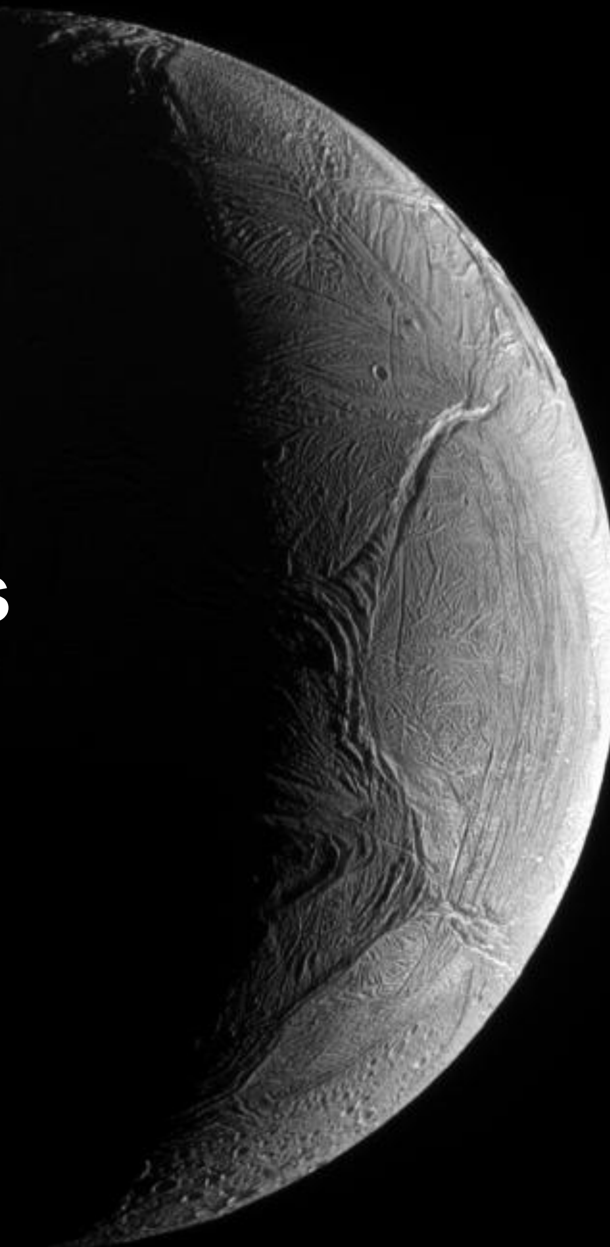
Jet Propulsion Laboratory
California Institute of Technology

# JPL Planetary SmallSats



SmallSat Reliability TIM
February 14, 2017
John D. Baker

# Why Small Planetary Spacecraft?

*Perform targeted science while demonstrating new instruments and small spacecraft capabilities.*

*Go new places*

*Increase the frequency of Science missions*

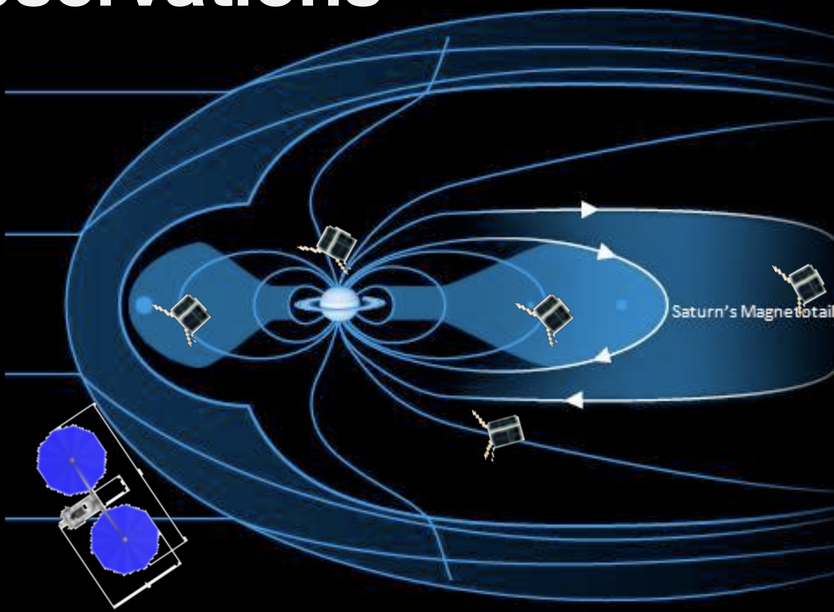
*Validate instrument and S/C technologies*

