PHOENIX MET. Diane V. Michelangeli[1], Allan Carswell[1,2], Clive Cook[1], Mike Daly[9], Cameron Dickinson[3], Tom Duck[3], David Fisher[4], Haraldur Gunnlaugsson[8], Ari-Matti Harri[7], Andrew Kerr[9] ,Carlos Lange[5], Nilton Renno[6], Peter A. Taylor[1] and James Whiteway[1], [1]Centre for Research in Earth and Space Science, York University, Toronto, Ontario, M3J 1P3, Canada. [2]Optech Inc., [3]Dalhousie University, [4]Geological Survey of Canada, [5]University of Alberta, [6]University of Michigan, [7]Finnish Meteorological Institute, [8]Århus University, [9]MDA Space Missions.

Introduction: The MET package on the Phoenix lander, a NASA scout mission led by Peter Smith from University of Arizona, will make continuous meteorological measurements of surface pressure and of temperature at 3 levels on a mast. There willalso be some wind measurements. A novel feature of Phoenix MET will be the use of a vertically pointing lidar provided by the Canadian Space Agency (CSA) to observe profiles of dust and water ice particles, typically in clouds at heights of order 5-10 km. In situ, surface humidity information, including Deuterium to Hydrogen (D/H) ratios, will come from the TEGA instrument while it is hoped that TECP will provide some atmospheric information as well as regolith data.

Some instrument details: Integration of the MET package is being undertaken by MDA Space Systems , Optech Inc., and the Canadian Space Agency. The pressure sensor is being provided by the Finnish Meteorological Institute (FMI) while a Danish team are providing a telltale to be used in conjunction with the SSI camera to determine wind speed and direction.

The temperature system. Three fine wire, butt welded thermocouples have been laser-welded across small C-frames. As shown in Figure 1, there will be

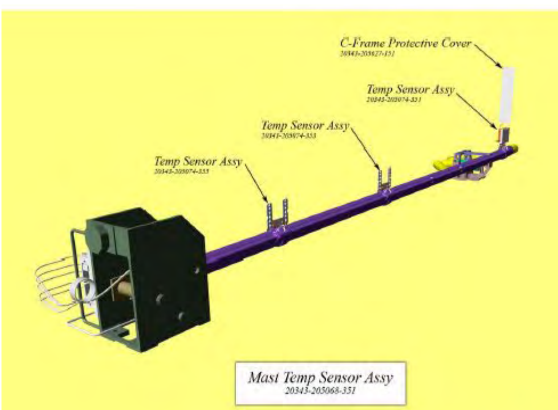

Figure 1 The mast and thermocouples: MDA drawing.

C-frames at three levels on the MET mast. The triple wires are to provide redundancy just in case a wire were to be broken, for instance due to impaction by a large dust particle. One thermocouple junction is exposed to the air as it blows past the MET mast while the "cold" junction is in an isthermal block at the base of the mast together with a platinum resistance thermometer. Accuracy requirements on the temperature measurements are +/- 1K for temperature and +/- 0.3 K for temperature differences between levels.

The pressure sensor. The FMI pressure sensor has 3 silicon diaphragm pressure sensor heads. One of these is the primary sensor head and the other two will be used for monitoring the condition of the primary sensor head during the mission. During the mission the primary sensor will be read with the sampling interval 2 s and the other two will be read only in Health Checks. The system will measure the Martian surface barometric pressure with a minimum accuracy of ±20 Pa, and a design goal of ±10 Pa. The time constant is estimated as approximately 3s with a resolution of 0.2 Pa. The significant advantage of the FMI sensor over those flown on Viking and Pathfinder is the much reduced mass.

The telltale. In the initial plans we had hoped to include a hot wire, hot film or sonic anemometer system, but budget and mass constraints precluded this. Realising however that some wind information was, to say the least, highly desirable we decided to use the SSI camera to record deflections of a small telltale.

Figure 2. Artists impression of the telltale.

After consideration of MPF type cones with a relatively high threshold wind speed we accepted an offer from the Danish group to provide a small lightweight telltale which will hang from a gallows on the top of the MET mast. The initial design worked well but did not survive the stringent vibration test requirements. At the time of writing a strengthened gallows and redesigned telltale are being developed and we are confident that these will survive.

