Contamination Control for Interplanetary Spacecraft

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Overview

- Comparison of CC for interplanetary missions with Earth orbiting missions
- Specific examples of CC for interplanetary missions
- Future CC issues for interplanetary missions

Unique aspects

- Guidance sensors need to work for extended durations
  - multiple maneuvers (e.g. tcm's)
  - often long after launch (e.g. orbital insertion at another planet)
- CC close to the sun (<1 au)
- Planetary Protection
- Other CC historical matters

Commonality

- Particles
- Molecular contamination
- Spacecraft instruments usually most sensitive

Particles in FOV of guidance sensors

- Particles released from surfaces and by separations / deployments
  - surface release mostly μmeteoroid impact
  - thermal (diurnal) cycling not present for 3-axis s/c or small far from sun for spinner
  - separations issue common to Earth & interplanetary missions
- Particles may stay near s/c
  - no orbital (non-inertial) "forces"
  - electrostatic fields and charges may be static

Particles in FOV of guidance sensors

- Effects
  - ➢ incorrect attitude for a maneuver (common to Earth orbiters & interplanetary s/c, e.g. TDRSS)
  - ➢ overuse of attitude control gas
    - Mariner 10 (Venus and Mercury)
  - ➢ false star sighting long-term history
    - Voyager (Jupiter, Saturn, Uranus & Neptune)
- Corrective measures
  - ➢ cleaning
  - ➢ software and flight operations changes

CC close to the sun

- Thermal control more sensitive to changes in solar absorptance α from molecular contamination
- UV photolysis (darkening) of deposition more prevalent
- Increased outgassing
  - ➢ possibly balanced by lower collection rates
  - ➢ but not for cold instruments

CC close to the sun

- Effects
  - ➢ spacecraft overheating
    - Magellan (Venus)
  - ➢ decrease in solar array output
    - Magellan
- Corrective measures
  - ➢ better CC, especially bake-outs
  - ➢ better mission design

Planetary Protection

- Protection of other solar system bodies from terrestrial contamination (to avoid precluding search for life)
- Has been the principal driver behind CC for interplanetary spacecraft (esp. for particles)
- Now stringent requirements only for Mars and Europa

Planetary Protection

- novel form of contamination - microorganisms
- control mostly by traditional (particle) contamination control methods
  - clean rooms
  - garment requirements
- "cleaning" can be common (alcohol wipe) or different (sterilization)
- verification of cleanliness unique (bio-assay)

Other CC historical matters .

- Galileo
  - engine plume contamination analysis for cyclically varying geometry with spun/ despun bus
  - data commutator lubricant contamination
- Mars Observer
  - possible contamination issue, preventing check valve in propulsion system from sealing properly

Future CC issues for interplanetary missions

- Planetary Protection also requires protection of Earth from potential extraterrestrial hazards
  - Mars sample return is being planned (again)
  - contamination of returned sample by biogenic materials (amino acids, carbohydrates, etc.) or dead "bug bodies" will confound science and possibly keep the sample in quarantine
  - cleaning without organic solvents for sample handling hardware (flight and GSE) is required

Future CC issues for interplanetary missions

- Very small spacecraft
  - molecular contamination sensitivity unknown, should be studied (but very small budgets)
  - more sensitive to particles
  - probably difficult to clean