# Science Pull for Planetary CubeSats

- **Science enablers**
  - Distributed measurements for dynamic processes
  - Impactor/observer architecture (cooperating assets)

- **High-risk, high-reward observations**
  - Access to unique vantage points
  - Risk assessment by sacrificial probe

- **Break new ground**
  - Exploration of uncharted regions



# Priority Planetary Science Measurements

*that can be done with cubesats*

- Imaging
- Volatile detection
- D/H ratio
- Atmospheric composition
- Atmospheric density
- Organic detection
- Surface composition
- Magnetic fields

*…this is only after working on this for 3 years.*

# Planetary Decadal Science Mapping and Instrument Availability

| THEME | KEY MEASUREMENTS | OBSERVATION STRATEGY | NANO/SMALLSAT-COMPATIBLE INSTRUMENTS GLOBALLY |
|---|---|---|---|
| **Origins** | Isotopic, elemental, mineralogical composition | In situ (atmospheres, surface) | APXS, **mini-TLS**, **IR spec**, Raman, LIBS, **Submm spec**, **UV Spec**, Gamma ray spec, Dust spec, **Mass Spec** |
| | | Returned sample (small bodies) | Sample Return Capsule *(possibly Acquisition as well)* |
| **Planetary Habitats** | Volatile, organics composition, endogenic activity, heat budget, env | In situ, distributed network, subsurface (e.g., penetrators) | **Mass Spec**, micro-XRF, Geophysics Inst., imaging, IR spec, **mini-seismometer** |
| **Processes** | Atmospheric structure, dust, fields, geology | Close proximity, in situ, distributed networks | Cameras, IR spec, Mag, Transponders, Langmuir probes, **Mass Spec, mini-TLS**, dust counter, plasma |
| **Human Exploration (SKGs)** | Dust, fields, radiation, Dynamical properties, Mechanical properties, ISRU (composition) | Close proximity, in situ, extreme environments | Dust Counter, imaging, APXS, Geophysics Inst., accelerometers Subsurface probing, neutron spec, IR spec, radar sounder, **mini-seismometer** |

Green = exists Orange = in development (underline=@JPL) Red = does not

J. Castillo-Rogez

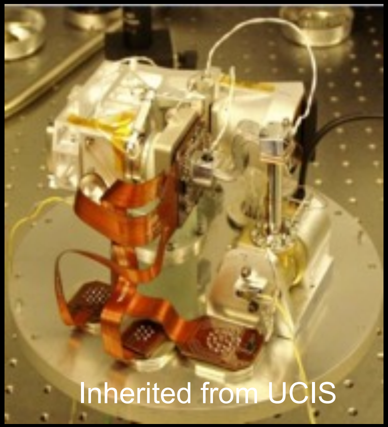
# New Miniaturized Science Grade Instruments

**QIT-MS**
**JPL**

**Quadrupole Ion Trap Mass Spectrometer**

2.5 kg, 2U, isotopic accuracy <1%, leverages foldable edge-connected electronics

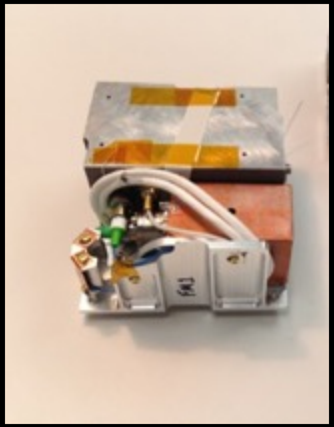
**SWIS**
**JPL**




**Snow and Water Imaging Spectroscopy**

High-throughput, low-polarization, high-uniformity spectrometer, 350-1700 nm spectral range

