Nodes: A Flight Demonstration of Networked Spacecraft Command and Control

Saturday, August 6th, 2016

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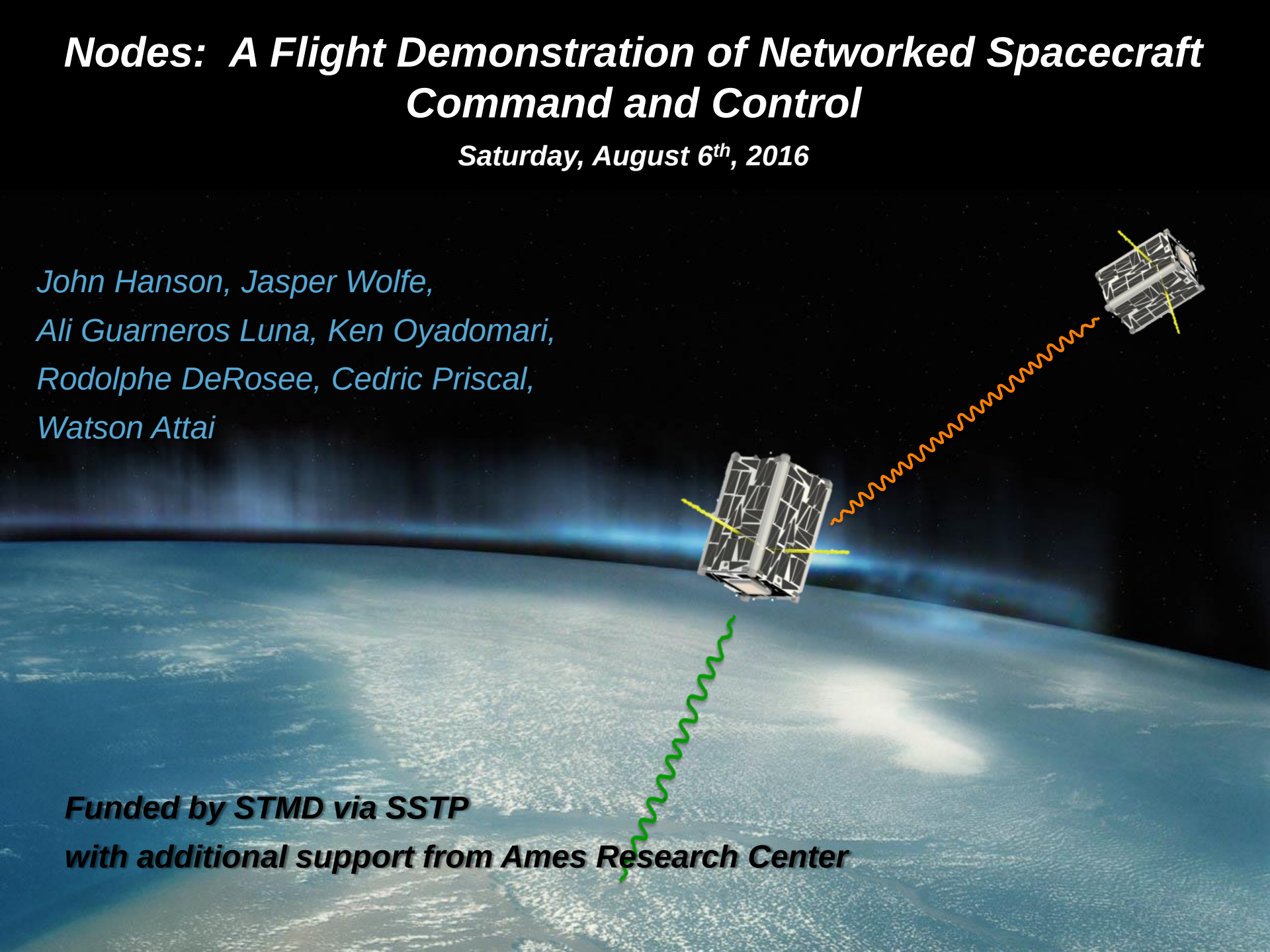

