

Phoenix (PHX) Mission

Mission Description and Phases



Revision and History Page

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Phoenix Mission Description and Phases

The Mars Scout mission consisted of one spacecraft and Scout hardware, which included Phoenix lander [SMITH2008 and GUINNETAL2008]. Phoenix was launched August 4, 2007, on a Delta II 7925 launch vehicle. The spacecraft design was based on the Mars Surveyor Program 2001 (MSP'01) configuration for cruise and entry, descent, and landing. The spacecraft will follow a long coast trajectory from Earth to Mars, with Phoenix landing in the Northern Plains on May 25, 2008 UTC. The Earth-Mars range will be 1.84AU at the time of Phoenix's landing.

The day after a successful launch, the spacecraft was commanded out of Safe Mode and setup for transition to nominal cruise phase operations. During the nearly 10-month cruise to Mars, both the spacecraft and the science instruments will be checked out via a number of planned activities. Also during cruise, the teams that will be operating the spacecraft during the critical 'end game', Entry, Descent, and Landing (EDL), and early surface timeframes will be practicing their roles via a series of Operational Readiness Tests (ORTs). As with all NASA planetary missions, telecommunications with the spacecraft are enabled by the Deep Space Network (DSN). A downlink (D/L) bit rate of 40 bps from Phoenix is required to be supportable at all days past launch.

From Entry minus 60 days onward, the mission is in a subphase of cruise known as approach, within which the activity level dramatically increases. During this phase there will be continuous DSN coverage (21 passes/week is equivalent to 24/7 coverage) and four TCMs as the spacecrafts flight path is fine tuned for delivery into the martian atmosphere. Seven minutes prior to atmospheric entry the spacecraft separates from the cruise stage and reorients itself to the entry attitude. The EDL (Entry, Descent, and Landing) phase lasts approximately seven minutes from entry through touchdown, and is broken into hypersonic, parachute, and terminal descent subphases, all of which require the spacecraft to be in a different configuration.

Following its soft touchdown between 65 degrees N to 72 degrees N latitude, the Lander will, after waiting 20 minutes for the dust to settle, perform a number of critical activities. These 'Sol 0' (a sol is a mars day) activities include deployments of the landed solar arrays, the bio-barrier covering the Robotic Arm (RA), and the Surface Stereoscopic Imager (SSI) and Meteorological (MET) masts, after which the Lander will go to sleep to conserve energy. The Lander will wake up for 10 minutes for the first post-landed UHF communication pass one ODY or MRO orbit period (approximately 2 hours) after landing. After relaying eagerly anticipated data to the orbiter(s) during that first pass, the Lander will go to sleep again. Sol 1 activity is expected to begin at roughly 9 a.m. Local Mean Solar Time (LMST) the following sol.

The first seven sols after Landing are known as the characterization phase, with pre-planned activities running from a minimum of 3 hours on Sol 1 to a maximum of 6.5

hours on Sol 6 (the Lander is active for up to 7 hours during the nominal surface or digging phase). The performance of the spacecraft's power, thermal, and UHF subsystems will be thoroughly characterized during this phase, and the Thermal and Evolved Gas Analyzer (TEGA), Microscopy, Electrochemistry, and

Conductivity Analyzer (MECA), and MET instruments will go through their initial checkouts and prepare for nominal operations. Concurrent with these activities, the EDL and Sol 0 data that were stored in the non-volatile (flash memory) will be relayed to the ground. The SSI will image as much of the Lander as it can see and characterize the workspace and surrounding environment. Most important for mission success will be the 'unstow' of the RA and the subsequent practice sample transfers that it will perform on Sol 5. The Robotic Arm Camera (RAC) located on the 'wrist' of the RA will be used to image the footpads and the TEGA cover, as it is the only imager that can be maneuvered into the proper viewpoint for these pictures. The seventh sol does not currently contain any planned activities because it will be used for margin against activities that fail or otherwise require additional time to complete during characterization.

After the Robotic Arm is checked out, the digging phase commences. The digging phase activities include digging a trench in front of the Lander, and the analysis of soil samples at various trench-depths by the Lander instruments. This phase continues until the End-of-Mission on Sol 90. Operations during this phase will be conducted at the University of Arizona and the mission operators will be working on Mars time (one martian sol is equivalent to 1.02749125 Earth days, or 24 hours, 39 minutes, 35.244 seconds).

