduced by atmospheric uncertainties. Hybrid parachute triggers, actually used on

Phoenix, allow fine tuning the delivery point. Finally, a hazard avoidance approach that leverages over 20 years and hundreds of millions of dollars of cruise missile sensor development has been designed that would not only allow the lander to spot and dodge a 6-inch rock from a mile up, but also could be used to enable surface rendezvous with a prior mission asset. This hazard avoidance capability was baselined for Phoenix until the landing site was shown to be benign enough to descope it. The combination of these technologies, enabling for crewed missions and certain Mars Sample Return Architectures, can be demonstrated on a Phoenix platform.

Lockheed Martin has been developing Mars Sample return concepts since the 1970s and continues to this day. Over the last ten years, detailed designs for mars ascent vehicles, their landers, and sample handing chains have been created, as well as rendezvous orbiters for those architectures that require them. A wide variety of strategies have had detailed design efforts (and even patent applications) including direct return, deep space rendezvous, libration point rendezvous, mars orbit rendezvous, in-situ resource utilization and more exotic ones. Sample handling, encapsulation, and planetary protection approaches have been taken to the point of EDU testing. These end-to-end sample handling design exercises allow a derivation of sample handling requirements for all the elements of a sample return architecture, including the MAV, landers, rovers, orbiters, and sample return capsules.

MAV technologies and design approaches (Figure 3) have been developed that would allow sample return to be conducted on smaller scales and at lower costs than currently envisioned, including on a scaled up Phoenix platform. The wide variety of MAV designs studied to date has provided a deep understanding of the requirements on MAV and their effect on the design and the cost. Not only is sample mass a driver, but injection accuracy, environmental conditioning of the propulsion system in transit and on the surface, telemetry capability and fraction of the sample chain carried on the MAV all have profound impacts on the MAV design and its affordability.

Lockheed Martin has developed the only U.S. sample return capsules to bring back planetary samples from beyond the Earth moon system (Stardust, Genesis). Based on these experiences, Mars Sample Return (MSR) capsules have been designed for the full spectrum of MSR architectures studied. Detailed requirements derivation and even trades studies to decide which flight element should carry which functions have been conducted. The result is a large set of designs to draw on depending on the desired architecture.

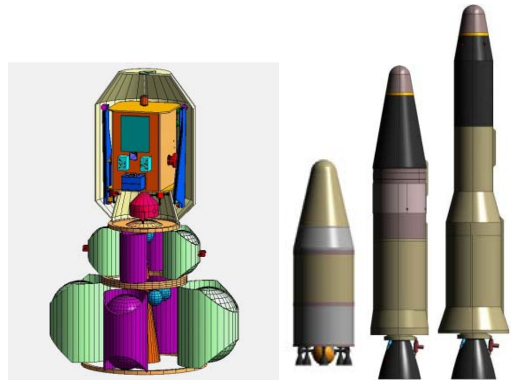

Figure 3. Various Mars ascent vehicle designs.

Lockheed Martin has also provided XSS-11, one of the only orbital rendezvous spacecraft flown to date. This experience, coupled with a wide array of rendezvous vehicle design studies and delivery of nearly a dozen deep space spacecraft over the last 20 years, provides a strong basis for affordable MSR orbital rendezvous capabilities.

Lockheed Martin Mars mission experience, both flight and development, over the last 40+ years has resulted in a broad understanding of the needs and opportunities for exploring Mars.

Connection to Human Exploration: Lockheed Martin has extensive experience with payload accommodation and has been working low cost mission concepts that address critical science and human exploration requirements for atmosphere and subsurface characterization. We have been working closely with the planetary community to develop low-cost, innovative lander mission concepts, such as seismology, ice penetration and life detection. These missions would provide critical measurements for human exploration such as extant life and potential biohazards, subsurface ice, and global weather characterization. Innovative affordable Mars sample return mission options, such as libration point rendezvous and deep space rendezvous, have strong potential benefit not only to robotic sample return but also to human missions to Mars. In, addition, our innovative low-cost, lightweight Mars Ascent Vehicle options have strong benefit to both robotic sample return and human Mars missions.

[1] Warwick, R.W. (2003) *Proceedings IEEE Aerospace Conference, Vol 8,* 3553-3564.