Mini-RF: Synthetic Aperture Radar on LRO
Mini-RF has demonstrated its ability to make high-quality SAR images in S- and X-bands at two different resolutions. Initial analysis of images and backscatter data indicate that Mini-RF is a fully functional imaging SAR, capable of providing new and unique information about lunar surface properties. The principal mission of LRO is to gather strategic information about the lunar surface and its environment to enable a variety of surface missions, exploration and activities. Mini-RF can collect information about the Moon that directly addresses lunar strategic knowledge needs and contributes to LRO Level 1 requirements. Mini-RF data complements other LRO instrument data by providing additional information on the physical environment and properties of the lunar surface. Mini-RF currently collected non-polar nighttime data using spare downlink capacity.
Specifications

• Mini-RF, a lightweight hybrid-polarization Synthetic Aperture Radar (SAR), is an SOMD-ESMD jointly funded technology demonstration.

• Images terrain in two wavelengths and two resolutions
  • S-band $\lambda =12.6$ cm
  • X-band $\lambda =4.2$ cm
  • Baseline resolution (75 m/pixel)
  • Zoom resolution (15 m/pixel)

• Mini-RF can measure topography by interferometry.
  • 15 m/pixel, sub-meter vertical resolution

• Mini-RF’s hybrid-polarization technique permits measurement of Stokes parameters which provide detailed characterization of the backscattered field of the lunar surfaces.
LCROSS Support

Mini-RF south-polar S-zoom coverage acquired in support of LCROSS

Faustini, 39km
LCROSS Support Continues

Pre Impact

Post Impact
Examples of Mini-RF Data

Mini-RF SAR data co-registered with Clementine UVVIS context mosaics.
Mini-RF data is synergistic with LROC data

Bessel crater, D=16 km 21.8°N 17.9°E

Mini-RF OC S-band zoom

Apollo 15 Pan frame AS15-9328
Crater inside Apollo Basin
Mini-RF enhances the ability of LRO to meet its level 1 requirements

- **Mini-RF data uniquely determines RF backscatter properties of polar permanently shadowed areas**
  - Best technique for mapping extent, physical state, and purity of polar ice
  - Complementary to polar observations of other LRO instruments (LOLA, LEND, LAMP & DIVINER)

- **Mini-RF provides direct measurement of lunar surface decimeter-scale roughness, smoothness, & characterization of the regolith**
  - Essential for landing site certification, exploration traverse planning
  - Complementary information to decameter-scale surface slope (LOLA) and meter-scale roughness (LROC NAC) data

- **Mini-RF provides unique scientific data to permit better exploration and utilization planning**
  - Maps of polar cold traps; best technique for surface imaging of dark areas
  - Maps of low-backscatter materials at non-polar locations (e.g., dark mantle pyroclastic deposits, possible exploration targets and feedstock for ISRU)
  - Study of crater ejecta, extent and distribution, crater evolution, regolith formation, degradation and erosion, subsurface properties
  - Only way of acquiring farside radar data
Mini-RF can measure topography complementary to the LOLA data, by filling in gaps in LOLA coverage near the equator.
Mini-RF south-polar S-zoom coverage acquired in support of LCROSS

Faustini, 39km
Mini-RF is already acquiring data of potential Constellation landing sites.
Higher ilmenite abundances cause reduced radar backscatter.
Top-level Performance Requirements

- Operation at two frequencies
  - Information on scattering function
  - Demonstrated by imaging at both S & X bands
- Range swath width
  - S-band baseline resolution: 6 km
  - S-band zoom, & X-band resolution: 4 km
  - Compliance demonstrated directly by SAR images
- Resolution
  - Baseline 150 m, Zoom 30 m.
  - Correlation computed from range compressed SAR data compared to ideal response
- Sensitivity
  - Most important for ice detection
  - Analysis of data indicates that Mini-RF meets NE $\sigma_0$ specs
Conclusions

- Mini-RF has and will continue to work with LCROSS

- Mini-RF is collecting high-quality data of use to ESMD & SMD

- Mini-RF enhances the ability of LRO to meet its level 1 requirements
  - Mini-RF data uniquely determines RF backscatter properties of polar permanently shadowed areas
  - Mini-RF provides direct measurement of lunar surface decimeter-scale roughness, smoothness, & characterization of the regolith
  - Mini-RF can acquire topography information to increase equatorial coverage