**MAG**
**JPL**



**Advanced Vector Helium Magnetometer**

Comparable performance to Cassini magentometer (***Now being used by Europa)***

**Imager**
**NASA**

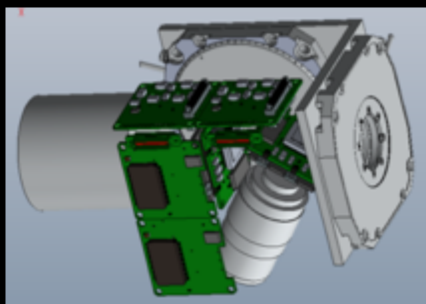
**High-Resolution Visible Camera**

Used for science, optical navigation, and Autonomous Navigation demonstration

*Tested/developed for CubeSats, extensible to larger missions*

# Science Grade Instruments in Development

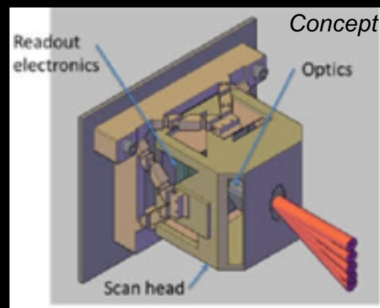
**Mini-APIC**
**JPL**



### Advanced Pointing and Imaging Camera

2.5 kg, 2U, Co-aligned narrow angle camera (NAC) and star camera; High res NAC with ≤50 μrad image resolution, 8º FOV; Star camera with 12º FOV and absolute pointing knowledge; 2-DOF actuation with sub-pixel-level pointing knowledge over ±60º scan range;

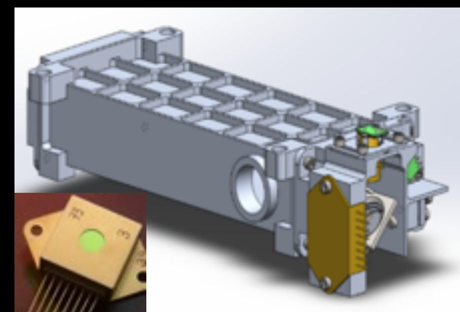
**Point Spectrometer**
**JPL**




### SWIR-MIR Point Spectrometer

2U, Point spectrometer for simultaneous identification and characterization of $OH/H_2O$ and silicates for surface volatile detection.

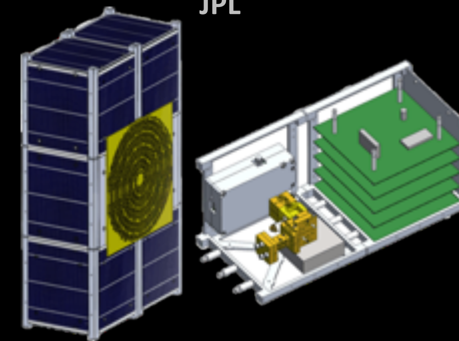
**Mini-TLS**
**JPL**



### Tunable Laser Spectrometer

2U, miniaturized 2 channel tunable laser spectrometer for compositional analysis with 5-10x increase in sensitivity and 5x reduction in power

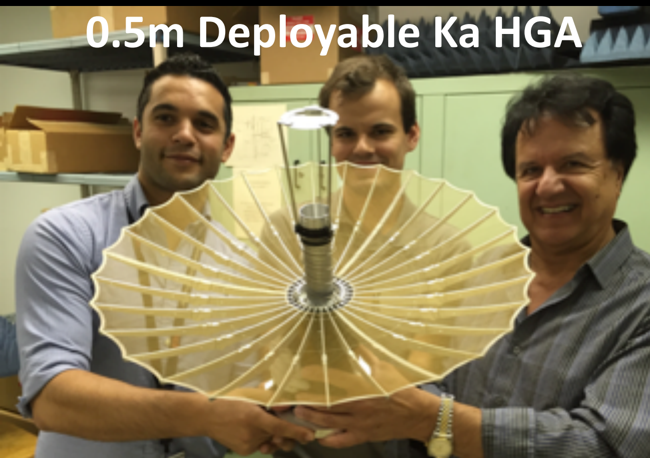
**Mini-Submm Spec**
**JPL**



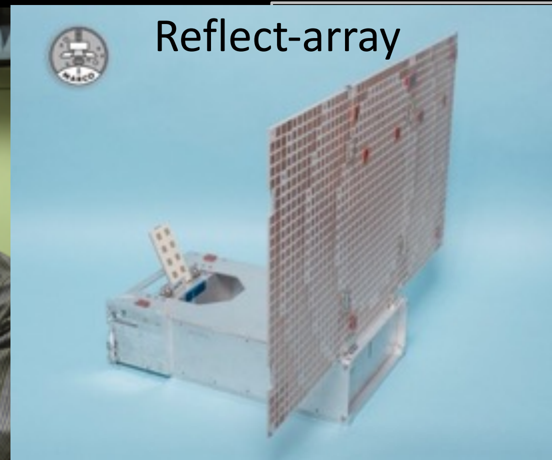
### Submillimeter-wave Spectrometer

2U, *D/H ratio measurement on comets* and *Limb sounding to characterize planetary atmosphere* (distribution of gases, temperature profile, and gravity waves); CMOS synthesizer and wideband receiver operating from 440 GHz to 600 GHz and integrated flat antenna with compact waveguide calibrator.

