



# NASA Ames Flight Instrument Group - MARS Exploration Efforts Overview

Vandana Jha, Donald Banfield, Anthony Colaprete, Amanda Cook, Bruce White, Matthew Garrett, Abraham Rademacher, Jared Shimada, Arwen Davé, Parul Agrawal and Olga Stotzky; NASA Ames Research Center, Moffett Field, CA, 94035

## Flight Instrument Group (FIG) Overview

### Introduction:

The Ames Flight Instrument Group (FIG) development activities include:

- 1) Saltation Sensor
- 2) Mars Sonic Anemometer (MSA)
- 3) Doppler Wind Thermal Sounder (DWTS)
- 4) Nephelometer Experiment (NephEx)
- 5) Kinect Imaging System
- 6) Down-hole drill Near-Infrared spectrometer (dNIR)
- 7) Digital Micromirror Device Steering System (DMDSS)

These efforts are non-flight but are considered high-priority research as they feed into future potential flight missions.

Our goal is to raise the Technology Readiness Level (TRL) through environments testing so they are selectable in a flight mission proposal

### Saltation Sensor

- Saltation is a dominant factor in dust lifting, important to Mars weather and geology, with impacts to the safety of human exploration.

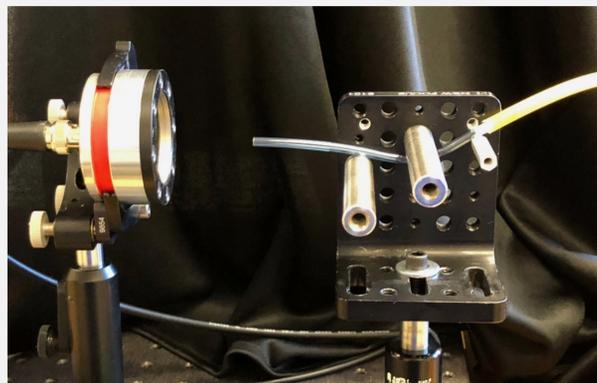


Fig.1. Saltation sensor showing the ambient pressure grain air gun to the right and a capacitive transducer target at left.

### Key features:

- Detecting grain impacts in typical Mars particle size range (100um-1mm), resolving impact size, speed, and height at impact rates up to ~1000/second
- Can share a lander or rover with the MSA and use the same instrument back-end to detect the critical wind stress threshold for sand motion.

### Future Plan

- Mature capabilities from a lab prototype to an Engineering Test Unit using similar architectures to the MSA
- The field prototype will be characterized in the lab with well-defined impacts before being tested in an active dune field, alongside state-of-the-art (but notably less capable) commercial instrumentation.

MatISSE funded sensor will reach TRL 6 in 2025.

## Mars Sonic Anemometer (MSA)

- MSA measures turbulent eddies by transmitting chirp across wind using ultrasonic transducer.
- can rapidly take multiple samples of wind (20 Hz)
- can measure slower wind speeds (~0.05 m/s) than current planetary weather stations (~1Hz and ~2m/s).
- opens new avenues of research into Mars surface-to-atmosphere exchange.



Fig.2: TRL5 prototype of the Mars Sonic Anemometer in the Mars Wind Tunnel at Aarhus, Denmark.

### Key features:

- Sensor more durable than recent Mars wind sensors.
- Has spin-offs that can validate surface-atmosphere interactions on Mars, Titan, Earth, Venus, Saturn, Uranus, and Neptune.
- Useful in direction-finding for elephant infrasound's (and possibly gunfire in anti-poaching efforts).
- Can be recast as a hydrogen ortho-para sensor for a giant planet descent probe.

