NASA's PLANETARY AEOLIAN LABORATORY: EXPLORING AEOLIAN PROCESSES ON EARTH, MARS, AND TITAN. D. A. Williams[1], [1]Ronald Greeley Center for Planetary Studies, School of Earth & Space Exploration, Arizona State University, Box 871404, Tempe, Arizona 85287 (David.Williams@asu.edu).

Introduction: The Planetary Aeolian Laboratory (PAL), supported by NASA's Planetary Geology and Geophysics (PG&G) program, is a unique facility used for conducting experiments and simulations of aeolian processes (windblown particles) under different planetary atmospheric environments, including Earth, Mars, and Saturn's moon Titan. With the death of PAL founder Ronald Greeley in 2011, there is concern in the planetary aeolian community whether the PAL will be maintained for continued use by planetary scientists. This presentation will review the PAL facilities, what are their current capabilities, how can interested scientists propose to NASA to use them, and what are the long-term plans for their continued use.

What is PAL?: The PAL includes one of the nation's largest pressure chambers for conducting low-pressure research. The primary purpose of the PAL is to enable scientific research into aeolian processes under controlled laboratory conditions, and enable testing and calibration of spacecraft instruments and components for NASA's solar system missions, including those requiring a large volume simulated Martian atmosphere. The PAL consists of: 1) the Mars Wind Tunnel (MARSWIT) and 2) Titan Wind Tunnel (TWT) located in the Structural Dynamics Building (N-242) at the NASA Ames Research Center (ARC) in Mountain View, California and administered by Arizona State University (ASU). Also available (although not officially part of the PAL facilities) are: 3) an ambient pressure/temperature wind tunnel (ASUWIT) and 4) a vortex (dust devil) generator (ASUVG) on the Tempe campus of ASU, which is part of the ASU School of Earth and Space Exploration (SESE) and the Ronald Greeley Center for Planetary Studies. The TWT just came online in June 2012.

Capabilities of PAL Facilities:

ASU Wind Tunnel (ASUWIT). The ASUWIT consists of a 13.7-m long, 0.7 m high, 1.2 m wide open-circuit boundary-layer wind tunnel that operates under ambient temperature and pressure conditions and is capable of wind speeds of 30 m/sec. Air is pulled through the tunnel by a large fan mounted in the downwind section of the tunnel. A viewing area of the test bed is encased by plexi-glass with doors to access the test section for the setup of experiments. The ASUWIT facility can measure wind speed, temperature and humidity inside the tunnel, and physical conditions in the room outside of the tunnel are also collected. These data include laboratory temperature, humidity and barometric pressure. Wind conditions exterior to the building, including wind direction and speed, are also recorded. Independent sources power the pressure transducers, humidity sensors, anemometers, and wind vanes.

ASU Vortex Generator (ASUVG). The ASUVG consists of a large fan mounted above a moveable table. A variable-speed motor controls the speed of an 0.5 m fan mounted above the testing table and can be adjusted for various results. A large board of pressure transducers is available and can be setup to collect wind pressure points in various areas of the test section. Currently the vortex generator's data is fed to a Windows PC running LabView™. The test section measures 1.2 x 1.2 m. The fan can have its height adjusted vertically and horizontally; likewise, the table can be adjusted in the X, Y and Z directions during experiments.

Mars Wind Tunnel (MARSWIT). Put into operation at ARC in 1976, MARSWIT is used to investigate the physics of particle entrainment by the wind under terrestrial and Martian conditions, conduct flow-field modeling experiments to assess wind erosion and deposition on scales ranging from small rocks to landforms (scaled) such as craters, and to test spacecraft instruments and other components under Martian atmospheric conditions. MARSWIT is a 13-m long open-circuit boundary-layer wind tunnel within a large environmental chamber that operates at atmospheric pressures ranging from 1 bar to 5 millibars at speeds as high as 100 m/sec. The chamber has an inside height of 30 m and an inside volume of 13,000 cubic meters. PAL draws its vacuum from the Thermal Physics Facilities' Steam Vacuum System and can be evacuated to Mars analog pressure (4 torr) in about 45 minutes. Due to the high cost to operate the vacuum system an agreement was struck in which PAL draws its vacuum almost exclusively as a ride-along with other NASA Ames projects/facilities. Aside from this agreement, reserved vacuum service is available provided sufficient funding is presented and there are no scheduling conflicts.

