

Martian Sonic

Anemometer

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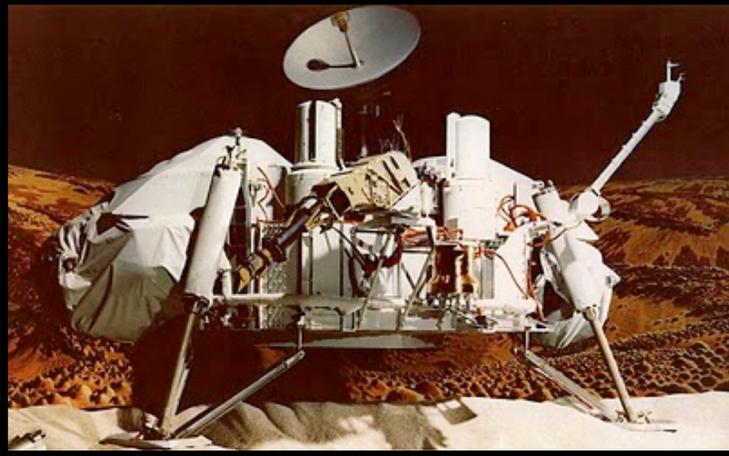
IPPW8

Martian Sonic Anemometer

Overview:

- Why measure winds on Mars?
- Surface-atmosphere fluxes
- Why do we need a better anemometer?
- How does it work?
- What are its specifications?

Why Measure Winds on Mars?



- Basic measurements from only 4 locations
 - Insufficient sampling
 - Limited capabilities



- Orbiting sounders reveal only part of the story
 - Bottom scale height poorly observed
 - ~60% of atmospheric mass!
 - Clear disconnect between orbital & surface meteorology

Why Measure Winds on Mars?



- Safe Delivery of S/C to/from Martian surface
 - Wind shears in Boundary Layer



- Hazards due to Aeolian Processes
 - Dust storms, Dust Devils
 - Know when to protect optics
 - Know when to expect solar panel cleaning

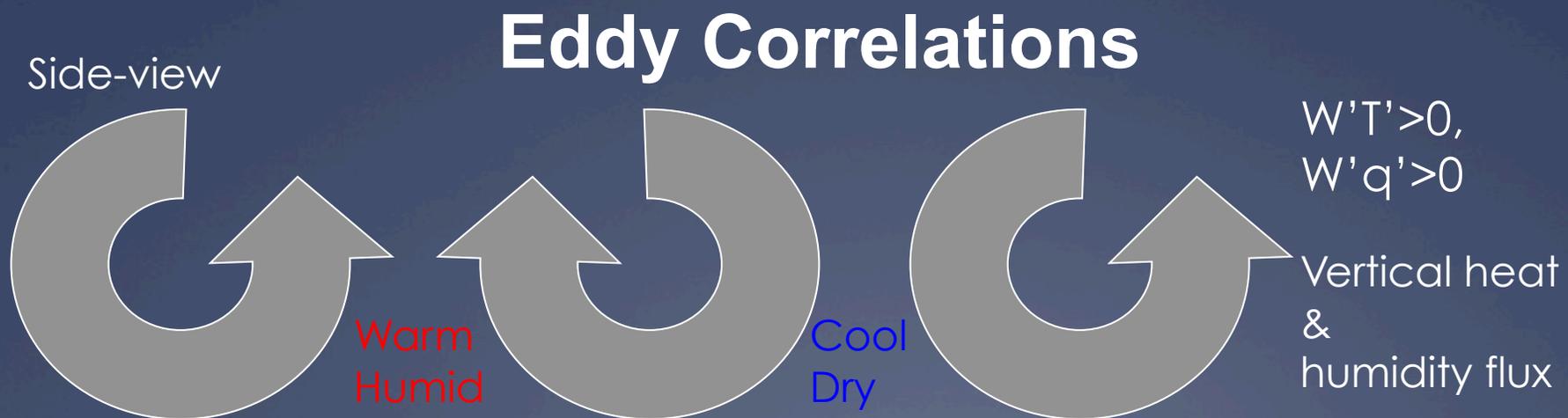
Why Measure Winds on Mars?

