New Moon Explorer (NME) CubeSat Mission Concept

Planetary CubeSat Symposium
June 27, 2019

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2016HO3 is a Near-Earth companion representing the closest, most stable quasi-satellite to Earth

- Discovered by Pan-STARRS on April 27, 2016
- 40-100 meters in diameter
- Earth MOID 0.0348 AU (5.25 M km)
- Fast rotator with an estimated rotational period of 0.467 hours
Mission/Science Objectives

• Science Objectives
  • Observe Earth’s ‘new moon’, the newly discovered near-Earth companion 2016HO3
  • Obtain spin rate, pole position, shape, structure, mass, density, chemical composition, temperature, thermal inertia, regolith characteristics, and spectral type
  • Radio science to determine precise mass and internal structure of the asteroid, preferably during close Earth flyby

• Technology Objectives
  • Continue incremental development of solar sail technology
  • Demonstrate use of thin-film power technologies

• Strategic Objectives
  • Address synergies across multiple NASA and industry needs
Spacecraft Features

- Low-cost 12U form factor
- Solar Sail propelled
  - 200 m² toughened CP1 quadrant configuration
  - 4x 10.5-m Slit-tube composite booms laminate designed using Roccor Solar Sail Tool (SST)
  - Active Mass Translator MMS
- Planar, bi-pedal ‘LISA-T’ for power generation and telecommunications
- Deep space CubeSat avionics as utilized on MarCO (launched 2018) and NEA Scout and IceCube missions (launch 2020)
- Cold gas for momentum desaturations and impulsive events
- Leverages developmental lessons learned from the NEA Scout mission
Solar sails use photon pressure on thin, lightweight, reflective sheets to produce thrust.

**Ideal Case**

- **Sail**
- **Thrust Vector**
- **Incident Photons**
- **Sun Angle**
- **Sail normal vector**
- **Reflected Photons**
Momentum Management System

- Solar Radiation Pressure imparts a persistent torque on the spacecraft for the duration of the mission.
- Use of expendable propellant to maintain desired Solar Sail attitude and/or desaturate reaction wheels would be mission limiting, particularly in small form factors.
- A momentum management system is needed to accompany a solar sail concept.
- NEA Scout utilizes Active Mass Translation (right) while IKAROS utilized Liquid Crystal Devices.
Thin-Film Power Generation

- Leverages technology development from Lightweight Solar Array and anTenna (LISA-T)
- Thin-film photovoltaics coated with polyimide and solvent bonded on Toughened CP1
- Cells electrically interconnected via micro-welded ribbons and embedded traces
- Placed on independent substrate and deployed (can be integral to Solar Sail)
- Phased array antenna can be similarly embedded resulting in integrated propellantless propulsion, power generation, and telecommunications capability
Deployed Solar Sail Approximate Scale

New Moon Explorer (200 m²)

NEA Scout (86 m²)

NanoSail-D (10 m²)

School Bus

Folded, spooled and packaged

12U Stowed Flight System
Concept of Operations

**Lunar Fly-by 1**
- De-tumble
- Initial Health Check
- LISA-T deployment
- Cold gas TCM to target LGA

**Earth Fly-by 1**
- Minimum Ops, Periodic Tracking
- Rehearsal of science activities

**Earth Fly-by 2**
- ~1-2 additional lunar flybys to target departure
- Instrument calibration @Moon

**Cruise**
- Target Detection
- Unresolved and Resolved imagery
- High resolution surface imaging (full surface)
- Slow, close flyby

**Target Reconnaissance & Proximity Ops**
- <0.25 AU
- 4kbps+ D/L (34m DSN) and/or 2kbps+ (21m MSU DSN affiliate)

**Data Downlink**
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Co-Author Acknowledgements

- Les Johnson (Marshall Space Flight Center)
- Leslie McNutt (Marshall Space Flight Center)
- Alexander Few (Marshall Space Flight Center)
- John Carr (Marshall Space Flight Center)
- Jared Dervan (Marshall Space Flight Center)
- Darren Boyd (Marshall Space Flight Center)
- Joseph Nuth (Goddard Space Flight Center)
- Dana Turse (Roccor)
- Aaron Zucherman (Morehead State University)
- Benjamin Malphrus (Morehead State University)
- Michael Combs (Morehead State University)
NASA’s Near Earth Asteroid Scout

The Near Earth Asteroid Scout Will:
• Image/characterize a NEA during a slow flyby
• Demonstrate a low cost asteroid reconnaissance capability

Key Spacecraft & Mission Parameters
• 6U cubesat (20 cm X 10 cm X 30 cm)
• ~86 m² solar sail propulsion system
• Manifested for launch on the Space Launch System (EM-1/2019)
• Up to 2.5 year mission duration
• 1 AU maximum distance from Earth

Solar Sail Propulsion System Characteristics
• ~ 7.3 m Trac booms
• 2.5µ aluminized CP-1 substrate
• > 90% reflectivity
NEA Scout Flight System
NEA Scout Hardware Overview
Launch

Dispense

Checkout

Pre-deploy Ops

Deploy, Sun Pointed to Generate Power

Earth Pointed for LISA-T Downlink

Cyclic Operations

Sun Pointed

Earth Pointed

LISA-T Communications with Helical Antenna

Host Communications

Disposal

Target Duration:
1 Months minimal
4 Months nominal
6+ Months desired

National Aeronautics and Space Administration
Traditional assembly:

1. Add interconnects: Attached by hand
2. Cover cells Spin by hand
3. Bond to substrate Spin, then Laydown by hand
4. String Cells Attached by hand
5. Electrical routing Laydown/attach by hand
6. Electrical grouting Insulation by hand

PAPA:

1. Add adhesive polymer Laydown via print
2. Place solar cells Laydown via vacuum tool
3. Add interconnects and buses Laydown by print
4. Add cover Laydown via print
Payloads

• Visible imager inherited from EECAM (Mars 2020 and OCO-3 programs)

• Filter wheel assembly (color variations)

• Infrared camera (compositional variations)
  • Sensitive to 1-100 microns
  • Micro-bolometer detector
  • Modified COTS Mid-Wave Infrared (MWIR) imager
  • Stripe bandpass filters mounted on focal plane array

• Spectral type improved by Keck telescope (Hawaii)
  • Could descope filter wheel
3D View of Mission