EDSN - Edison Demonstration for SmallSat Networks
Overview

Small Spacecraft Technology Program
Space Technology Mission Directorate
Current monolithic mission architectures enable high quality science data but only provide single point time repeated measurements. New science discoveries require improvements in mission architectures to include time varying, multi-point and time correlated measurements to fully understand complex, fluctuating and interactive phenomenon.
Swarm Technology Infusion Avenues

- Independent, cooperative mission elements
  - Survey/inspection
  - Sample return (future potential)
  - Autonomous Deep Space missions
  - Hybrid architectures; mothership + probes (Asteroid “Fighter Escorts”)

- Heliophysics & Astrophysics
  - Multipoint measurements – (Heliophysics)
  - Distributed space elements – arrays (Astrophysics)

- Earth Sciences & DoD
  - Persistence
  - Wide geographical area coverage
  - Resiliency and robustness
  - Flexibility
  - “A Swarm” vs “A Train”
The study of the heliophysics system requires **multipoint observations** to develop understanding of the coupling between disparate regions: solar-wind, magnetosphere, ionosphere, and thermosphere, and mesosphere on a planetary scale and to resolve temporal and spatial ambiguities that limit scientific understanding…To enable future missions it would be wise to accelerate the development of **spacecraft technologies for supporting small satellites**, including **constellation** operations and **inter-spacecraft coordination**. …A constellation mission utilizing small satellites would radically improve our understanding of the dynamics of the coupled thermosphere/ionosphere system.”

NRC - Solar and Space Physics: A Science for a Technological Society – 2012

- **HiDEF** (NASA SMD - Heliophysics Roadmap 2009)
  - 90 spacecraft in swarm in range of low earth, polar orbits
  - Globally monitor electric field and thermosphere density
- **ARMADA** (NASA SMD - Heliophysics Roadmap 2009)
  - Swarm of 25 to 100 spacecraft in pseudo-random orbits
  - GPS Receivers with Radio Occultation and TEC capabilities
  - Drag model inferred from GPS
- **COSMIC-II** (NRC - Earth Science Decadal Survey 2007)
  - GPS Receivers with Radio Occultation and TEC capabilities
  - Persistent, real-time GPS monitoring in L1/L2 with 6 – 10 spacecraft
Edison Demonstration of SmallSat Networks (EDSN) Project

Project Summary
- **HQ Directorate:** Space Technology Mission Directorate
- **Governing PMC:** NASA Class D Category III Project
- **Project Manager:** Deborah Westley
- **Performing Organization(s):** ARC, MSFC
- **Partners:**
  - Montana State University – Payload provider
  - Santa Clara University – Ground Station operator
- **Description:** The EDSN Mission will launch a swarm of 8 low-cost small satellites and demonstrate the operation of an intra-swarm communication link and multi-point sensing measurements.

Description
- **EDSN Spacecraft Assembly**
- **Montana State University EPISEM Payload**

ConOps
- 1) Collect Science Data
- 2) Crosslink Science Data
- 3) Science Data to Ground

Schedule (CY)

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Launched from PMRF
EDSN Mission Goal & Objectives

Mission Goal
• The EDSN project goal is to demonstrate that a swarm of spacecraft is capable of collecting multi-point science data and transmitting the data to the ground

Mission Objectives
• Deliver and flight demonstrate spacecraft-to-spacecraft communications link for spacecraft to transfer data to another spacecraft
• Deliver and flight demonstrate a system to collect multi-point science measurements and via Objective 1 transmit science data to the ground station
• Deliver and flight demonstrate spacecraft “active” pointing system
Each spacecraft (8) takes space weather data measurements (via EPISEM dosimeter)

Crosslink data transmission demonstrated on multiple spacecraft

Single spacecraft (“Mothership”) demonstrates a pointing capability and sends science data to the ground station
- Any spacecraft can be the “Mothership” ground relay
- Stretch goal to demonstrate upload during mission as swarm disperses

Beacon packets provide back-up science data
### SSTP Portfolio Technology Matrix

<table>
<thead>
<tr>
<th>SSTP Projects</th>
<th>EDSN</th>
<th>CPOD</th>
<th>ISARA</th>
<th>OCSD</th>
<th>Phonesat</th>
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Mission Extensibility

Conceptual Mission: NEO investigation

Future Spacecraft (notional)

EDSN

X-link Comm

ΔV

ISARA, OCSD

Comm

CPOD, OCSD

RPO

EDSN

SSTP portfolio addresses a number of key technologies
Not shown: Phonesat
Other future: Autonomy, Structures, Power
RPO = Rendezvous and Prox Ops
PhoneSat: The Android App Plug&Play Satellite

