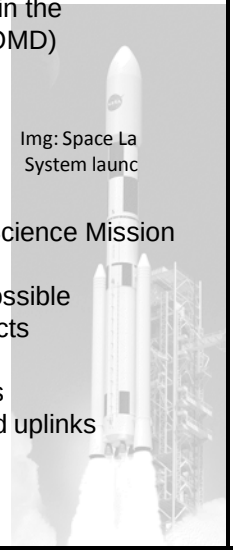
L2 Deep Space Binocular Telescope

Overview:

Submitter: Rebecca Farr/NASA/MSFC/EV71

Key collaborators:

Level 1 Exploration Systems Development (ESD) Office in the Human Exploration Operations Mission Directorate (HEOMD)
Space Launch System Outer Loop Team
Marshall Space Flight Center Advanced Concepts Office
Advisor: Dr. Marc Postman, Astronomer, GSFC STSci



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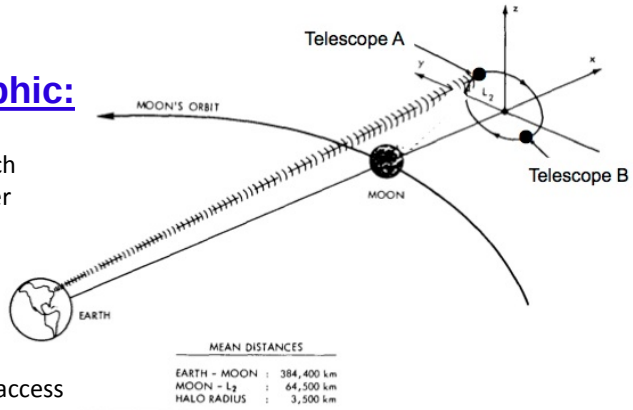
Goals of the proposed concept:

- Enable early synergism between SLS and a major Science Mission
- Leverage existing NRO assets to best possible use
- Enable new astronomical observations hitherto impossible
- Establish comprehensive catalog of near-Earth objects
- Establish comprehensive Exoplanet catalog
- Enable very long duration astronomical observations
- Enable long duration, daily data down-and command uplinks
- Enable 28 day repeat sky surveys in the ecliptic
- Enable out of ecliptic astronomical observations
- Enable NEO stereo observations and detection

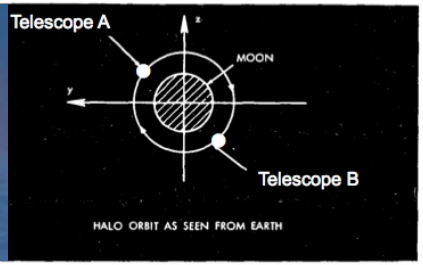
Ops Concept Graphic:

- SLS Evolved Launch Vehicle
  - Double payload, one launch
- Telescopes in view whenever Moon is visible.
- 12 hours of real-time data downlink time/day
- 12 hours of real-time commanding/day
- World-wide ground station access



- Perform housekeeping at times of eclipse (monthly).

Moonrise at the South Pole



Description:

Concept, implementation and operations approach:

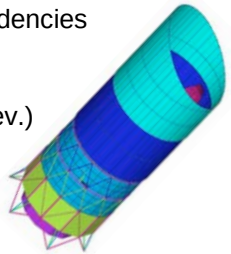
- Launch dual telescopes to halo orbit about L2, beyond Moon
- Operate in tandem or independently
- Always in view, as long as the Moon is above the horizon

Observations:

- 28 day ecliptic survey (not 97 minutes)
- Little limit to out-of-ecliptic viewing
- Days-long observations possible (not hours or minutes)
- Hours of real-time observation and commanding per day
- Binocular or independent observation modes
- Instrument suite TBD by astronomical community
- Promote global collaboration opportunities and dependencies

Readiness level of key technologies:

- Launch vehicle system ready by 2022 (Concurrent dev.)



Utilization of human exploration capabilities:

- SLS Heavy Lift, launch in 2022-2025
- Human servicing capability via Waypoint Station

Synergism: Multiple Mission Values to NASA:

ASTRONOMY and SPACE SCIENCE:

- Baryon Acoustic Oscillations
  - Survey 20k deg^2 of sky; > 10^8 galaxies
  - Objects in redshift range: $0.7 < z < 2.0$
- Weak Lensing
  - Survey 10k deg^2 of sky
- Type Ia Supernovae
  - Identification
  - Observe redshift and evolution
- Exoplanet Catalog
  - Light Curves
  - Internal Coronograph
  - Nulling Instruments
- Binocular Imaging Astronomy
  - Wide field Vis/NIR camera
  - Narrow field camera supports HST class astronomy
  - Days of exposure time

HUMAN EXPLORATION:

- L2 Waypoint
  - Experience getting there
  - Experience operating there
- Near Earth Objects
  - Survey and catalog
- Formation Flying GN&C

TECHNOLOGY DEVELOPMENT:

- Lift Capability
  - Exercises the Space Launch System
  - In-Space propulsion development
- Data Management
  - Large amounts of data
  - Challenging ground data system
  - Processing, archive & distribution
- Software Development
- Precise range measurements

Earth-Moon L2 Deep Space Binocular Telescope

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Key collaborators:

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Human Exploration Operations Mission Directorate
Space Launch System (SLS) Outer Loop Evolvability Team
MSFC Advanced Concepts Office
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PRIMARY CATEGORY: Planetary Science

GOALS - The main goals of the proposed concept include enabling early synergism between SLS and a major science mission to leverage existing NRO assets to their best possible use, for as many stakeholders as possible.