- To understand surface/atmosphere exchange:
i.e., Fluxes between surface/atmosphere
 - Water fluxes for stability/climate
 - Heat flux for surface energy balance
 - Momentum flux for aeolian processes
 - Bio-tracer effluent fluxes (e.g., CH₄) for finding plume sources
- Provide more robust measures for model validation
 - T, P & Horizontal winds don't validate mesoscale models adequately
 - Adding flux measurements removes model ambiguity
 - Improved models mean safer s/c delivery & operations



How Would you Directly Measure Surface/Atmosphere Fluxes?

- Boundary Layer Transport almost always through turbulent motions
- Directly measure turbulent eddy winds (3-D) & scalar desired for flux
- Correlate the vertical winds with the scalar's perturbations
- Requires:
 - 3-D winds
 - Sensitive instruments (winds < 50 cm/s)
 - Fast response instruments (> 10 Hz)



Why Do We Need a Better Anemometer?

Viking Hot-Film Sensor:

Radiative errors, Slow Response, 2-D

Pathfinder Hot Wire:

Uncalibrated, slow response, 2-D

Pathfinder Wind Socks:

slow response, high data rate

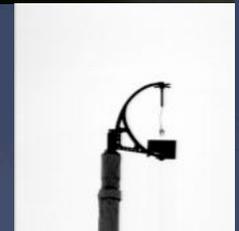
Phoenix Telltale:

Slow response, high data rate

MSL REMS:

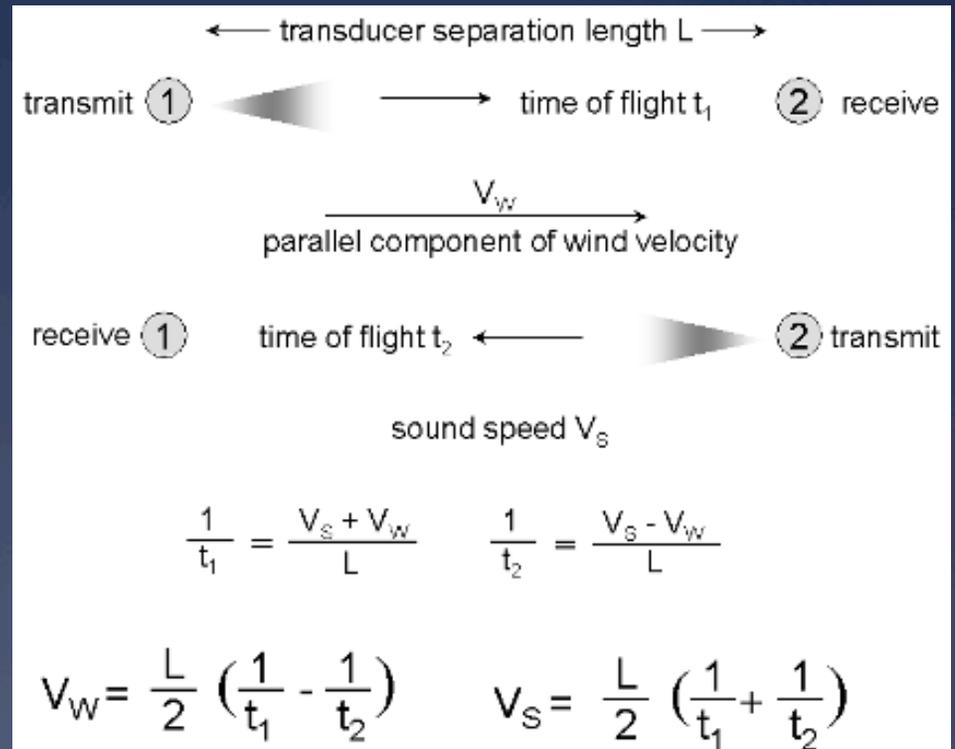
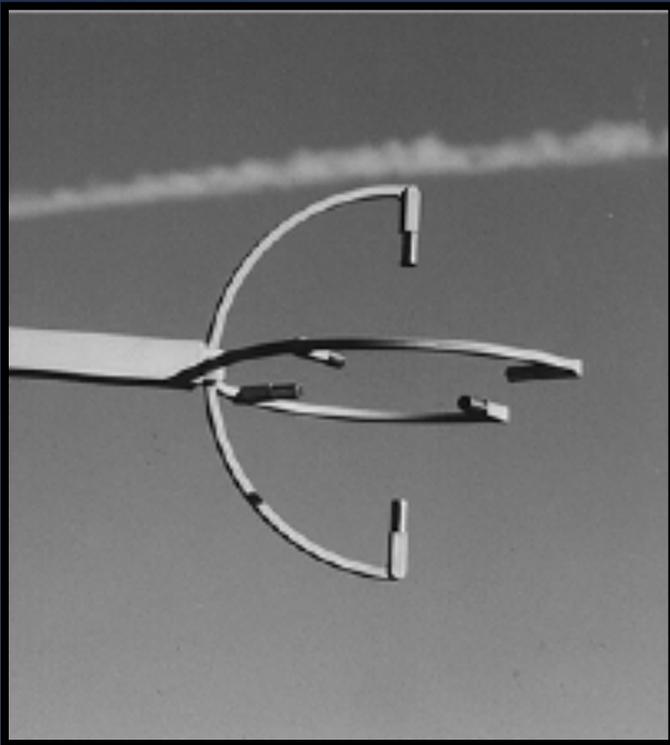
Slow response