CURRENT STATUS OF THE PROJECT

• **PhoneSat 1.0**
  - Google Nexus One, StenSat radio, watchdog, 12 Li-Ion batteries and 4 retro-reflectors
  - Passed FRR on November 2012
  - 2 units successfully flown on Antares I launch (April 2013)
  - $3,500 per satellite (components)

• **PhoneSat 2.0.β**
  - Google Nexus S, StenSat radio, torque coils, solar cells, watchdog, router, sensor interface and 4 Li-Ion batteries
  - Passed FRR on November 2012
  - 1 unit successfully flown on the Antares I launch (April 2013)
  - $7,300 per satellite (components)

• **PhoneSat 2.0**
  - PhoneSat 2.0.β + Reaction wheels and Microhard radio
  - FRR: April 2013
  - ELaNa IV launch: September 2013
  - $7,800 per satellite (components)

MILESTONES FOR 2013

PhoneSat 2+ versions will develop new sub-systems to increase the capabilities of the ultra cheap easy-to-program PhoneSat bus

• **PhoneSat 2.0** Android App development
• **ELaNa IV or V launch**: PhoneSat 2.0 (Sept 2013)
• **PhoneSat 2.x** ELaNa V and future opportunities
• New concepts for PhoneSat 3.0 development:
  - Engage the Android development community to provide satellite Android Apps
  - Upload an Android App through the radio
    - Star tracker using the smartphone camera
    - GPS transceiver
  - Modulating Retro Reflector for Optical Communication test
    - Test piezo-electric components for high accuracy ADCS
    - IOIO board phone interface
    - Deployable solar panels

THE ANDROID APP SATELLITE

• The PhoneSat platform, based on the Android open source operating system, will open the space industry to more than a million Android programmers around the world
• The PhoneSat project plans to leverage the continual development of the billion-dollar Smartphone industry
• Shifting the space paradigm from a hardware problem to a software problem
• New flight software and updates will be coded by anyone with Android programming skills
• Universities and Research groups will have access to the PhoneSat platform through international competitions

ULTIMATE GOAL: THE ANDROID APP PLUG&PLAY SATELLITE

The Plug&Play nature of the PhoneSat bus, together with the open-source Android platform, will enable rapid hardware and software satellite development

• The project has already demonstrated the capability of adding new sub-systems to the bus: EDSN, KickSat projects
• Hardware modularity will allow Plug&Play for many different payloads
• The Android platform will enable rapid, cheap and adaptable software development
Proximity Operations Nano-Satellite Flight Demonstration

**Contractor:** Tyvak Nano-Satellite Systems LLC

**PI:** Scott MacGillivray/Tyvak

**Subcontractors:**
- 406 Aerospace
- Applied Defense Solutions
- Analytical Graphics Inc.
- California Polytechnic State University, San Luis Obispo

**Project Summary**

<table>
<thead>
<tr>
<th>Description/ConOps</th>
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<tr>
<td><strong>Concept of Operations</strong></td>
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<tr>
<td>Two 3U CubeSats will demonstrate rendezvous, proximity operations, docking and servicing, and formation flight over a 1-year nominal mission.</td>
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**Launch**

- Launch is planned for second quarter of CY2015 (selected by CSLI).
- Orbit inclination > 30° for ground coverage considerations and altitude should nominally support 1 year of on-orbit operations.
ISARA – Integrated Solar Array and Reflectarray Antenna for High Bandwidth CubeSat

**Project Summary**

**Center:** Jet Propulsion Laboratory  
**PI:** Richard Hodges  
**PM:** Biren Shah  
**Subcontractors:**  
• Pumpkin, Inc. (spacecraft bus)  
**Objective:**  
• Demonstrate a high bandwidth Ka-band data downlink system for cubesats

**Concept of Operations**

• One 3U cubesat employs a large, deployable solar array that doubles as a Ka-band reflectenna providing up to 100 Mps of data downlink capability.

**Description**

Solar array (top)  
Ka-band reflectarray (bottom)

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**Launch**

• Launch planned for CY2014 (selected by CSLI)  
• LEO from 300km to 700km at 51.7° is acceptable.  
• GTO orbit would also be considered.
Integrated Optical Communications and Proximity Sensors Demonstration (OCSD)

Summary

Contractor: Aerospace Corp.
PI: Siegfried Janson
Subcontractors: N/A

Objective:
- Demonstrate radar ranging, optical downlink, cold gas propulsion, and cross-track motion sensing technologies on a cubesat proximity operations mission.

Concept of Operations
- Two 1.5U cubesats execute formation flying and rendezvous operations using radar, optical flow sensor and cold gas propulsion.
- Demonstrate laser-comm downlink.

Schedule (CY)

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Launch
- Launch is planned for mid CY2015 (selected by CLSI)
- LEO at 500km is sufficient.