Calibration and characterisation: Intensive calibration and charcterisation activities have taken place for all instruments. The thermocouples and platinum resistance thermometer (for the isothermal block) have been individually calibrated over the temperatue range -150C to + 25C and calibration curves will provide T to within 0.1K over this range. These calibrations were in thermal baths with the cold junction at 0C. Further end-to-end tests have confirmed the performance in situations with the cold junction at other temperatures. Thermocouple units have also been tested in a Mars environment using a dual wind tunnel that can be cooled. This was designed and built at York University to fit inside a vacuum chamber backfilled with CO_2 to Mars pressures. This facilty allowed us to determine the time constant of the thermocouples and their response to solar radiation. Both are functions of wind speed. Typical values at the temperatures and pressures anticipated for the Phoenix MET station are 0.5 s and 0.5 K.

The pressure sensors have been calibrated by FMI and end to end tests performed by MDA and CSA engineers at the David Florida Laboratory in Ottawa.

The lidar system: The bright green beam in the artists imprssion of the Phoenix lander (Figure 3) may exaggerate the intensity of the laser beam used to study boundary-layer dust and low-level water ice clouds above the lander site but the lidar does represent a key component of the MET package and is the main reason why CSA is a partner in the mission.

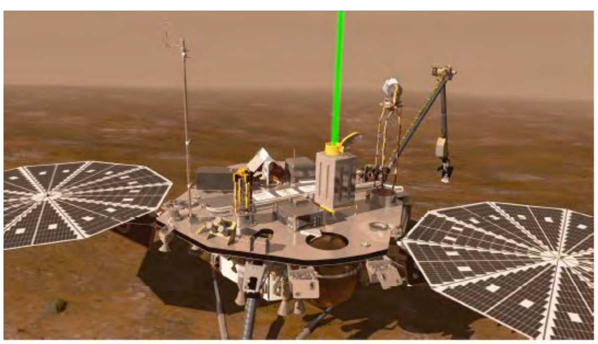

Figure 3. Artists impression of the Phoenix lander clearly showing the lidar and MET mast.

Based on many years of experience with the use of lidar systems on Earth, Optech Inc. proposed the use of a lidar on the Phoenix lander. The initial proposal called for scan and tilt capability to facilitate the study of dust devils as well as vertical profiles but mass budget constraints have precluded this. A trade-off was to provide dual wavelength capability for the lidar (1064 nm , infra-red and 532 nm, green). This feature will allow us to discriminate between dust and ice particles on the basis of the colour ratio of the backscattered light. In order to obtain experience with a lidar equivalent to the "Flight Lidar" to be sent to Mars, the York University lidar team have constructed a "Field Lidar" which is equivalent in function, as indicated in Figure 4. The Field Lidar is being used in a series of field projects to establish the characteristics of backscattered light from upper atmosphere cirrus clouds and desert dust. Initial results indicate that discrimination between the two should be possible with this system.

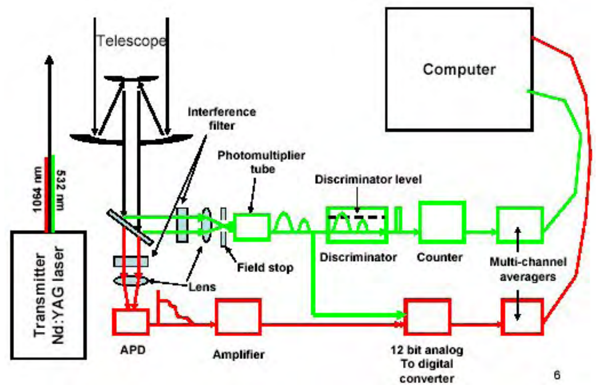

Figure 4. Schematic diagram for the Phoenix lidar system. This applies to the Flight Model as well as the Field Lidar.

The lidar unit transmits pulses of collimated laser light upwards into the atmosphere and observes the time sequence of backscattered light received through the telescope. The delay between pulse emission and detection tells us the range to the object backscattering the light while the intensity can be interpreted in terms of backscatter cross section. The transmitted beam and the slightly offset telescope field of view do not immediately intersect and the minumum rage has been designed as 50 m. Maximum range is expected to be of order 10 km, depending on the sensitivity of the detectors and the amount of background light entering the detector system. Detailed modelling and laboratory determination of the "overlap" between the emitted beam and the field of view of the telescope are an important component in allowing quantitative interprestation of the returned signals. A critical step will be a "side-by-side" test in the Earth atmosphere of the flight and field lidars plus comparisons with data from a more powerful RMR lidar operated by Dalhousie university. This is planned for late 2006.

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