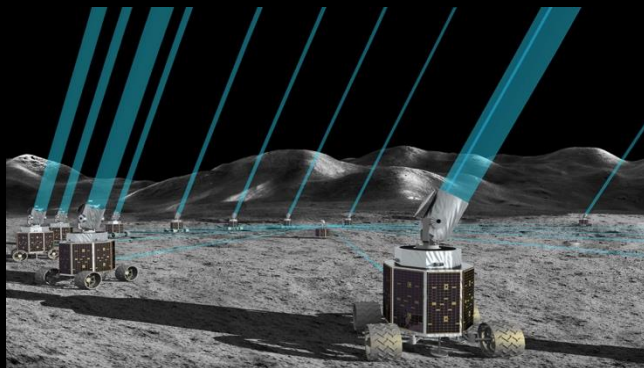


The Artemis-enabled Stellar Imager (AeSI)

Presentation to the Ad Astra Workshop/Multiple Aperture Concepts Session
Technologies and Capabilities Day
in Pasadena, CA – September 1-3, 2026



(Britt Griswold/GSFC)

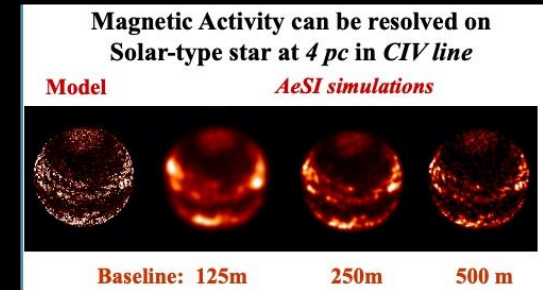


Dr. Kenneth Carpenter
NIAC Fellow, HST Ops. Project Scientist
NASA's GSFC

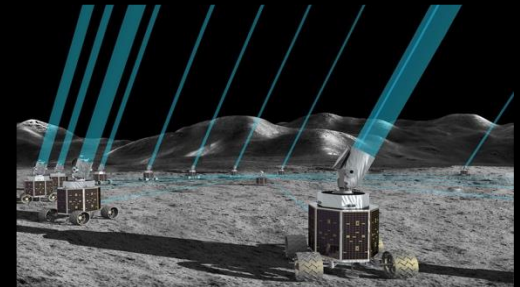
- **A lunar surface-based UV/optical interferometer concept that leverages our return to the Moon and the prior free-flying Stellar Imager (SI) study**

- End goal: reconfigurable 30-element interferometer, deployed, operated and serviced in collaboration with the Artemis program
- Primary goals are in stellar astrophysics and heliophysics:
 - Magnetic processes; stellar interior structure
 - **Predictive dynamo models for the Sun and stars**
 - Exoplanet host star characterization
 - Also: supernovae, symbiotic and variable stars, and AGN
- All require high angular resolution UV/Optical spectral imaging
- **NIAC-funded Phase I study led by Ken Carpenter/NASA-GSFC**
 - Established feasibility
 - Identified technical tall poles and potential benefits of lunar site
 - Enabled evaluation of trades relative to the free-flying version
- **AeSI Homepage:** <https://hires.gsfc.nasa.gov/si/aesi.html>

