This artist's concept depicts NASA's Phoenix Mars Lander a moment before its 2008 touchdown on the arctic plains of Mars.
Image: NASA/JPL-Calech/University of Arizona

The Delta II rocket with the Phoenix spacecraft onboard lifts off.
Image: NASA/Sandra Joseph and John Kechele

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Phoenix 2007 Lander on Mars

Onboard pressure sensor based on Vaisala BAROCAP® technology

On May 25th, 2008, NASA's Phoenix 2007 Lander successfully touched down on Mars' northern polar region. The landing site is at 68 degrees north latitude, 233 degrees east longitude, in an area called Scandia and Vastitatis Borealis Marginal. The landing site is above the Martian polar circle. The local season in Mars is currently late spring-early summer. Therefore the Lander is carrying out its 90- to 150-day mission at a time of year with nightless nights. After the summer season, the approaching winter, and decreasing daylight and available energy will mean that operations will have to cease, and contact with the Lander will be lost.

The Phoenix Lander carries a versatile suite of scientific instruments to analyze soil, observe local meteorology and take macro and microscopic images of Mars.

The onboard meteorological instrument includes a pressure sensor, based on Vaisala BAROCAP® technology, for atmospheric barometric pressure measurement. This instrument was developed by the Finnish Meteorological Institute.

Phoenix science

The Phoenix mission has three scientific goals:

1. *To study each phase of the history of water at the landing site*

Geological evidence suggests that liquid water once flowed on Mars and created rivers, lakes and seas. It is assumed that northern lowlands were once covered by sea and the subsurface ice there may be a remnant of that sea. This conclusion is supported by observations made by the Mars Odyssea orbiter's gamma spectrometer instrument and other satellite data. The water ice content of near-surface material in the northern polar regions may even be over 50%.

This subsurface ice may well be released over a period of millions of years as Mars experiences climate changes due to its wobbling rotation axis. On a shorter time scale, subsurface ice may well "breathe" every day, every season, converting tiny amounts of frost to water vapor and back. In this way, the ice table may slowly rise and recede as the climate changes.

The Phoenix Lander carries a versatile suite of scientific instruments to analyze soil, observe local meteorology and take macro and microscopic images of Mars.

