EDSN - Edison Demonstration for SmallSat Networks

The EDSN Intersatellite Communications Architecture

Sunday, August 2nd, 2014

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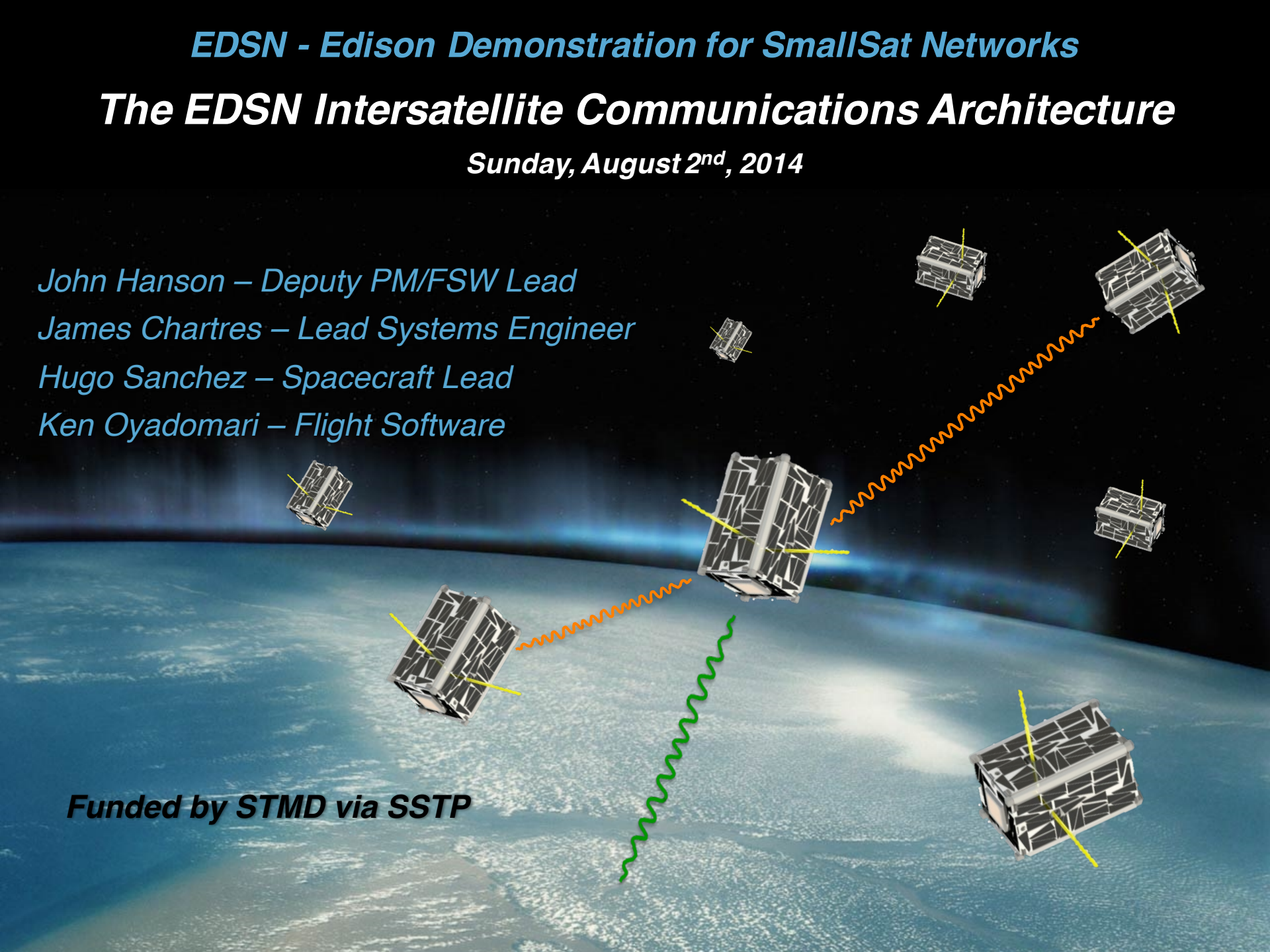
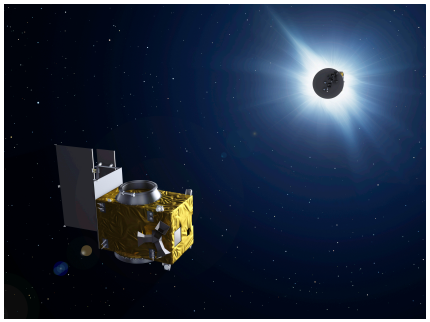


Funded by STMD via SSTP

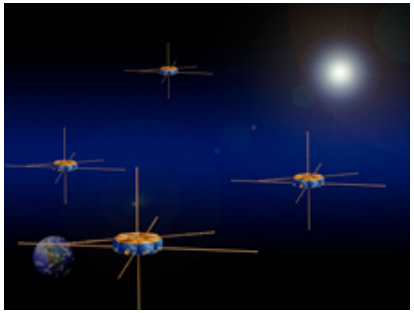
Science with Swarms

- 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

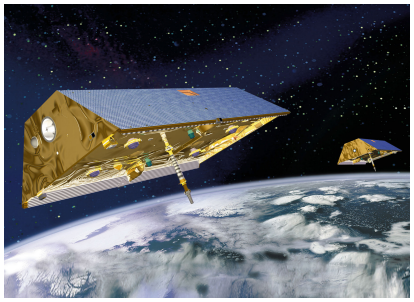
http://www.darpa.mil/.../System_F6.aspx



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



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

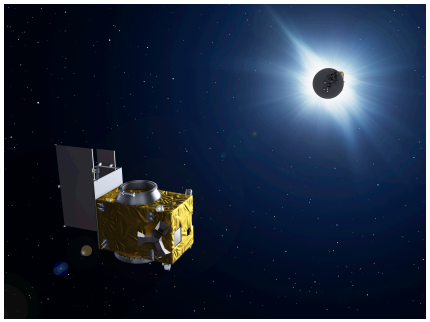


http://gracetellus.jpl.nasa.gov/

Cubesat Challenges

- Low electric power availability
- Limited ADCS hardware
- Ground support systems
- Maximizing available mass and power for payloads

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



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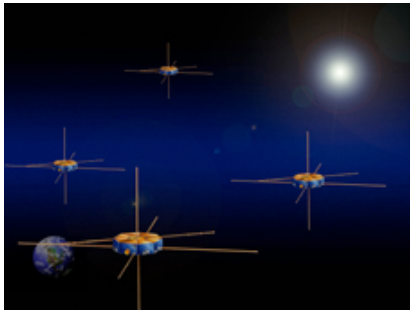

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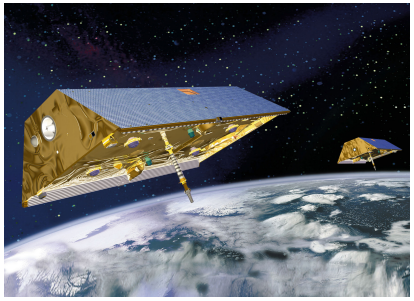