Funded by STMD via SSTP
with additional support from Ames Research Center

National Aeronautics and Space Administration

Ames

Discovery Innovations Solutions

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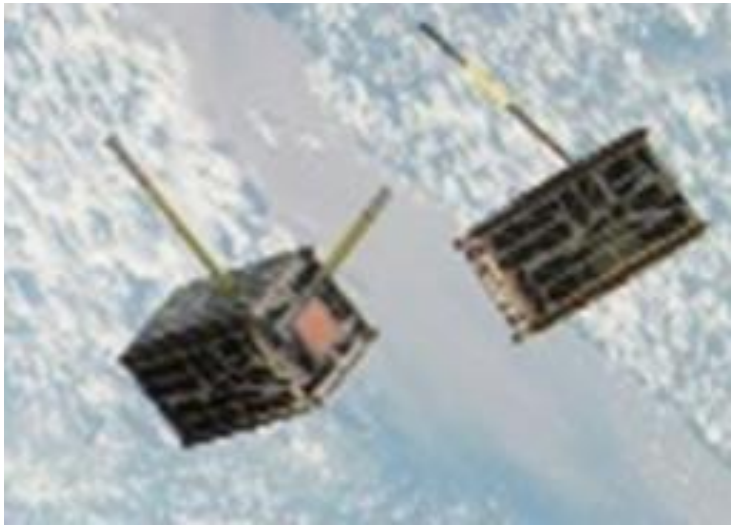
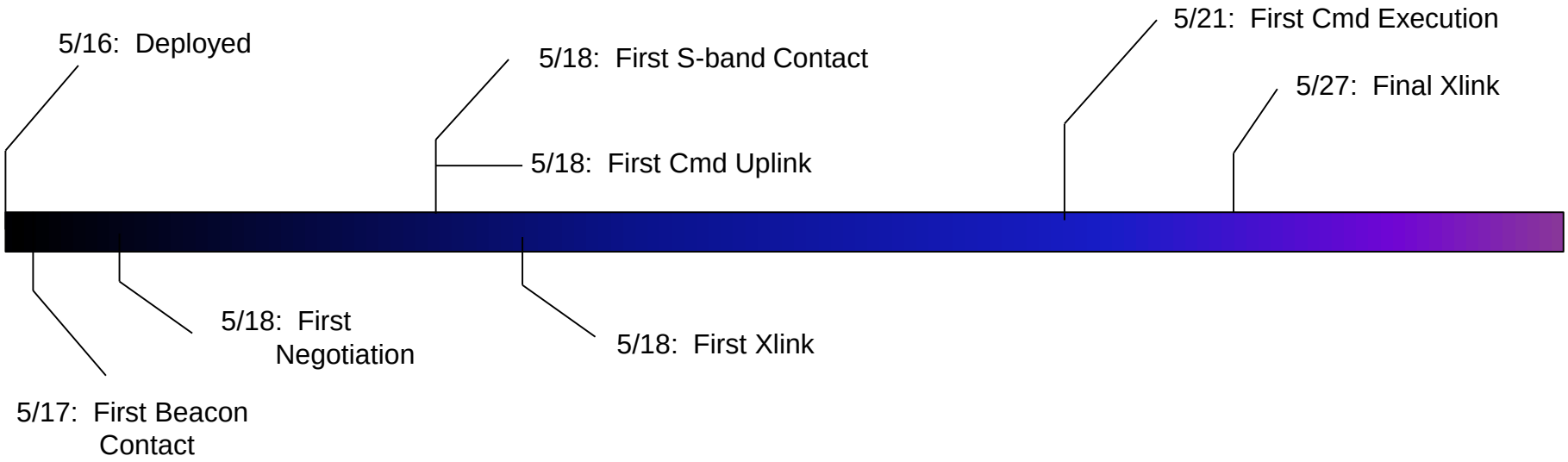
Nodes Mission Summary



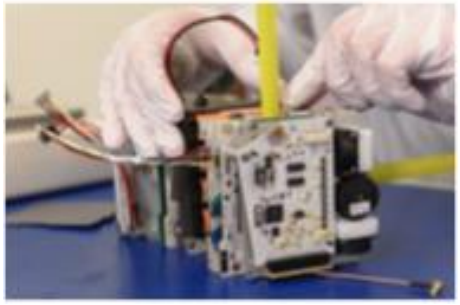
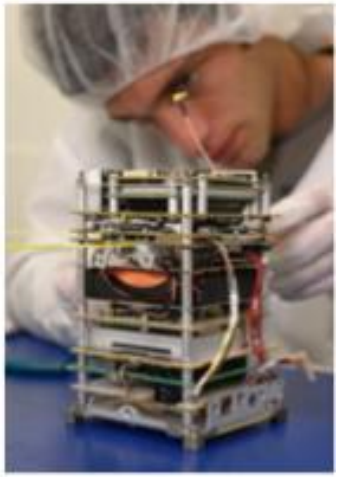
Mission Goal	Req'd	Ach'ved
Space-to-Ground Links	5	10+
Ground Command of S/C through Network	1	11
Perform Captaincy Negotiation	2	4
Collect Science Packets & Transfer to Ground	5	1,199 as of 7/27/16
Monitor S/C state-of-health	20 days	72 days and counting



