FARSIDE: A LOW FREQUENCY RADIO ARRAY FOR THE LUNAR FARSIDE. Jack. O. Burns[1] and Gregg Hallinan[2] on behalf of the FARSIDE team, [1]Center for Astrophysics and Space Astronomy, University of Colorado Boulder, Boulder, CO, jack.burns@colorado.edu, [2]California Institute of Technology, Pasadena, CA, gh@astro.caltech.edu.

Figure 1. An artist's impression of a habitable planet experiencing a coronal mass ejection (CME) from its host star, an active M dwarf. Detecting coronal mass ejections, energetic particle events and the magnetospheres of candidate habitable planets is a key science goal for the FARSIDE array. Credit: Chuck Carter/Caltech/KISS.

Introduction: FARSIDE (*Farside Array for Radio Science Investigations of the Dark ages and Exoplanets*) is a Probe-class concept to place a low radio frequency interferometric array on the farside of the Moon. A NASA-funded design study, performed in collaboration with JPL, focused on the instrument, a deployment rover, the lander and base station, delivered an architecture broadly consistent with the requirements for a Probe mission [1]. This notional architecture consists of 128 dipole antennas deployed across a 10 km area by a rover, and tethered to a base station for central processing, power and data transmission to the Lunar Gateway, or an alternative relay satellite (Fig. 2). FARSIDE would provide the capability to image the entire sky each minute in 1400 channels spanning frequencies from 100 kHz to 40 MHz, extending down two orders of magnitude below bands accessible to ground-based radio astronomy. The lunar farside can simultaneously provide isolation from terrestrial radio frequency interference, auroral kilometric radiation, and plasma noise from the solar wind. It is thus the only location within the inner solar system from which sky noise limited observations can be carried out at sub-MHz frequencies. This would enable near-continuous monitoring of the closest stellar systems in the search for the radio signatures of coronal mass ejections and energetic particle events, and would also detect the magnetospheres for the nearest candidate habitable exoplanets (Fig. 1). Simultaneously, FARSIDE would be used to characterize similar activity in our own solar system, from the Sun to the outer planets, including the hypothetical Planet Nine. Through precision calibration via an orbiting beacon, and exquisite foreground characterization, FARSIDE would also measure the cosmic Dark Ages global 21-cm signal at redshifts z ~50–100. It would be a pathfinder for a larger 21-cm power spectrum instrument by carefully measuring the foreground with high dynamic range. The unique observational window offered by FARSIDE would enable an abundance of additional science ranging from sounding of the lunar subsurface to characterization of the interstellar medium in the solar system neighborhood.

Science Implementation: The FARSIDE instrument front-end uses electrically short simple dipole antennas to achieve sky background noise-limited observations. The regolith in the lunar highlands is thick, has low conductivity, and varies slowly with depth removing the need for a ground plane. Calibration would make use of astronomical sources, as well as an orbiting calibration beacon that would map each antenna gain pattern together with the effect of the lunar subsurface. The implementation uses thin wires on the ground with the rest of the system leveraging existing designs: high space heritage front-end amplifiers, fiber optics, and a correlator system

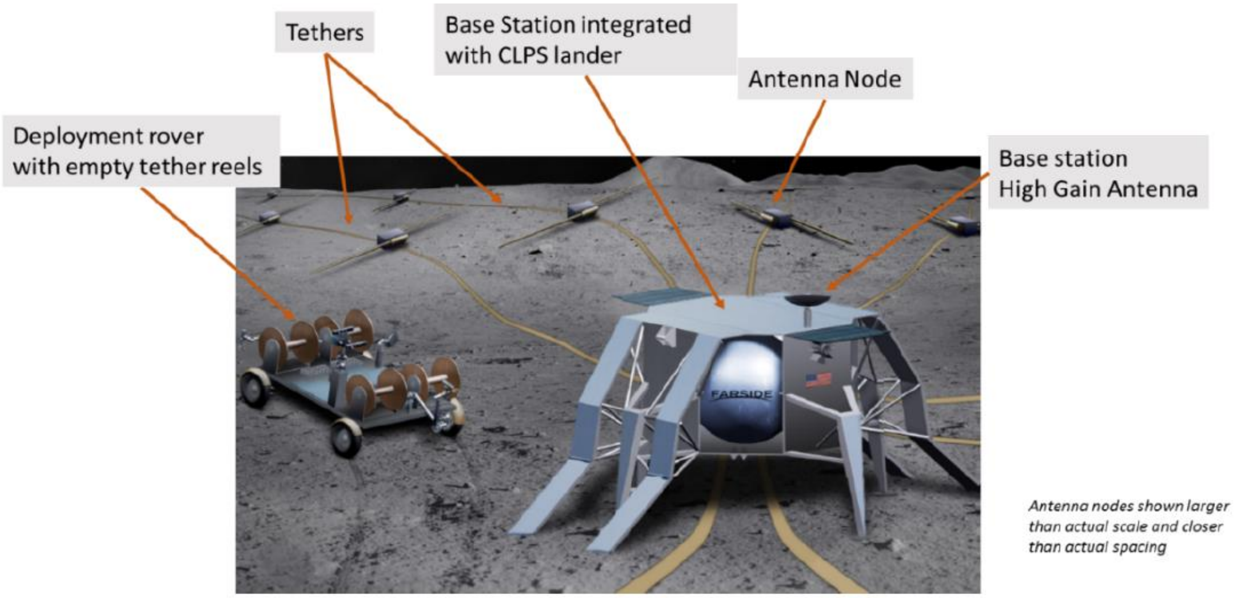

Figure 2. Overview of FARSIDE observatory after deployment of tethers and antennas. Credit: Robin Clarke, JPL.

used in ground-based radio astronomical observatories such as the Owens Valley Radio Observatory Long Wavelength Array (OVRO-LWA).

Table 1. FARSIDE Instrument Characteristics

Item	Value	Units
Type of Instrument	Radio telescope	
Number of channels	256	
Size/dimensions (for each instrument)	0.094 × 0.043 × 0.045	m × m × m
Instrument mass without contingency	169.0	kg
Instrument mass contingency	30	%
Instrument mass with contingency	219.6	kg
Instrument average payload power without contingency	235	W
Instrument average payload power contingency	30	%
Instrument average payload power with contingency	305	W
Instrument average science data rate without contingency	5,926	kbps
Instrument average science data rate contingency	30	%
Instrument average science data rate with contingency	7,704	kbps
Instrument Fields of View	10,000	sq. deg.
Pointing requirements (knowledge)	1	degrees
Pointing requirements (control)	N/A	degrees
Pointing requirements (stability)	N/A	deg/sec

The FARSIDE mission concept includes three components: a commercial lander (e.g., part of NASA's Commercial Lunar Payload Services) carrying the FARSIDE base station and a rover which deploys the array of antenna nodes. The baseline design of the base station includes a pair of enhanced Multi Mission Radioisotope Thermoelectric Generators (eMMRTG) to provide power for the receivers and the signal processing functions of the FX correlator, as well as communicating with the Lunar Gateway (or a similar data relay capability from the lunar farside) to send the science data back to Earth. The baseline rover would be solar powered, hibernating at night, and also includes a telecommunications subsystem to communicate with the Gateway during the array deployment operations phase. The 128-node array is configured in 4 petals to minimize rover travel on the lunar surface, with a deliberate asymmetry to improve imaging performance. The array would be deployed on 4 successive lunar days, one petal of 32 nodes deployed in the 10–14 Earth days of sunlight, with the rover hibernating during lunar night.

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