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: $dz \sim 250\text{ m (upper atm.)}$
  
  $dz \sim 20\text{ m (lower atm.)}$

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

- Pressure:
  
  $dP \sim 0.1\text{ mb (100 mb)}$
  
  $dP \sim 25\text{ mb (92 bars)}$

- Temperature:
  
  $1\text{ K}$

- Surface Wind:
  
  $w < 0.05\text{ m/s}$

**Example Venus Profile**

- Altitude: $z$ (km)
  
- Temperature: $T$ (K)
  
- Clouds
  
- Supersonic
  
- Subsonic
- Instrument Accommodation -

Pressure Vessel

Wind / Temperature Boom

IMU

Pressure / Temperature Boom
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 / Temperature Boom
- 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 -
- Directional Pitostatic Anemometer -

- 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 -

**Motherboard**

- **Control/Communications Interface**
  - Z-Axis, Impact Accelerometer Interface
  - JPL Daughter Board
  - Pressure
  - Temperature
  - Wind Speed

- **Pressure**
- **Temperature**
- **Wind Speed**

- **I/O LINES, TTL**

- **Main power**

- **Payload Power/data link**

- **Temp. Thermal couples Interface**

- **Magnetometers Interface**

- **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**

- **+5V, +/-12V**

- **CMD/DATA TRANSFER**

**NASA**
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