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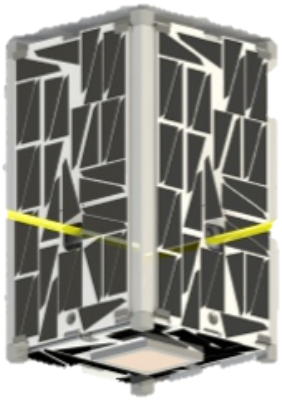


EDSN Mission Objectives

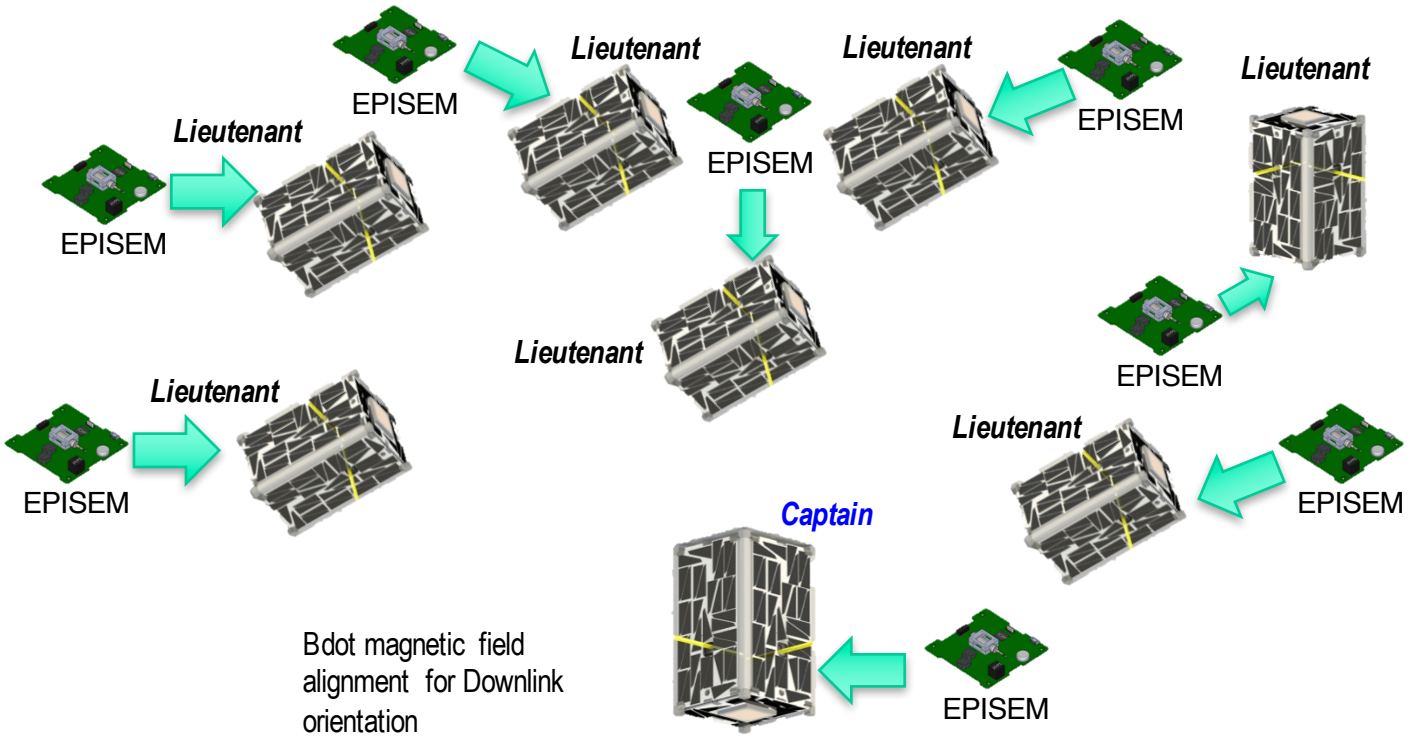
Mission Goal

Demonstrate that a swarm of satellites is capable of collecting multi-point science data and transferring the data to the ground

Mission Objectives

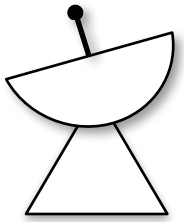
1. **Flight demonstrate one-way space-to-space data transfer whereby at least 2 satellites transfer data to a third satellite, which then transfers the data to the ground**
2. **Flight demonstrate a system to collect multi-point science measurements, transfer science measurements to another satellite and transfer to the ground**
3. **Flight demonstrate a reaction wheel based pointing system.**
4. **Assess the viability of satellites built with Commercial Off The Shelf (COTS) components to operate for 60 days**

Mission Overview



Bdot magnetic field alignment for Downlink orientation

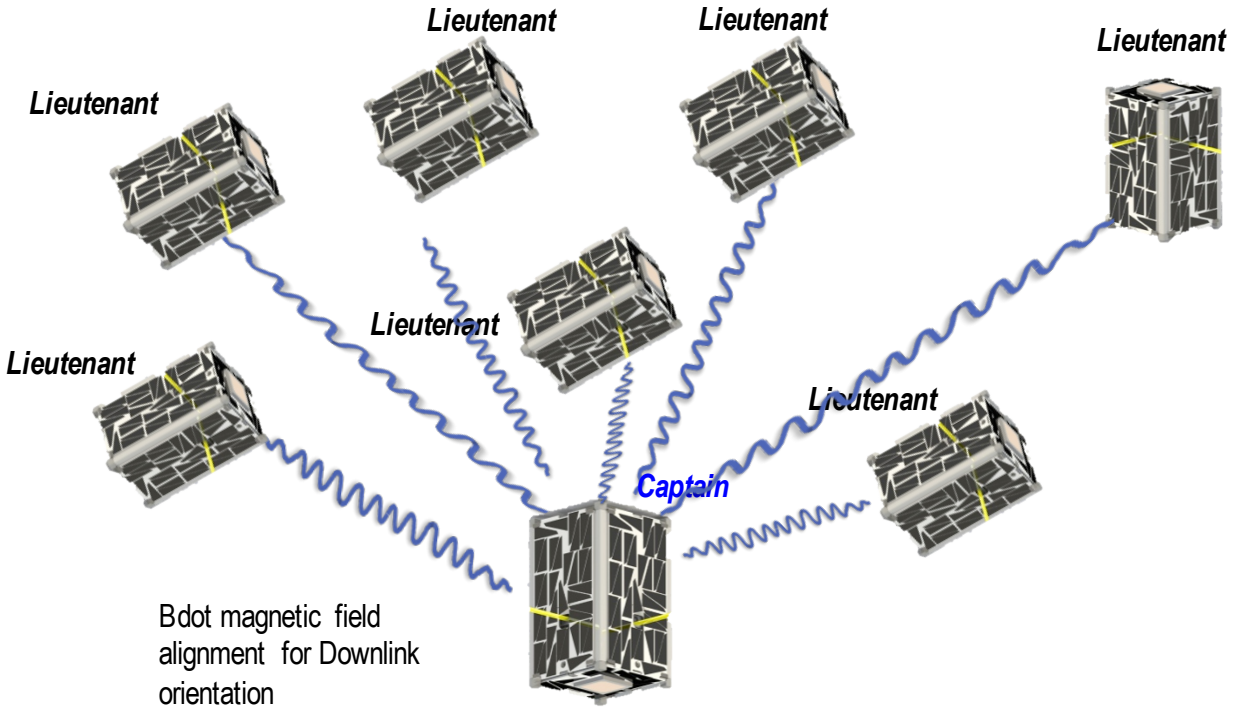
8x EDSN Satellites integrate into 2x NLAS Dispensers



