NETLANDER ATMIS WIND AND TEMPERATURE INSTRUMENTS

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Introduction: The NetLander Mission will deploy four small (~70 kg) landers on Mars, establishing a network of science stations whose primary focus is the characterization of the interior structure of Mars and its near-surface weather and climate. The NetLander mission is being implemented by a consortium of international agencies, which is managed by the Centre National d'Etudes Spatiales (CNES) of France.

The NetLander ATMospheric Instrument System (ATMIS). The ATMIS experiment will make coordinated atmospheric measurements from each of the 4 NetLander landing sites. At each site, ATMIS will record the atmospheric density structure as the probes descend through the Martian atmosphere, and then make time-resolved measurements of the atmospheric pressure, soil and atmospheric temperature, wind velocity, humidity, and dust optical depth for at least one Martian year.

ATMIS measurements from the 4 landing sites will be analyzed with Martian General Circulation Models (MGCMs) to describe the large-scale meteorological phenomena in the lower atmosphere, and assess their implications for the weather and climate. These phenomena include the low latitude Hadley cell, planetary scale waves, fronts, mesoscale storm systems, and regional to global dust storms.

ATMIS measurements will be taken throughout the Martian Solar day (Sol) and over a complete seasonal cycle to describe the physical processes responsible for the exchange of heat, mass, and momentum across the Martian planetary boundary layer. Measurements acquired from the 4 NetLander sites will help to discriminate the effects of surface albedo, thermal inertia, slopes, and roughness on the near-surface flow. They will also yield new insight into the processes that lift and transport dust and provide new constraints on the present-day aeolean weather rates.

ATMIS is an international experiment led by the Finnish Meteorological Institute (FMI). JPL will provide the ATMIS atmospheric temperature and wind sensors (ATMIS-WT), based on designs developed
ATMIS/ARES mast, which will be deployed

and flight qualified for Mars Polar Lander (MPL) MVACS. ATMIS-WT development is supported by the NASA Discovery Mars NetLander Mission of Opportunity.

The ATMIS-WT System: The ATMIS-WT sensor deployment approach is shown in Figure 1. The wind sensors and three of the temperature sensors will be installed on the ATMIS/ARES mast, which will be supplied by Oxford University. An additional temperature sensor assembly will be deployed near the surface by the Magnetometer (MAG) boom to measure temperatures within 10 cm of the surface. Their electronics will be installed on the ATMIS-WT daughter board, which is mounted on the main ATMIS board in the Spacecraft Electronics Compartment (SEC).

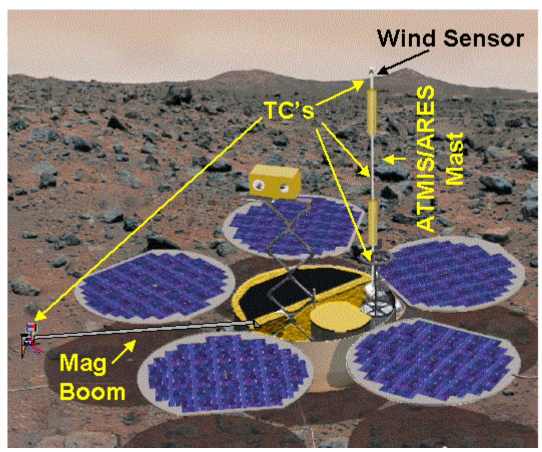

Figure 1: Mars NetLander, showing locations of the ATMIS-WT wind sensor and thermocouple (TC) sensors on the ATMIS/ARES Mast and the Mag Boom.

Atmospheric Temperature Sensors: JPL will provide four atmospheric temperature sensors for each of the NetLanders. These sensors will be deployed between the surface and ~1.3 m to measure the ambient atmospheric temperature and its vertical gradient near the Martian surface. Three of these sensors are mounted near the bottom, middle, and top of the above the NetLander deck (Figure 1). The fourth is mounted on the Soil Probe, which will be deployed to the surface by the MAG boom. Each temperature sensor consists of a thin-wire thermocouple (TC) assembly, similar to those used on the Viking and Mars Polar Lander. These sensors are designed to yield absolute accuracies of ±2 K at temperatures between 170 and 300K, with precisions of 0.1 K, and time constants of ~1-2 seconds in Mars conditions. The reference junctions for the TC's are located on an isothermal block assembly (IBA) whose temperature is monitored by a precision platinum resistance thermometer (PRT). The IBA for the sensors on the ATMIS/ARES Mast is incorporated into the base of the wind sensor. The IBA for the near-surface TC is located on the Soil Probe. The signals from the TC's are transmitted from their IBA's to the ATMIS-WT electronics board in the SEC on flex-print cables (Figure 2).

