Current efforts in the development of telecommunication technologies and services for future interplanetary CubeSat missions

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Introduction

- Currently, an increasing number of interplanetary missions is being planned and proposed.
- As these missions become increasingly popular, several parallel efforts are being performed to overcome one of the key bottlenecks in CubeSat exploration using small platforms: telecommunication.
- As the communication range increases, being able to provide a reliable communication link is always a challenge and it can strongly condition how the mission is designed and operated.
- This poster aims to provide an updated review of the current status of technologies in development to provide telecommunication services to future interplanetary missions.
- Recently, JPL Interplanetary Network Directorate commissioned a study related to the support of interplanetary small satellite missions. The main results of this study are included in a paper presented at the Calpoly CubeSat Workshop. Part of this poster refers to the results of the study.

Telecommunication Modelling (TeamXc)

TeamXc is a facility for rapid development of mission concepts for Cubesats and small satellites.
A telecommunication model specifically tailored for small spacecraft was developed to handle: LEO and interplanetary missions, single satellites and constellations
The model features: Link analysis (Excel), Coverage analysis (STK-Matlab), and components selection.

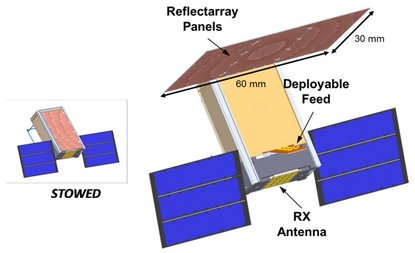
IRIS Radio

- Development began in 2013 in support of JPL's INSPIRE
- Iris occupies 0.4 U volume with a 0.4 Kg mass
- Iris has RF slices for X-Band and UHF.
- Supports CCSDS AOS framing, Turbo and convolutional coding.
- Data rates from 62.5 to 256,000 bps in downlink .
- Navigation support includes coherent Doppler, ranging, and Delta-Differential One Way (Ddelta-DOR) tones.
- DSN compatibility for version 1 has been formally verified at DTF–21
- Iris Version 2 supports three sets of transmit and receive antennas, and it is intended for longer duration missions, up to 2.5 years.

Antennas

REFLECTARRAY

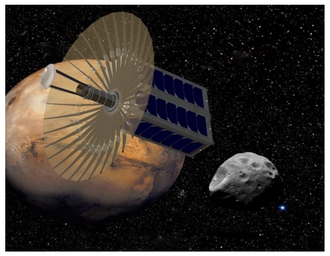
- Team: JPL (N. Chahat/R. Hodges)
- X-band antenna
- Antenna gain: 29.1 dBi (TX)
- Stowage volume: 2x20x30 cm (6U)
- Az beamwidth: 4.0°
- El Beamwidth: 7.0°

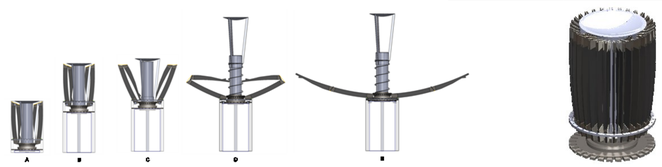


Courtesy: N. Chahat, R. Hodges (JPL/Caltech)

KaPDA- DEPLOYABLE

- Team: JPL (M. Thompson / J. Sauder / N. Chahat)
- Ka-band antenna
- Antenna gain: 42.5 dBi
- Stowage volume: 1.5U
- Az/El beamwidth: 1.2°

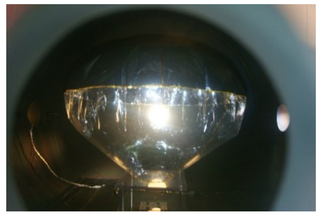


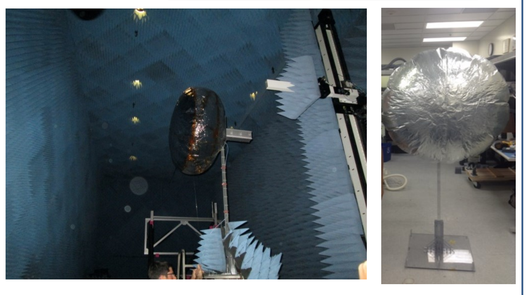


N. Chahat, J. Sauder, *et al.*, "CubeSat deployable Ka-band reflector antenna for deep space missions", IEEE MTT 2015.

INFLATABLE

- Team: JPL (A. Babuscia, R. Hodges, J. Sauder, L. Jones), MPI (J. Welinski), ASU (Prof. J. Thangavelautam)
- X Band antenna
- Antenna gain: 34 dBi
- Stowage volume: 0.5 U
- Az/El beamwidth: 4°
- Inflation: sublimating powder
- Advantage: high scalability





Figures: Inflatable antenna tests (Vacuum, Anechoic , Leakage)

DSN Support and GDS

- DSN (13 antennas) provides communications and tracking services for the commanding, telemetry, and monitoring of the health and safety of deep space spacecraft.
- Interplanetary SmallSat missions are typically highly cost-constrained, and might not be able to afford the traditional high-end communications and tracking services provided by the DSN.
- To reduce DSN costs for the interplanetary SmallSat missions, the Interplanetary Network Directorate (IND) is considering:
  - A number of variations on the MSPA schemes
  - CubeSat tracking packages. These package deals provide one price , including all of the standard services included in the DSN aperture fee.
  - A reduced pre-launch testing when a CubeSat mission consists of several spacecraft

One possible solution to guarantee support is the partnership of DSN with additional high gain ground stations operated by universities and other centers.
One example is the Morehead State 21 m dish.

Morehead dish. Courtesy of. B. Malphrus

- The Advanced Multi-Mission Operations System (AMMOS) provides ground data system functions needed to design, implement, and operate a Mission Operations System (MOS).
- AMMOS Multi-mission Data Processing and Control System (AMPCS) was adapted for interplanetary small satellites starting with INSPIRE.
- AMPCS allows to command and monitor their spacecraft in a way that is compatible with the DSN supported interfaces and protocols.

Future Work

Future efforts will focus on: miniaturization of components, migration to higher frequencies, development of multiple access schemes (ongoing work in CDMA), routing schemes for multi-hop communication, cooperative communication techniques.

Acknowledgment

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