Aeolus: A mission to study the winds and climate of Mars. A. M. Cook[1,2], A. Colaprete[1], D. Mauro[1,3], A. Dono-Perez[1,3], D. Mayer[1], A. N. Nguyen[1], D. G. Larrabee[1,2], A. Kashani[1,2], M. Ebert[1], K. D. Bonner[1], T.V. Snyder[1], D. D. Nguyen[1], Y. Shen[1], S. Montes[1,2], E. Uribe[1,2], K. Ronzano[1,2]. [1]NASA Ames Research Center, Moffett Field, CA 94035, [2]Millennium Engineering, Mountain View, CA, [3]Stinger-Ghaffarian Technologies, Moffett Field, CA

Introduction:

Aeolus is a mission to directly measure the winds and climate of Mars, by measuring surface and atmospheric temperatures, aerosol abundances, and Doppler shifts in atmospheric spectral lines. The Planetary Science Division's (PSD) Science Plan includes goals to "explore and observe the objects in the Solar System to understand how they formed and evolved" and to "advance the understanding of how the chemical and physical processes in our solar system operate, interact, and evolve." Aeolus studies of the Martian atmosphere are derived from these NASA goals. Aeolus objectives are to:

1. Characterize Mars global circulation processes, including seasonal and diurnal changes.
2. Determine the relative contributions to the global energy balance at Mars by measuring rejected solar radiation, and thermal emission from the Martian surface and atmosphere.
3. Measure Martian atmospheric aerosol (H_2O ice, dust) distribution.

To date, direct measurements of Martian wind speeds have only been possible at the surface, often only during daylight hours, and over small areas limited by rover traverse capabilities. From orbit, thermal measurements as well as images of dust storms and dune migration have provided inputs to derive the current state-of-the-art data sets in Mars climate modeling. However, Mars Global Circulation Models (GCM), like the one supported by the NASA Mars Climate Center at Ames Research Center, demonstrate that wind speeds derived from these indirect measurements may be more than 100% in error. For this reason, direct wind velocity measurements have been deemed "High Priority" by the Mars Exploration Program Analysis Group (MEPAG); measuring wind speeds and corresponding thermal data are vital to understanding Mars' climate. Notably, collecting data on Martian weather is paramount for planning landed and crewed missions at the surface. The measurements proposed for Aeolus will form the first set of global, seasonal, and diurnal data to characterize winds, which have a large influence on launch and landing constraints.

The mission concept for Aeolus consists of a single spacecraft in a near-polar orbit, allowing it to pass over all local times, with near-global coverage of the surface. Aeolus mission duration is 2 Earth years, equivalent to 1 Mars year, in order to capture climate patterns during each Martian season.

Spatial Heterodyne Spectrometers:

The Aeolus concept first came about as a response to a new type of miniaturized Spatial Heterodyne Spectrometer (SHS), which could make wind measurements at Mars more affordable due to reduced instrument mass and thermal stability. The Aeolus spacecraft includes a system of four of these miniaturized SHS modules paired to two orthogonal viewing telescopes. An example of the monolithic optical component is shown in Figure 1. This high-resolution near-infrared system can measure CO_2 (daytime absorption) and O_2 (day and night emission) lines in the Martian atmosphere. Doppler shifts in these lines, associated with winds speeds as low as 5 m/s, can be measured during Martian day and night. Identical modules are optically connected to one telescope each, so that each spectral line is observed with two orthogonal views as the spacecraft proceeds through its

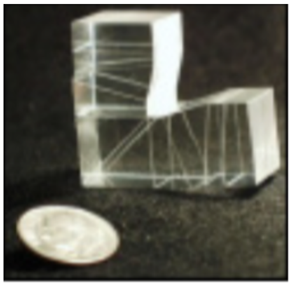

Figure 1. Each spatial heterodyne spectrometer module is up to 5x5 cm^2. The shape of each module is determined by the required wavelength of observation, which shifts the angle of diffraction gratings in the glass.

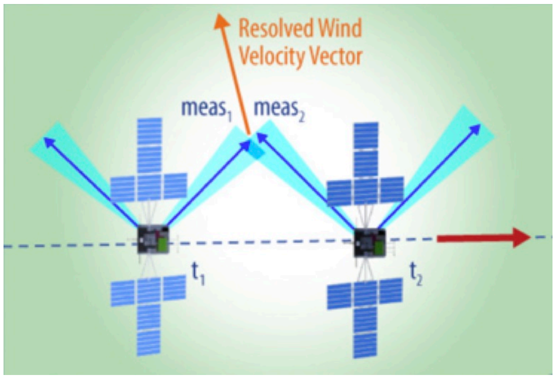

Figure 2. Fields of view for two telescopes optically connected to identical SHS modules. As the spacecraft proceeds along its orbit (to the right), each telescope views the same parcel of atmosphere from perpendicular angles to produce a wind vector.

orbit as shown in Figure 2. This allows line-of-sight wind speeds to be converted to wind vectors during ground processing.

Thermal Limb Sounder and Radiometers:

Aeolus also has the Thermal Limb Sounder (TLS) instrument to measure atmospheric temperature profiles and aerosol (H_2O ice clouds, dust) profiles. Finally, the Surface Radiometric Sensor Package (SuRSeP) will measure the total reflected solar radiance, and surface temperatures down to 140K and total water ice cloud and dust column densities. Figure 3 shows a schematic of how each instrument views the atmosphere (Martian limb) or surface. Together, these combined spectral and thermal measurements will provide a new understanding of the global energy balance, dust transport processes, and climate cycles in the Martian atmosphere. Combining direct wind observations and simultaneous observations of the atmospheric drivers that force these winds, Aeolus provides a unique data set to understand Martian circulation and validate Mars climate models. These data will also constrain the design space for future missions that fly or float in the atmosphere, descend through the atmosphere, or land and operate on its surface.

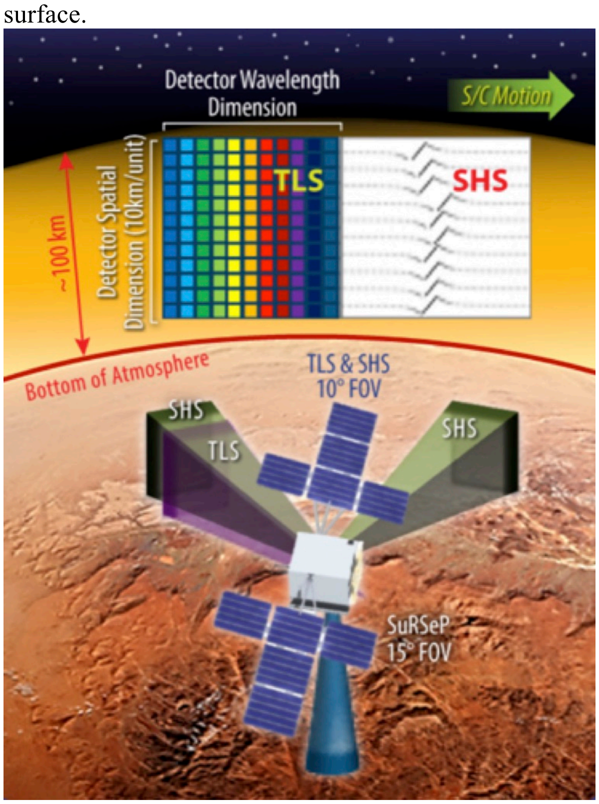

Figure 3. The combined fields of view for all three of the instruments in the Aeolus science payload.