All prior attempts have been limited in capability (i.e., ~1m/s @ ~1Hz) and often difficult to calibrate



What is a Sonic Anemometer?

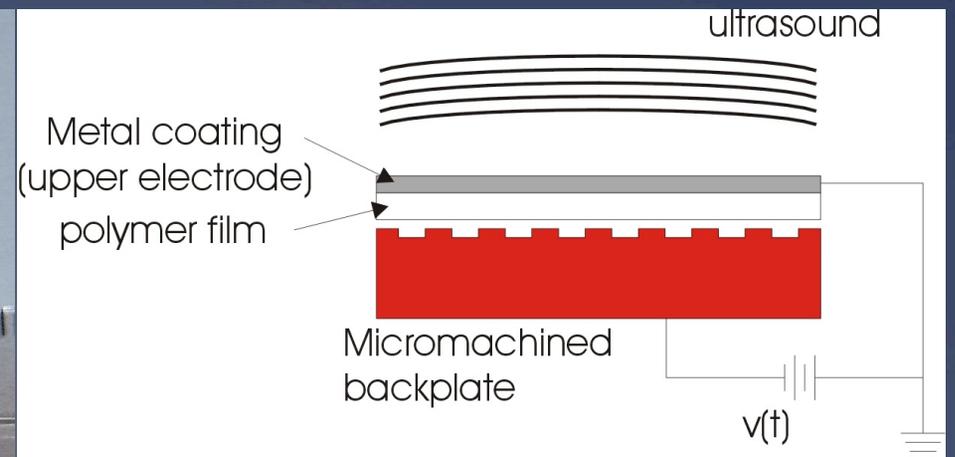
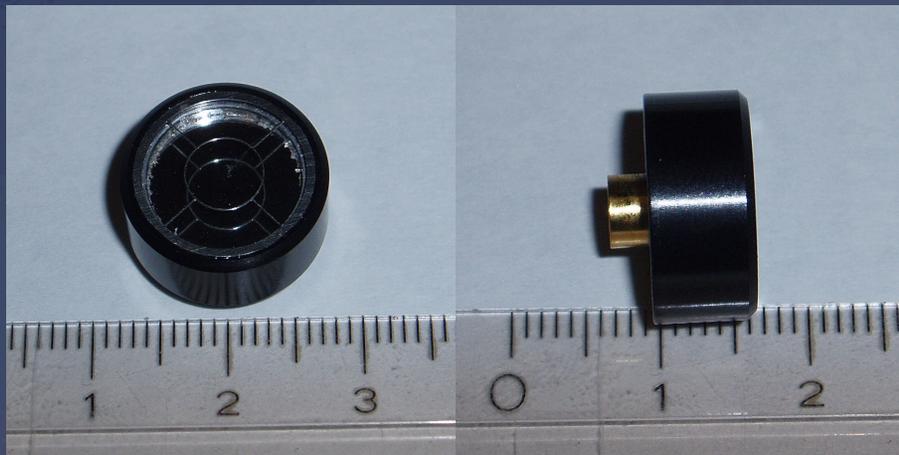
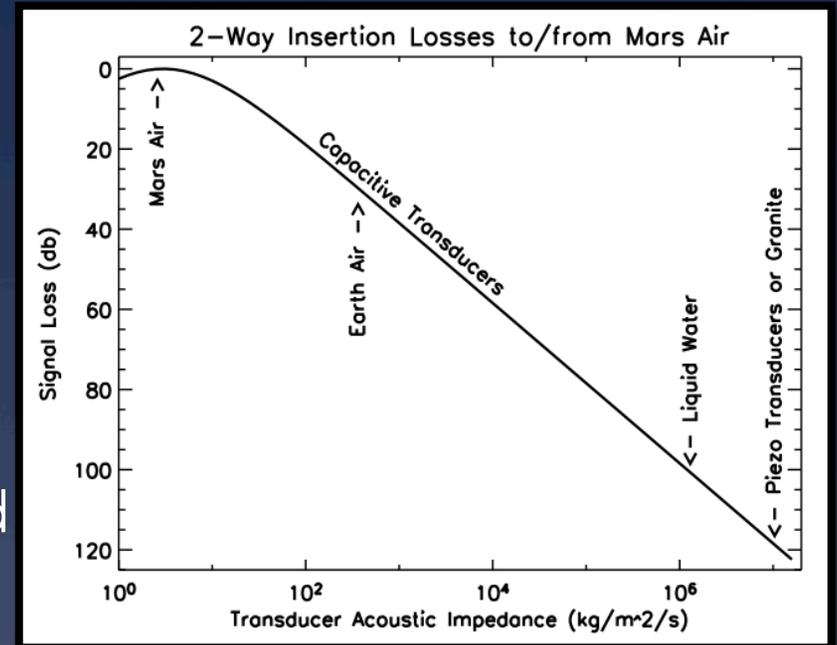
Sonic Anemometry is the premier terrestrial wind measurement technique for field-work. Fast, Accurate, Unambiguous