2. *To determine whether the arctic soil on Mars could support life*

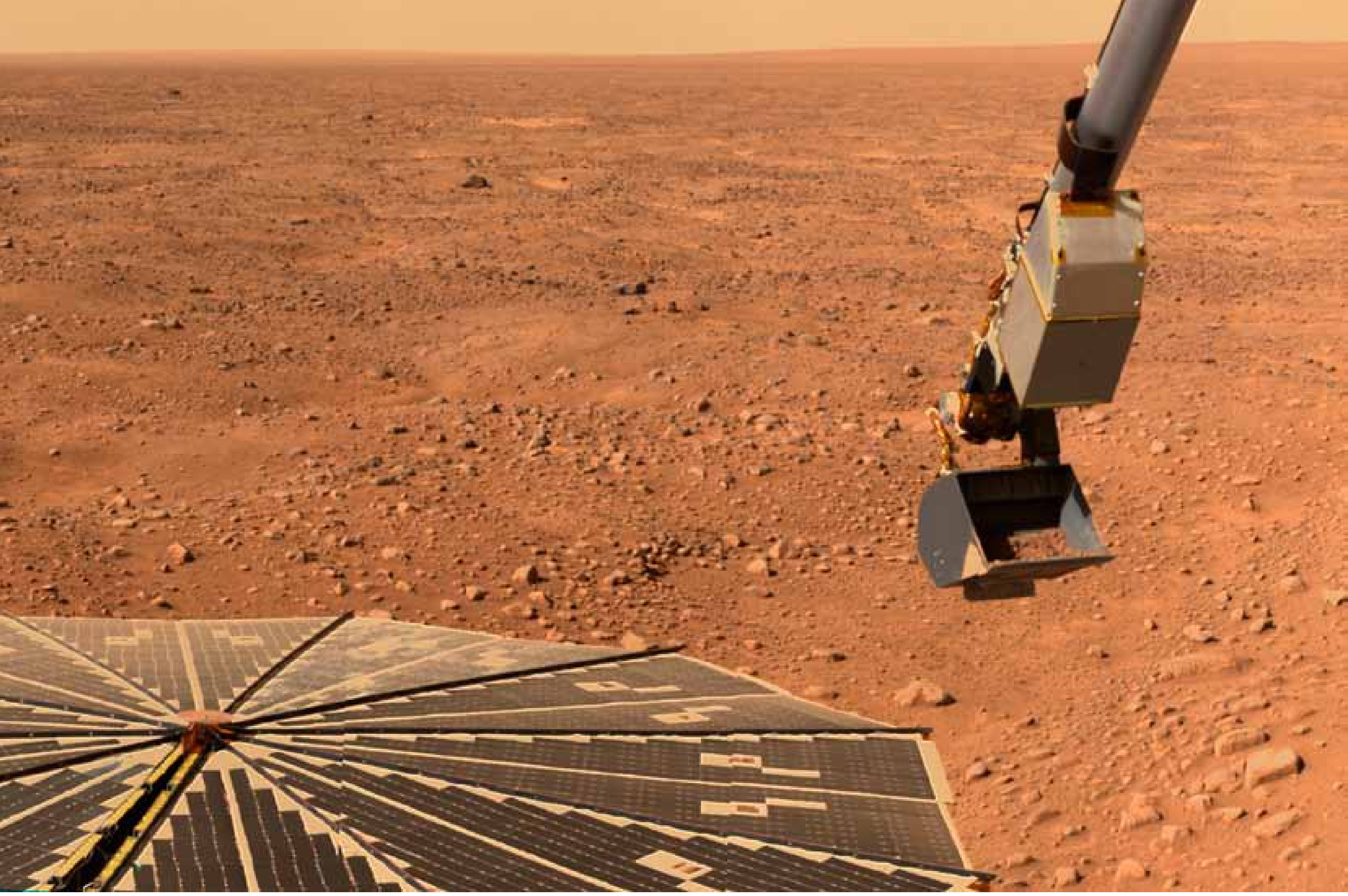
Life as we know it requires liquid water, but it does not necessarily require the continuous presence of this water. Phoenix is investigating the possibility that some of the ice in the soil of the landing site will melt and become biologically available during the warmer parts of long climate cycles. Phoenix is also investigating the possibility that certain organic compounds necessary to life as we understand it are present. However, Phoenix will not be carrying out direct microbiological experiments for detecting life.

3. *To study the weather on Mars from the polar perspective*

The amount of water vapor in Mars' polar regions varies significantly from season to season. Winds carrying water vapor can move water from place to place on the planet. Phoenix is monitoring temperature, pressure, winds, atmospheric dust, ice particles and clouds. These observations will help to increase the understanding of atmospheric dynamics and interaction between polar- and mid-latitudes. The circulation of volatiles (H_2O, CO_2) in the Martian atmosphere is an important part of the puzzle that is water and life on ancient Mars.

Phoenix Lander and experiments

The Lander's diameter is 1.5 m and its height is 2.2 m, when standing on its three landing legs. Its mass is 540 kg, including a 59-kg scientific payload. The Lander is powered by two solar arrays, measuring a total of 4.2 square meters and with a span of 5.2 m when deployed around the Lander. The power peaks are balanced by a lithium-ion battery, and telecommunication is provided by two UHF band antennas. The Phoenix Lander does not communicate directly with Earth as messages are relayed through the three satellites currently orbiting Mars: Mars



Phoenix Mars Lander's solar panel and robotic arm with a sample in the scoop. Photo: NASA/JPL-Caltech/university of Arizona.

Odyssey, Mars Reconnaissance Orbiter and Mars Express. Data rates vary between 8 kb/s to 128 kb/s.

Pressure sensor instrument

The Finnish Meteorological Institute developed the pressure sensor instrument for the Phoenix Lander. The pressure sensor is based on Vaisala technology and components. It has three BAROCAP® pressure sensors, and a THERMOCAP® temperature sensor for internal temperature monitoring. The instrument is built around the Vaisala proprietary ASIC (Application Specific Integrated Circuit).