Nodes Satellite Overview

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

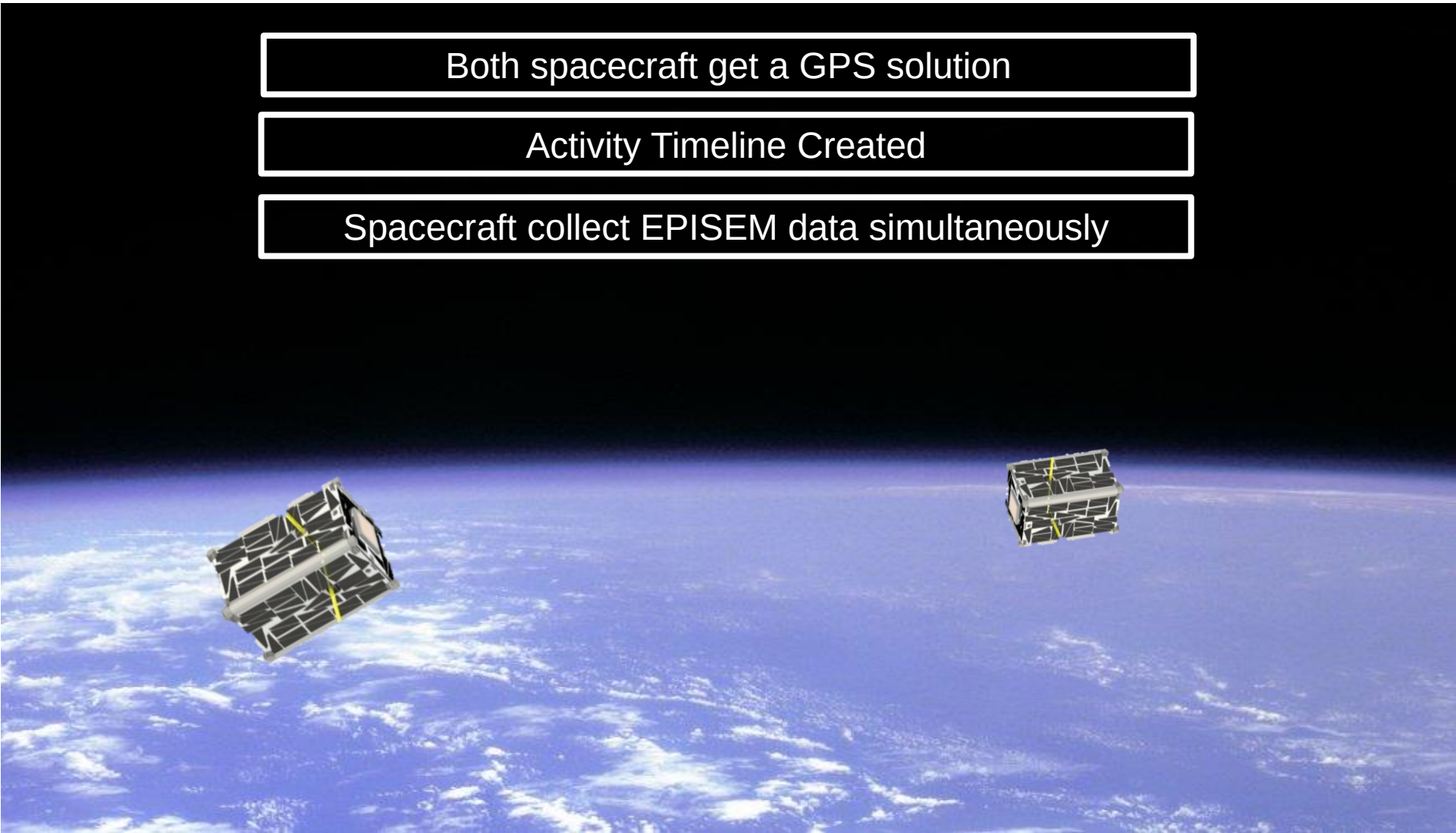
- **Flight demonstrate the commanding of a satellite through a network of satellites by transferring a command from the ground through a relay satellite to a target satellite and having the target satellite execute the command.**
- **Flight demonstrate the ability of a swarm to autonomously negotiate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

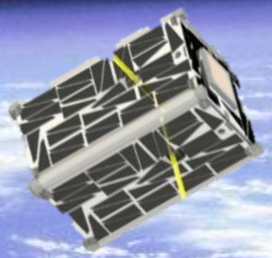
Spacecraft collect EPISEM data simultaneously

