The NASA Mars 2020 Mission Perseverance Rover Mastcam-Z Data Archive.

#7038

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What is Mastcam-Z?

A multispectral, zoomable, and focusable camera pair located on the Mars2020 Perseverance Rover's remote sensing mast (RSM) [1-3] .

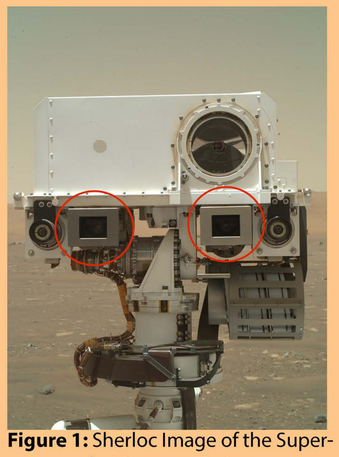

Figure 1: Sherloc Image of the Supercam and Mastcam-Z instruments. Mastcam-Z circled in red.

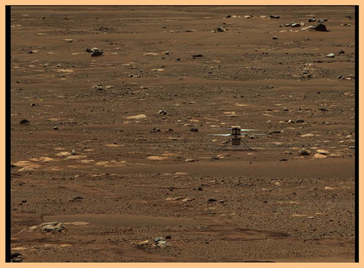

Figure 2: Radiance Calibrated Right Camera Image of the Ingenuity Helicopter from sol 59.

Highlights-

8-position filter wheel
- (Filter 0) RGB Bayer pattern color imaging
- (Filters 1-6)multispectral narrowband filters
- (Filter 7) neutral density filter for solar imaging

Capable of zoom, focal lengths 26-110 mm!
Capable of Video (~4 frames/sec 1280 × 720 pixels)

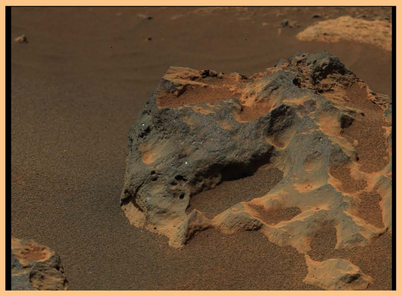

Figure 3: Radiance Calibrated Left Camera Image from sol 87.

Data Acquisition -

Images are acquired on Mars every sol (martian day) and processed at Arizona State University (ASU). These images are commanded in a variety of product types and stored in the camera Digital Electronics Assembly (DEA). Mastcam-Z full-frame images [See figures 2, 3, 6] have black columns (photo-inactive "masked" pixels) of 23 pixels on the left and 17 pixels on the right surrounding the 1600x1200 active pixels. Subframed images can (not always) have masked pixels [Figure 4]. These dark columns, when present in the image data, are used during calibration.

Mastcam-Z images are queued by the rover compute element (RCE) for downlink, by way of Mars orbiting spacecraft MRO, TGO, ODY, and Maven [4]. Once images have been downlinked, they get thoroughly checked for accurate pointing, metadata, saturation, focus, and completeness.

Mastcam-Z Product Types:
full-frame (1648 x 1200 pixels)
subframe (returning a portion of the 1648x1200 array)
thumbnail (8x subsampled lower res. of image)
compressed video groups of pictures (GOPs)
focus merges (z-stacks).

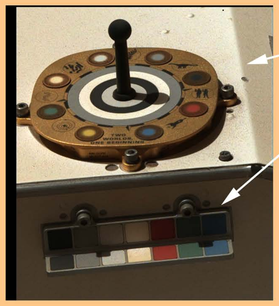

Figure 4: Radiance Calibrated Right Camera Image of Mastcam-Z Calibration Targets from sol 75.

Calibration -

The Mastcam-Z team at ASU generates radiance (RAD) and radiance factor (IOF) calibrated data products for all applicable observations. Mastcam-Z products are calibrated using a multi-step process [Figure 5] with values derived from a science calibration investigation of the instruments [2].

Calibration target (caltarget) images of the primary and secondary caltarget are periodically acquired near-in-time to most multispectral image sequences and used in nominal radiance factor calibration [Figure 4]. **The primary caltarget is used to verify and validate preflight calibration while on the surface, as well as tactical conversion from radiance to reflectance.The secondary cal target is used to affirm the results of the primary in calibration as well as to monitor dust buildup** [4,6].

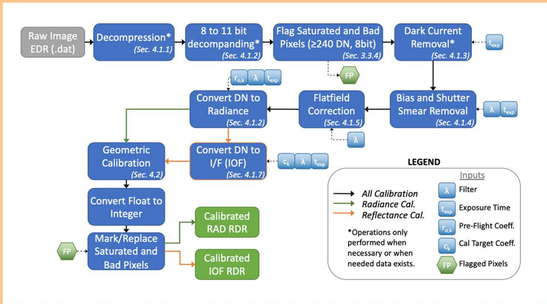

Figure 5: Mastcam-Z Calibration Pipeline Diagram [2]

