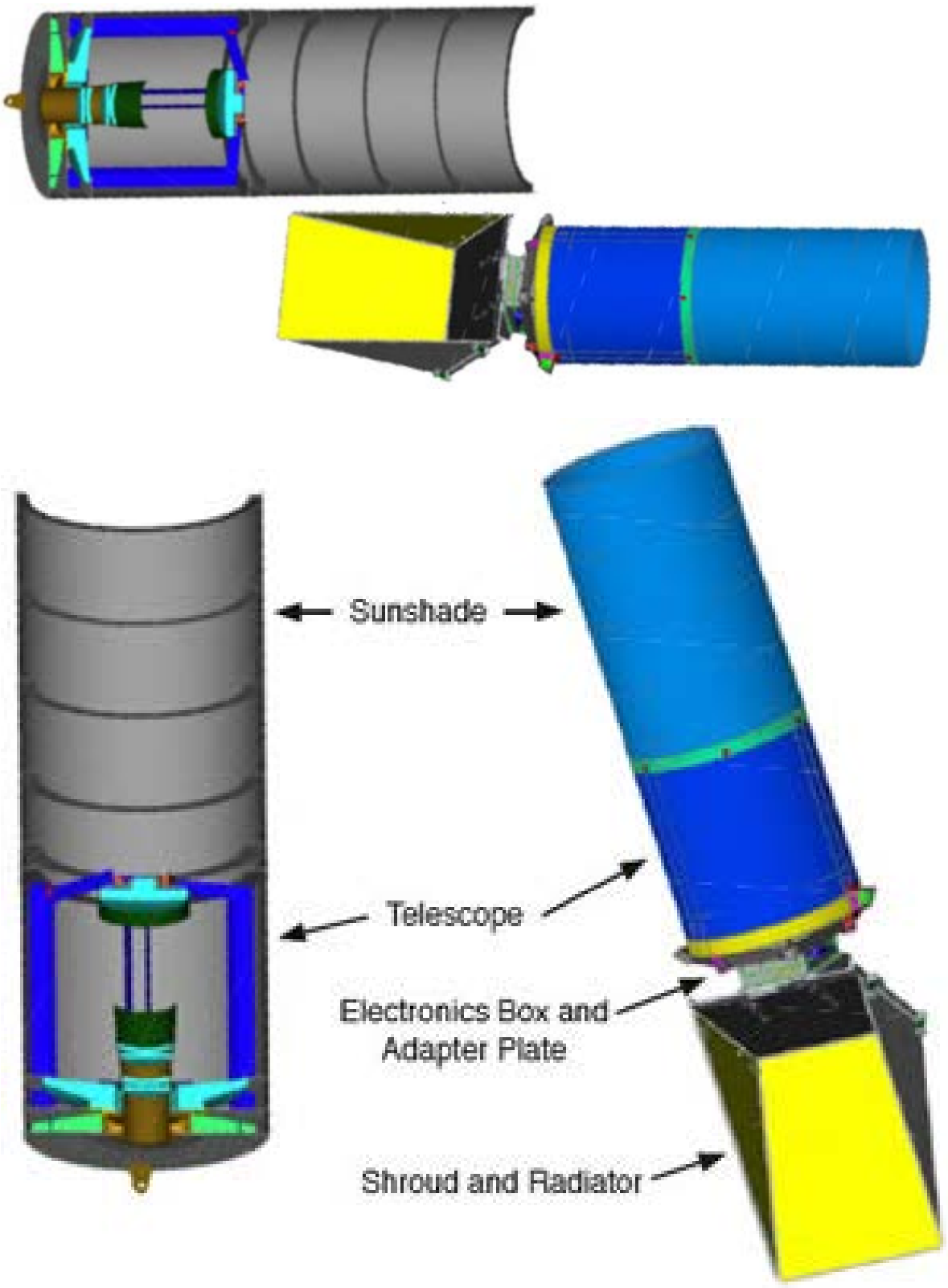
# University of Arizona Mars Orbiter (UA-MO)
# SIE 452/552 Spring 2017
# Instrument Payload Suite

**Mars Orbiter High Resolution Camera (MOHiResC) Suite**

This suite is a derivation of the Lunar Reconnaissance Orbiter Camera (LROC) and adapted for Mars operations. It consists in two Narrow Angle Cameras (NAC) and in a Wide Angle Camera (WAC). Instrument characteristics diagrams are reported below:

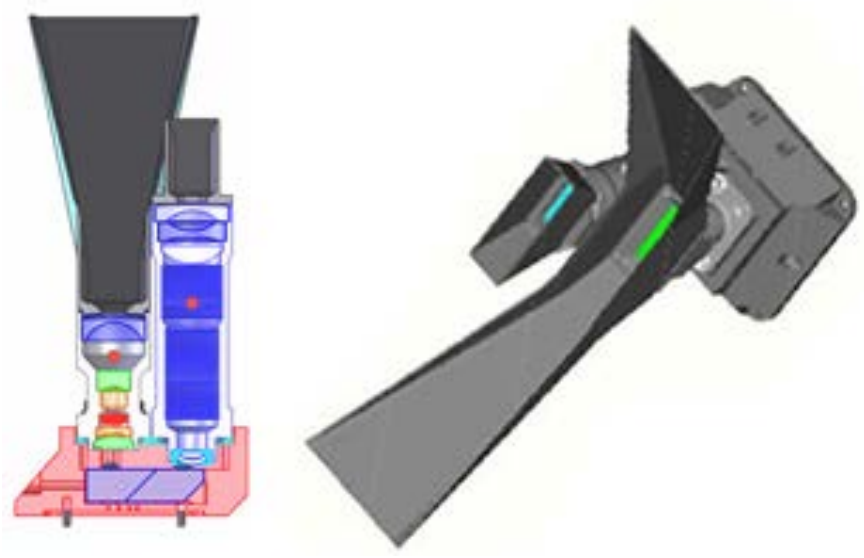
***Narrow Angle Camera***

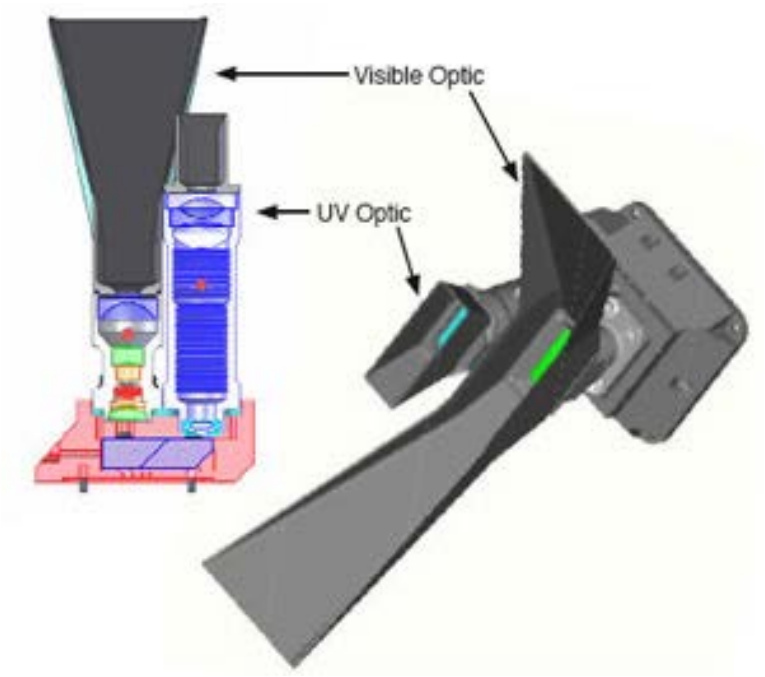
| Parameter | Performance NAC-L | Performance NAC-R |
|---|---|---|
| FOV | 2.8502° | 2.8412° |
| IFOV (nadir) | 10.0042 µrad | 9.9764 µrad |
| image scale at 50-km altitude | 0.5 meter/pixel | |
| max. swath size at 50-km altitude | 2.49 × 26.1-km | 2.48 × 26.1-km |
| f/# | 3.577 | 3.590 |
| focal length | 699.62 ± 0.08 mm | 701.57 ± 0.09 mm |
| distortion coefficient *k* | 0.0000181 ± 0.0000005 | 0.0000183 ± 0.0000005 |
| optical center location | sample 2548 ± 8 | sample 2568 ± 8 |
| primary mirror diameter | 198 mm | |
| system MTF (Nyquist) | 0.23 | |
| Gain | 90.5 ± 2.6 $e^-$/DN | 92.5 ± 1.5 $e^-$/DN |
| detector noise | 101 ± 7 $e^-$ | 97 ± 1 $e^-$ |
| detector full-well | 334,000 ± 31,000 $e^-$ | 352,000 ± 4100 $e^-$ |
| SNR (mare at 70° incidence angle) | > 42 | > 42 |
| Spectral response | 400–760 nm | |
| radiometric accuracy* | 1% relative, 10% absolute | |
| detector digitization | 12 bit, encoded to 8 bit | |
| data link to SCS | LVDS, 30 Mbps | |
| temperature sensors | 2 per electronics box, 2 per telescope | |
| lossless compression ratio | 1.7:1 | |
| Voltage | 28 ± 7 V DC | |
| peak power | 9.3 W | |
| orbit average power | 6.4 W | |
| mass (both NACs) | 16.4 kg | |
| volume (length x diameter) | 118 cm × 27 cm (incl. radiator) | |


