Nodes: A Flight Demonstration of Networked Spacecraft Command and Control

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John Hanson, Jasper Wolfe, Ali Guarneros Luna, Ken Oyadomari, Rodolphe DeRosee, Cedric Priscal, Watson Attai

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Nodes Mission Summary

### Mission Goal

<table>
<thead>
<tr>
<th>Mission Goal</th>
<th>Req'd</th>
<th>Ach’ved</th>
</tr>
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<tbody>
<tr>
<td>Space-to-Ground Links</td>
<td>5</td>
<td>10+</td>
</tr>
<tr>
<td>Ground Command of S/C through Network</td>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td>Perform Captaincy Negotiation</td>
<td>2</td>
<td>4</td>
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<tr>
<td>Collect Science Packets &amp; Transfer to Ground</td>
<td>5</td>
<td>1,199 as of 7/27/16</td>
</tr>
<tr>
<td>Monitor S/C state-of-health</td>
<td>20 days</td>
<td>72 days and counting</td>
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</tbody>
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5/16: Deployed

5/17: First Beacon Contact

5/18: First S-band Contact

5/18: First Cmd Uplink

5/18: First Xlink

5/21: First Cmd Execution

5/27: Final Xlink
Based on Existing EDSN Designs/Hardware

- 1.5U solid Pumpkin Chassis
- Smartphone as main processor
- 6 Solar Panels
  - 4 identical 1.5U panels with 35 cells
  - 2 identical 1U panels with 15 cells
- MicroHard transceiver for S-Band downlink
- Lithium UHF transceiver for space-to-space
- StenSat UHF transmitter for beacon
- 4 RF Antennas
  - GPS and S-band patches on 1U faces
  - Lithium and beacon monopoles off 1.5U faces
- EPISEM radiation monitoring payload
- 4 18650 Li-Ion Batteries
- ACS – magnetometer and torque coils
- Novatel OEMV-1 GPS receiver
- 9 PCB subassemblies electrically inter-connected through a single backplane PCB
Nodes Mission Objectives

- Flight demonstrate the **commanding of a satellite through a network of satellites** by transferring a command from the ground through a relay satellite to a target satellite and having the target satellite execute the command.

- Flight demonstrate the ability of a swarm to **autonomously negotiate** which spacecraft shall take the role of leader (Captain) based on criteria dependent on the states of the two satellites.

- Collect and downlink time synchronized multipoint science data using EPISEM instrument.
Simultaneous Multipoint Science Data Collection

- Both spacecraft get a GPS solution
- Activity Timeline Created
- Spacecraft collect EPISEM data simultaneously
Simultaneous Multipoint Science Data Collection

Crosslink session starts at preloaded UTC's

Lieutenant turns on UHF receiver at specific local clock time, corrected to UTC
-> Low power solution
Simultaneous Multipoint Science Data Collection

Captain requests data from Lieutenant
Simultaneous Multipoint Science Data Collection

Lieutenant Responds with Data
Simultaneous Multipoint Science Data Collection

Captain Sends Data to Ground Station

Mission Objective met 5/18/16
1,199 Packets Downlinked to Date
Autonomous Network Configuration

Captain Requests Negotiation Data from Lieutenant

Lieutenant Responds with Data
Autonomous Network Configuration

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Captain Promotes Lieutenant to Captain if Necessary

Lieutenant Acknowledges Promotion

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Mission Objective met 5/18/16
Four Negotiations Held
5/20/16: LT Promoted to CPT
Ground Commanding Through Network

Mission Objective met 5/21/16
11 Commands Executed by LT
Science with Swarms

- Probing Earth-Sun interactions with gradient measurements of magnetosphere properties
- Synthetic aperture radar
- Multi-point tomographic measurements
- Geopotential measurements
- Large sparse array telescopes
- Coronograph based missions
- Explore properties of other planets, comets and near-Earth objects

http://www.esa.int/.../About_Proba-3
http://mms.gsfc.nasa.gov/
http://gracetellus.jpl.nasa.gov/