FARCAM
Exploring the Lunar Surface

TELEPHOTO RECONNAISSANCE IMAGING FOR LUNAR ROVER APPLICATIONS (FARCAM)

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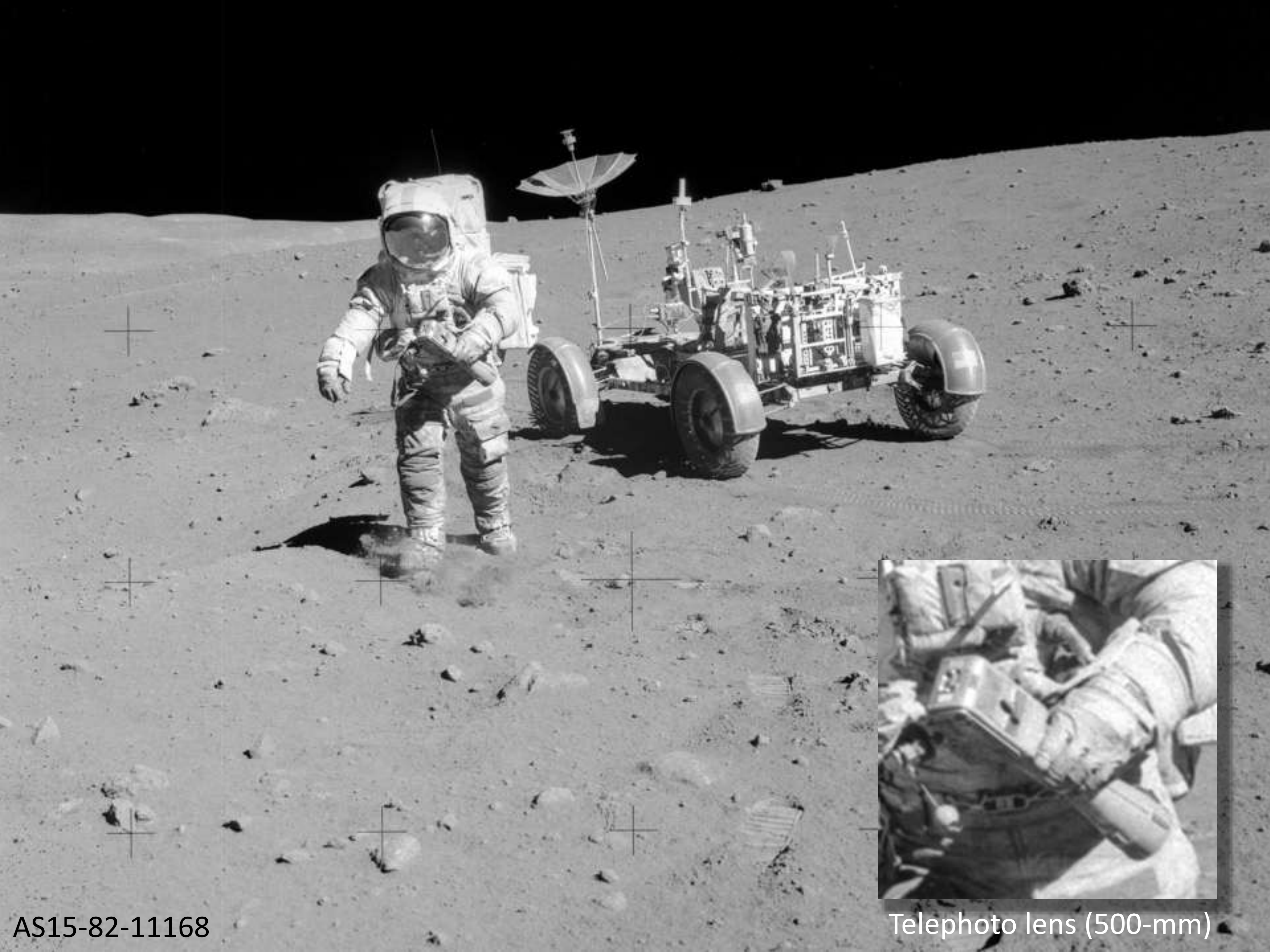
Rationale