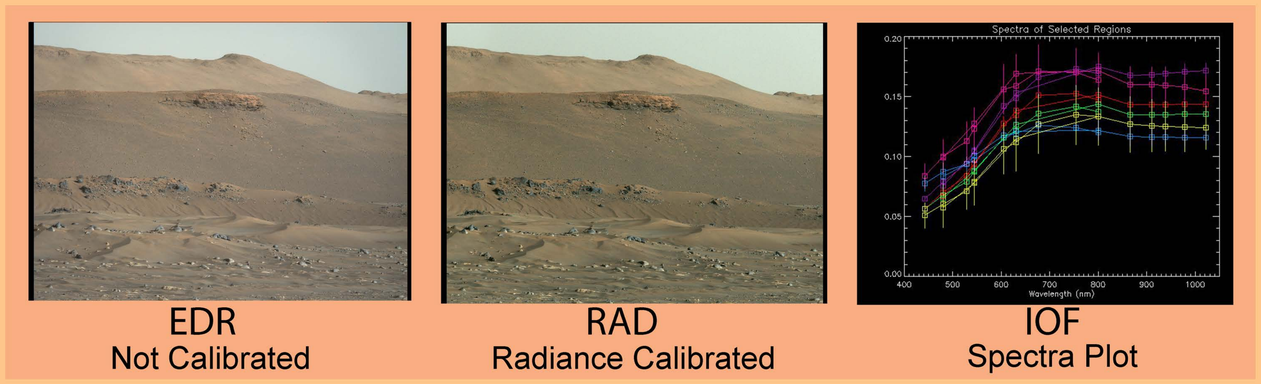

Figure 6: Comparison of an EDR ("raw", decompanded) Mastcam-Z image next to an ASU Radiance calibrated RAD image. The spectra plot demonstatrates use of an IOF image for science.

The Mastcam-Z Data Archive-

This archive will be in the PDS Cartography and Imaging Sciences node.

The first release will be available August 2021 through the PDS website (https://pds.nasa.gov/) and will include RAD & IOF data products (PDS Image format, and PNG formatted browse images) for sols 0-89 at an estimated data volume of 31GB. The RAD & IOF have an attached ODL3 image label for heritage tool compatibility and the PDS4-compliant detached XML label (same filename with either .IMG or .XML extension)[Figure 7]. See Figure 8 below for ODL to XML example label mapping.

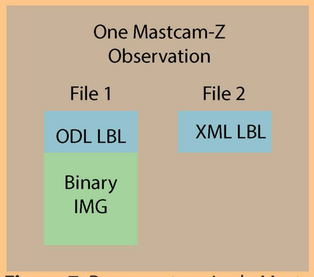

Figure 7: Represents a single Mastcam-Z archived product with image data and an attached ODL label and detached PDS4 XML label. Both files (1 & 2) have the same filename with a different extension.
example: file.IMG & file.XML

```
ODL_VERSION_ID              = ODL3

ARTICULATION_DEVICE_ANGLE =
(8.52212e-05,-0.000298274,-4.26106e-05,
                4.26106e-05,0.0145634,-0.0149768,
                0.0218974,-0.00818103,0.0,0.0,0.0,0.0,
                0.0,0.0)
ARTICULATION_DEVICE_ANGLE_NAME =
("LEFT FRONT WHEEL STEER MOTOR",
                "RIGHT FRONT WHEEL STEER MOTOR",
                "LEFT REAR WHEEL STEER MOTOR",
                "RIGHT REAR WHEEL STEER MOTOR",
                "LEFT BOGIE","RIGHT BOGIE",
                "LEFT DIFFERENTIAL",
                "RIGHT DIFFERENTIAL",
                "LEFT FRONT WHEEL DRIVE MOTOR",
                "RIGHT FRONT WHEEL DRIVE MOTOR",
                "LEFT MIDDLE WHEEL DRIVE MOTOR",
                "RIGHT MIDDLE WHEEL DRIVE MOTOR",
                "LEFT REAR WHEEL DRIVE MOTOR",
                "RIGHT REAR WHEEL DRIVE MOTOR")
```

Figure 8: Attached ODL image label to detached XML label mapping. ODL section on the left, correspodning xml section on the right.

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>

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</geom:Device_Angle_Index>
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Future Releases- Derived atmospheric properties in the form of an ASCII table, pre-flight calibration data acquired during ATLO testing, as well as cruise data products will be available in future releases [7].

Major Takeaways

The Mastcam-Z radiance calibrated (RAD & IOF) data products for sols 0-89 will be available on the PDS Cartography and Imaging Node August 2021. These images are spectacular for scientific exploration into the Martian surface within Jezero crater and are thoroughly vetted for completeness and accuracy.

For more information on upcoming and future PDS releases see https://pds.nasa.gov/
For more information on Mastcam-Z images, publications, and the team, check out https://mastcamz.asu.edu/

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Acknowledgments: Banner mosaic made by K. Crawford using sol 38 zcam08009 images of the Santa Cruz target.
Figure-1 Source Product:SI1_0045_0670932474_015ECM_N0031416SRLC07021_000085J
Figure-2 Source Product:ZR0_0059_0672184729_575EDR_N0032046ZCAM05029_110085J
Figure-3 Source Product:ZL0_0087_0674657148_098EDR_N0040048ZCAM08046_110085J
Figure-5 Source Product:ZR0_0075_0673604249_303EDR_N0032430ZCAM03014_048085J
Figure-6 Source Product:ZL0_0077_0673757728_990EDR_N0032430ZCAM03126_1100LUJ

References:[1] Bell, J.F., et al. Space SciRev 217, 24 (2021). https://doi.org/10.1007/s11214-020-00755-x. [2] Hayes, A.G., et al. Space SciRev 217, 29 (2021). https://doi.org/10.1007/s11214-021-00795-x.[3] Farley, K.A., et al. Space Sci Rev (2020) 216:142 (2020). [4] Bell, J.F. et al., Mars 2020 Mastcam-Z Investigation Experiment Operations Plan (EOP) v3.1, (2018) JPL D-101346. https://doi.org/10.1007/s11214-020-00762-y. [5] Malin, M.C. et al. (2013). Mars Science Laboratory Project Software Interface Specification (SIS).[6] Kinch, K.M., et al. Space Sci Rev 217, 46 (2021). https://doi.org/10.1007/s11214-020-00774-8[7] Mehall, L. K., et al., (2019) 4th Planetary Data Workshop Abstract #7060.