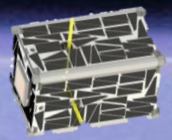


Simultaneous Multipoint Science Data Collection

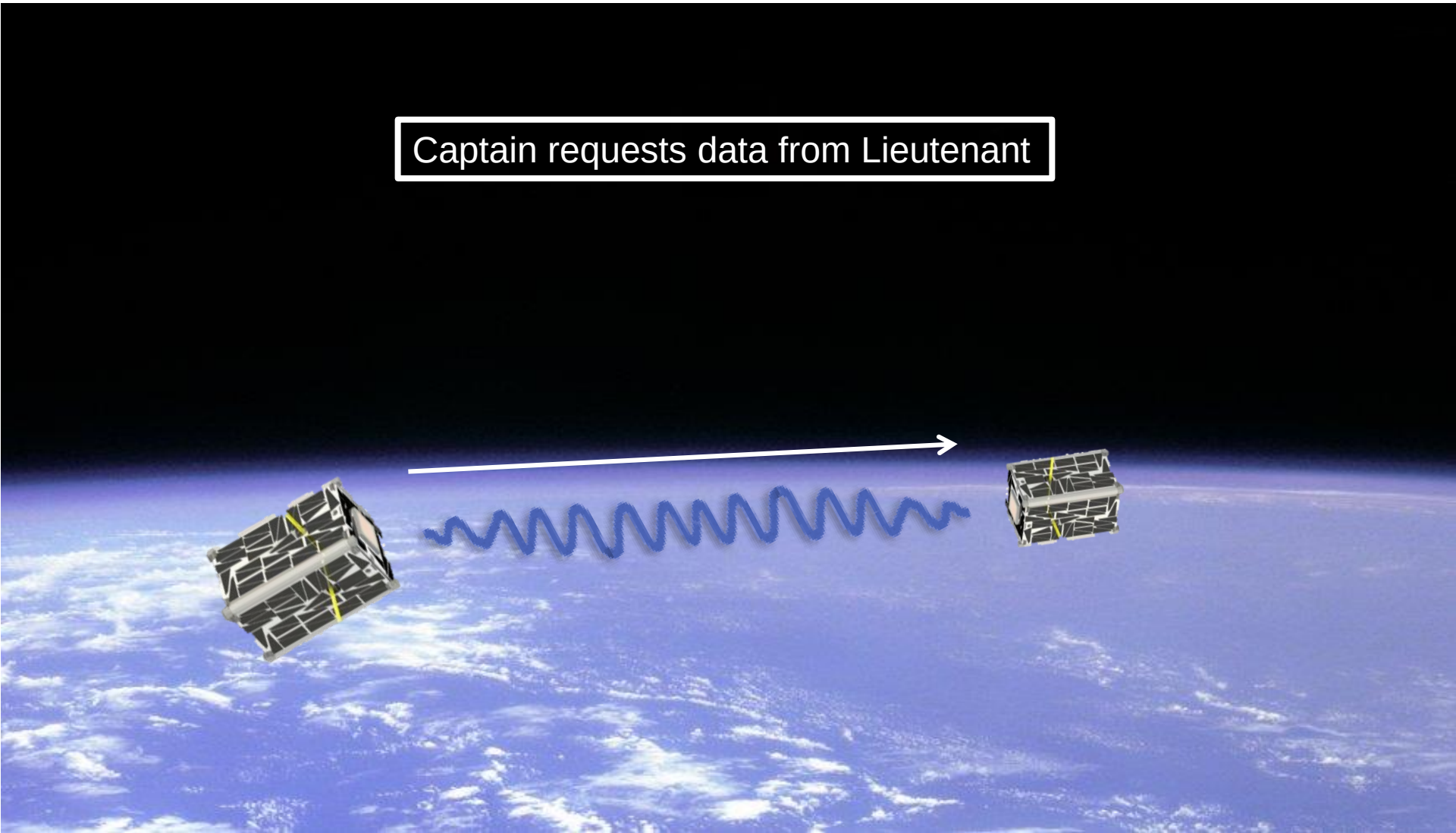
Crosslink session starts at preloaded UTC's

Lieutenant turns on UHF receiver at specific local clock time, corrected to UTC
-> Low power solution