AeSI Overview



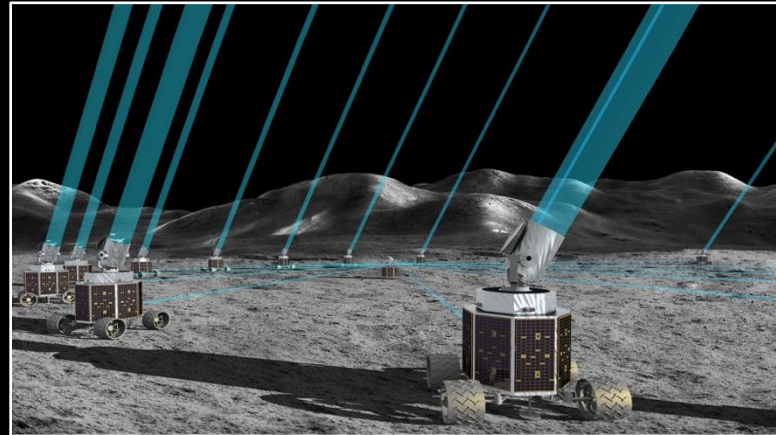
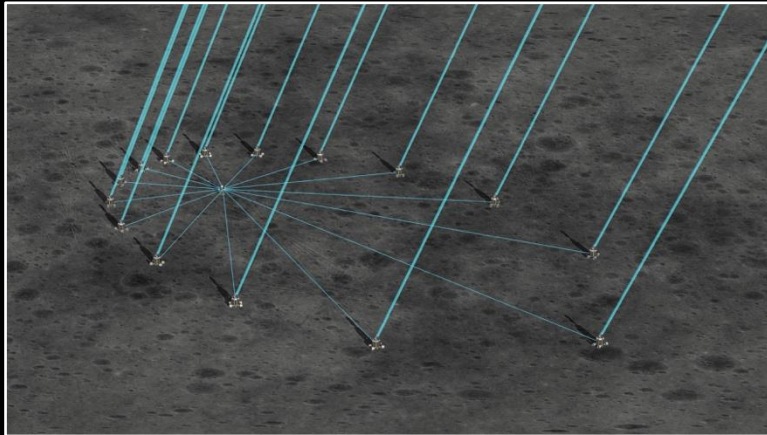
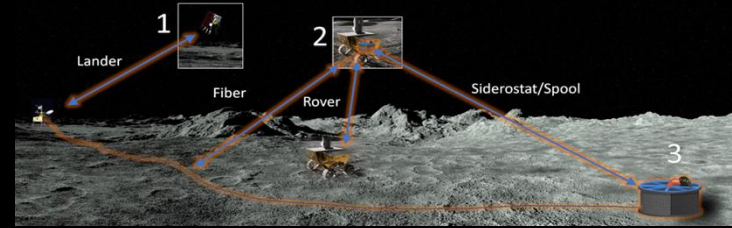
Simulated AeSI observations



Phase I design for the Artemis-enabled Stellar Imager.
(Illustration by B. Griswold)

Our Proposed Approach

- Start with a small demonstration (pathfinder) mission to show feasibility of interferometry from the Moon and to generate some early science results (e.g., MoonLITE, Gerard van Belle)
- In parallel, continue the development of a long baseline interferometer concept that will enable a quantum leap in our capabilities to observe the Universe in Ultra High Definition: Artemis-enabled Stellar Imager (AeSI).



Demanding Design Drivers

- Need to survive the night/enable observations through the night:
drives power requirements
 - Likely means surface nuclear reactor (fission) or feed from Artemis infrastructure
 - Beamed power extremely useful in either case
(e.g., <https://spacenews.com/star-catcher-signs-power-beaming-deal-with-aethero/>)
- Required Surface Mobility
 - Challenging to move mirror stations around for delay compensation, which may require surface ‘paving’ or perhaps rails.
- Sufficient Target availability/sample sizes
 - South Polar location significantly limits #targets visible; lower latitude sites preferred
- Need for higher UV-Sensitivity due to # of reflections in delay-lines, requiring
 - Better-reflectivity UV mirror coatings
 - More sensitive detectors, esp. for 1200-1600 Å
- Dust and scattered light mitigations

Required Technology Developments

- **Power Stations that enable continuous operations through lunar night and day:**
 - Best option: Nearby Surface Nuclear Reactor, as being developed by Artemis
 - Alternative: power supplied by Artemis infrastructure, with efficient power transmission
- **Control System to align carts and optics after reconfigurations**
 - also investigate possible need for ‘rails’ or surface ‘paving’ to support required mobility
- **Lower-latitude lunar sites for AeSI and other observatories:**
 - the ability to site the array at lower, non-polar latitudes would tremendously increase the scientific productivity of the observatory and unlock AeSI’s full potential
- **Dramatically better reflectivity UV mirror coatings and more sensitive UV detectors:**
 - higher-QE UV detectors, higher-reflectivity coatings (shared needs with HWO)
- **Space-qualified delay lines:**
 - innovative fewer-reflection delay-line designs
- **Dust and Scattered light mitigations:**
 - Refined dust/scattered light control systems/protocols

Technology Development Plan

- **Power Stations that enable continuous operations through lunar night and day:** Artemis development of surface nuclear reactors and/or other Artemis-supplied power
- **Control system to align carts and optics after array reconfigurations:** NIAC Phase II, or alternative, proposal
- **Lower-latitude lunar sites for AeSI and other observatories:** advocate in the astronomical and Artemis communities for the necessary developments
- **Dramatically better reflectivity UV mirror coatings and more sensitive UV detectors:** Habitable Worlds Observatory (HWO) will drive this
- **Space-qualified delay lines:** funds to be sought for GSFC/MSFC engineering effort
- **Dust and Scattered light mitigations:** seek funds for using MSFC regolith-chamber and PLANET-lab testing facilities and Regolith Adherence Characterization experiment results