Operations are autonomous

Activities are either time or time & position based

Mission Overview



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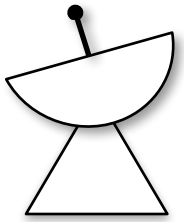

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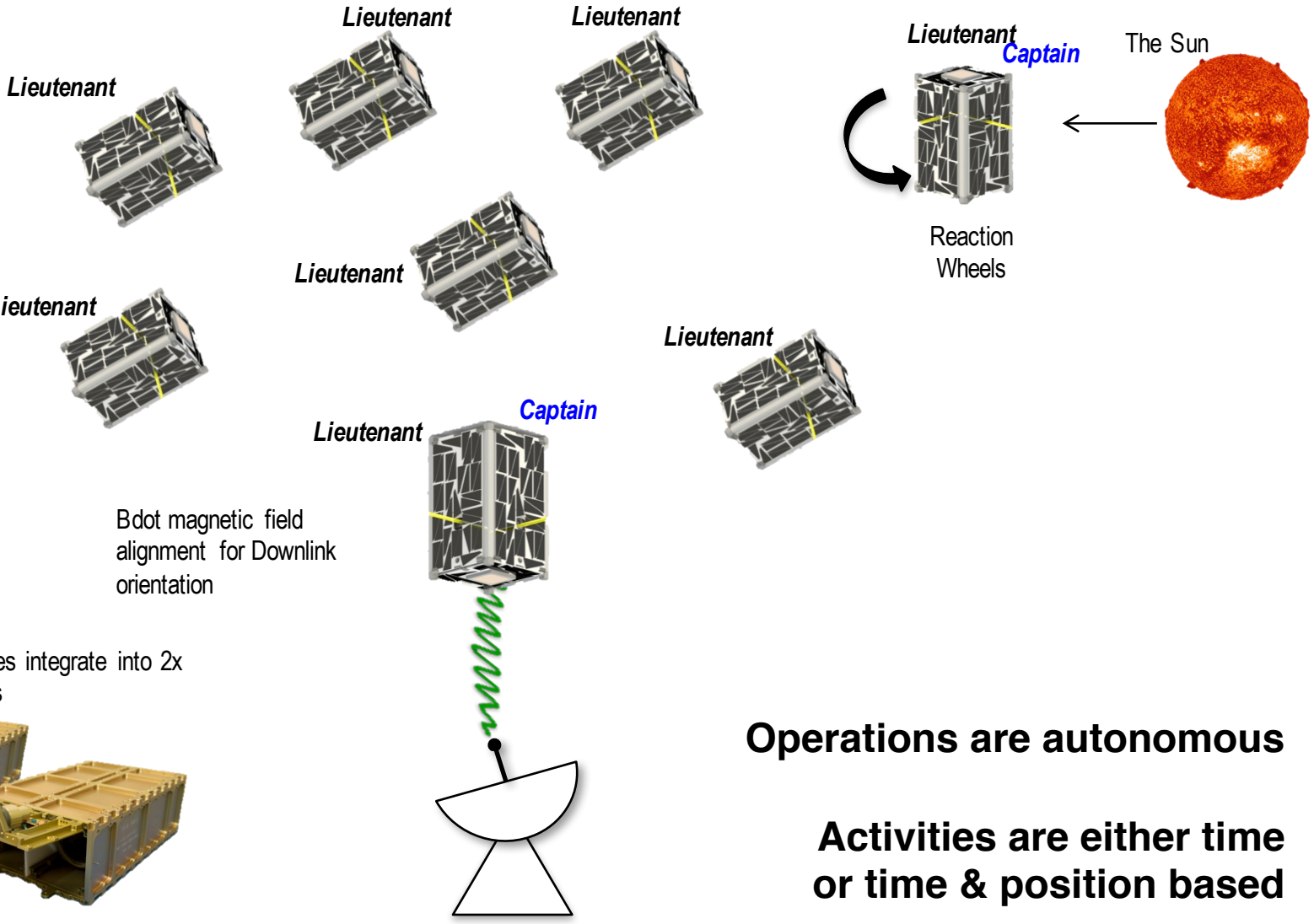

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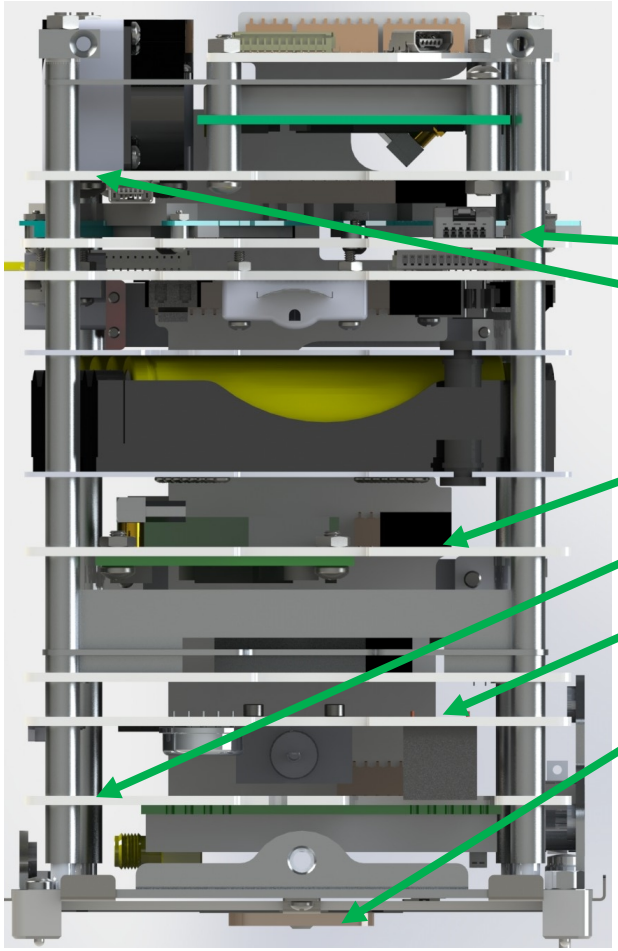
EDSN Spacecraft Characteristics



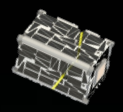
- Eight identical spacecraft
- 1.5U Cubesat
- Primary processor – Nexus S Phone
- MicroHard MHX2420 S-band (downlink)
- Stensat UHF Beacon
- AstroDev Li-1 UHF transceiver (crosslink)
- EPISEM payload
- Novatel OEMV-1 GPS Receiver
- Li-Ion Batteries (2800 mAh)
- 1 W orbit average power