Simultaneous Multipoint Science Data Collection



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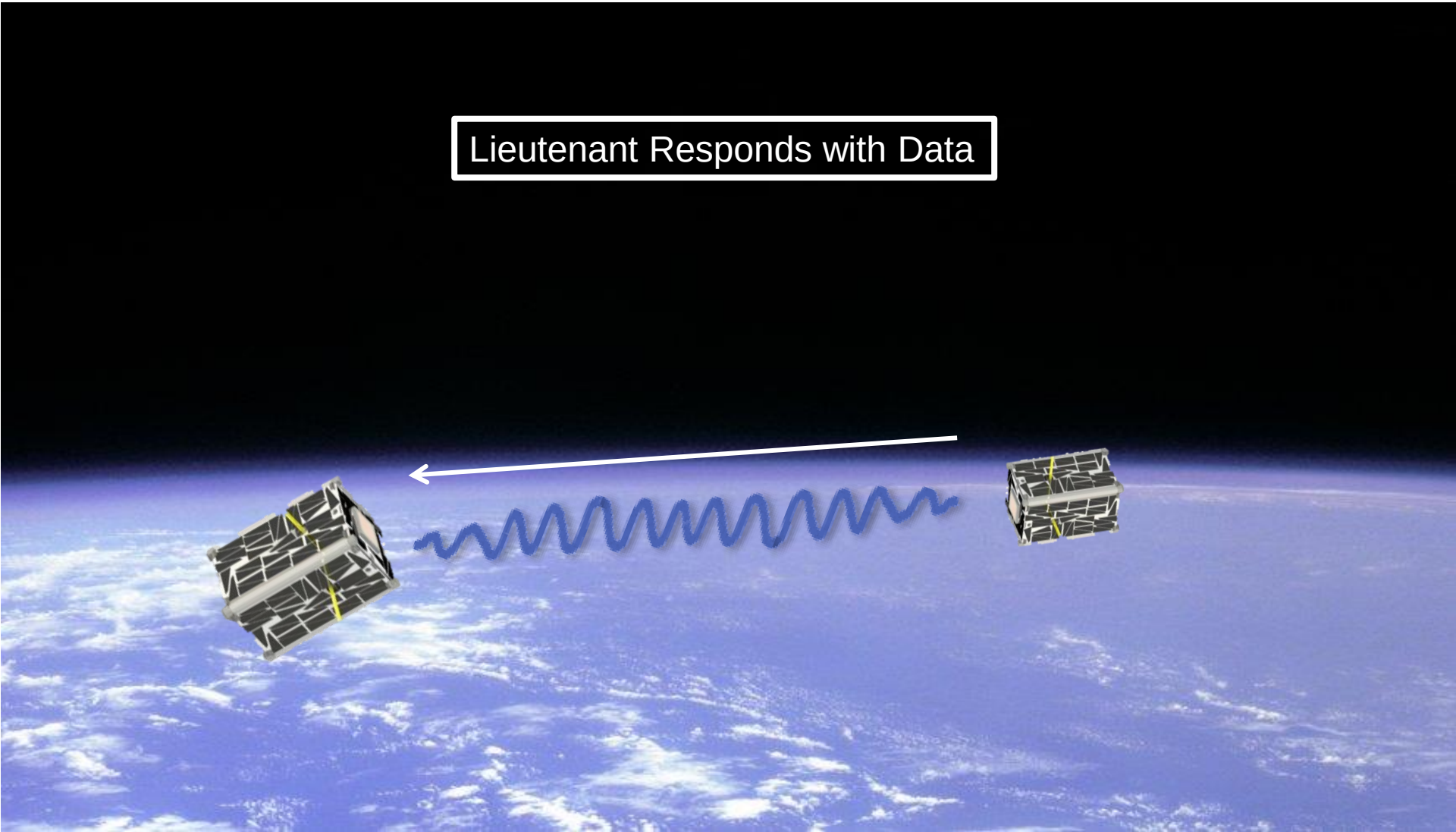
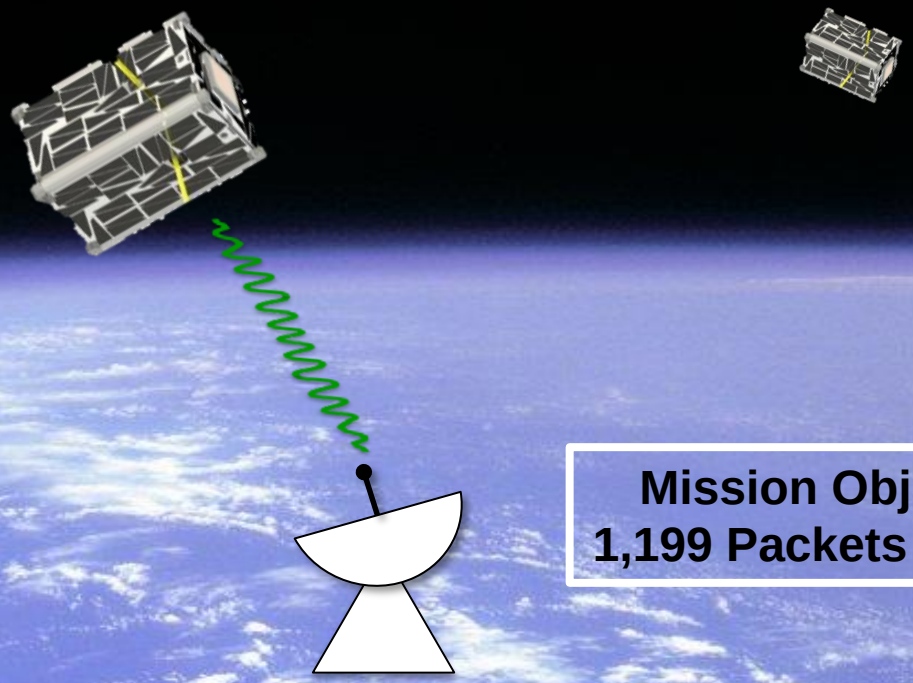