Sunshade
Telescope
Electronics Box and
Adapter Plate
Shroud and Radiator

### *Wide Angle Camera*

| Parameter | Visible | UV |
|---|---|---|
| FOV (monochrome/color) | 91.9°/61.4° | 59.0° |
| IFOV (nadir) | 1.498 mrad | 7.672 mrad (4 × 4 binning) |
| image scale (nadir, 50-km altitude) | 74.9 m/pixel | 383.5 m/pixel |
| image frame width monochrome | 104.6-km | – |
| image frame width 7-band color | 59.6-km | 56.8-km |
| image format monochrome | 1024 samples × 14 lines | – |
| image format color (for each band) | 704 samples × 14 lines | 128 samples × 4 lines (binned) |
| f/# | 5.052 | 5.65 |
| focal length | 6.013 mm | 4.693 mm |
| system MTF (Nyquist) | 0.37 | |
| Gain | $25.9 \pm 0.7$ $e^-$/DN | |
| detector noise | $66 \pm 4$ $e^-$ | |
| detector full-well | $46{,}100 \pm 3600$ $e^-$ | |
| SNR (at 1000 DN) | $> 150$ | |
| radiometric accuracy* | 1% relative, 10% absolute | |
| detector digitization | 11 bit, encoded to 8 bit | |
| data link to SCS | RS422, 2.5 Mbps | |
| temperature sensors | 1 | |
| lossless compression ratio | 1.7:1 | |
| Voltage | $28 \pm 7$ V DC | |
| peak power | 2.7 W | |
| orbit average power | 2.6 W | |
| Mass | 0.9 kg | |
| volume (width × length × height) | 15.8 cm × 23.2 cm × 32.3 cm (incl. radiator) | |






**Additional Information**

Both cameras are conductively and radiatively isolated (i.e. they radiates to space). Active thermal control is operated via radiators and heaters. Contamination control regards mainly optics. The pointing requirements in the nadir direction are assumed to be 0.01 mrad control with 0.005 mrad knowledge (3-sigma). The sun exclusion angle is assumed to be 28 degree about the telescope axis. Temperature limits are -20 to 30 deg Celsius (operational) and -30 to 40 deg Celsius (non-operational).

**Mars Orbiter Thermal Emission Imaging Spectrometer (MOTEIS)**

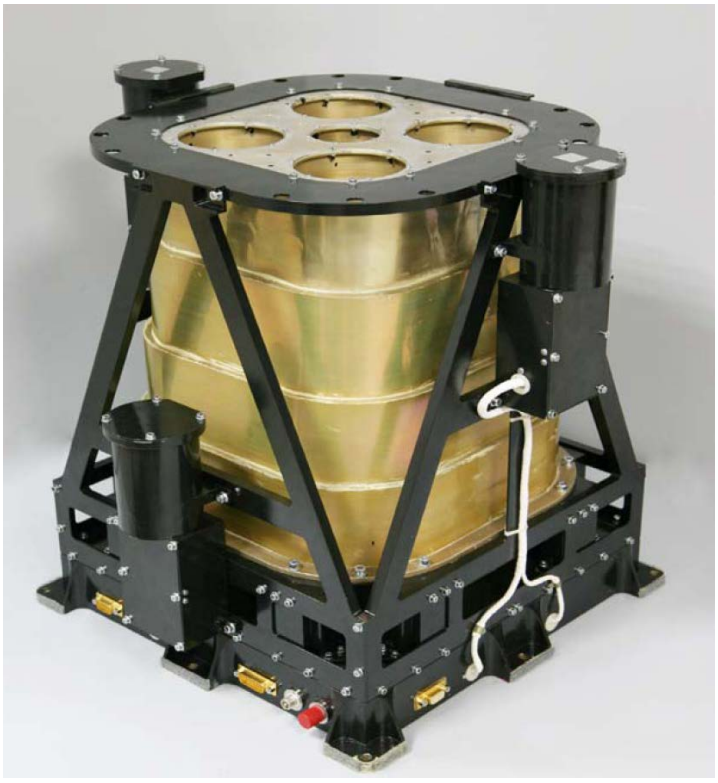
MOTEIS is an evolution of the Mars Odyssey 2001 THEMIS Instrument. The instrument characteristics are indicated below:

| | |
|---|---|
| Quantities to be measured: | Emitted radiance in 10 ~1-$\mu$m bands (9 different wavelengths) centered between 6.8 and 14.9 $\mu$m at 100 m per pixel spatial resolution |
| | Solar reflected energy in 5 ~50 nm bands centered from 0.42 to 0.86 $\mu$m at 18 m per pixel spatial resolution |
| Detectors: | Multi-spectral IR imager: 320 $\times$ 240 element uncooled micro-bolometer array |
| | Visible imager: 1, 024 $\times$ 1, 024 element silicon array |
| Expected performance: | NE$\Delta\varepsilon$ @ 245 K & 10 $\mu$m = 0.005. |
| | NE$\Delta$T @ 245 K & 10 $\mu$m = 0.5 K. |
| | NE$\Delta$T @ 180 K = 1 K. |
| | SNR > 100 in visible imager at 0.25 albedo, 60° solar incidence angle |
| Optical/Mechanical Design: | 12-cm effective aperture f/1.6 telescope to view nadir shared by multi-spectral IR and visible imagers. Internal calibration flag provides calibration and Sun avoidance protection functions. IR spectrometer is 10-strip filter pushbroom design with time delay integration. Visible multi-spectral imager is 5-strip filter frame-scan design. |
| Fields of View: | IR imager has a 4.6° (80 mrad) cross-track by 3.5° (60 mrad) down-track FOV with a 0.25 mrad (100 m) IFOV at nadir. |
| | Visible imager has a 2.66° (46.4 mrad) cross-track by 2.64° (46.1 mrad) down-track FOV with 0.045 mrad (18 m) IFOV in 1024 $\times$ 1024 pixels at nadir. The two imagers are spatially bore-sighted. |
| In-Flight Calibration: | Periodic views of an internal calibration flag. |
| Thermal Requirements: | Operating range −30 °C to +30 °C. Non-operating range −30 °C to +45 °C. No detector cooling required. |
| Digital Data | 8-bit delta radiance in IR imager |
| | 8-bit radiance in visible imager |
| Data rate: | IR imager has instantaneous internal rate of 1.17 Mbits/sec. Data rate to spacecraft after real-time compression is 0.6 Mbits/sec. |
| | Visible imager has instantaneous internal rate of up to 6.2 Mbits/sec. Data rate to spacecraft is < 1.0 Mbits/sec. 4 Mbyte RAM internal data buffer for data processing and buffering for delayed output to spacecraft. |
| On-board Data Processing: | IR imager: Gain and offset; time delay integration, and data compression in electronics; data formatting using spacecraft computer. |
| | Visible imager: Lossless and predictive compression in firm-ware; selective readout and pixel summing on spacecraft. |
| Solar Protection: | Provided by calibration flag in stowed position. |
| Mass: | 11.2 kg |
| Size: | 29 cm by 37 cm by 55 cm |
| Power: | 14 W orbital average |

**Mars Orbiter High Energy Neutron Detector (MOHEND)**

MOHEND is an evolution of LEND on-board NASA LRO. The physical characteristics and performances are given below.

| Parameter | LEND instrument |
|---|---|
| **Mass** | 26.3 kg |
| **Power Consumption** | 13 W |
| **Size** | 460 x 460 x 440 mm |
| **Function** | Collimated neutron spectrometer |
| **Energy range** | From thermal energies up to 15 MeV |
| **Time resolution** | Variable, > 1 s |
| **Spatial resolution on the surface** | 5 km from the 50 km orbit |
| **Spatial resolution inside the subsurface** | 1-2 m |
| **Working range of temperature** | From -20 ºC up to +50 ºC |
| **Telemetry volume** | 250 Mb per day |
| **Warranty time** | 5 years |



**Mars Orbiter Laser Altimeter (MOLA)**
MOLA is an evolution of laser altimeters already flown on previous Mars programs. The physical characteristics and performances are reported below.

Electrical Power (28 V):
- Cruise: 21 W
- Orbital Average: 23.1 W
- Orbital Peak: 33.1 W

Electrical Regulation: 28 V +/- 2V
Data rate range:
Mass: 25 Kg
Sun avoidance angle : 28 deg about telescope axis
Temperature limits ops/non=ops: -20 to 30 deg Celsius, -30 to 40 deg Celsius
Thermal I/F: Conductively and radiatively isolated from S/C.
Active thermal control: Heaters
Contamination control: Optics