Measures wind speed via sound pulse travel-time differences. Temperature is inferred from sound speed.

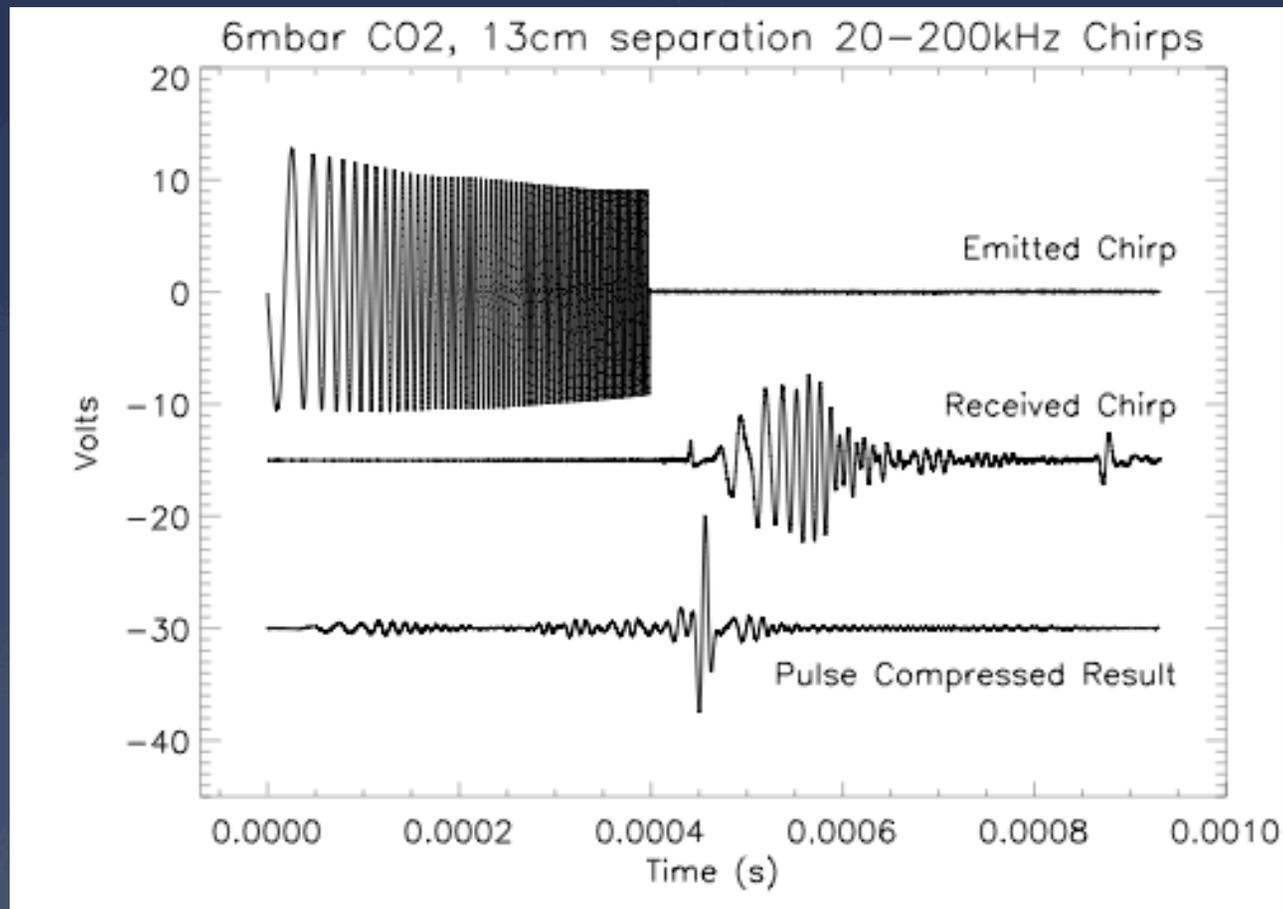
Why hasn't it been done Before?