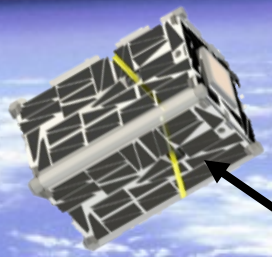
1. Acquire GPS Solution

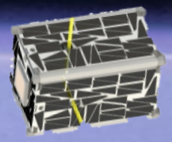
Comms Architecture

All spacecraft acquire a GPS solution

All spacecraft correct local clocks to match GPS time







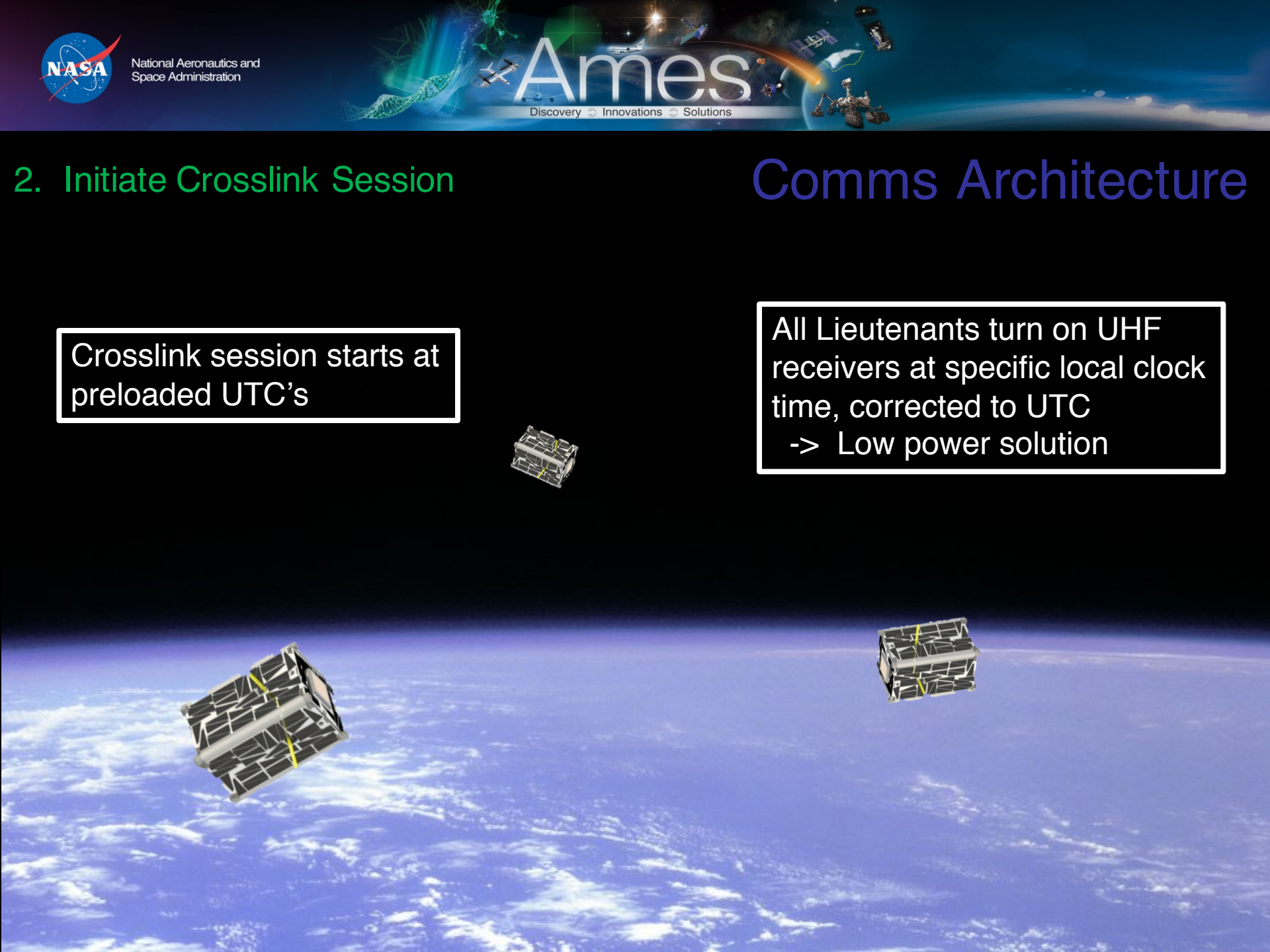
Captain Selected based on GPS time

2. Initiate Crosslink Session

Comms Architecture

Crosslink session starts at preloaded UTC's

All Lieutenants turn on UHF receivers at specific local clock time, corrected to UTC
-> Low power solution

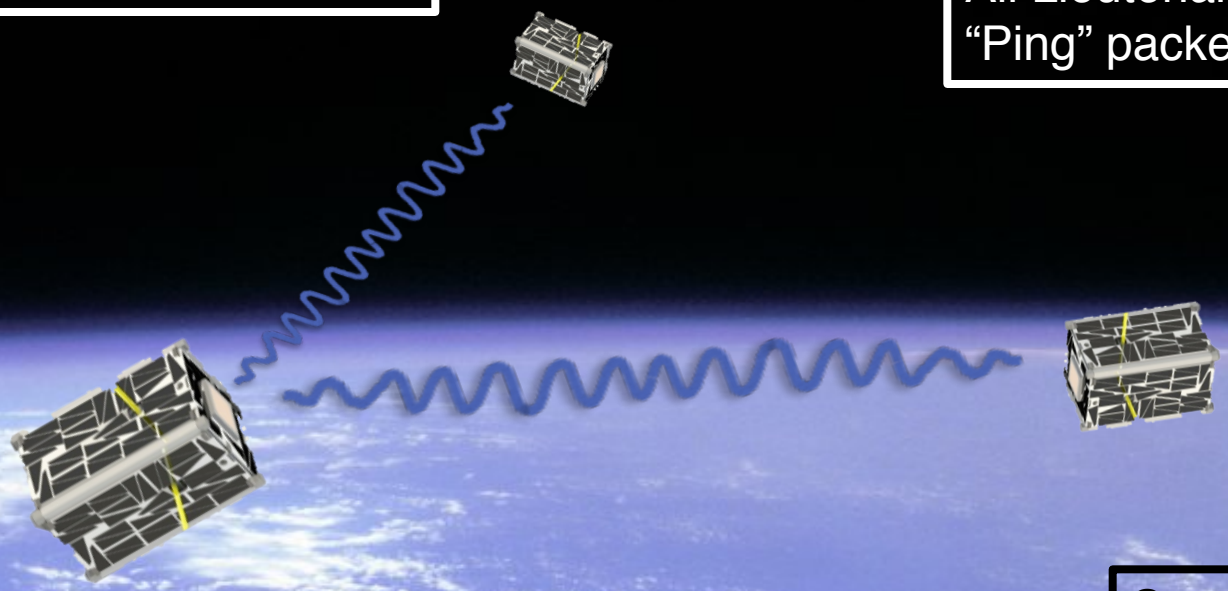


2a. Initiate Crosslink Transaction

Comms Architecture

Captain initiates transaction
- Addresses “Pings” to one Lieutenant in swarm via omni UHF transmission