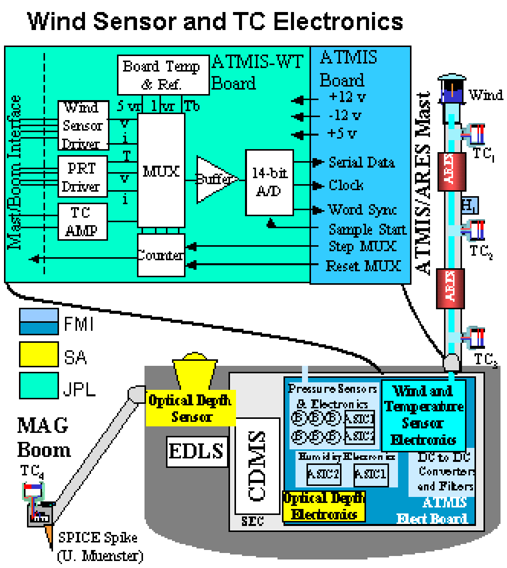

Figure 2: Schematic block diagram showing the ATMIS –WT sensors and electronics, and there interfaces with other components of the ATMIS experiment.

Temperature Data Rates: To resolve rapid temperature variations, TC's must be sampled at 0.2 to 1 Hz. A single temperature sample includes

- 4 atmospheric TC's (3 on the ATMIS/ARES Mast, one on the Mag Boom)
- The voltage and current of the 2 IBA PRTs
- 2 reference (zero point) TC's mounted on IBA PRTs.

Each measurement is digitized to 14 bits and recorded as a 16-bit word, yielding 160 bits/sample. If samples are collected for 5-minute periods every half Martian hour throughout the sol, the total raw data volume is 2.3 Mbits/sol. These data will be calibrated on board and averaged over each 5-minute interval or transmitted directly to Earth.

The NetLander Wind Sensor: The horizontal wind velocity at the top of the ATMIS/ARES boom will be monitored by a directional, constant-over-temperature, hot-wire anemometer, similar to the one developed for the Mars Polar Lander MVACS payload. The wind sensor control circuit maintains the hot wire at ~100 °C above ambient atmospheric temperature, and the wind speed is determined by measuring the power needed to maintain the hot wire at this temperature. As the wind speed (or ambient atmospheric density) increases, the convective cooling of the hot wire increases, and more power is needed to maintain its temperature. The ATMIS-WT wind sensor is designed to measure horizontal wind speeds between 0.1 and 80 m/sec. The wind speed accuracy is ~1m/sec for winds below 10 m/sec and ~10% above that.

The wind direction is determined by detecting the heated plume that is blown downwind from the hot wires. This plume is detected by one or more of the 18

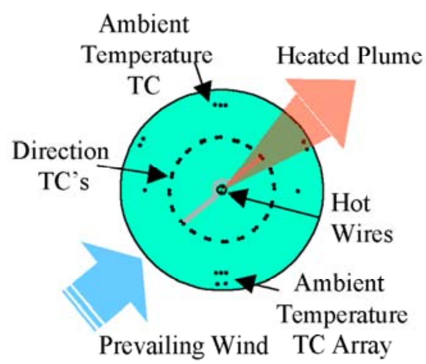

Fig. 3: Top view of wind sensor showing placement of central hot wires, surrounding direction TC's and the ambient temperature TC's. As the wind blows across the hot wires, the heated plume is detected by the direction TC that is downwind. One of the 2 ambient temperature TC arrays is always upwind.

TC arrays that surround the hot wires (Figure 3). The wind direction TC's are spaced at 20° angular increments, yielding a wind direction resolution of ±10°. These TC's are identical to those used to measure atmospheric temperatures, but they are connected differently, such that they measure the temperature difference from one side of the hot wire to the other, instead of the ambient atmospheric temperature.