The mission has been described in many papers, including a pre-landing set of papers in TBD special section of Journal of Geophysical Research - Planets, and post-landing special issues of TBD. [GUINNETAL2008]

MISSION PHASES

DEVELOPMENT

The development phase began with the start of mission funding in January 2003. During this phase, the science and technology requirements were tested and analyzed, and the spacecraft and mission were designed. The instruments and spacecraft were developed and tested at Lockheed Martin in Denver, CO before delivery to Cape Canaveral. The design of the spacecraft trajectory and mission operations were also determined during this period.

Spacecraft Id : PHX
Target Name : MARS

Mission Phase Start Time : 2003-01-15
Mission Phase Stop Time : 2007-08-03
Spacecraft Operations Type : LANDER

LAUNCH

The launch phase for each vehicle began at the final countdown through spacecraft separation from the upper stage. Phoenix was launched August 4, 2007, at 926 UTC (526 EDT) from launch complex 17A at Cape Canaveral Air Force Station, Florida. The launch azimuth was 93 degrees. The boost portion of the launch vehicle trajectory took approximately 10 minutes, and was followed by a short coast phase in a parking orbit for approximately 15 minutes. After third stage burnout, the upper stage despun the stack using a yo-yo despin system. Separation of the third stage occurred approximately 36 minutes after launch.

Spacecraft Id : PHX
Target Name : MARS
Mission Phase Start Time : 2007-08-04
Mission Phase Stop Time : 2007-08-04
Spacecraft Operations Type : LANDER

CRUISE

The cruise phase for each spacecraft began soon after separation from the third stage and ended 60 days before entry into the Mars atmosphere. The duration of cruise phase will be about 236 days for Phoenix. The major activities during this phase include: checkout and maintenance of the spacecraft in its flight configuration, monitoring, characterization and calibration of the spacecraft and payload systems, software parameter updates, attitude correction turns, navigation activities for determining and correcting the vehicle's flight path, and preparation for EDL and surface operations, including EDL X-band communication tests. No science investigations will be conducted during cruise, except for instrument health checkouts.

Spacecraft Id : PHX
Target Name : MARS
Mission Phase Start Time : 2007-08-04
Mission Phase Stop Time : 2008-03-26
Spacecraft Operations Type : LANDER

APPROACH

The approach phase was dedicated to the activities necessary to ensure a successful Entry, Descent, and Landing for the spacecraft, beginning 60 days before entry into the Martian atmosphere and ending at the atmospheric entry interface point 125km from the surface of Mars. The main activities during this phase were: acquisition and processing of navigation data to support development of the final trajectory correction maneuvers and activities leading up to the final turn to the entry attitude and separation from the cruise stage 7 minutes before entry.

Spacecraft Id : PHX
Target Name : MARS
Mission Phase Start Time : 2008-03-26
Mission Phase Stop Time : 2008-05-25
Spacecraft Operations Type : LANDER

ENTRY, DESCENT, AND LANDING

The EDL phase lasts approximately seven minutes from entry through touchdown, and is broken into hypersonic, parachute, and terminal descent subphases, all of which require the spacecraft to be in a different configuration. Phoenix can land safely if the conditions allow the spacecraft to stay within its defined entry corridor. However, if it drifts away from the nominal parameters, there is a steep rise in the chance of failure. Graceful degradation is the desired situation and it is difficult to achieve for Phoenix. Therefore, the working group has spent several years finding the best set of parameters such as the entry angle, the atmospheric properties on the day of landing (Michaels and Rafkin, 2008), the speed at which the parachute is released, and the transition to powered descent (see EDL timeline in Fig. 5). In addition, the rock distribution and ground slopes determine the final touchdown success rate. Thousands of Monte Carlo calculations, each with a randomly selected set of incoming trajectory, atmospheric, and landing site parameters, are used to predict the percentage of successful landings.

Landing day, May 25, 2008, at about 4:30 pm PDT, will be controlled from JPL and is devoted to deploying the solar arrays, extending the SSI mast, releasing the MET mast, and opening the bio-barrier. A small number of SSI images will be taken both of the spacecraft to verify deployments as well as the surface. All available downlinks will be used to gather data needed to assess the health of the spacecraft so that the science activities can begin. Once the spacecraft is power positive, has two-way communications, and is thermally stable then the control is transferred to the UA Science Operations Center in Tucson. [GUINNETAL2008]

Spacecraft Id : PHX
Target Name : MARS
Mission Phase Start Time : 2008-05-25
Mission Phase Stop Time : 2008-05-25