All Lieutenants receive “Ping” packet

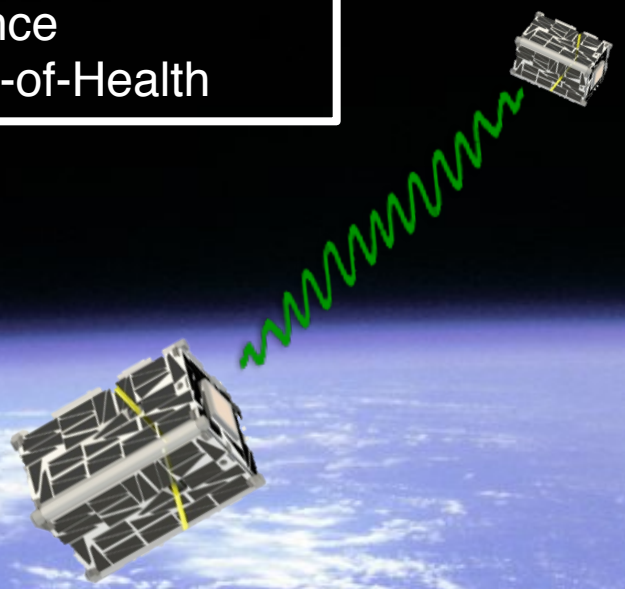


Captain sends six ping packets

2b. Collect Crosslink Data

Comms Architecture

Addressed Lieutenant responds with data
- Science
- State-of-Health



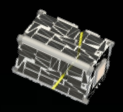
Other Lieutenants parse packets, but don't respond

Lieutenant identifies one or more ping packets

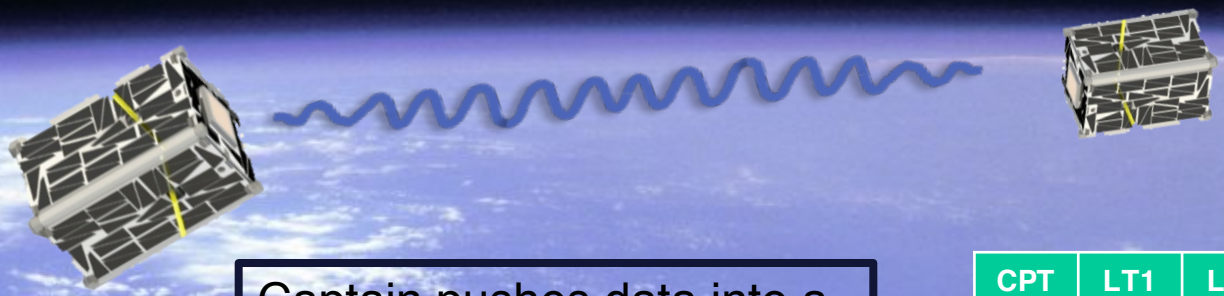
2c. Collect Data from Swarm

Comms Architecture

Captain sends "Ping" to each spacecraft in swarm, collecting data



Each Lieutenant responds to its "Ping" in turn



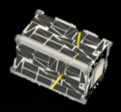
Captain pushes data into a data structure for storage and later downlink

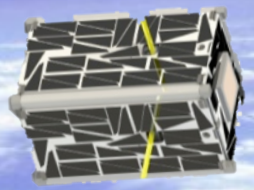
CPT	LT1	LT2	LT3	…	LT7
PtP	P1	P1	P1	…	P1
SOH	P2	P2	P2	…	P2
SC1	P3	P3	P3	…	P3

