# THE MARS 2020 WATSON IMAGING SUBSYSTEM OF THE SHERLOC INVESTIGATION AND ANTICPATED EARLY RESULTS.

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**Introduction:** In February 2021, the Mars 2020 Perseverance rover is anticipated to touch down in Jezero crater, Mars. Perseverance is unique in that it will conduct *in situ* science as well as cache samples for eventual return to Earth for analysis in terrestrial laboratories. It will explore the geologic setting within Jezero over a range of scales in order to address fundamental questions about the evolution of Mars and assess whether there is evidence of past or present Martian life. The Wide Angle Topographic Sensor for Operations and eNgineering (WATSON), one of two imaging subsystems within the Scanning Habitable Environments with Raman and Luminescence for Organics and Chemicals (SHERLOC) instrument [1,2], acquires images that support scientific study of Jezero crater and sample acquisition, as well as rover and instrument operations (Fig. 1). WATSON serves a number of roles; it 1) provides color context imaging of SHERLOC and Planetary Instrument for X-Ray Lithochemistry (PIXL) analysis locations, placing the spatial distribution of organics and mineralogy detected by SHERLOC and the elemental maps generated by PIXL within the context of rock texture and structure; 2) acquires stand-alone observations of rock structures and textures from the outcrop to the grain scale; and 3) images rover components and other instruments to monitor their health and condition. We plan to present images acquired within the first ~30 sols of operations.

**WATSON Details:** WATSON, a build-to-print copy of the Mars Science Laboratory (MSL) Mars Hand Lens Imager (MAHLI) [3], is part of the SHERLOC Turret Assembly (Fig. 1). The observation pathways for WATSON and the SHERLOC spectrometer (plus the Autofocus and Context Imager, ACI) are not co-boresighted. As such, an arm move is required for them to each observe the same target. Further, the design of the spectrometer within the available volume on the arm necessitated that their fields of view are rotated relative to one another. However, their observations are still straightforward to co-locate (Fig. 2).

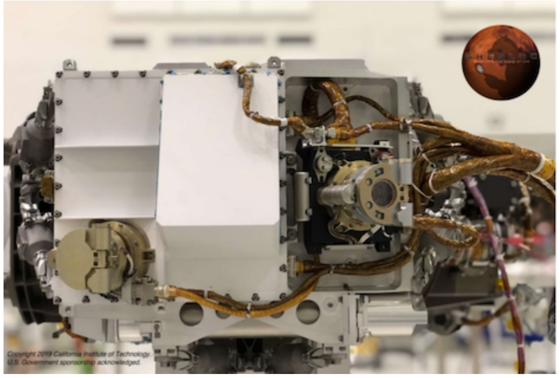

**Fig. 1:** SHERLOC (left) and WATSON (right) mounted on the Perseverance robotic arm turret.

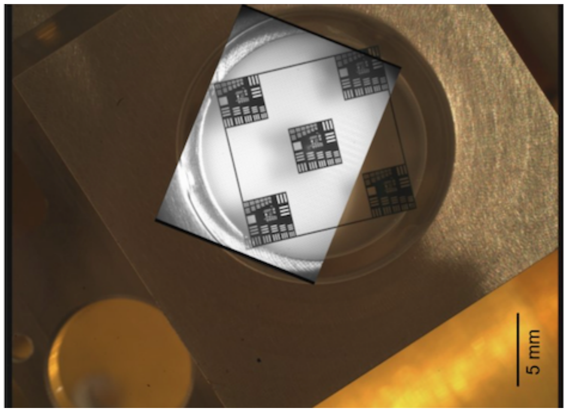

**Fig. 2:** WATSON (color) and SHERLOC ACI (grayscale) fields of view over a BK7 resolution target on the SHERLOC calibration target during rover system thermal testing [1].

WATSON is focusable at working distances (front lens element to a target) from 1.8 cm to infinity and yields color via a Bayer pattern filter over a 1600x1200 pixel CCD [2]. WATSON does not possess contact sensors; rather, its location relative to a target can be established by the facility contact sensor on the turret [4] or by WATSON range finding (see below). WATSON has white light and UV (365 nm) LEDs to illuminate targets for night imaging (Fig. 3).

**Anticipated Use Cases:** As with MAHLI on MSL, WATSON offers Perseverance the advantages provided by a color camera focusable over a wide range of working distances, with positioning flexibility offered by its location at the end of the robotic arm. Thus, the variety of MAHLI use cases [e.g., 3], a few of which are reported below, informs those expected for WATSON.