Simultaneous Multipoint Science Data Collection

Captain Sends Data to Ground Station

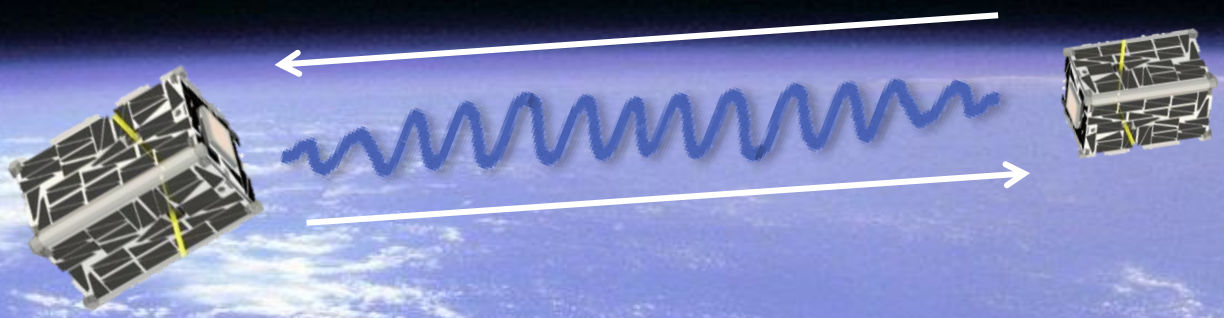


Mission Objective met 5/18/16
1,199 Packets Downlinked to Date

Autonomous Network Configuration

Captain Requests Negotiation Data from Lieutenant

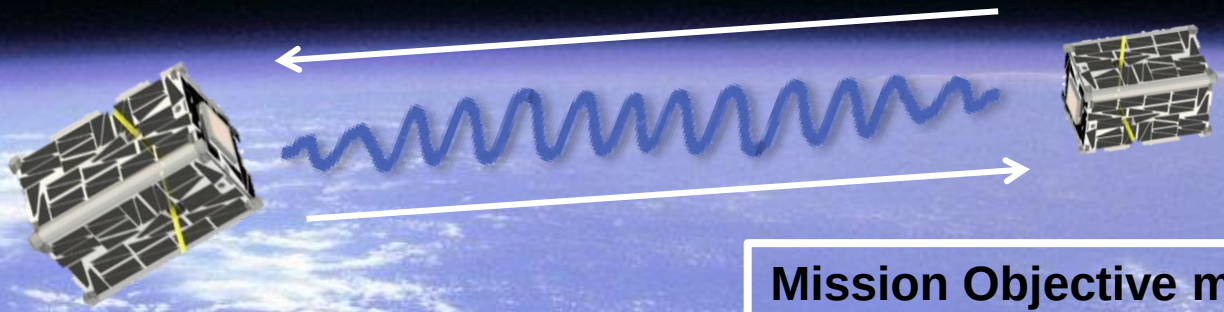
Lieutenant Responds with Data