The pressure sensor is part of the onboard Meteorological Station, which is operated by a computer. When energy and data link capacities allow, pressure readings are taken every two seconds, together with mast temperature sensors. This data is then downlinked to Earth. When the Lander's resources are being used by the other instruments, pressure and temperature data readings are taken at 8-minute intervals. However, if an interesting weather phenomenon is encountered (a dust devil, weather front, etc.), the two-second intervals are restored.

The Phoenix Lander's pressure sensor is already the fifth Vaisala BAROCAP® pressure sensor to be used on planetary space missions. Three earlier attempts to get the pressure sensor on Mars failed because of unsuccessful spacecraft launches or landings (Mars-96, Mars Polar Lander -99, Beagle-2 -03). The Huygens Lander made a successful landing onto Saturn's moon, Titan, in 2005, and the onboard BAROCAP® recorded the pressure profile of Titan's atmosphere during the three hour landing.

The Finnish Meteorological Institute joined the Phoenix program in 2004. Development of the Phoenix pressure sensor was based on experiences from earlier projects and on the specific requirements of the Phoenix mission. Several prototypes were built and tested at the Finnish Meteorological Institute before the final Flight Models were built. Two "Flight Models" were built and tested. One was installed in the Phoenix Lander and the other was a "Flight Spare" model, in case any problems were encountered with the actual Flight Model prior to launch.

Surface Operations Center based in Tucson, Arizona

Jouni Polkko and Henrik Kahanpää from the Finnish Meteorological Institute participated in the Phoenix landing event and the first-week operations in Tucson, Arizona. The Lander was controlled by the Jet Propulsion Laboratory (JPL) in Pasadena, California, during the interplanetary cruise phase and entry into Mars' atmosphere. After the landing, operations were taken over by the Arizona University, which maintains the Phoenix Surface Operations Center in Tucson, Arizona. This is the first time that a NASA spacecraft has been operated outside of NASA.

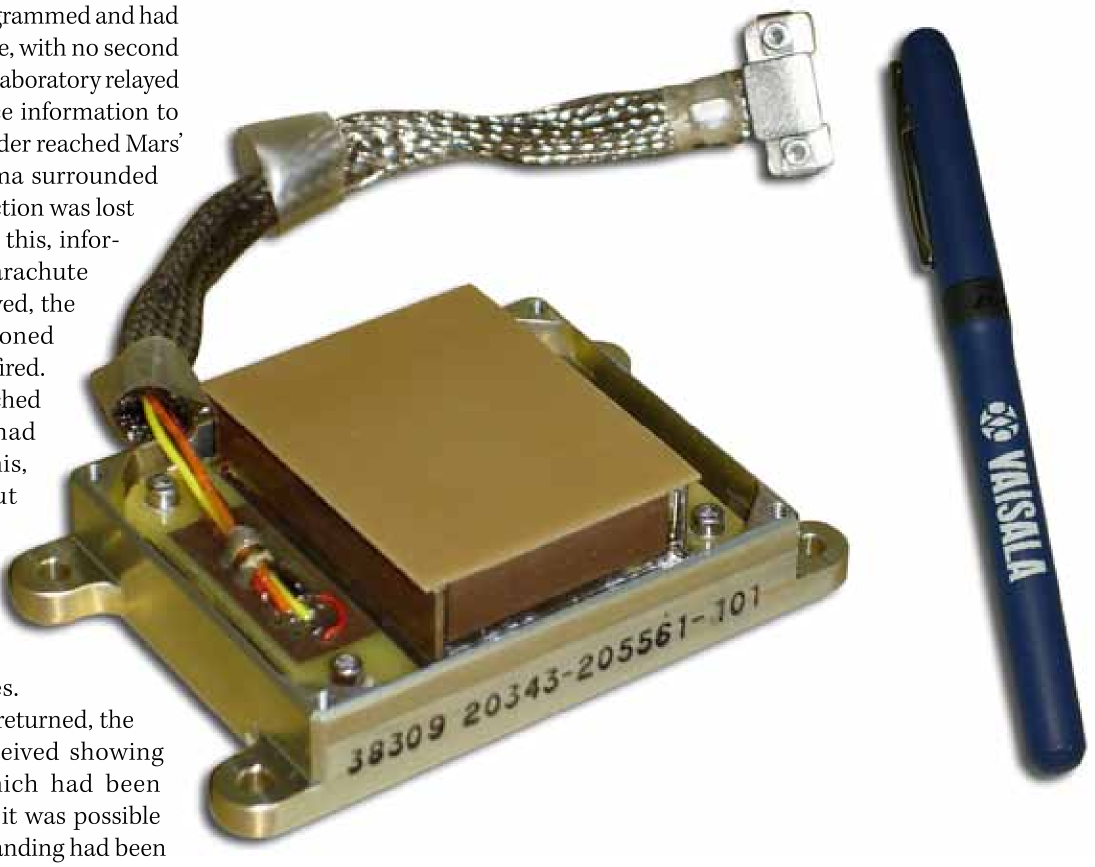
The landing took place on Sunday afternoon on May 25th (Tucson local time). The time delay between Mars and Earth was 15 minutes 20 seconds on the landing day, and everything occurs this much earlier in Mars. Therefore, everything had to function correctly during the last phases of approach and landing.

