The Lunar polar Hydrogen Mapper (LunaH-Map) CubeSat Mission

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Mission overview

- Selected by NASA for SIMPLeX program in November 2015 to fly a 6U cubesat carrying a planetary science payload on SLS EM-1 in 2018
- Led by ASU in collaboration with NASA centers, JPL, and commercial companies
- Will complete low perilune (10 km) passes over lunar south pole to map hydrogen abundance and distribution in PSRs
Mission objectives

● Technology demonstration
  ○ Design, build, fly and acquire in-flight data with a CubeSat-sized neutron spectrometer
  ○ Demonstrate a modified eHaWK+ solar array design in-flight
  ○ Maneuver using a low-thrust ion propulsion system (for ~8 months) to enter a lunar polar orbit
  ○ Demonstrate scheduled communications, tracking, and spacecraft operations with an interplanetary CubeSat

● Science: evaluate uniformity of hydrogen across the lunar south pole
  ○ Map hydrogen abundances of no less than 0.6% WEH (600 ppm) +/- 120 ppm
  ○ Map hydrogen abundances at spatial scales of less than or equal to 15 km² in the top 1-m of lunar regolith

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Development timeline

- Program Kickoff: Nov. 2015
- Preliminary Design Audit: Jul. 25, 2016
- Systems Integration Review: Jun. 23, 2017
- Delivery to KSC: Jun. 2018
- SLS EM-1 Launch: Sept. 2018

Design Development Integration & Test Anxiously Wait

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Mission timeline

**DEPLOYMENT**
- 00:00:00 Separation
- 00:00:15 Start CPU Boot
- 00:01:00 Solar Arrays Deployed
- 00:10:00 Sun Pointing Achieved
- 01:00:00 Propulsion Initialization
- 02:00:00 Momentum Unloading Burn
- 12:00:00 Checkout Complete, Pre-Burn Ranging

**CRUISE**
- 24:00:00 Start of First Burn
- 48:00:00 Burn check ranging
- 130:30:00 Lunar Fly-by
- 202:00:00 Post Fly-By Burn
- 70 Days Lunar Capture

**TRANSITION**
- 70 days Sequence of burns and ranging contacts

**SCIENCE**
- 430 Days Start of Science Phase
- 430 Days Science Orbit
- 490 Days Disposal?

**SCIENCE ORBIT X 141**
Mini-NS Payload

- < 2.5U detector using Cs$_2$YLiCl$_6$:Ce ("CLYC") scintillator material to detect epithermal neutrons
- Neutron spectroscopy is well suited for resource constrained missions
  - Low power, low mass, and low data volume
  - Challenge is to maximize surface area of detector for achieving statistically significant count rates compared to previous missions (e.g. LEND, LPNS)
- Need precise attitude determination, but not necessarily pointing control

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Spacecraft overview

- MMA eHAWK+ gimballed arrays
- BCT XACT ADCS system
- BCT XEPS and batteries
- Patch antennae
- Busek BIT-3 ion thruster
- Mini-NS payload
- Space Micro CSP C&DH
- JPL Iris radio

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Challenges

1. Developing subsystems as spacecraft is being developed — must have a flexible schedule, design, and team
2. Small budget → small team… like a startup!
3. Many low TRL components flying for the first time on EM-1 or post-integration
4. More autonomy necessary when handling faults during cruise due to relatively infrequent contacts with ground