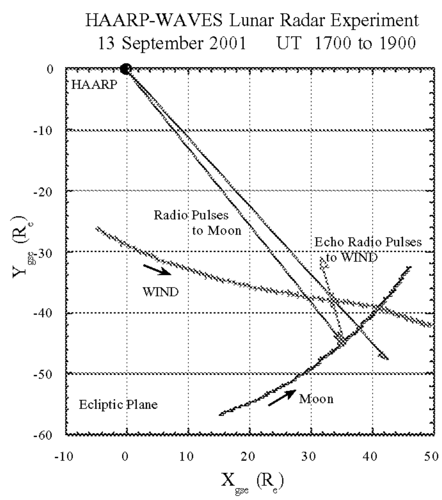
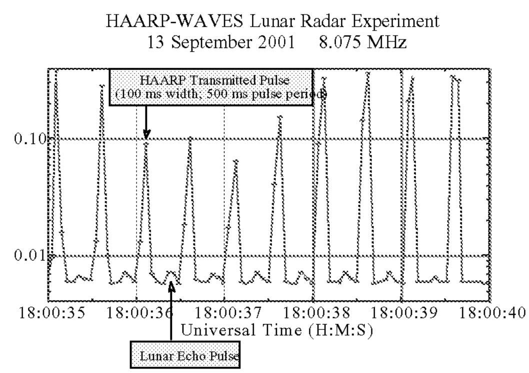
LUNAR RADAR CROSS SECTION AT LOW FREQUENCY. P. Rodriguez[1], E. J. Kennedy[1], P. Kossey[2], M. McCarrick[3], M. L. Kaiser[4], J.-L. Bougeret[5], and Yu. V. Tokarev[6], [1]U. S. Naval Research Laboratory, Information Technology Division, 4555 Overlook Ave., SW, Washington, DC 20375, [2]U. S. Air Force Research Laboratory, Space Vehicles Directorate, 29 Randolph Rd., Hanscom AFB, MA 01731, [3]Advanced Power Technologies, Inc., 1250 24[th] St., NW, Washington, DC 20037, [4]NASA/Goddard Space Flight Center, Laboratory for Extraterrestrial Physics, Greenbelt, MD 20771, [5]DESPA-DASOP, Observatoire de Paris, 5, Place Jules Janssen, 92195 Meudon Cedex, France, [6]Radiophysical Research Institute, B. Pecherskaya St, 25, Nizhny Novgorod 603600, Russia

Introduction: Recent bistatic measurements of the lunar radar cross-section have extended the spectrum to long radio wavelength. We have utilized the HF Active Auroral Research Program (HAARP) radar facility near Gakona, Alaska to transmit high power pulses at 8.075 MHz to the Moon; the echo pulses were received onboard the NASA/WIND spacecraft by the WAVES HF receiver. This lunar radar experiment follows our previous use of earth-based HF radar with satellites to conduct space experiments [1]. The spacecraft was approaching the Moon for a scheduled orbit perturbation when our experiment of 13 September 2001 was conducted. During the two-hour experiment, the radial distance of the satellite from the Moon varied from 28 to 24 R_m, where R_m is in lunar radii. The figure below shows the geometry of the experiment, in the solar ecliptic plane.



Measurements: HAARP pulses with widths of 100-ms and pulse periods of 500 ms provided about 12,000 data samples of the direct and echo radiowaves integrated over 20 ms. From these pulse-echo pairs we obtain the lunar radar cross-section using the radar equation. We obtain an average cross-section of about 15% of the geometric cross-section, with maximum values of about 50%. Previous determinations [2], [3], of the lunar radar cross-section at shorter wavelengths have suggested an increase of the cross-section with increasing wavelength. Our measurement confirms this dependence and extends the spectrum of lunar radar cross-sections to a wavelength of 37 meters.

The HAARP-WAVES experiment provided evidence of high reflectivity locations on the lunar surface that may be associated with topographical features that preferentially return an echo signal to the satellite. The motion of the spacecraft apparently changed the aspect sufficiently to allow several such regions to be sampled. The following figure illustrates a 5-second interval of data showing the direct HAARP pulses and the echo lunar pulses as received by the WAVES instrument.



Conclusion: This new technique for long wavelength radar cross-section measurement is free of scintillation effects caused by the earth's ionosphere and provides a relatively clean measurement of the lunar radar cross-section. High power long wavelength radars, such as HAARP, can enhance our methods of lunar research. We suggest that future lunar radar experiments with lunar-orbiting spacecraft can provide a new window on lunar topography and subsurface conductivity measurements.

References: [1] Rodriguez P. et al. (1998), *Geophys. Res. Lett., 25,* 257-260; (1999), *Geophys. Res. Lett., 26,* 2351-2354. [2] Evans J. V. and Pettengill G. H. (1963), in *The Solar System, Vol. IV, The Moon, Meteorites, and Comets,* 129–161, edited by B. M. Middlehurst and G. P. Kuiper. [3] Davis J. R. and Rohlfs D. C. (1964) *J. Geophys. Res., 69,* 3257-3262.