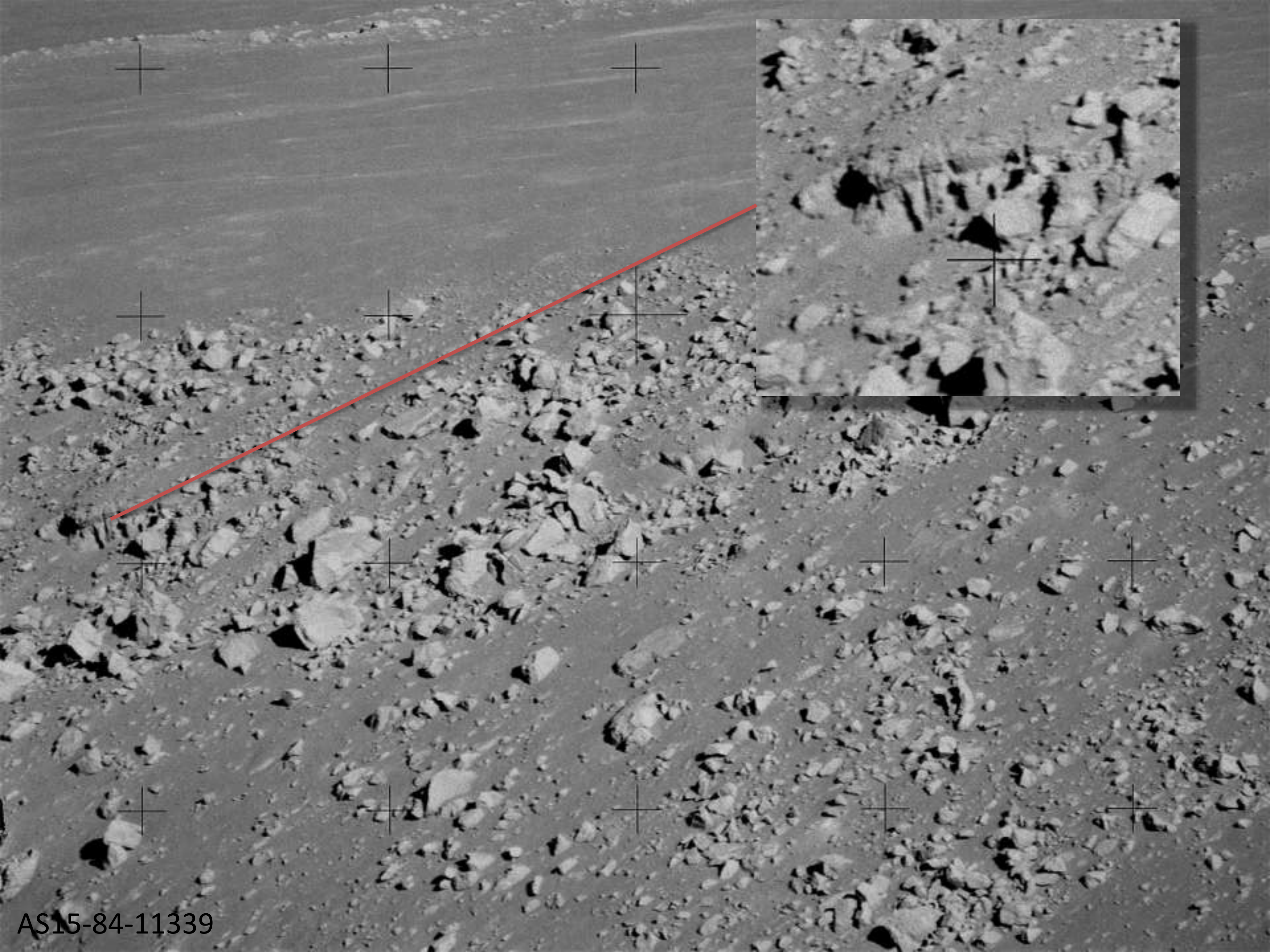
Decadal Survey and the Lunar Exploration Roadmap call out critical science and exploration measurements from the surface to tie orbital remote sensing datasets to physical characteristics (composition, maturity, roughness)

Major advances in lunar science and exploration require a long lived and capable rover

A long lived and capable science and exploration rover (*i.e.* Intrepid, LEAG 2011) needs telephoto imaging -- FARCAM

- Determining where you might want to go
- Understanding where you cannot go
- Gathering data of areas where you do not have time to go