- Air density is ~0.5% of terrestrial
- Coupling sound into this is hard
- Terrestrial instruments use Piezos
- We use capacitive micro-machined ultrasonic broadband transducers



Why hasn't it been done Before?

- Increase S/N by using chirps & pulse compression
- Requires on-board processing

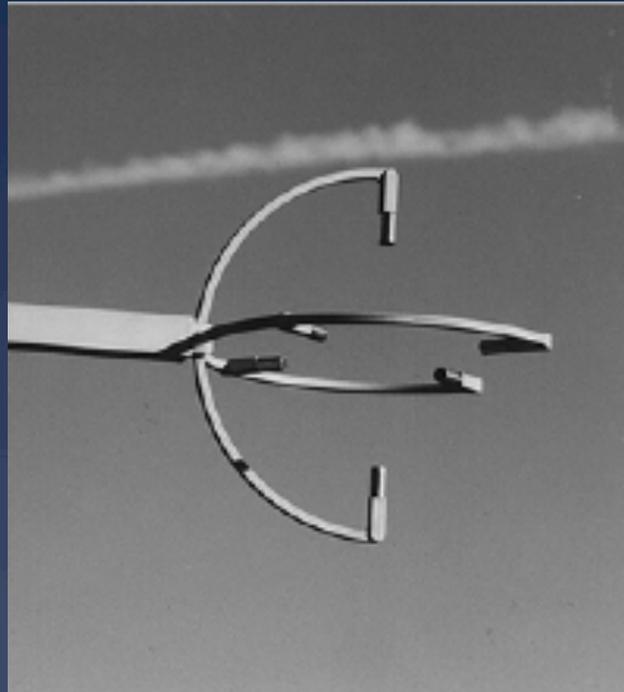


What are its Specs?

- Sensitivity $< \sim 5$ cm/s @ > 20 Hz, T to ~ 0.2 K
- Eventual flight configuration specs:
 - ~ 1 kg including Meteorology mast
 - ~ 2 W when operating, instant off/on.
- Currently TRL 4-5, aiming for TRL 5-6 next spring
- Testing at Mars Wind Tunnel, Aarhus, Denmark March 2012
- Stratospheric balloon flight in May 2012



Martian Sonic Anemometer



You want this on your next Mars
Probe Mission Proposal!

Thank you