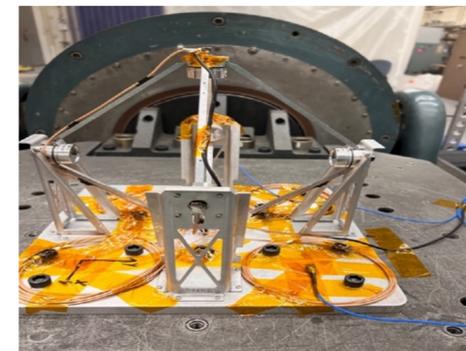


Fig.3: Mars Sonic Anemometer, including three orthogonal pairs of transducers, during successful vibration test in the Engineering Evaluation Lab at NASA Ames

## Environmental Testing

- The performance of sensor at Mars-like conditions of 6mbar CO2 operating at 20Hz is validated at the Danish Mars Wind Tunnel.
- The transducers survived an Ames random vibration test per APR 8070.2/GEVS as well as a JPL 2000-g impact test as part the SHIELD lander development.
- A prototype has returned data from a NASA stratospheric balloon flight.

There is interest from a discovery mission to Venus and NASA's Scientific ballooning program, as well as infrasound detection from Sandia.

Novel wind sensor for Mars is TRL6, ready for upcoming flight opportunities.

## Doppler Wind and Temperature Sounder (DWTS)

### First Direct Observations of Martian Winds

- Global observation of entire atmosphere
- High fidelity wind and temperature data for weather models
- Unprecedented coverage, sensitivity and economy

### How?

- Onboard gas cell is reference for doppler shift and absorption line width.
- Ozone enables night & day global wind measurements (@210K)
- Low-cost simple, static, small IR camera
- Image the limb with static, small, gas-filtered camera to sense Doppler shift
- No spectroscopic hardware required!

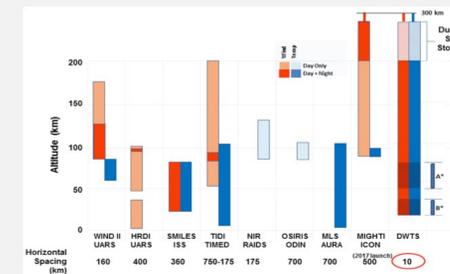


Fig.4: DWTS altitude and day/night coverage compared to current instruments.

Fig.5: The DWTS instrument will view the Earth's limb perpendicular to the velocity vector with a 20° horizontal and 10° vertical FOV

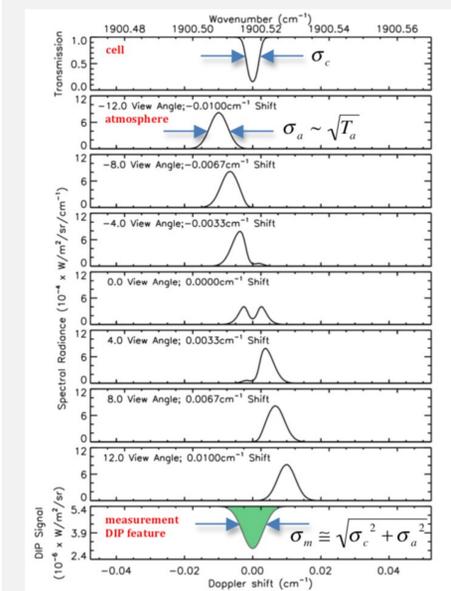
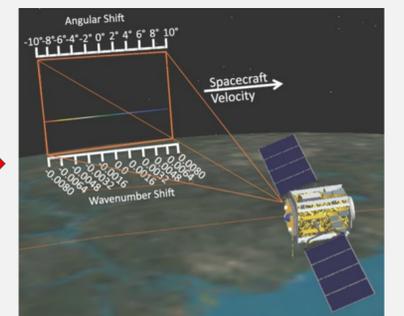


Fig.6: Illustration of the DWTS concept using one emission line feature

- Top panel shows transmission through the instrument's onboard gas cell vs. wavelength (Fig 6).
- Middle 7 panels show atmospheric emission reaching the detector vs. wavelength from 7 different viewing angles of the same parcel of air.
- Bottom Panel shows the Doppler Integrated Pass ("DIP") signal (see Gordley & Marshall 2011). The position of the signal minimum provides the cross-track wind vector component. DIP area (shaded green), normalized by the maximum signal, provides a direct measure of cell content.
- Measurements of  $\sigma_c$  and  $\sigma_m$  allow the atmosphere  $\sigma_a$  and therefore atmospheric temperature,  $T_a$ , can be determined.