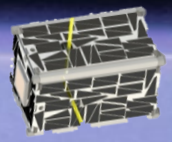
3. Initiate Downlink Activity

Comms Architecture

Captain aligns with local magnetic field



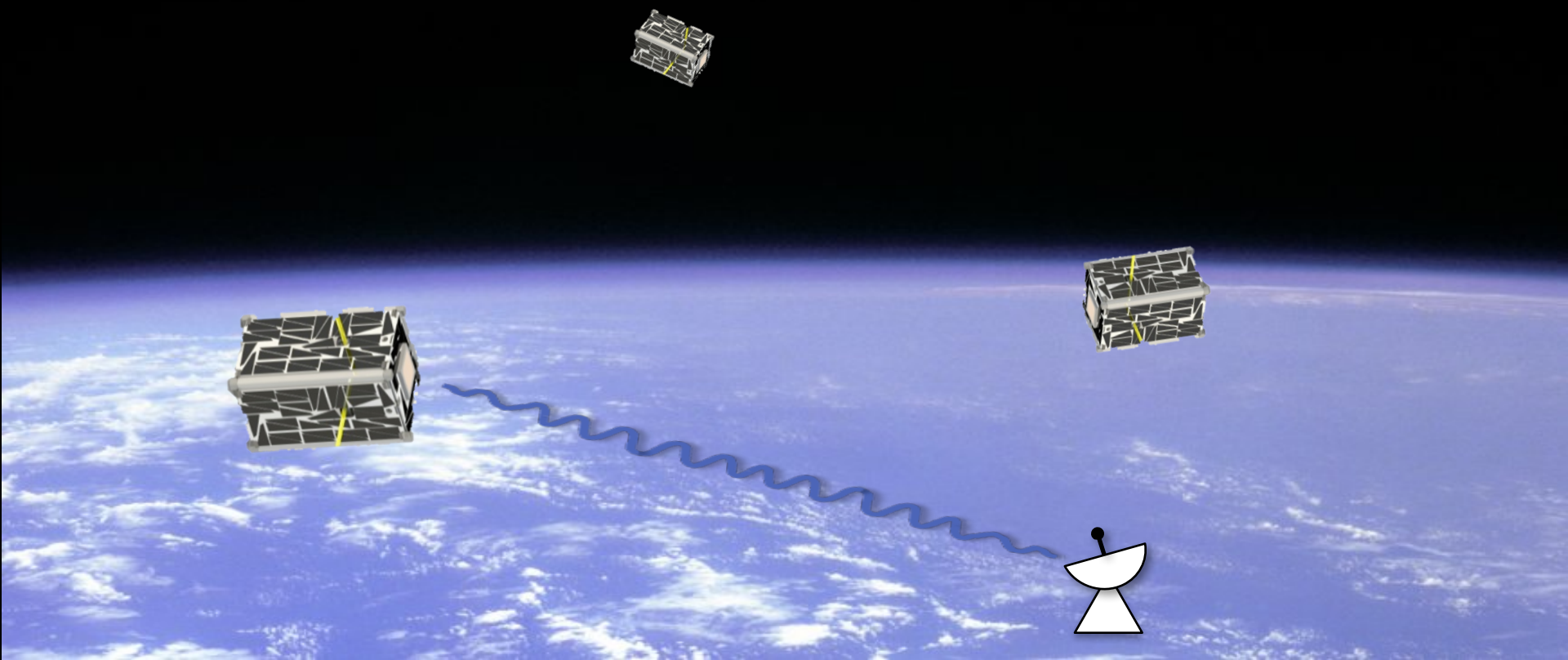




4. Send Data to Ground

Comms Architecture

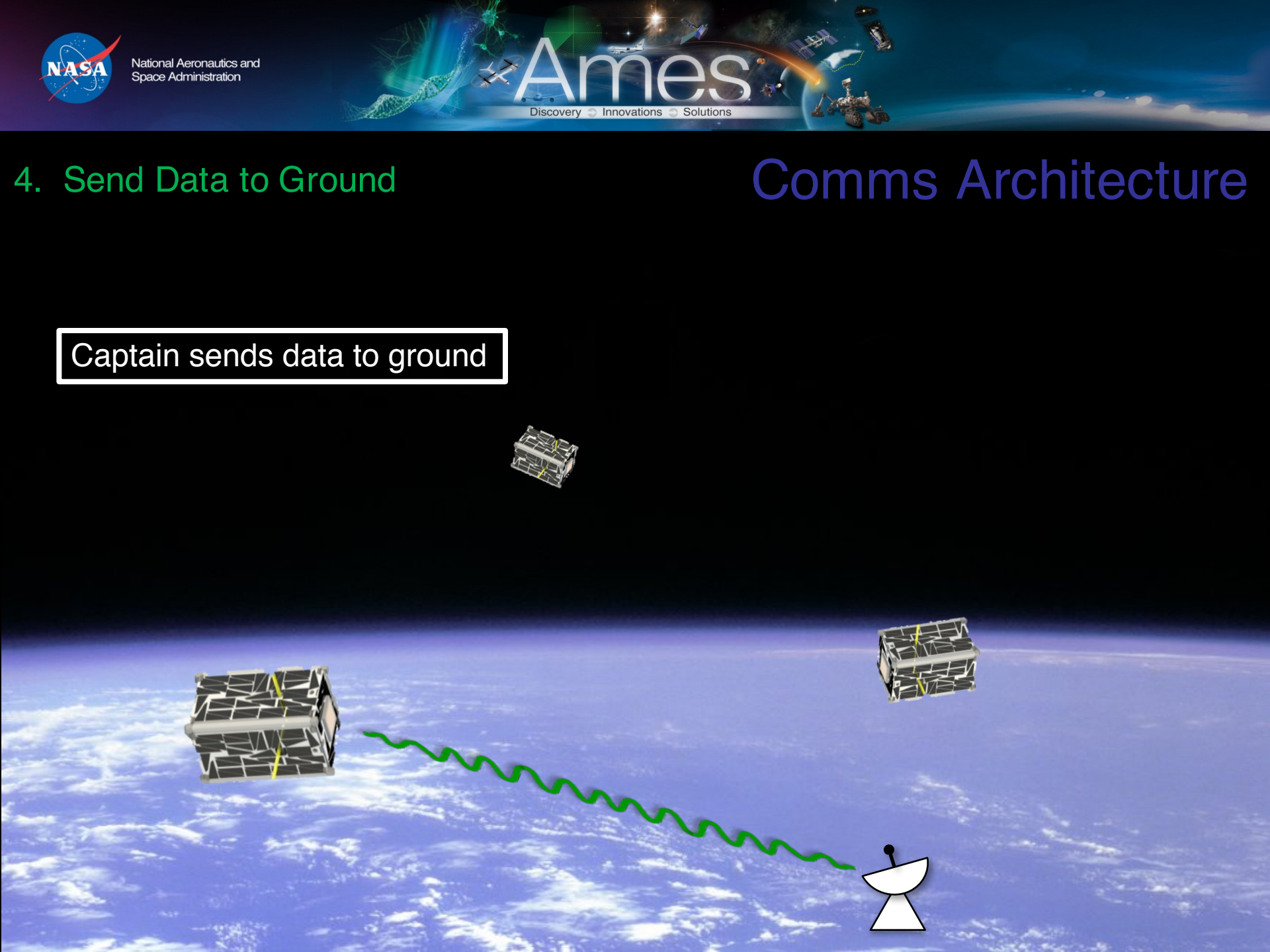
Ground Station Establishes S-band Link



4. Send Data to Ground

Comms Architecture

Captain sends data to ground



1. Acquire GPS Solution …

Comms Architecture

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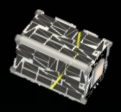
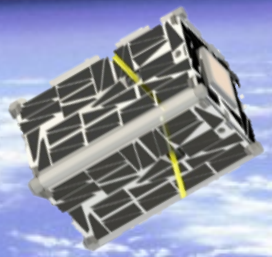
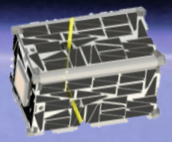
All spacecraft correct local clocks to match GPS time

