The Venus SAGE Atmospheric Structure Investigation

Anthony Colaprete
Dave Crisp
Clayton La Baw
Stephanie Morse
- Experiment Goals and Objectives -

- To accurately define the state properties as a function of altitude from below the $10^{-4}$ mb level (~150 km) to 92 bars (surface).
- To measure the stability of the atmosphere, and identify convective layers and stable layers, where they exist.
- To detect cloud levels from changes in the lapse rate at their boundaries.
- To provide state properties within the cloud levels, and thus provide supplementary information on cloud composition.
- To search for and characterize wave structure within the atmosphere.
- To search for and measure the intensity and scale of turbulence.
- To measure descent and surface wind speed and direction.
- To provide Lander altitude and attitude during decent for descent imaging analysis.
- To provide a back-up landing sensor.
**Measurement**

- **Altitude**
  - $dz \sim 250$ m (upper atm.)
  - $dz \sim 20$ m (lower atm.)

- **Acceleration & Attitude**
  - $a \sim 3$ $\mu$g (threshold)
  - $a \sim 0.05$ g (peak)
  - $\Theta_v \sim 0.5$ mrad s$^{-1}$

- **Pressure**
  - $dP \sim 0.1$ mb (100 mb)
  - $dP \sim 25$ mb (92 bars)

- **Temperature**
  - $1$ K

- **Surface Wind**
  - $w < 0.05$ m/s

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**Example Venus Profile**

Altitude:
- Measured variations
- Threshold and peak values

Acceleration & Attitude:
- Measured angular rates

Pressure:
- Differential pressure

Temperature:
- Measured values

Surface Wind:
- Measured velocities
- Instrument Accommodation -
Measurement:
  • Acceleration in 3 axis (x,y,z)
  • Roll, pitch and yaw rates

Accelerometers:
  • x, y and z axis low impact sensors
  • +/- 20 g range
  • < 1 micro g accuracy
  • z axis, high impact sensor
  • +/- 1000 g range
  • < 0.1 g accuracy

Gyroscopes:
  • +/- 300 degree/sec range
  • < 0.03 degree/sec accuracy (< 0.5 mrad/sec)
- Pressure Sensor Implementation -

- Pressure manifold holds pressure transducers with three ranges cover pressure range
  - 0.01 to 1 bar
  - 0.1 to 10 bar
  - 1 to 100 bar

- Fully redundant system
  - Provides method to measure pressure offset and gain drifts

- Micromachined capacitive aneroid barometers used
  - MVACS/HASI heritage
  - No new technology, but modifications needed for high temperature operation
- Temperature Sensor Implementation -

Schematic of an atmospheric temperature TC sense junction and reference junction on the isothermal block

- Thin-wire thermocouple (TC) assemblies deployed on 2 fixed booms
- Reference junctions are located on an isothermal block inside probe body
  - temperature monitored by a precision platinum resistance thermometer (PRT)
- Accuracy: ±1 °C, 150 ≤ T ≤ 750 °C  Precision: ~0.01 °C (14-bit)
- Time Constant: <1 sec
- Wind / Temperature Boom -
• 1-cm diameter sphere with six pressure ports equally spaced around its equator and two additional pressure ports located at its fore and aft poles.

• Speed and direction can be derived from pressure differences measured at these eight ports.

• During decent the fall speed will be derived from the wind sensor and used to adjust pressure measurements for dynamic effects.

• Surface winds measured to < 0.05 m sec⁻¹
- SYSTEM ARCHITECTURE -

- **JPL Daughter Board**
  - Pressure
  - Temperature
  - Wind Speed
  - Temp. Thermal couples Interface
  - Magnetometers Interface
  - Payload Power/data link

- **Motherboard**
  - +5V, +/-12V
  - I/O LINES, TTL

- **Interfaces**
  - Z-Axis, Impact Accelerometer Interface
  - Z-Axis, Accelerometer Interface
  - Y-Axis, Accelerometer Interface
  - X-Axis, Accelerometer Interface
  - X-Axis, Gyro Interface
  - Y-Axis, Gyro Interface
  - Z-Axis, Gyro Interface

- **Power**
  - Main power
  - CMD/DATA TRANSFER
- Future ASI Development -

High Pressure and Temperature, Miniaturized Sensors

• AlGaN/GaN-based microsensors (Kyung-ah Son, JPL)
  Small: $\sim 1 \text{cm}^3$
  Low mass: $<5 \text{g}$
  Low power: $<10 \text{ mW}$

• Broad Operational range
  Temperature: 4 K-1000 K (0.1 °C)
  Pressure: 0-10 kbar ($<5\%$)

Highly Integrated Systems

• Integrated power, com., C&DH, and structure