Autonomous Network Configuration

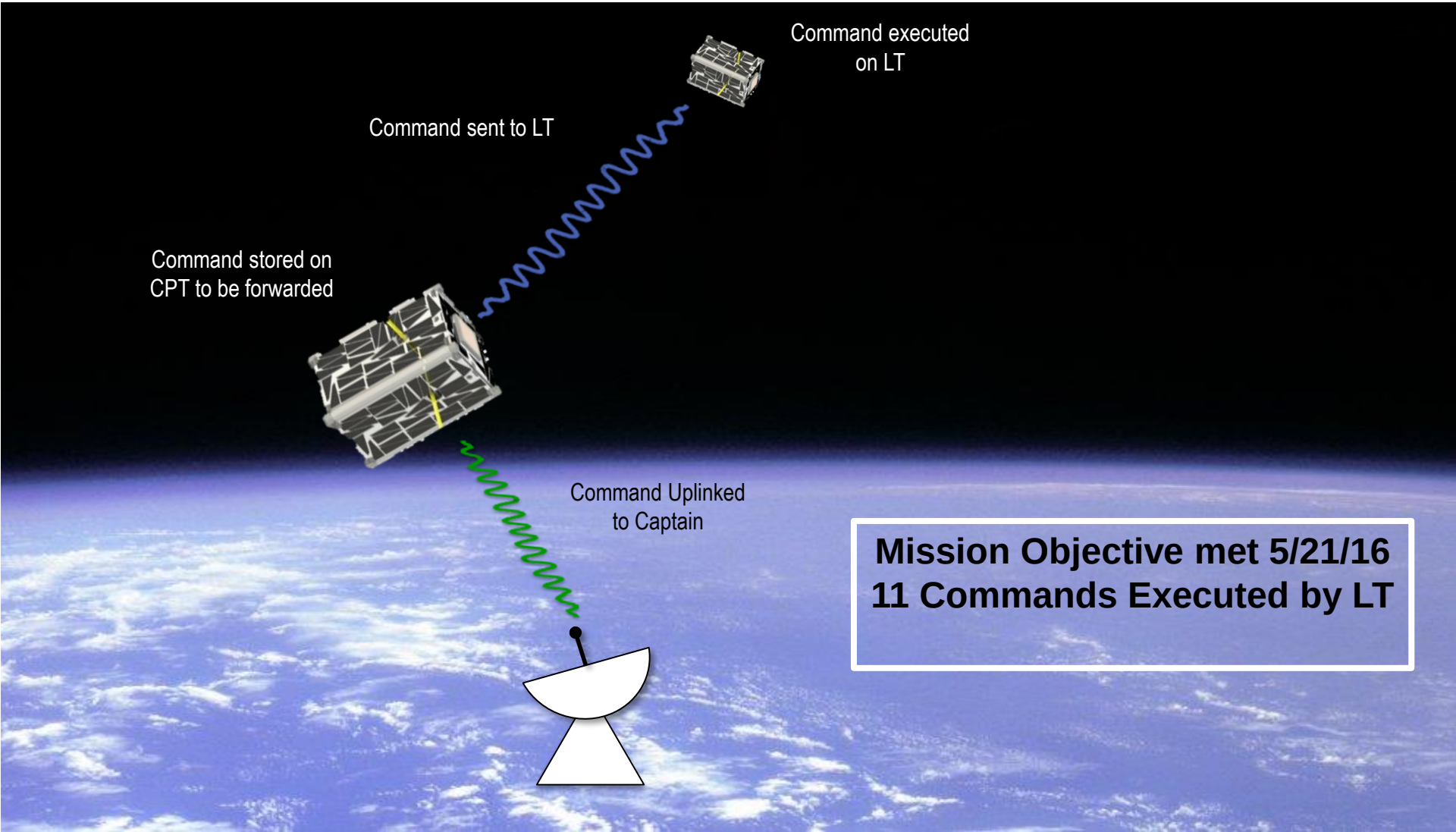
Captain Promotes Lieutenant to Captain if Necessary

Lieutenant Acknowledges Promotion



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

Ground Commanding Through Network



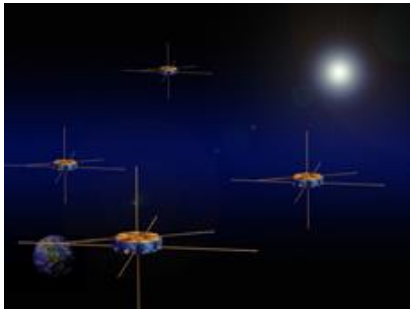
Mission Objective met 5/21/16
11 Commands Executed by LT

