HOW TO COLLECT IN SITU OBSERVATIONS OF AEOLIAN PROCESSES? S. Diniega[1], [1]Jet Propulsion Laboratory, California Institute of Technology (serina.diniega@jpl.nasa.gov).

Why the focus on in situ observations: Aeolian (wind-driven) sand and dust are known to significantly influence landscape evolution and climate across the solar system (Figure 1) [1-3]. To complement the extensive orbit-based studies of wind-driven geomorphology, bedforms, and sediment transport, high-temporal resolution in situ observations that are required for accurate modeling of the relevant surface and atmospheric processes [4-5]. Such observations need to enable robust correlation of environmental drivers with the activity, so as to validate or calibration models. Additionally, characterization of both the environment and activity requires identification of trends and variations over multiple scales (e.g., capturing diurnal and seasonal wind velocity patterns as well as the timing and magnitude of gusts).

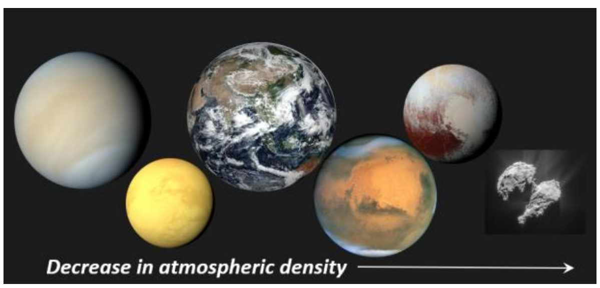

Figure 1. Solar system bodies where known or hypothesized aeolian features have been identified, in order of atmospheric density. From left: Venus, Titan, Earth, Mars, Pluto, comet 67P Churyumov-Gerasimenko.

Current state of knowledge and capability: To date, Mars is the only planetary body where some in situ measurements of meteorology and aeolian activity have been acquired. However, on previous Mars missions the instruments were accommodated sub-optimally among other payload elements and thus did not yield the type of comprehensive, integrated, detailed data needed to robustly test and guide models. Optimal, high-fidelity, and long-duration in situ investigations of aeolian processes outside of Earth have not yet been accomplished, due to technology limitations including:

- the high costs of delivering any mass to another planet's surface, resulting in spacecraft attempting a convolution of objectives due to fewer opportunities;
- the size and complexity of instruments providing the precisions and high frequencies required to address outstanding questions, as well as the number of complementary measurements needed to completely capture both a process and its environmental drivers;
- difficulties in instrument accommodation to minimize environmental perturbations (and thus measurement inaccuracies), especially with spacecraft design that includes meteorological experiments as add-ons after the host spacecraft has been designed rather than considering the proposed meteorological science early in the mission architecture design cycle; *and*
- the duration, cadence and resources needed for an observational scheme that captures both the background trends/cycles as well as sporadic (and unpredictable) peak environmental conditions.

However, recent advances in small lander design (especially to Mars), instruments, and concept of operations designs make low-cost, low-risk, and high-value mission concepts feasible in the next decade [6]. (One small lander concept is shown in Figure 2.)

The next steps: This presentation will summarize the main science parameters of interest for in situ investigation of planetary aeolian processes, along with current relevant instrument and mission concept development (e.g. Table 1). Furthermore, discussion is solicited on these topics as well as the identification of required considerations with regards to instrument choices within an integrated payload, accommodation of that payload onto a rover or lander, selection of a landing site, and concept of operations strategies for in situ observation collection. (For even more discussion on these topics, please see the upcoming *Optimizing Planetary In Situ Surface-Atmosphere Interaction Investigations* workshop [7].)

Acknowledgments: This presentation is based on many discussions and publication efforts by many members of the planetary aeolian, terrestrial aeolian, and engineering communities; please see the referenced documents to get a sense of the main contributors. A portion of the work described was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration (80NM0018D0004).

References: [1] Diniega et al., 2017, *Aeolian Res.*, **26**, 5–27, doi:10.1016/j.aeolia.2016.10.001. [2] Newman, C., et al., 2021, *BAAS*, **53(**4), PS&A DS 2023–2032 white paper e-id. 278, doi:10.3847/25c2cfeb.726b0b65. [3] Titus et al., 2021, *BAAS*, **53(**4), PS&A DS 2023–2032 white paper e-id. 188, doi:10.3847/25c2cfeb.038c0952. [4] Diniega et al., 2021, *Geomorphology*, **380**, 107627, doi:10.1016/j.geomorph.2021.107627. [5] Diniega et al., 2021, *BAAS*, **53(**4), PS&A DS 2023–2032 white paper e-id. 123, doi:10.3847/25c2cfeb.950513cc. [6] Diniega et al., in press, *2022 IEEE Aerospace Conference*. [7] Optimizing Planetary In Situ Surface-Atmosphere Interaction Investigations workshop, https://www.hou.usra.edu/meetings/planetinsitu2022/, 28 June–1 July 2022. [8] Barba et al., 2021, *2021 IEEE Aerospace Conference* (50100), 1–7, doi:10.1109/AERO50100.2021.9438338.

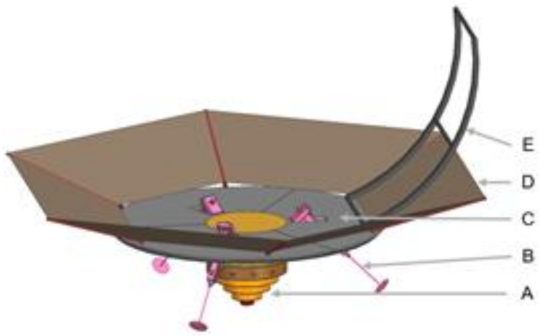

Figure 2. View of SHIELD lander [8] in the landed configuration. A: impact attenuator, B: leveling legs, C: top deck, D: drag skirt, E: roll cage. The lander, including drag skirt, is ~2.5 m across and the roll cage reaches ~1.5 m above the ground. Figure is from [6].

Table 1. A sample payload suite from [6], thought to be possible to fit within current SHIELD power, mass, and volume resources, with measurements of interest.

Instrument	Collected data
Sonic Anemometer	• Three-dimensional wind speeds • Temperature estimates (based on observed speed of sound)
Laser dust velocimeter and anemometer	• Three-dimensional flux rate for transported sand and dust • Grain sizes within transport layer
Tunable Laser Spectrometer	Amount of CO_2, H_2O, and other trace atmospheric gas(es)
Saltation Sensor	Detection of size, height, and velocity of saltating grains (via impact on the sensor)
Flux radiometers	• Local energy balance • Ground temperature (with downward facing radiometer)
Cameras	• Environmental context • Identify and characterize visible appearance of meteorological phenomena, such as clouds, dust devils, and dust storms • Image grains on ground or lander to estimate size/shape and constrain variability and composition
Pressure Sensors	Surface pressure measurements, including variations due to meteorological phenomena
Temperature Sensors	Near-surface thermal profile