Pascal  A Mars Climate Network Mission

Pascal Team
Principal Investigator: Bob Haberle, ARC
Deputy PI: Aaron Zent, ARC

• **US Co-I’s:**
  – Conway Leovy, UW
  – David Catling, UW
  – Tim Schofield, JPL
  – Dave Atkinson, UI
  – Jim Murphy, NMSU
  – Chris Webster, JPL
  – Peter Smith, UA
  – Anthony Colaprete, ARC
  – Ron Greeley, ASU
  – Jeff Barnes, OSU
  – Jill Bauman, ARC

• **International Co-I’s:**
  – Jean-Pierre Pommereau, SA
  – Pascal Rannou, SA
  – Francois Forget, LMD
  – Frederic Hourdin, LMD
  – Oliver Talagrand, LMD
  – Ari Matti Hari, FMI

• **Industry Partners:**
  - Ball Aerospace (Prime)
  - LMATC (Surface Station)
  - Aerotherm (Entry System)

• **Mission Management:**
  - JPL
Science Objectives

(1) Joint characterization of the near-surface general circulation and its interaction with the surface.
   - Measure the surface signature of the general circulation
   - Monitor aeolian processes & water exchange

(2) Determine how the general circulation controls the dust, water, and CO₂ cycles

(3) Provide a basis for comparative planetary meteorology

(4) Provide a weather monitoring infrastructure for future missions and synergy for all observations

==> Characterize the Present Global Climate System <==
Pressure and Opacity Are the Most Important Measurements

- Pressure gives column mass
  - Pressure gradients related to winds
- Opacity gives the forcing
  - Measures extinction of solar radiation
- The combination also gives
  - CO₂ cycle
  - Dust cycle
Mission Design Philosophy

Capable landers:
- Address multiple disciplines
- Become heavy and expensive
- Cannot deliver enough landers

Tradeoff:
- Instead of many measurements at a few sites
- Make a few measurements at many sites

Focus payload on key measurements:
- Pressure and Opacity
- Then enhance the science as resources permit

~ 20 kg Entry Mass
Pascal  A Mars Climate Network Mission

How Many Stations are Needed?

- Need broad latitudinal coverage
  - sample each meteorological regime
    - 1 in tropics
    - 1 in mid-latitudes of each hemisphere
    - 1 in polar regions of each hemisphere
- Need to resolve longitudinal structure
  - wave 2 is dominant feature
  - need at least 4 stations ~ 90° apart
- Don’t need many polar stations

No. Stations

General Circulation

5

5x4 = 20

20-4 = 16

CO₂ Cycle

Need 16 for CO₂ cycle

NASA Ames Research Center
The Pascal Mission

Global network of 18 weather stations

Stations operate for 3 Mars years

Landed measurements:
- pressure (hourly)
- opacity (hourly)
- temperature (every 15 minutes)
- wind speed (every 15 minutes)
- water vapor (twice per sol)
- B&W panoramic images (1/Mars Mo)
**Pascal EDL Measurements**

**Entry Science**
- 18 T-profiles
- 10-80 km
- Global
- Late AM/PM local times

**Descent Imaging**
- ~ 10 images
- Res: >30 cm/pix
Pascal  A Mars Climate Network Mission

Mission Concept

• **Launch:** 9/27/07 (20 day window)
  – Delta III-3940
  – Type II trajectory

• **Mars arrival:** 10/19/08 ($L_s = 146^\circ$)
  – Release probes on approach

• **Probe entry, descent, and landing:**
  – Aeroshell, Parachute, Air bags
  – Entry data stored for later transmission
  – No communication during EDL

• **Autonomous surface ops:** 3 Mars years

• **Station power:**
  – Milli-watt Power Generator (MPG)

• **Communication:**
  – MEP Orbiters
  – Mars Express
  – Others?
Pascal A Mars Climate Network Mission

Pascal Probe Deployment Sequence

- Doppler, range, and Delta-DOR tracking cuts off 2 days prior to each Deployment Sequence (DS).
- DS 1 at E - 25 days: 6 probes released.
- DS 2 at E - 20 days: 6 probes released.
- DS 3 at E - 15 days: 6 probes released.

E - 10 days contingency deployment:
- Probes from DS 1 land along this annulus.
- Probes from DS 2 land along this annulus.
- Probes from DS 3 land along this annulus.

- Carrier S/C flies by Mars – obtains probe EDL telemetry.
- Probe from DS 1
- Probe from DS 2
- Probe from DS 3

- Mars rotation

Distribution in longitude due to combination of different landing times and Mars rotation.

Note: not all probes shown. Not to scale.
**Pascal**  A Mars Climate Network Mission

---

**Pascal EDL Sequence**

- **Entry**
  - Speed = 6 km/s
  - Landing in 4 minutes

- **Self orientation**

- **Aft dome separates**

- **Parachute deployment separates entry probe from science package**
  - $Q = 700$ Pa
  - $M = 1.5 - 2.2$

- **Airbag inflates immediately after chute deployment**

- **Airbag protects science station at impact – numerous bounces**

- **Chute separates after first impact**

- **Jettison airbag and initiate landed operations**

---

- **~ 80 km**
- **~ 1 minute**
- **5-10 km**
- **~ 3 Mars years**

---

**Ames Research Center**

---

**Ball**

---

**ITT Industries**

---

**Lockheed Martin**
Sample Network Configuration
Probe Entry System

- 70° half angle cone
- Hemispherical backshell
- 20 kg entry mass
Pascal  A Mars Climate Network Mission

The NASA Ames GCM & Probes

Excellent tool to plan EDL:
• Winds
• Atmospheric density

Provides BC’s for Mesoscale Models:
• Dan Taylor (MM5)
• Scot Rafkin (MRAMS)

Pascal would provide the BEST validation of the GCM
Predicted $3\sigma$ Winds at $z = 50$ m for $Ls = 140$
Pascal Future

• Next Scout opportunity scheduled for 2011
• Much development work is needed
  - Power Source
  - Science Station
  - EDL system
  - Instrument prototypes
• Funding the development effort will be difficult
  - No single source
• Pascal’s future is very uncertain