The pressure and temperature of the air flowing through the wind sensor must be measured to estimate wind speeds from the measured power dissipation. The atmospheric pressures are inferred from the ATMIS pressure instrument, which is installed in the SEC. Because there are large temperature gradients near the Martian surface, the temperature of the air incident on the hot wire is measured by a pair of atmospheric TC's that are integrated into the wind sensor structure. Ambient temperature measurements are made on either side of hot wire to ensure that at least one of the two TC's is outside of the heated plume. The wind sensor TC's have reference junctions on the IBA at the base of the wind sensor. Signals from the wind sensor hot wires and TC's will be transmitted from the IBA to the electronics box on shielded cables.

Wind Sensor Data Rates: Like temperatures, wind velocities must be sampled at 0.2 to 1 Hz to resolve convection, dust devils, and other rapidly varying phenomena. Each wind sample includes

- hot wire voltage and current,
- 2 ambient temperature TC's
- 9 outputs from the 18 direction TC arrays.

If each of these 13 values is digitized (14-bits) and stored as a 16-bit word, each sample requires 208 bits. If the wind direction is determined on board, each sample includes only 5 words, and the sample size falls to 80 bits. For this case, if ATMIS-WT collects data for 5-minute periods at 1 Hz every half Martian hour throughout the sol, the total data volume for winds would be 1.15 Mbits/sol.

Sensor Control and Readout Electronics: The control and readout electronics for the ATMIS instruments are located primarily in the NetLander SEC. The control and readout electronics for the JPL-supplied temperature and wind sensors will occupy a single daughter board that is mounted on the main ATMIS board. The ATMIS-WT daughter board will also control and read out the platinum resistance thermometers (PRT's) integrated into the FMI-supplied humidity sensors, the housekeeping temperature sensors on the ATMIS board, and the output from the ATMIS Optical Depth sensor.

Analog signals from the sensors are multiplexed and then digitized by a 14-bit Analog to Digital converter. The ATMIS-WT sensors are controlled the main ATMIS board, and their data are read out by the NetLander command and data management system (CDMS). This system is designed to sample all ATMIS-WT sensors at rates as high as 1 Hz.

The ATMIS-WT daughter board has dimensions of 110 x 61 x 15 mm and a total mass allocation of 120 grams. Its power consumption will vary from ~220 to 477 mW, depending on wind speed (the largest values assume a worst-case continuous wind speed of ~80 m/s). The mean power allocation is 365 mW.

ATMIS-WT Operations: Regular sampling throughout each sol and throughout the seasonal cycle is needed to achieve the objectives of the ATMIS experiment. On a typical Martian sol, the ATMIS wind and temperature sensors will be sampled at rates of 0.2 to 1 Hz for 5-minute periods every 30 minutes throughout the sol. These data will be used to characterize the weather and climate throughout the diurnal and seasonal cycles. This sequence can be augmented with continuous sampling periods designed for studying boundary layer processes. For example, an hour-long, 1-Hz sampling sequence could be scheduled from 1-2 PM local Mars time each day to monitor the heat and momentum transport during the warmest time of the day. A second hour-long sequence could be scheduled to precess through the Martian day, to characterize boundary layer processes at other times.

The sampling sequence for ATMIS-WT can be modified by commands sent from the NetLander Operations Center at CNES in Toulouse. The details of the commanding and downlink cycles are still under development, but the current plans are based on a series of multi-day "Work Plans" that are developed, uploaded, and executed autonomously by each lander. This asynchronous approach is necessary because there is no direct link between each lander and the Earth, such that uploads and downloads must be made through a relay orbiter. This operations approach will work well for ATMIS because this is a monitoring experiment that requires repetitive measurements that can be programmed in advance.

Conclusions: The NetLanders will provide the first opportunity to acquire *in situ* meteorological measurements from a network of 4 stations on the Martian surface. The ATMIS wind and temperature sensors described here are only two elements of the most comprehensive environmental instrument suite yet deployed on Mars. Measurements collected by this suite of sensors can be combined with the aid of sophisticated models to dramatically improve our understanding of the near-surface weather and climate of Mars. This information should also facilitate future exploration, since the Martian planetary boundary layer will be the working environment for landers, rovers, and future manned expeditions to this planet.