Leveraging of External Capabilities

- The Baseline designed *AeSI* architecture makes widespread use of developments already being pursued for Artemis infrastructure
 - 1) Pre-Launch support
 - 2) Transportation: to lunar orbit and to the lunar surface
 - 3) Deployment: Transportation to observatory site, unpacking of elements, and distribution of the *AeSI* telescope nodes on the Lunar surface
 - 4) Communications between the hub and Earth
 - 5) Pointing, Navigation, and Timing (PNT) to support array management
- Commercial developments of rovers, power sources, etc. may be of use
- Overlap of requirements for Habitable Worlds Observatory (HWO) will likely provide solutions for enhanced UV reflectivity mirror coatings and enhanced UV detector sensitivities

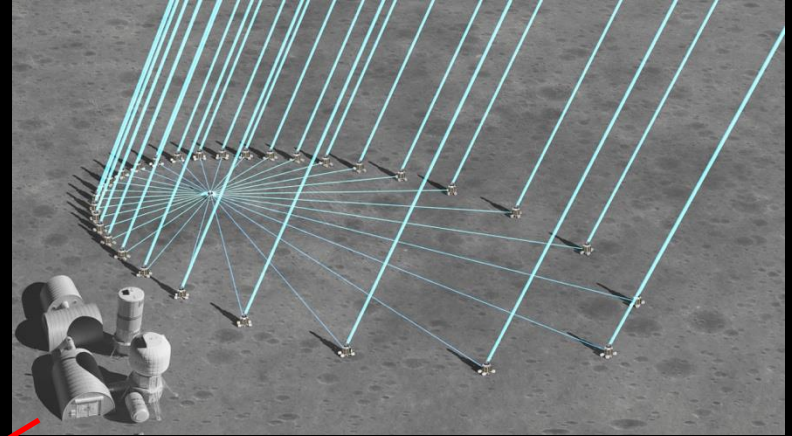
Deployment, Servicing with Artemis

- The launch & transportation to the lunar surface near an Artemis base camp is one of the primary contributions of Artemis to AeSI. Candidate launch vehicles include: Starship, New Glenn, SLS
- AeSI's location on the Moon means servicing will be much easier than at L2.
 - Utilize the resources of Artemis to transport new hardware from Earth to the Lunar surface & then to observatory site
 - Use a mixture of human and/or robotic services to perform both maintenance and upgrades
 - Robots could become increasingly important if we are able to site the observatory at lower lunar latitudes to improve science productivity



The Value of Humans on-site for AeSI

- On-site Astronauts will be of great value to AeSI, especially in its deployment, commissioning, and servicing.
 - This requires a habitat and hanger-like facilities in which extra mirror carts, hubs, and components could be housed and in which the astronauts could work in a shirt-sleeve environment on complex tasks.
- An ongoing presence would allow for the continuing servicing of components, e.g., there might always be a spare mirror cart or two in the hanger being refurbished for use when there is a failure in the operating array. New hubs could be prepared in that same hanger.



A non-polar site is of great interest for AeSI

- Current Plans dictate a south polar site in the vicinity of an Artemis Base
 - Primary advantage of such a location is the robust support that would be available from the Artemis base, in terms of infrastructure, astronaut & robotic support.
 - However, the number of targets accessible over the course of the year is significantly limited by a South Polar location. This drives the size of the mirrors and overall array baselines to larger, more expensive values to obtain the required sample-sizes.
- Non-polar sites provide significant advantages
 - The number of astronomical targets observable over the course of a year is $\sim 2x$ larger at low latitudes (lunar and ecliptic!) vs. what can be seen from polar regions
 - Duration of daylight and dark, nighttime hours is much more regular and allows for a better, more efficient, and more highly productive design and operations
- Technology Development needed: either plan to establish Artemis bases at lower latitudes or develop long-range rovers or remote habitats to enable astronaut/robotic Artemis support of non-polar regions

AeSI Concept Development Team

Mission concept under development by NASA/GSFC in collaboration
with experts from Industry, Universities, and Astronomical Institutes