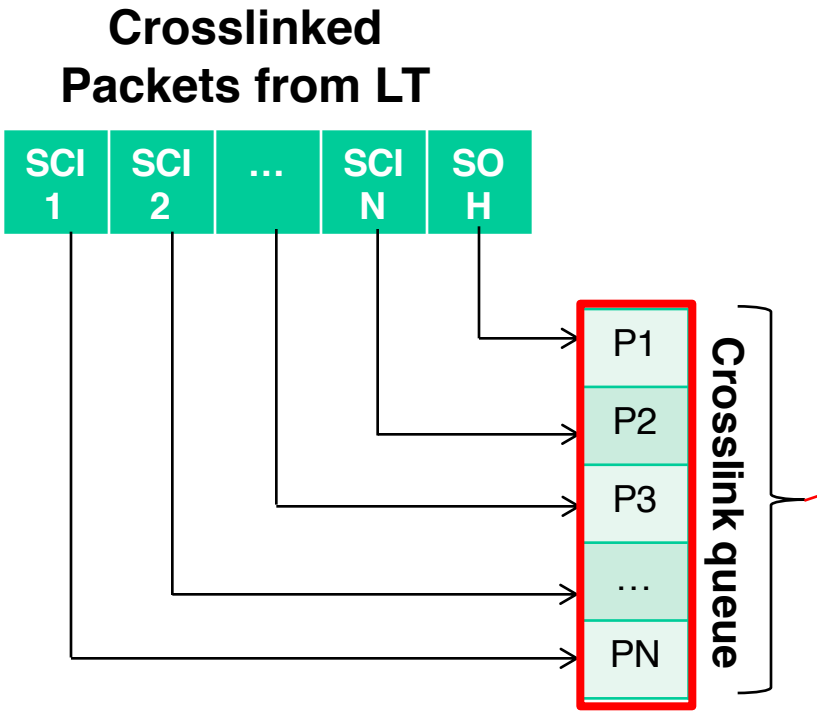






Captain Selected based on GPS time

Crosslink



downlink stacks

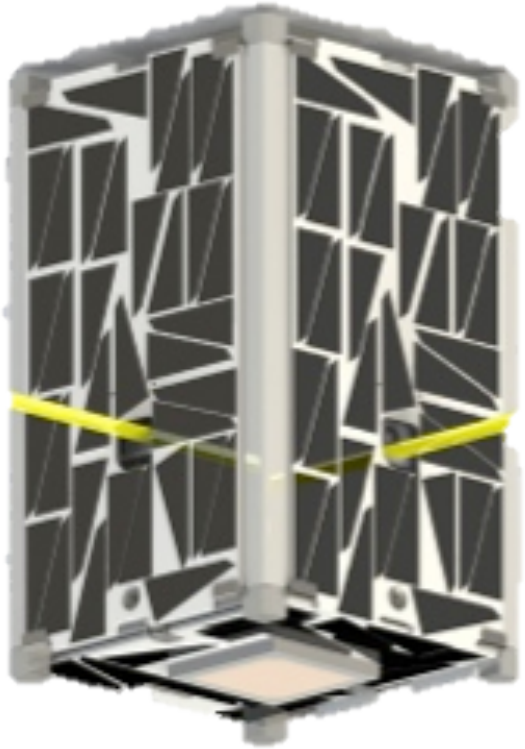
CPT	LT1	LT2	LT3	…	LT7
PtP	P1	P1	P1	…	P1
SOH	P2	P2	P2	…	P2
SC1	P3	P3	P3	…	P3
SC2	P4	P4	P4	…	…
SC3	P5	P5	…	…	…
…	P1-o	…	…	…	…
	P2-o				
	P3-o				
	P4-o				
	P5-o				
	…				

Packets in the downlink stack **from previous sessions** or major cycles are pushed down in the stack


OUTPUT OFF

EDSN Demonstrates …

- Time synchronized measurements on spatially distributed platforms
- One-way operation of the swarm (data collection) through a single spacecraft that is in periodic contact with the ground
- Autonomous operation of the swarm (i.e. without intervention from ground control)
- Redundancy in swarm operations through the simple, pre-scripted periodic hopping of the Captain

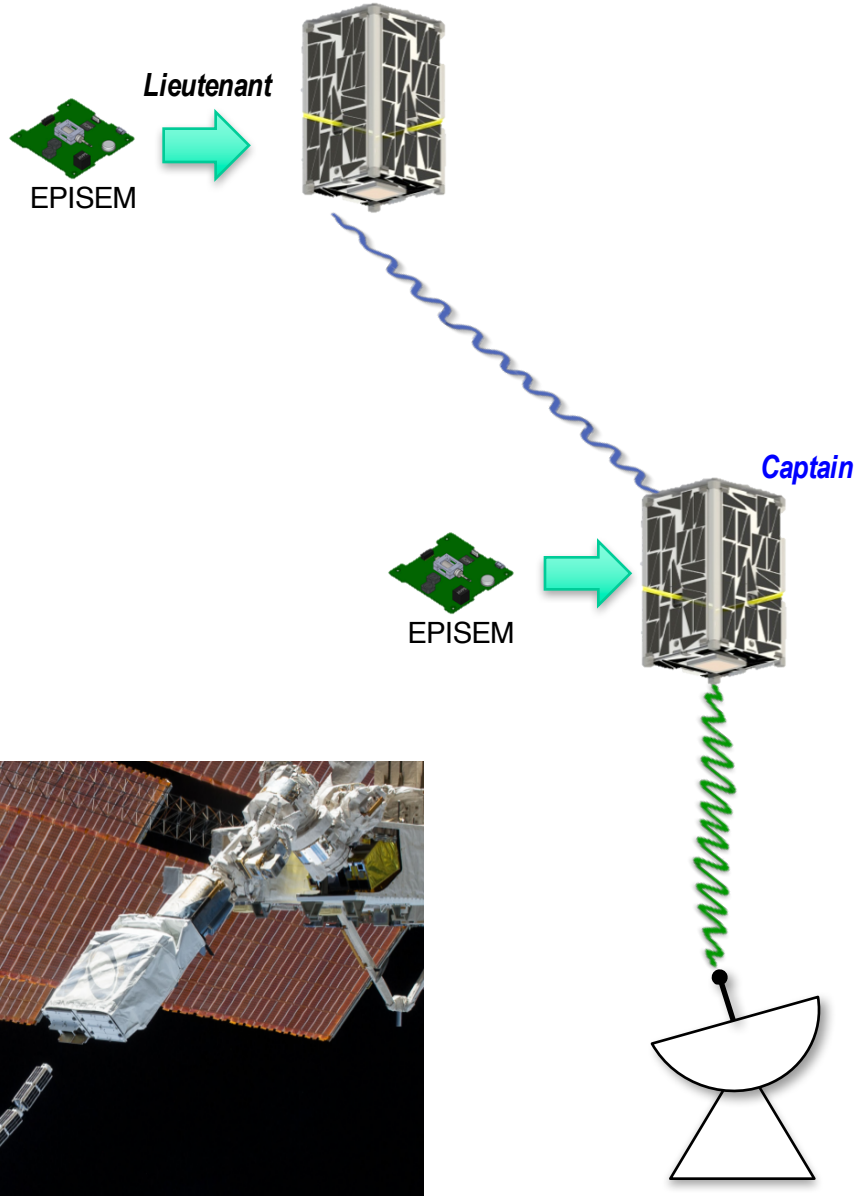


Future Enhancements

- Routing of ground commands through network
- Autonomous configuration and control of the network by the swarm
- Time synchronized measurements by command from the Captain
- Improved synchronization of time across the swarm
- Improved formation knowledge through DGPS
- Mapping of network topology
- Routing of packets through the network by multiple hops
- Multiple Captains
- Passing of large data files between spacecraft (e.g. image files)
- Prioritization of data messages by the Captain or Lieutenant for downlink
- Addition of ACK/NACK protocol
- Multiple ground stations to increase data throughput
- Addition of tandard network layer to the system to take advantage of COTS software and protocols
- Interlinking of multiple Captains to create a “cluster of clusters”.