AS15-82-11168
Telephoto lens (500-mm)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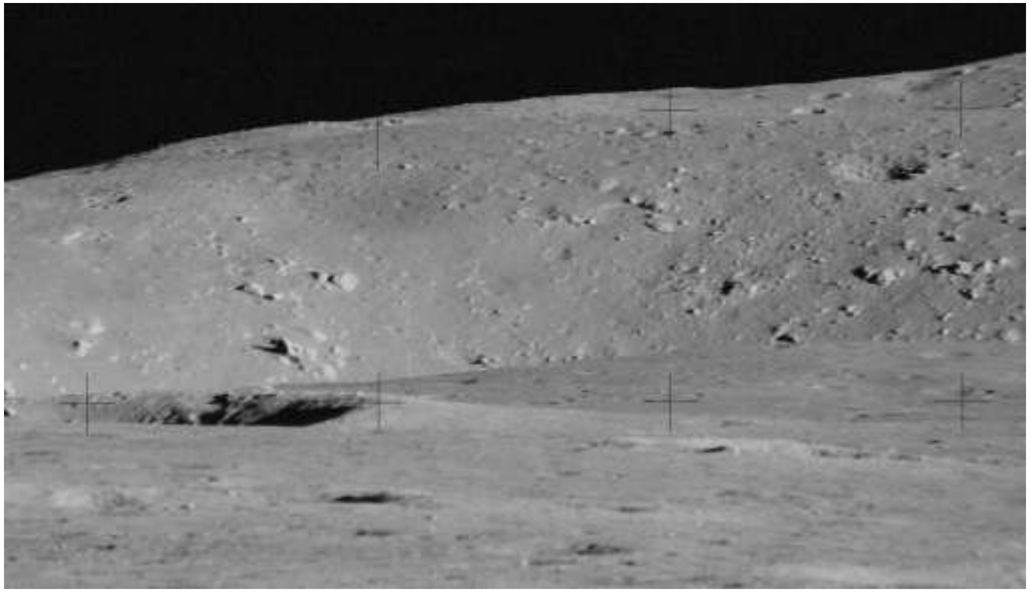
FARCAM Specifications

- 110 mm focal length
- 1.2 kg
- f/8 aperture
- 5.5 micron pixels
- 2336 × 1752 pixel array
- → Pixel scale 5×10^{-5} radians
- 5 cm per pixel at 1 km
- 6.7° x 5.0° FOV
- → 117m × 88m at 1 km
- 10 msec to 500 msec exposures

  (noon to Earthshine and inside shadows)
- Color options: 3-color Bayer filter (also add narrowband filter wheel)