Ken Carpenter	NIAC Fellow, PI (NASA-GSFC)	Dave Mozurkewich	Lead System Engineer (Seabrook Eng)
Vladimir Airapetian	Science Definition (Amer. Univ.)	Sarah Peacock	Science Definition, Study Co-Mgr, Outreach Co-Lead (UMBC/GSFC)
Tabetha Boyajian	Ground Interferometry Expert (LSU)	Noah Petro	Artemis Expert (GSFC)
Derek Buzasi	Astereoseismology (U. Chi)	Lori Pigue	Lunar Environment Expert (USGS)
Jim Clark	Mechanical Engineer (NPOI)	Jayadev Rajagopal	Science Definition (NOIRLab)
Michelle Creech-Eakman	Ground Interferometry Expert (MRO)	Gioia Rau	Deputy Program Lead (CUA)
Ashley Elliott	Postdoc, Interferometry Expert (GSFC)	Gerard van Belle	Interferometry Expert, Mission Design Lead (Las Cumbres Obs.)
Jon Hulberg	Postdoc, Science/AI (GSFC)	Debra Wallace	Chief Science Engineer, Dust Mitigation (MSFC)
Margarita Karovska	Science Definition Co-Lead (CfA)	Kim Weaver	Senior Advisor, Space Missions & Space Interferometry (GSFC)
David Leisawitz	Space Interferometry Expert (GSFC)		
Peter Maksym	Science Definition, Lunar Environment Testing (MSFC)		
Jon Morse	Senior Advisor, Lunar Science & Infrastructure (ASU)		

Backup Slide

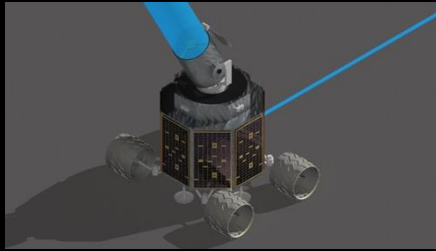
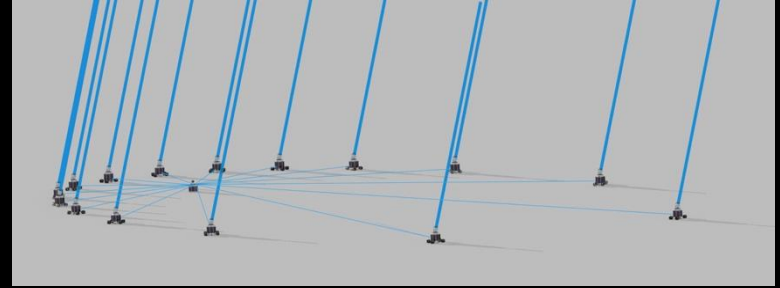
NIAC Phase 1 Design: GSFC Integrated Design Center (IDC)

Stage 1: 15 rovers (mirrors) configured in 1-km major axis elliptical array to avoid long delay-lines

Stage 2: upgrade to 30 rovers, enhanced hub

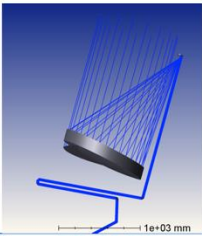
Could be deployed in smaller, more numerous stages if desired

Assumes near-polar site, but easily adapted to lower latitude site



Cart/Telescope Optics

Integrated Design Capability / Instrument Design Laboratory



1e+03 mm

Mirror Station:

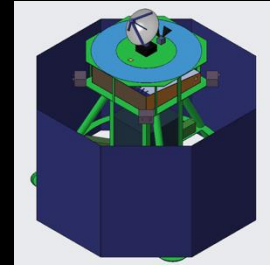
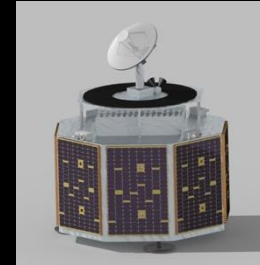
artist's concept (B. Griswold) and internal optics (IDC/D. Mozurkewich)

IDC: Engineering Study

- Systems
- Mechanical Design
- Optical Design
- Communications
- Thermal
- Power

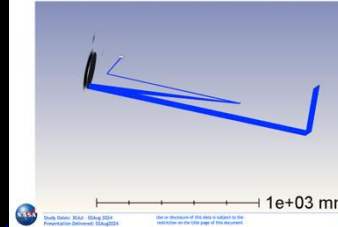
Conclusion: Feasible!!!

IDC provided many good recommendations for further studies and technology development.



Hub Optical Path

Integrated Design Capability / Instrument Design Laboratory



1e+03 mm

Hub: artist's concept (B. Griswold) and internal details/optics (IDC & D. Mozurkewich)

(Britt Griswold/GSFC)