Spacecraft Operations Type : LANDER

CHARACTERIZATION PHASE

The characterization phase of the mission will begin after the Sol 0 activities have been completed. This phase will last 8 Martian sols (each sol being 24.66 hours) after landing for Phoenix, while the performance of the lander's power, thermal, and UHF subsystems as well as the MECA, TEGA, and MET instruments will be characterized and prepared for operation. Data collected on Sol 0 will be relayed to the ground, and the SSI will image the lander and surrounding environment. The DSN is scheduled for 10 sols. The Robotic Arm will be unstowed and complete several practice sample transfers to prepare the lander equipment for the primary mission. [GUINNETAL2008]

Spacecraft Id : PHX
Target Name : MARS
Mission Phase Start Time : 2008-05-26
Mission Phase Stop Time : 2008-06-05
Spacecraft Operations Type : LANDER

PRIMARY MISSION (DIGGING PHASE)

Phoenix's primary missions will last for 90 Martian sols from time of landing. During this phase, a wealth of science and engineering information will be collected from the lander and instrument payload. Activities during this digging phase will include the digging of a trench in front of the lander with the RA and analyzing soil samples from various depths with the lander instruments. The instruments will also photograph and take measurements related to the martian atmosphere.

Spacecraft Id : PHX
Target Name : MARS
Mission Phase Start Time : 2008-06-05
Mission Phase Stop Time : 2008-08-25
Spacecraft Operations Type : LANDER

MISSION OBJECTIVES SUMMARY

Mission Objectives Overview

The mission has a set of science and technology objectives. The science is closely aligned with the Mars Exploration Program objective of determining the degree to which Mars

provided conditions necessary for formation and preservation of prebiotic compounds and whether life started and evolved. This objective can be broadly stated as defining habitability of Mars and providing an understanding of roles of tectonic and climatic processes in possibly providing the conditions that led to life. The presence of water and its interaction with crustal materials is of fundamental importance. Thus, the primary objectives are focused on investigating the history of water in all forms on Mars and assessing the biological potential of the soil-ice boundary.

The four primary science goals are:

- (1) to study the history Of the ground-ice and its emplacement mechanisms,
- (2) to address the affect that subsurface ice has on the local surface geomorphology,
- (3) to characterize the climate and local weather of the landing site, and
- (4) to address the habitability of the icy soil.

These Science objectives are subdivided into four primary categories in order to align with the management structure of the four Science Theme Groups.

Science Theme Groups

Climate Theme

The science objectives in relation to characterizing the present climate include:

- (1) To determine the daily and seasonal variations in temperature, dust opacity, pressure, and humidity at the landing site,
- (2) To determine the exchange of water vapor with the subsurface, including D/H ratios of the atmosphere and surface samples, near-surface air temperature and surface temperature, and atmospheric water-vapor abundance throughout the mission,
- (3) To determine the bulk atmospheric composition, including isotopic ratios of 3 major elemental components C,O, and Ar, and
- (4) To measure the acceleration during EDL to constrain models of the atmospheric density profile.

Geomorphology and Physical Theme

The next several goals are those of the geomorphology and physical properties theme group and will be related to the RA instrument goals of digging a trench to an impenetrable layer or 50cm below the surface and gathering samples from the surface to the trench bottom and delivering them to the instruments on deck. These objectives include:

- (5) Image regional and local landforms and surface deposits and place observations in the context of orbital data,

- (6) Identify any subsurface layering and distribution of subsurface water ice,
- (7) Determine subsurface mechanical properties as a function of depth and correlate with visual, textural, chemical, and mineralogical data,
- (8) Use image data to determine the morphology, topography, reflectance, and photometric behavior of excavated minerals, and
- (9) Characterize surface and subsurface physical properties.

Chemical and Mineralogy Theme

Additional objectives for the lander will be investigated in the chemistry and mineralogy themed group and include:

- (10) Measure the concentration and gradient of elements and minerals in the surface and subsurface, particularly organics, salts, hydrated minerals, sulfates, carbonates, oxidants, and other volatile-rich substances, and correlate these with ice, and
- (11) Verify the presence and identify the form of H₂O on the surface and within the subsurface and provide this data for validation of models.

Biological Potential Theme

The final theme group is the biological potential theme group, dedicated to incorporating the data from the other science teams to

- (12) Measure the biological potential of the surface and subsurface environments by determining if liquid water has been present, measuring compounds formed from the biogenic elements C, H, N, O, P, S, by measuring the concentrations of biologically relevant ions including K, Ca, Mg, Na, and by assessing the redox potential. These objectives will provide the basis for addressing the first four goals of the Phoenix mission, based on the objectives determined by the Mars Exploration Program.

References

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SMITHTAL2008

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