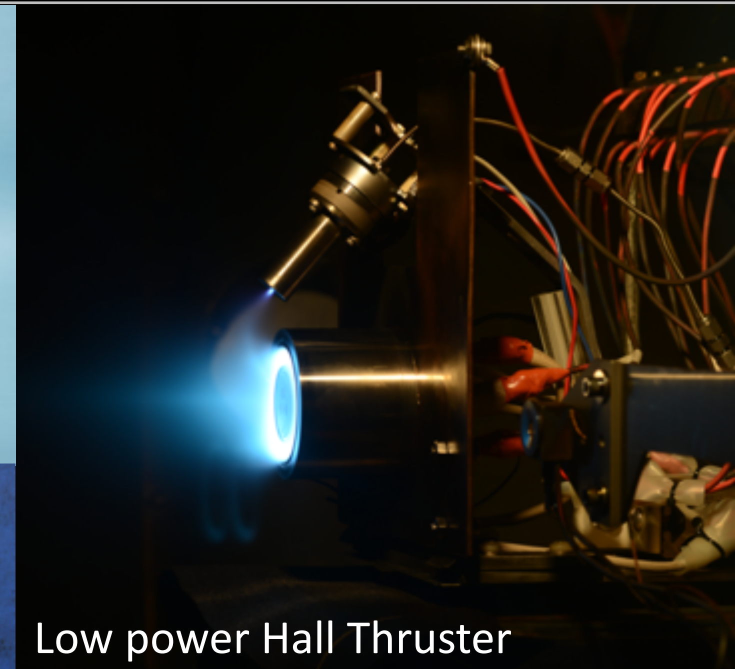
# Current JPL Planetary SmallSat Capabilities



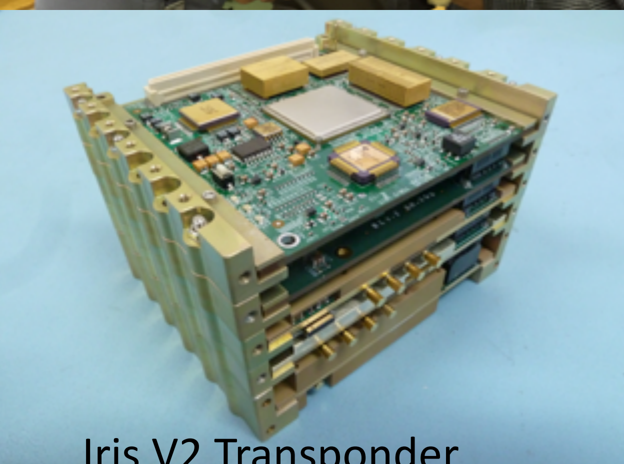
0.5m Deployable Ka HGA



Reflect-array



Low power Hall Thruster



Iris V2 Transponder


LEON 3 FT Computer 'Sphinx'