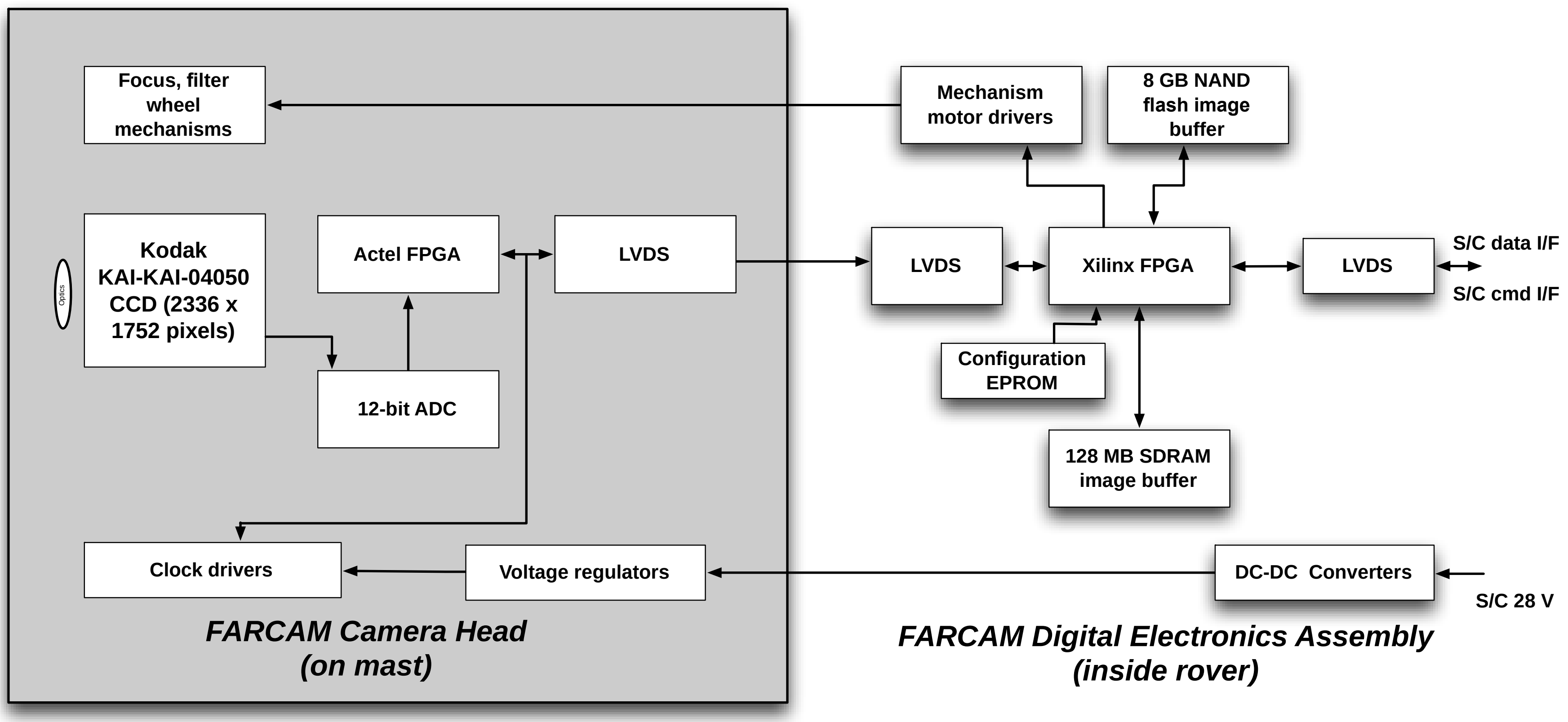
Apollo 15 telephoto image of Pluton crater

Digital Electronics Specifications

- Commanding, compression, buffering
- Mounted “inside” rover
  - 1 kg
  - 7.5 W idle, 12 W active (includes camera power)
- 8 GByte internal buffer permits storage of 4,000 raw frames
  - 360° × 80° mosaic
  - 3 science color filters
  - ≥ 20% overlap between frames
  - 2x compression (JPEG-LS)
- Sub-framing
- Thumb-nails

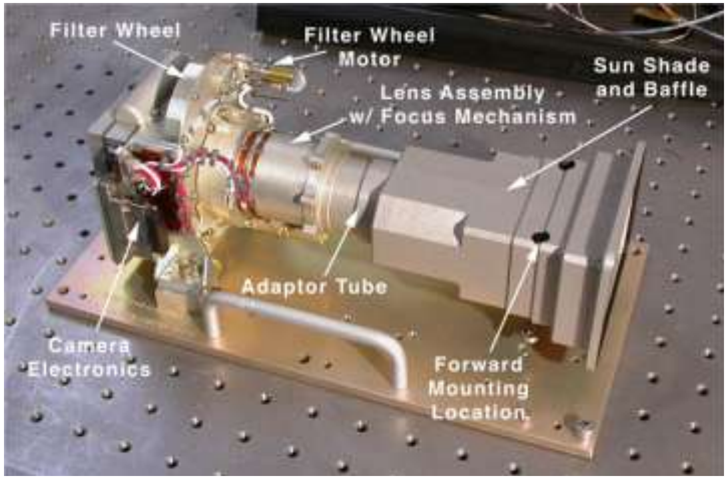
MSL Mastcam 100 mm Image
Flanks of Mt. Sharp, 15 km away

FARCAM Block Diagram



MSL Mastcam M-100 Heritage

- 100 mm focal length
- f/10 focal ratio
- 5.1 x 6.8° FOV
- 1200 x 1600 pixels (7.4 µm)
- Bayer pattern filter RGB color
- Focus mechanism (2 m to infinity)
- Filter wheel for narrowband color
- Works on Mars!



