Technology Investments in Venus Exploration

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The Planetary Instrument Definition and Development Program (PIDDP) funds scientific research and engineering efforts focused on the development of innovative instrument systems that show promise for use in future scientific investigations on NASA Planetary Science missions.
• PIDDP has contributed to the development of more than half of all flight hardware flown on or selected for NASA’s planetary missions since the program’s inception in ~ 1980.

• It is regarded by the scientific and engineering community as a highly successful and critical component of NASA’s Planetary Science Division.
PIDDP Activities

• Feasibility studies of emerging techniques or component technologies
• Miniaturization of existing instruments such as rock age dating systems, spectrometers, seismometers, chemical sensors and gas chromatographers
• Development of new detectors, optical elements, supporting electronics
• Laboratory instrument breadboarding, brassboarding, and complete instruments system
• Field demonstrations

“PIDDP also invests in sample collection and sample handling technologies.”
Venus Technologies Sought

High temperature/pressure survivability technologies
✓ New materials
✓ Batteries
✓ Electronics
✓ Possibly, cooled containers for long-term in-situ missions

Development of robust scientific instruments and sampling systems:
✓ Age-dating systems
✓ Spectrometers
✓ Seismometers
✓ Sub-surface drilling technologies
163 Investments in Planetary Instrument Technologies Between 2007 and 2011

- Neptune Moons (Triton) 1
- Uranus Moons (Miranda, Ariel, Umbriel, Titania, Oberon) 2
- Saturn Moons (Mimas, Enceladus, Tethys, Dione, Rhea, Titan) 13
- Jupiter Moons (Io, Europa, Ganymede, Callisto) 19
- Neptune 2
- Uranus 2
- Saturn 2
- Jupiter 3
- Search for Life on Mars 2
- Understand Mars Processes and History of Climate 25
- Determine Evolution of Mars Surface and Interior 29
- Earth Moon 18
- Venus 18
- Mercury 3
- Meteorites and Interplanetary dust particles 3
- Moons of Mars 1
- Asteroids, Comets, Kuiper belt objects 20

Venus Instrument Technologies represent 11% of the current PIDDP portfolio
Measuring Heat Flow on Venus: A Flux Plate Approach
PI: S. Smrekar/ JPL

Technical Objectives:

- Achieve good thermal coupling to the surface while maintaining thermal gradient between sensors
  
  **Approach:** Use Carbon Nanotubes (CNTs), which have high thermal conductivity at 460°C, to couple plate to surface

- Obtain high measurement precision (rapid equilibrium)
  
  **Approach:** keep plate small (current concept ~10 cm by 3 cm)

- Mitigate the effects of variations in surface physical properties (not too large a thermal contrast)
  
  **Approach:** match surface conductivity and emissivity to the extent possible

- Operation in the Venus environment
  
  **Approach:** No exterior electronics other than temperature sensors

Carbon Nanotube array bundles are approximately 320 µm tall.
Development of a Membrane Inlet System for Use in Harsh Environments

PI: Tim Brockwell/ Southwest Research Institute

Science Objective

Mass spectrometers will play a major role in the investigation of planetary atmospheres. The use of membrane inlet is applicable wherever the ambient pressure would overwhelm the pumping system of a spectrometer and is advantageous in dusty or condensing environments that would block conventional inlets.

Schematic of the Membrane Testing Apparatus
Development of a Membrane Inlet System for Use in Harsh Environments

PI: Tim Brockwell/ Southwest Research Institute

Technical Objective

To determine the suitability of membrane inlets for future missions to Mars, Venus and Saturn by the creation of an environment simulator to reproduce the mission conditions and to determine the corresponding characteristics of the candidate membranes.

Schematic of the Membrane Testing Apparatus
Science Objective

Seismometry on Venus has been identified as a fundamental measurement with revolutionary scientific implications. However, there is a fundamental question as to whether such measurements can be performed given the high temperature, harsh environments of Venus.
Technical Objective

• This project will design, fabricate, and demonstrate a high temperature proof-of-concept seismometer operating at 500°C.

• Bring together the leading technology developer for high temperature electronics and sensors, a leading planetary researcher, and company at the forefront of high temperature sensor development.

• Approximate TRL: $\text{TRL}_{in} \sim 2$; $\text{TRL}_{out} \sim 3-4$
Program Goal

The ETNA program outlines a 2-year effort to develop harsh environment integrated microelectronics based on field emission from carbon nanotubes (CNTs) for use in space and planetary missions.

These CNT-triodes are immune to ionizing radiation and are capable of operating over a wide temperature range (~20K to ~900K). Our goal is to demonstrate both analog and digital integrated circuit building blocks using this CNT-triode electronics paradigm.

This project addresses the NASA goal of solar system exploration, specifically of Venus, volcanic vents on Io, the lower atmospheres of the Jovian planets, Jupiter’s moons, asteroids, etc.
SiC-based Robust Uncooled X-ray Detectors for Extreme Planetary Environments

PI: Kyung-ah Son/JPL

Fabrication of new generation SiC Schottky diode detectors

SiC X-ray detectors

4x4 Detector Array

Detector Housing

Developing SiC-based X-ray detectors that will enable an uncooled, chemically and thermally stable, radiation-hard, high resolution X-ray detector capable of operating over wide ranges of temperature and pressure and in caustic and strong radiation environments, which are expected in the future Venus and outer planet missions.
Technical Objectives:
To establish sampling capability for missions to Venus by advancing the development of a ultrasonic/sonic driller and corer that can operated at temperatures as high as 500°C.

Technology Development Partners     PI: Yoseph Bar-Cohen, JPL, yosi@jpl.nasa.gov, 818-354-2610
JPL: Col: Mircea Badescu, Xiaoqi Bao, and Stewart Sherrit
Penn State University: Lead Col: Tom Shrout, Col: Shujun Zhang and Beth Jones
Education outreach (Space Grant students): Scott Widholm and Patrick Ostlund, JPL
Recent Accomplishments:
✓ Developed novel design that makes the drill a rotary-hammer - the rotation is generated by the vibration of the piezoelectric actuator.

✓ Completed isothermal tests of LiNbO3 piezoelectric discs at 500°C for 1000 hours which yielded no change in properties

✓ Successfully drilled at 460°C thru a 25 mm thick brick sample in 21 minutes accumulated time

✓ Submitted several New Technology Reports

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**Description – What is it?:**

A small, high temperature, high pressure chamber to simulate environmental conditions on Venus’ surface. (e.g., 740 K and 95.6 bar)

Small size allows for quick turn-around testing of components and experiments. Conditions are monitored in real-time.

**The Basics:**

- Internal dimensions: diameter 12.7 cm (5 in) depth 30.5 cm (12 in)
- Monitored via NI LabView
- Operating parameters:
  - Max pressure 96 bar
  - Temp range 298K – 740K
  - Gases: CO₂, N₂, SO₂ (ppm) or mixture

**Objectives:**

- Test instruments and/or components to be proposed for Venus missions (i.e., Discovery/New Frontiers)
- Conduct Venus appropriate experiments (e.g., surface-atmosphere reactions)
- Explore different chamber configurations for a range of experimental options
Proposals Due Date: August 26, 2011

Expected Budget for 1st Year of Awards: $3M

Number of Selected Awards: 10-15

Max duration of Awards: 3-Years
Thank You for Your Attention

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