Science with Swarms

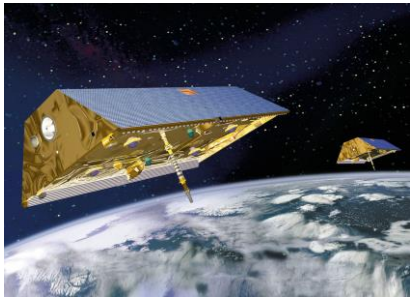
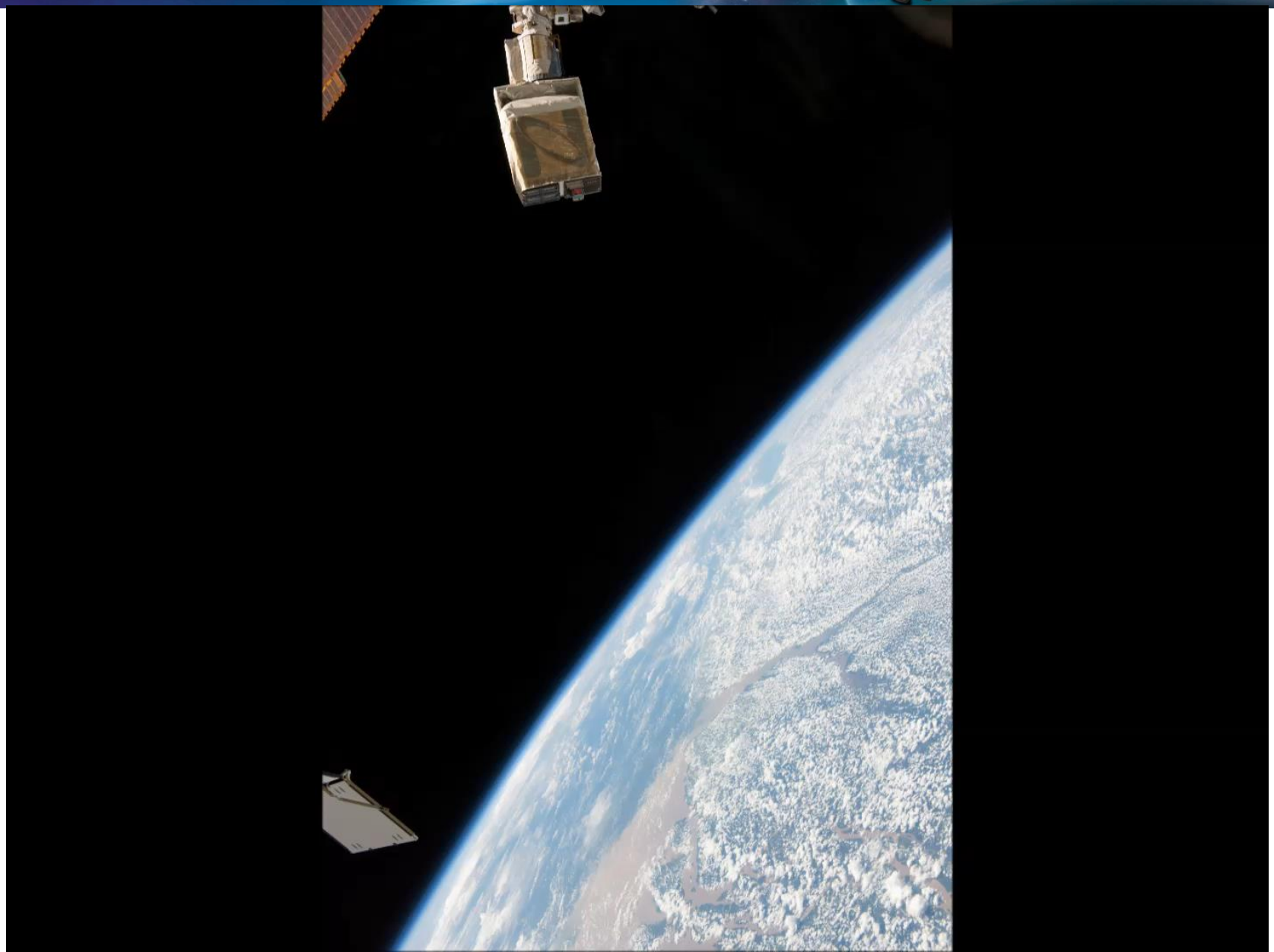
- Probing Earth-Sun interactions with gradient measurements of magnetosphere properties
- Synthetic aperture radar
- Multi-point tomographic measurements
- Geopotential measurements
- Large sparse array telescopes
- Coronograph based missions
- Explore properties of other planets, comets and near-Earth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

http://www.darpa.mil/.../System_F6.aspx

http://www.esa.int/.../About_Proba-3



http://mms.gsfc.nasa.gov/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