MSL Mastcam 100 mm Flight Unit

MSL Mastcam 100 mm ground cal target image

15 km>

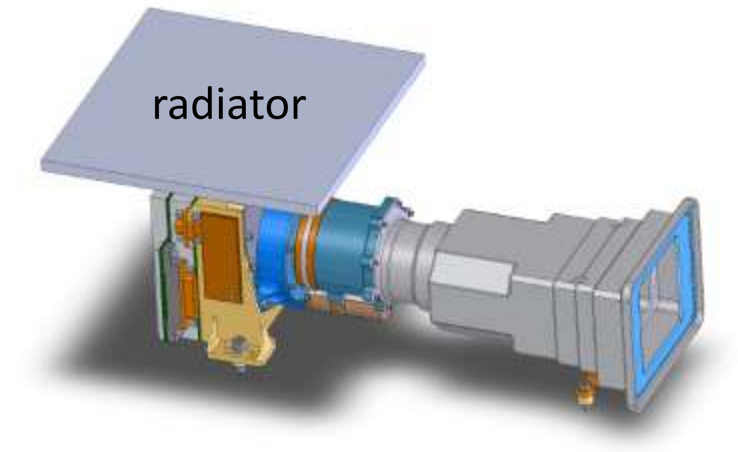
3 m>

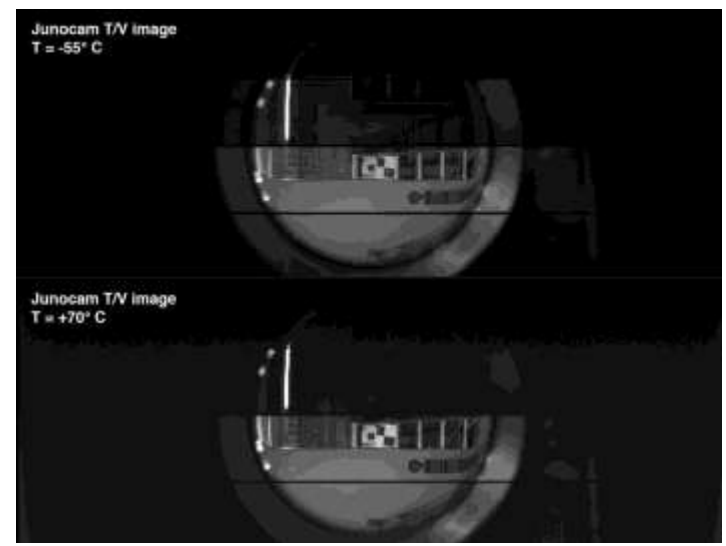
FARCAM Challenges

- Mass – well understood from Mastcam and Junocam
- Power - well understood from Mastcam and Junocam
- Schedule - better understood from Mastcam and Junocam
- Dust – Focus mechanism sealed, dust on the lens is a secondary issue—FARCAM is not close to surface, front element has 6” sunshade to keep any dust on front window in shadow
- Thermal – see next slide

Thermal

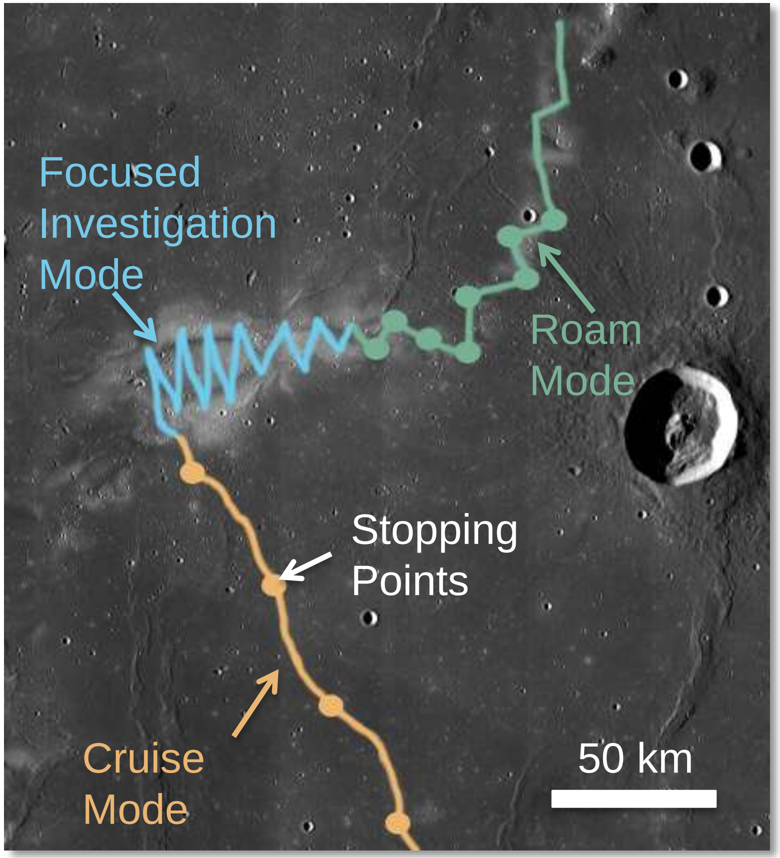
- FARCAM designed to survive the lunar night, operate over the lunar day
- Night case (-180° C): Mastcam is qualifieded to survive at -135° C, requires only 0.5 W survival heat at night
- Day case (120° C): average power dissipation only 2.5 W, so CCD can be kept <35°C with 6 x 6 in. upward facing radiator (silver teflon surface) and MLI everywhere else
- Low dark current detector (Truesense CCD) and fast readout (10 MHz) yields acceptable images even at +70°C, so we have substantial thermal margin





