JPL is able to apply its technologies, facilities, and expertise to assist our partners in product improvement and problem solving to reduce risk.

Contamination Control Engineering
JPL Contamination Control Engineering

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Contamination Control Engineering for Payloads, Systems, and Missions

- JPL has extensive expertise fielding contamination sensitive missions—in house and with our NASA/industry/academic partners.
- Development and implementation of performance-driven cleanliness requirements for a wide range missions and payloads.
  - UV-Vis-IR: GALEX, Dawn, Juno, WFPC-II, AIRS, TES, et al
  - Propulsion, thermal control, robotic sample acquisition systems
- Contamination control engineering across the mission life cycle:
  - System and payload requirements derivation, analysis, and contamination control implementation plans
  - Hardware Design, Risk trades, Requirements V-V
  - Assembly, Integration & Test planning and implementation
  - Launch site operations and launch vehicle/payload integration
  - Flight ops
- Personnel on staff have expertise with space materials development and flight experiments
  - LDEF, MATLAB, MSX, EOIM-3, SAMMES
Contamination Control Process
- Telescope Aperture: 50 cm
- Optical Design
  - Modified Ritchey-Chretien with Aspheric corrected
  - Far UV band 0.135—0.180 \( \mu \) m
    Near UV 0.180—0.300 \( \mu \) m
- System Cleanliness Requirements
  - Molecular: < 0.065 \( \mu \) g/cm
  - Particulate: < 1 PAC
AIRS—Atmospheric Infrared Sounder

- **Spectral Range**
  - IR 3.74 -- 15.4 μm
  - Visible/NIR 0.41--0.94 μ
- **58 K focal plane**
  AIRS focal plane
  cryocooler, developed under contract with TRW
- **Scanning Optics**
- **Cleanliness Requirements**
  - Molecular: <1 μg/cm²
  - Particulate: < 0.02 PAC
Specialized Capabilities

• Molecular Contamination Spectral Effects (MCSE) Chamber
  – *In situ* measurement of optical effects of contamination

• Molecular Contamination Investigation Facility (MCIF)
  – Multiple temperature materials outgassing measurement

• Extensive library of materials outgassing data
  – MCIF (Modified MSFC-1559)
  – ASTM-E595

• Contamination Modeling
  – JPL-Developed molecular contamination transport codes
    • Space vacuum: System- and payload-level
    • Diffusion/convection environments: Habitable and extra-terrestrial atmospheric
    • System contamination issues associated with electric propulsion
Contamination Transport Modeling at JPL

Convection/Diffusion:
MSL at Mars (8Torr CO₂)

Vacuum Transport: Juno Vault Venting

Contamination Transport Driven by Wind Direction

- Concentration is a very strongly-peaked function of the wind direction.
- Worst case wind direction, were used to set the outgassing requirement.
- Vent flux requirement of 100 ng/cm²/hr set on the MSL vent, the largest source of contamination on the rover, easily meets the SAM Atmospheric Inlet contamination limit of 1 ppb.
Characterization of Contaminants

Molecular Contamination Spectral Effects (MCSE) Chamber

- Measure and evaluate the transmissive and reflective spectral effects of lenses and mirrors from VUV to Infrared wavelength. Turbo molecular drag (oil-free)—range: 1K to 5E-07 torr Dual cryo-pumped vacuum – total pressure: 1E-07 to 1E-09 torr

- Molecular Contamination Monitoring Capabilities
  - Quartz crystal microbalances (QCM): One cryo-quartz crystal microbalance (CQCM)– range 5K to 350K, 10 MHz Aluminum-plated crystals, Sensitivity: 3.5x10^-9 gm/cm2/Hz
  - Residual Gas Analyzer (RGA)

- VUV-UV-Visible-NIR-IR Spectroscopy
  - Reflectance, Transmission
  - 120 nanometers to 25 microns

- Temperature control
  - K-Cell: +20 C to +165 C
  - Target control range: 15 K to 350 K

- BRDF (future capability)
  - Nd:Yag (1.06 nm)
  - CO2 (10.6 nm)
  - HeNe (635 nm)
TEST CONFIGURATION AND CONDITIONS: The test can be conducted using the provided hardware/electronic components (source contaminant), which would be placed inside the Knudsen-Cell type sample heat exchanger, inside the test chamber.

- Pressure: < E-05 Torr
- Three Quartz Crystal Microbalances
  - Independent temperature control
- Sample heat exchanger continuously variable to simulate mission operational temperature profile
Conclusions

- JPL has capabilities and expertise to successfully address contamination issues presented by space and habitable environments
- JPL has extensive experience fielding and managing contamination sensitive missions
- Excellent working relationship with the aerospace contamination control engineering community

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