APPROACH - We propose launching both telescopes to a halo orbit about the Earth-Moon Libration Point 2 (L2), approximately 60,000 km beyond the Moon, where they will operate either in tandem or independently.

The L2 halo orbit beyond the Moon will enable new astronomical observations, namely very long duration (days) binocular astronomical observations of targets of interest, coupled with long duration (hours at a time) real-time data downlink and command uplink capabilities. Proximity to the moon will allow daily visibility above the horizon for ground stations at virtually any location on Earth, for up to 12 hours at a time.

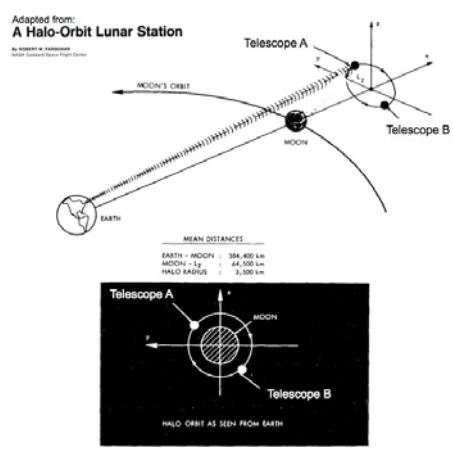

Fig 1. A Schematic of the Earth-Moon L2 location and how the orbit would appear from Earth are shown. Moonrise images from the South Pole, Greenbelt Maryland and California are shown to illustrate global visibility of the Earth-Moon L2 halo orbit.

The L2 halo orbit will allow 28 day repeat sky surveys in the ecliptic and out of ecliptic astronomical observations with minimal field-of-view blockages. Stereo

observations will quickly detect rapidly moving targets for creation of a comprehensive catalog of near-Earth objects. The stereo capability will also enhance the capability to establish a comprehensive Exoplanet catalog.

The telescopes could be operated in either binocular or independent observation modes, using an instrument suite to be determined by the astronomical community. This unique Observatory would promote global collaboration opportunities and dependencies

OPERATIONS CONCEPT- An SLS Evolved Launch Vehicle will be used to launch the dual telescope payload in one launch and deliver payload and Cryogenic Propulsion Stage (CPS) to target delivery point. CPS will provide additional delta v to set payload on a trans-lunar trajectory and ultimately, deliver it to the L2 location. Onboard spacecraft reaction control propulsion systems will provide the velocities necessary for attaining the halo orbit circularization and for station-keeping about L2. Fine observation pointing during astronomical observations will be accomplished via gyroscope reaction systems. Electrical power will be supplied by solar panels.

The telescopes will be in view to anyone on Earth whenever the Moon is above the horizon. This will allow up to12 hours per day of real-time data downlink and real-time commanding. Visibility will allow world-wide ground station access. Housekeeping would be performed at times of New Moon, when stray light from the full Moon could degrade observations (monthly).

The L2 halo orbit allows for a 28 day ecliptic survey (not 97 minutes) with little limit to out-of-ecliptic viewing. Days-long observations will be possible (not hours or minutes), coupled with hours of real-time observation, data downlinking and commanding per day.

Some possible astronomical observations include, but are not limited to: Baryon Acoustic Oscillations Survey (20k deg^2 of sky; > 10^8 galaxies); Weak Lensing Survey (10k deg^2 of sky); Type Ia Supernovae identification and observation; Exoplanet and NEO cataloging; Binocular Imaging Astronomy using wide field Vis/NIR camera and narrow field of view camera for HST class astronomy.

KEY TECHNOLOGIES AND SYNERGISM- Launch vehicle system and spacecraft systems are at a similar state of design and readiness, consisting presently of existing pieces of hardware and other critical elements that must yet be designed and built. Operability for both is anticipated in the 2022-2025 timeframe. This will allow for concurrent development of the integrated spacecraft/launch vehicle system.

By exercising the Space Launch System, this mission will augment and strengthen already planned development of a human-rated heavy lift capability, and should the Waypoint Station concept be implemented, astronauts could

provide in-space maintenance of the telescopes. This mission would provide experience in manned deep space navigation and precision docking, as well as experience in formation flying.

Key technology development areas include lift capability, deep space manned mission experience, in-space propulsion system development and spacecraft power management. In addition, the huge amount of data this mission would create will provide technology challenges in data management, ground data system acquisition, processing, archive and distribution, which will in turn, no doubt spur significant software development.