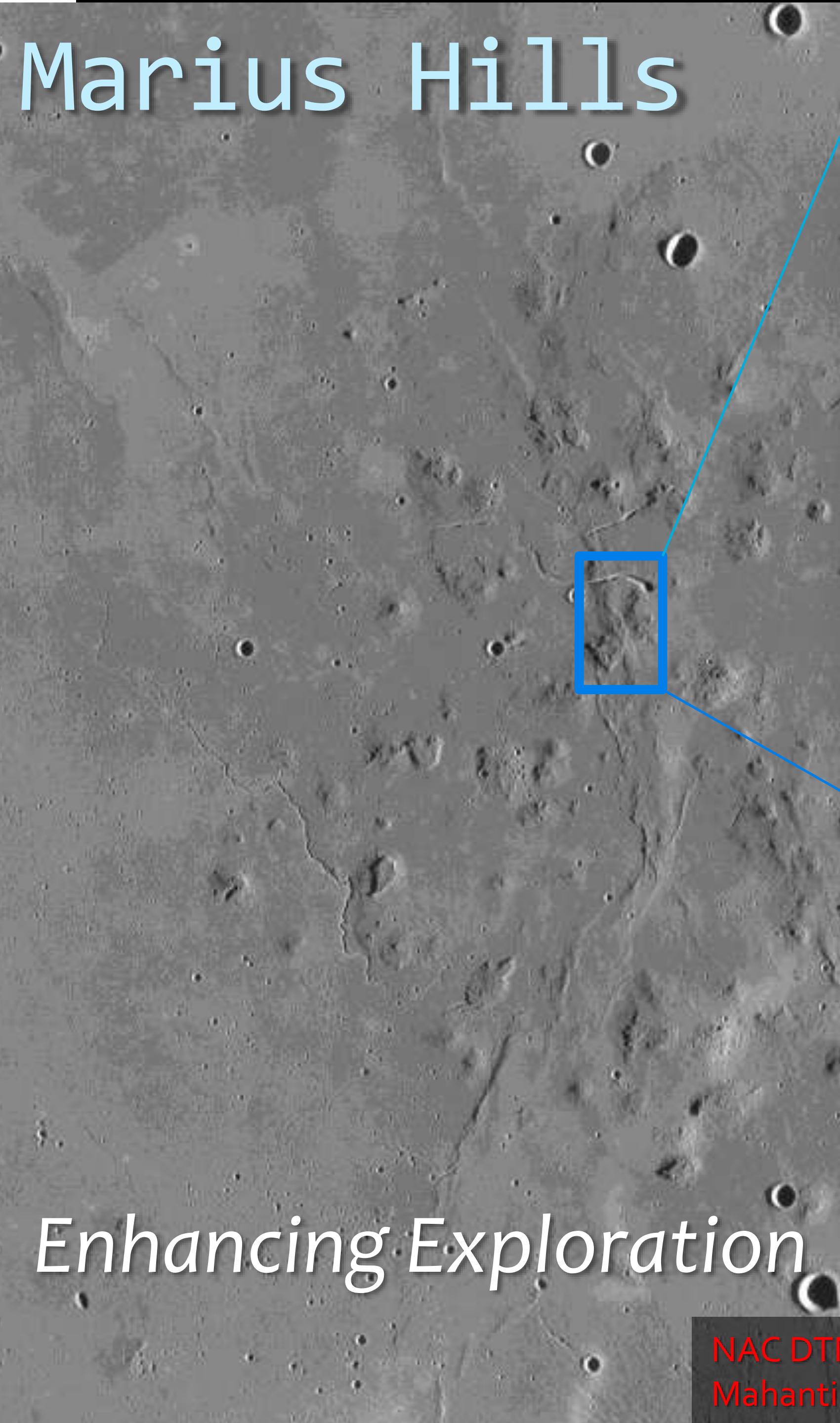
Concept of Operations

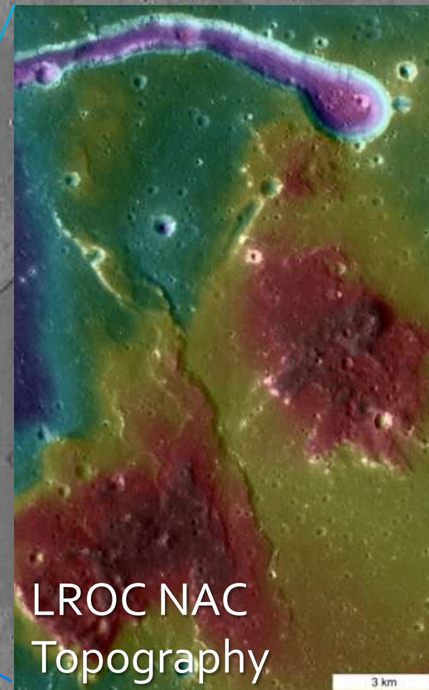
- The objective of FARCAM is to scout out potential traverses, identify hazards, and collect a valuable scientific dataset
- FARCAM will be used in all phases of exploration:
  - Cruise Mode
    - Identify and monitor hazards along the traverse
    - Scout out traverse options
    - Collect complete panoramas at stopping points
  - Focused Investigation Mode
    - Collect detailed images of the site (sub-mm)
    - Gather context images of the surrounding terrain
    - Obtain geometric stereo images for science and traverse planning
  - Roam Mode
    - Similar to cruise mode, but stopping at regular intervals to acquire partial panoramas and identify traverse options and image far targets



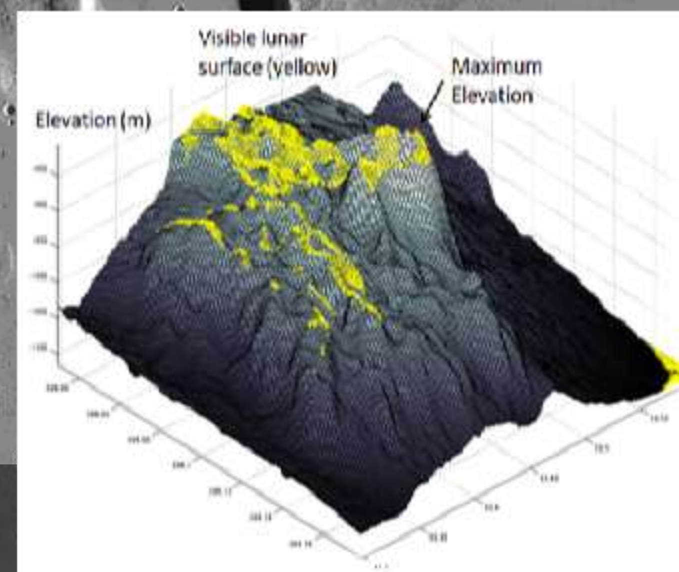
Traverse through Reiner Gamma

Marius Hills





- Terrains like the Marius Hills are too complex (150+ volcanoes) to explore all features
- FARCAM provides stand-off geoscience capability to dramatically increase science return
- LRO data enables detailed exploration planning



NAC DTM Viewshed Analysis
Mahanti et al. (LEAG 2012)

Enhancing Exploration

FARCAM Summary 1

- Long range imaging is essential for success of rover exploration
- FARCAM heritage and design simplicity minimize risk
- Design flexibility allows some customization for area specific or goal specific mission profiles
- Increasing by an order of magnitude the area studied by the rover, FARCAM makes the rover a more efficient tool for lunar exploration

FARCAM Summary

The next logical step in lunar exploration is a long lived highly mobile science and exploration rover with FARCAM!

Determining where you might want to go

Understanding where you cannot go

Gathering data of areas where you do not have time to go