Everything was preprogrammed and had to succeed the first time, with no second try. The Jet Propulsion Laboratory relayed landing event sequence information to Tucson. When the Lander reached Mars' atmosphere, hot plasma surrounded the Lander and connection was lost for five minutes. After this, information confirming parachute deployment was received, the heat shield was jettisoned and the retro rockets fired. Finally the Lander touched down. The landing had been perfect. After this, connection was shut down for two hours as the Lander deployed the solar panels and other deployables and recharged its batteries. When the connection returned, the first images were received showing the solar panels, which had been opened. At this point it was possible to announce that the landing had been a success and exploration of Mars' polar region could begin.

After the landing the operations crew have started to live by Martian time, as this is how the Lander operates in Mars. Each day on Mars, called "sol", lasts 40 minutes longer than each day on Earth, so Mars' time shifts forward by 40 minutes every day. The first scientific data, including meteorological data, arrived on Monday afternoon on May 26th. According to this data, the pressure instrument was working perfectly. Pressure at the landing site on Mars was about 8.55 hPa, and during the following days, the first dust devils had already been observed by the pressure instrument.

At the time of writing, the Phoenix operations are continuing as planned and the mission is closing its mid-point. The first proof of subsurface permanent frost has been found. Evidence of an ancient sea has also been discovered. The first analyses of the findings will continue over the next few months.

Operations will continue as long as the dimming sunlight provides enough power. Connection will be lost around November or December. Phoenix has not been designed to withstand the Martian polar winter. However, for curiosity's sake, some attempts will be made to wake the Lander up during the next Martian summer. ■



Phoenix Lander's pressure sensor instrument.

Instruments onboard the Phoenix Lander

The Phoenix payload includes several instruments, three of which are suites of multiple tools.

- Robotic Arm for digging and handling samples. The arm is 2.35 meters long, and includes a camera for close-up images.
- Surface Stereo Imager for taking accurate stereo pictures of the landing sites. The camera may also be tilted upwards in order to assess conditions in the atmosphere (dust, water vapor, clouds). The camera has two 1 M pixel CCD sensors.
- Thermal and Evolved Gas Analyzer with a mass spectrometer for analyzing soil samples and an oven for heating up the samples.
- Microscopy, Electrochemistry and Conductivity Analyzer with an optical microscope, atomic force microscope and electrochemical sensors for inspecting samples. The instrument adds water (from Earth) to the samples in order to study soluble chemicals.
- Meteorological Station with a pressure sensor, three temperature sensors on a 1.2-meter mast, wind sock and LIDAR to carry out experiments to detect dust and ice particles above the Lander.

Further information:
phoenix.lpl.arizona.edu
www.vaisala.com/barometricpressure