Propulsion

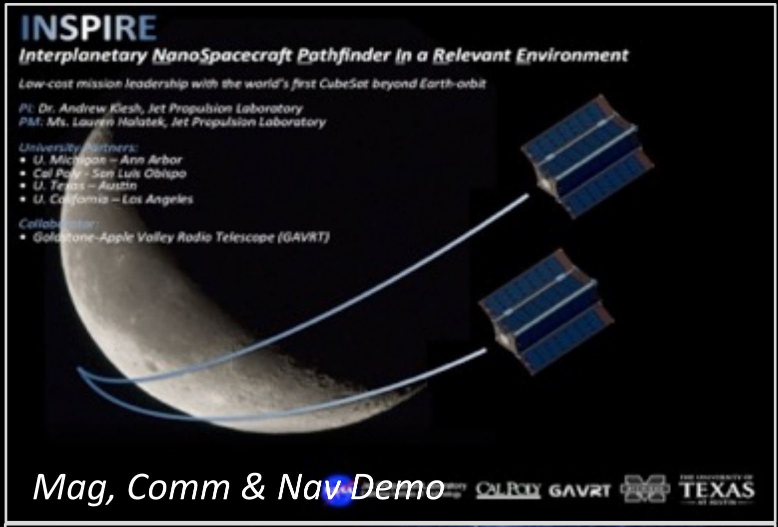

Cold gas

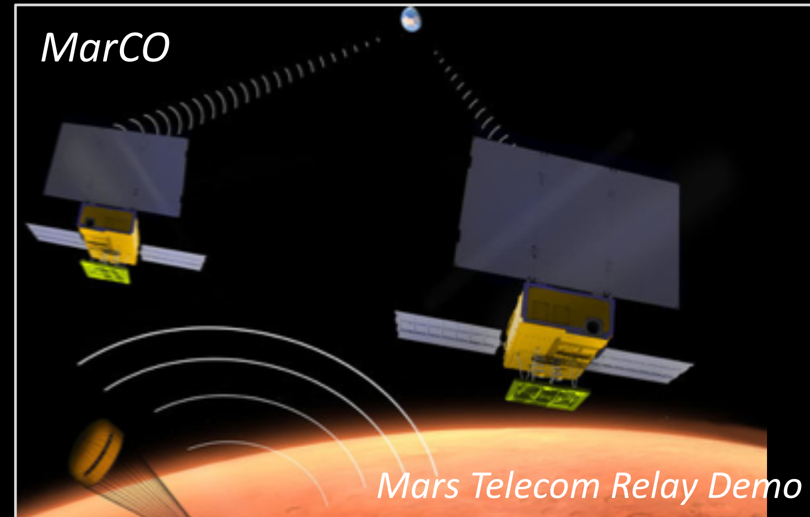
# Planetary SmallSat Mission Challenges

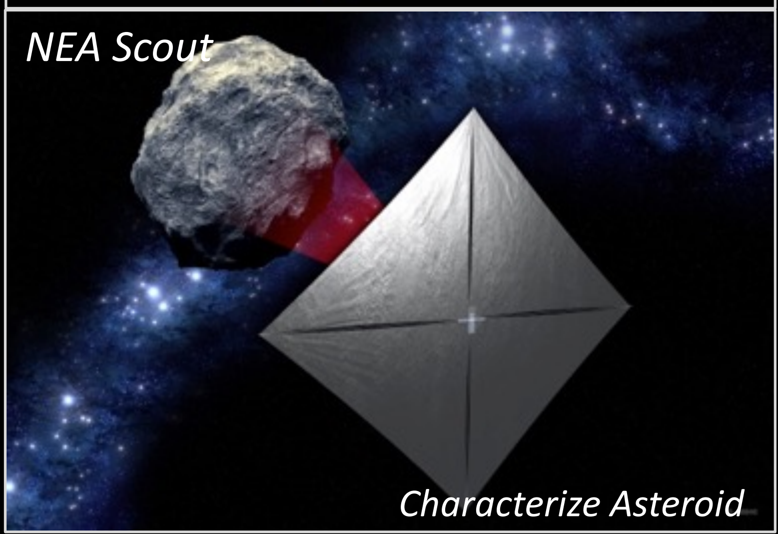
*Unique from LEO*

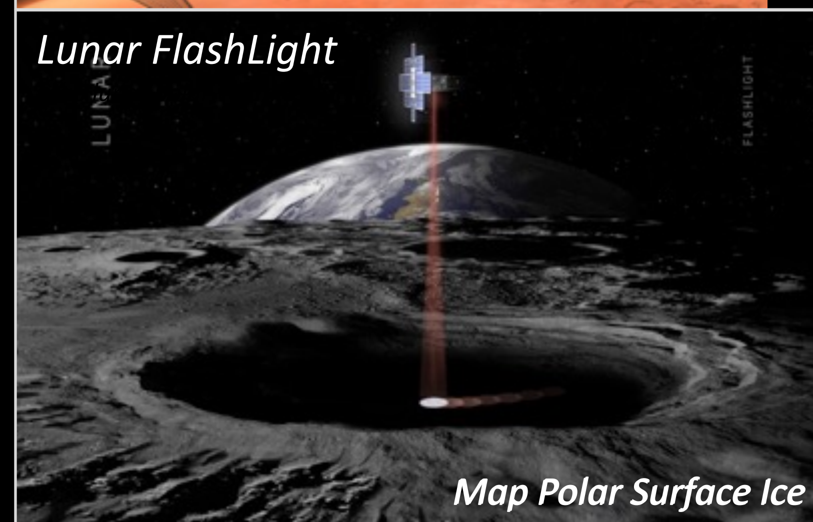
- Beyond the Earths Magnetosphere
  - Increased Galactic Cosmic Radiation
  - Increased Solar Particles
- Thermal environments
- Longer distances
- Limited communication

# In Development…




| | | | | | |
|---|---|---|---|---|---|
| Bio-Sentinel (ARC) | Lunar IceCube (MSU) | Luna-H (ASU) | CUSSP (SWRI) | MSU DSN Ext | PSDS3 Studies |