The MARSWIT instrumentation includes differential pressure transducers (Setra 239 and MKS 226A) that are used for measuring free-stream wind velocities and deriving wind profiles. These have a range of ±0.5 inches of a water column. A Vaisala model DMP-248 dewpoint and temperature transmitter is used to monitor the temperature and relative humidity within the chamber. A DigiVac model 2L760 digital vacuum gauge measures the chamber pressure from Earth standard to the minimum allowable operating pressure (1 bar to 5 millibars) of the chamber. The MARSWIT is equipped with a high-speed (500k samples/s capability) analog-to-digital data acquisition system from National Instruments, Inc. Installed and operated on a dedicated computer, the system is capable of simultaneously measuring 64 analog channels, each of which can be independently accessed. The system is controlled by the National Instruments software package LabView™. This system allows for the simultaneous acquisition, analysis, and visualization of wind tunnel temperature, pressure, and velocity. Other analog and digital instruments can be incorporated to suit experimental requirements.

Titan Wind Tunnel (TWT). The TWT is a remodel of the Venus wind tunnel (operated 1981-1994), and became operational in June 2012. The TWT is a closed-circuit, pressurizable (to 20 bars) wind tunnel with an overall dimension of 6-m by 2.3-m. Included in the remodel were upgrades to a newer, higher performance motor, advanced motor controls, and new instrumentation. Overall tunnel pressure is determined by visual observation of a calibrated gauge (manufactured by Wika Instrument Corp., + or – 1psig) attached to the front of the tunnel instrument panel. Differential pressure is measured (for flow velocity calculation) by a custom designed sensor (manufactured by Tavis Corp.). This sensor is connected to a stack valve that determines which pitot tube is being “read” (traversing or fixed). The voltage from the sensor is sent to a data acquisition module (manufactured by Measurement Computing Corp.) and processed for interpretation by TracerDAQ software installed on a laptop computer. Initial tunnel operations required measurements be made in the test section to develop “Boundary Layer Profiles” characteristic of the tunnel. To accomplish this, a custom designed traversing pitot tube assembly was built and incorporated into a removable test plate. Electrical lines for instrument control and data capture, as well as pneumatic lines from the pitot tube exit from beneath the test plate to a signal pass-through port in the bottom of the test section. The electrical lines run to the control and data capture units that are connected to a laptop computer. The pneumatic lines run to the stack valve, which is connected to the differential pressure sensor. At the conclusion of the BLP work, this “instrumented” test plate was removed and a “blank” test plate was substituted to allow observation of materials selected for threshold testing and bedform development. With the “instrumented” test plate removed, the stack valve is adjusted for the fixed pitot tube to be ‘read” by the differential pressure sensor. The fixed pitot tube resides in a straight section of the tunnel opposite the test section. Test section velocities can be calculated from readings taken from the fixed pitot tube.

How can I use the PAL Facilities: The PAL facilities are open to all NASA-funded researchers in aeolian studies. The PAL is funded by the NASA Planetary Geology and Geophysics program, in which new Announcements of Opportunity to Propose (AO) are released annually as part of NASA’s Research Opportunities in Space and Earth Science (ROSES), typically available in January or February of each year. This should be the primary R&A program to submit proposals to conduct laboratory studies with the PAL. However, Mars-related wind tunnel work theoretically could also be proposed to the Mars Fundamental Research Program (MFRP), and Titan-related wind tunnel work could also be proposed to the Outer Planets Research Program (OPRP), *pending NASA HQ approval*.

Although the PAL facilities are funded by PG&G, there are still costs associated with the operation and maintenance of these facilities that must be encumbered by the user. Because the PAL facilities are administered by ASU, *you must budget for PAL operations in your proposal as a subcontract to Arizona State University.* The fixed daily cost to use the ASU facilities is being determined, excluding materials, special equipment, and your travel costs. Currently, there is no separate charge to use the PAL facilities at NASA ARC, which are fully funded through July 31, 2015, but this may change in future years.

Future Plans for the PAL Facilities: ASU wishes to honor Ron Greeley’s legacy in supporting planetary aeolian studies [1] by continuing to maintain and manage the PAL facilities at ASU and ARC, and to make them as capable laboratories as possible, so that they may be useful resources to NASA and the aeolian community for many years to come. But they are seriously underutilized, and for NASA to justify maintaining these facilities, they require more usage. If you ever considered proposing to NASA for wind tunnel work, now is the time!

If you wish to use the PAL facilities, please contact PAL Director David A. Williams (David.Williams@asu.edu) at Arizona State University for more details and to schedule your work.

References:

[1] Greeley, R. and Iverson, J. D. (1985) *Wind as a Geologic Process on Earth Mars, Venus, and Titan,* Cambridge University Press, Cambridge, UK, 333 pp.