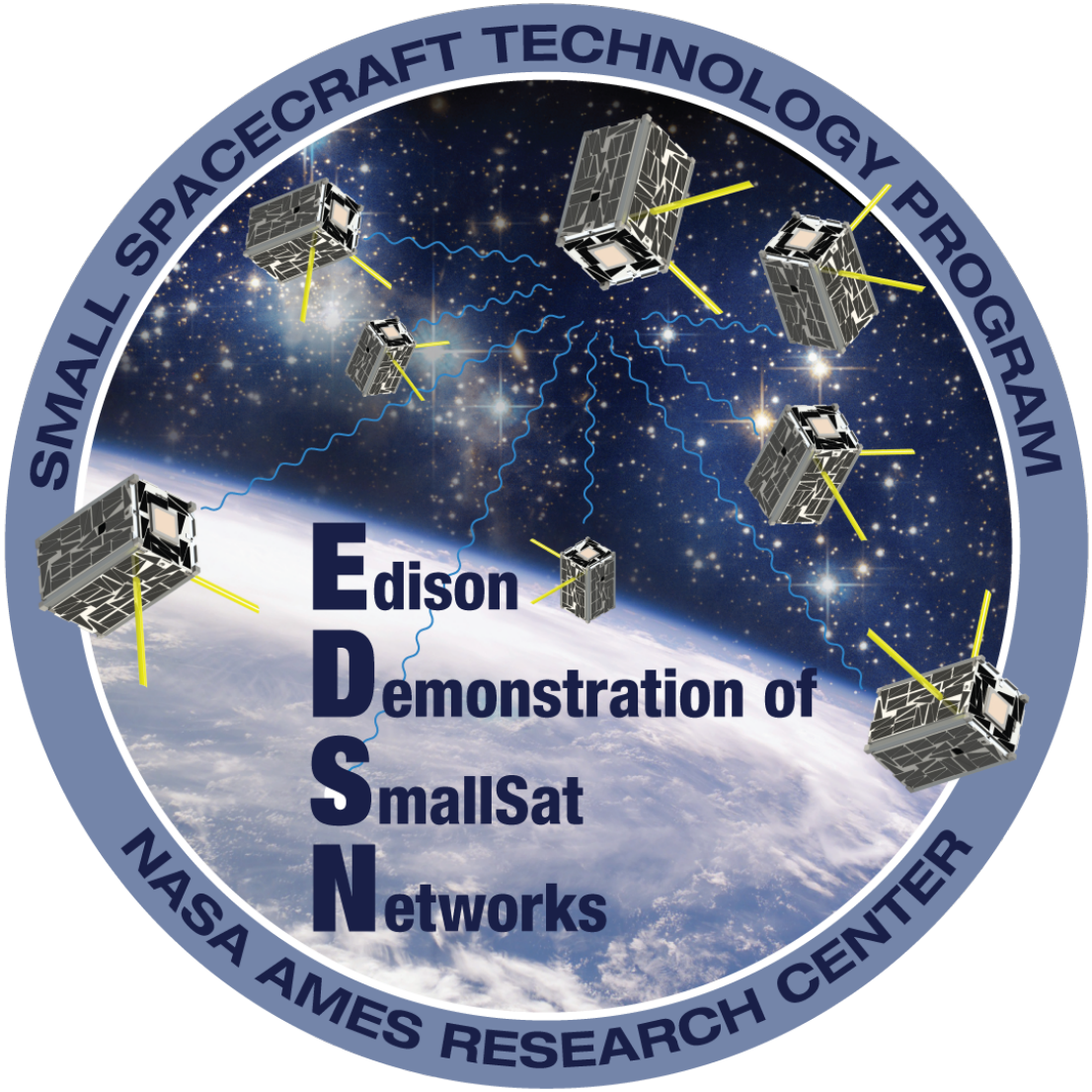
Future Enhancements

- **Routing of ground commands through network**
- **Autonomous configuration and control of the network by the swarm**



Nodes

- Demonstration of swarm control technologies
- Delivery to Nanoracks in September, 2014
- Downlaunch from ISS in Q1, 2015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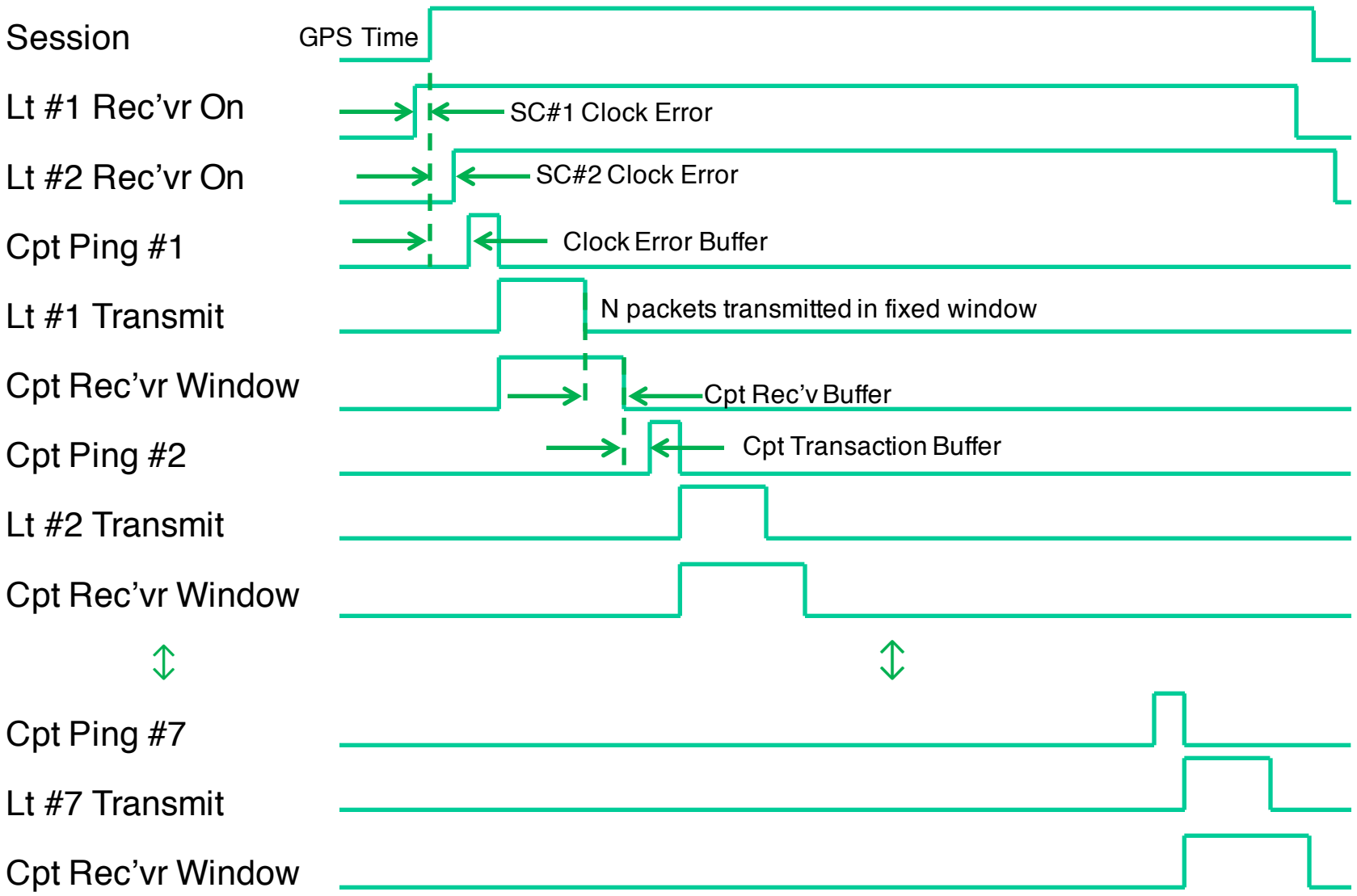
Questions?


Session
GPS Time
Lt #1 Rec'vr On
SC#1 Clock Error
Lt #2 Rec'vr On
SC#2 Clock Error
Cpt Ping #1
Clock Error Buffer
Lt #1 Transmit
N packets transmitted in fixed window
Cpt Rec'vr Window
Cpt Rec'v Buffer
Cpt Ping #2
Cpt Transaction Buffer
Lt #2 Transmit
Cpt Rec'vr Window
Cpt Ping #7
Lt #7 Transmit
Cpt Rec'vr Window