Near Earth Asteroid (NEA) Scout

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• What is a solar sail?
• A brief history of solar sailing
• NASA’s Near Earth Asteroid Scout mission
How does a solar sail work?

Solar sails use photon “pressure” or force on thin, lightweight reflective sheet to produce thrust.
Topics

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- 100 kg spacecraft
- 8 triangular sail blades deployed from a central hub after launch by the inflating of structural tubes.
  - Sail blades were each 15 m long
  - Total surface area of 600 square meters
- Launched in 2005 from a Russian Volna Rocket from a Russian Delta III submarine in the Barents Sea:

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Rocket Failed
NASA Ground Tested Solar Sails in the Mid-2000’s

Two 400 square meter sail were autonomously deployed and tested at Plumbrook
NanoSail-D Demonstration Solar Sail

Mission Description:

- 10 m² sail
- Made from tested ground demonstrator hardware
NanoSail-D2 Mission (2010)

- Minotaur IV Launch
  - Nov. 19, 2010
  - 5:24pm PST
  - 650km, 72° inclination

- FASTSAT Separation
  - ~20min

- NanoSail-D2 Ejection MET Day 7+

- NanoSail-D2 Free Flight

- NanoSail-D2 De-Orbit
  - 70-120 Days After Sail Deployment

- NanoSail-D2 Sail Deployment
  - 72 Hours After Ejection
Interplanetary Kite-craft Accelerated by Radiation of the Sun (IKAROS)

Liquid crystal device power was off.

Liquid crystal device power was on.
Fortunately, IKAROS accomplished with Icarus could not...
STMD Technology Demonstration Mission (TDM)

Based on one of the 400 m² NASA Demonstrators:
- Cold Rigidization Boom Technology
- Aluminized Sun Side
- High Emissivity Eclipse Surface
- Beam Tip Vane Control

Sunjammer Solar Sail Demonstration Mission

83 m² ISP L’Garde Solar Sail 2004

318 m² ISP L’Garde Solar Sail 2005

1200 m² L’Garde Sunjammer was to launch in 2015
Sunjammer Solar Sail Demonstration Mission (TDM)

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Canceled

Based on one of the 400 m² NASA Demonstrators:
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2015’s LightSail-A (The Planetary Society)

32 m²
No active ‘sailing’
3U cubesat
Topics

• What is a solar sail?
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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 (20cm X 10cm X 30 cm)
- ~86 m² solar sail propulsion system
- Manifested for launch on the Space Launch System (EM-1/2018)
- 1 AU maximum distance from Earth

Leverages: combined experiences of MSFC (PM, SE and Solar Sail) and JPL (flight system bus, instrument and science) with support from GSFC, JSC, & LaRC

Close Proximity Imaging
Local scale morphology, terrain properties, landing site survey

Target Reconnaissance with medium field imaging
Shape, spin, and local environment
• HEOMD’s Advanced Exploration Systems (AES) selected 3 cubesats for flight on SLS EM1
• Primary selection criteria:
  - Relevance to Space Exploration Strategic Knowledge Gaps (SKGs)
  - Life cycle cost
  - Synergistic use of previously demonstrated technologies
  - Optimal use of available civil servant workforce

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NEA Scout Roles and Responsibilities

Near Earth Asteroid Scout

- Project Manager: Leslie McNutt (MSFC)
- Science PI: Julie Castillo-Rogez (JPL)
- Solar Sail PI: Les Johnson (MSFC)
- Spacecraft System: JPL
- Solar Sail System: MSFC
• **NEA SCOUT SHALL HAVE THE CAPABILITY TO ADDRESS KEY STRATEGIC KNOWLEDGE GAPS AT A NEAR EARTH ASTEROID**

  • **Full Success Criteria:** Fly by a near Earth asteroid and acquire images sufficient to determine the target volume, shape model, asteroid spectral type and meteorite analogs, rotational properties (pole position, rotation period), orbit, debris/dust field in local environment, and regolith characteristics.

  • **Minimum Success Criteria:** Fly by a near Earth asteroid and acquire images sufficient to estimate the target volume, the asteroid spectral type, determine rotational properties (pole position, rotation period), and orbit.

  • **Rationale:** This requirement addresses the need to fill Strategic Knowledge Gaps related to asteroids as a precursor to subsequent safe and successful human missions. The data obtained will also support the advancement of science interests in asteroids.
Concept of Operations Overview

- **SLS EM-1 Launch**: L+4 days, Sail Characterization
- **Lunar Fly-by 1**: Separation from SLS, De-tumble, Initial Health Check, ~10m/s dv to target 1st lunar fly-by
- **Lunar Fly-by 2+**: Instrument Calibration
- **Cruise**: Minimum Ops, Periodic Tracking, Rehearsal of science activities
- **Target Search and Approach**: Sub-pixel imaging of target, On-board image co-adding to achieve detection SNR, Ephemeris and color addressed
- **Target Reconnaissance**: Minimum science success criteria addressed
- **Proximity**: Slow target fly-by, Full success criteria addressed
- **Data Downlink**: <1 AU Earth dist., ~1 kbps DTE (34 m DSN), On-board science processing
- **High Resolution Imaging (10 cm/pixel)**
- **Imaging of the resolved target**
- **Target Scan Imaging (Image Stacking)**
- **Approximate timeline**: L+4 days, L+47 days, L+764 days, C/A-L+794 days, L+810 days
Near Earth Asteroid Scout Asteroid Flyby

Target Detection and Approach:
50K km, Light source observation
SKGs: Ephemeris determination and composition assessment (color)

NEA Reconnaissance
<100 km distance at encounter
50 cm/px resolution over 80% surface
SKGs: volume, global shape, spin properties, local environment

Close Proximity Science
High-resolution imaging,
10/px over >30% surface
SKGs: Local morphology
Regolith properties

JPL IntelliCam
(Updated OCO-3 Context Camera)
Baseline Target: 1991 VG

- Diameter ~ 5-12 meters
- Albedo is unknown
- Position is known within 2700 km (1-σ) but optical observation opportunity in July ‘17 will decrease uncertainty to a few 100s km
- Rotation period between a few minutes and less than 1 hour
- Unlikely to have a companion
- Unlikely to retain an exosphere or dust cloud
  - Solar radiation pressure sweeps dust on timescales of hours or day
Integrated flight system, stowed sail; Credit: JPL
Solar Sail Subsystem Overview

- Spacecraft Wire Channel
- Single Sail Spool
- Boom Deployers
- Deployment Motor
- TRAC Booms

Solar Sail Subsystem without sail, Credit: NASA
Test Deployment with Linear Springs

Early prototype, Credit: NASA
Deployed Solar Sail

School Bus

6U Stowed Flight System

Folded, spooled and packaged in here

Human