*Nested imaging*. WATSON will commonly acquire a suite of nested images of a single target that cover a range of fields of view and resolutions to fully interrogate a target. One such suite images a target after it has been ground by the rover's abrasion bit [4]. One context image (~105 µm/pixel, ~17x13 cm FOV) from 27 cm working distance will support localization of the abraded patch relative to pre-abrasion imaging. One moderate resolution image from 10 cm (~43 µm/pixel, ~7x5 cm FOV) will capture the 4.5 cm diameter abraded patch in a single image. A second moderate resolution image from 7 cm (~32 µm/pixel, ~5x4 cm FOV) will yield an image from within the abraded patch of resolution traceable to those of the Mars Exploration Rover Microscopic Imager [e.g., 5] and the APXS documentation images MAHLI acquires at each MSL contact science target [e.g., 3]. The motivation of this particular image is creation of a multi-decade dataset of Martian rock textures at a consistent scale. Either of the moderate resolution images can be acquired as a stereo pair that can be used to assess target surface relief. The final image of the suite will be from 3-4 cm (~18-21 µm/pixel, <~3.5x2.5 cm FOV) for detailed texture observations of the interior of the abraded patch. SHERLOC ACI [1] will also image the interior of the abraded patch at ~10.1 µm/pixel resolution before and after SHERLOC spectroscopy measurements. Thus, WATSON imaging provides context and localization for SHERLOC observations.

*Borehole imaging*. Coring and caching samples is a key objective of the Mars 2020 mission, but imaging of the acquired sample before it is sealed is limited to one end of the sample via the CacheCam, part of the Sampling and Caching Subsystem within the rover body [4]. WATSON can observe the interior of the borehole left behind after sample extraction, documenting the structure and texture within the drilled target, and permitting correlation of identifying characteristics on the acquired sample surface with the borehole interior. Such imaging provides context for planned SHERLOC and ACI observations of the borehole walls, and records placement of SuperCam laser shots [6] which supports interpretation of chemistry data. MAHLI experience dictates such imaging is best accomplished at night with illumination provided by white light LEDs (Fig. 3), which combats self-shadowing within the borehole that occurs during daylight imaging.

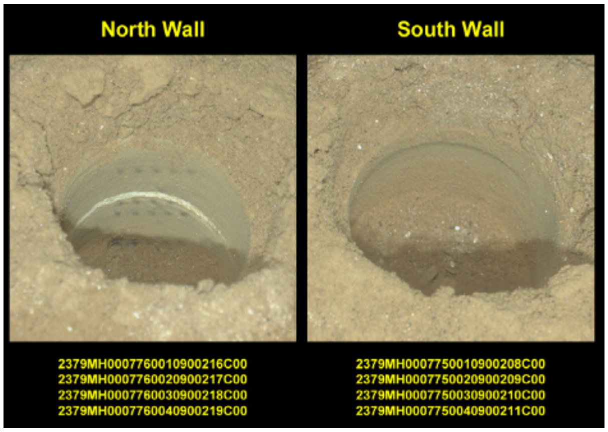

**Fig. 3:** Example of borehole imaging. MAHLI night imaging of the interior of the "Aberlady" drill hole [2]. Individual MAHLI image IDs that contributed to these focus stack products are listed. The image records ChemCam laser shots (dark gray array at left) and notable features in the borehole walls.

*Range finding*. Pre-flight calibration defined the relationship between the WATSON focus motor count and the working distance to a target [1,2]. This relationship permits the motor count of an in-focus image to serve as a measurement of working distance to the target. WATSON finds focus on a target via an autonomous autofocus algorithm [2]. Focus information is usually established within a 480x480 pixel subframe image prior to a full frame image of the same target. The motor count of the focus-establishing subframe defines the distance to the target, and the arm position at which this image was acquired can be saved by the arm software. With the distance to the target at a given WATSON/arm position established, subsequent, closer imaging of the target can be planned with the distance to target defined for WATSON more accurately than with the arm knowledge alone. This process is called range finding. As on MSL, Mars 2020 will use the process to plan close approach imaging (<4 cm working distance) over challenging targets (e.g., unconsolidated fines). WATSON range finding will also permit close-approach imaging of a sampling target before drilling, as strict contamination controls preclude contact with the surface before sampling [4].

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**References:** [1] Bhartia, R. et al. (2021) *SSR,* **217***,* in press. [2] Edgett, K.S. et al. (2019) doi: 10.13140/RG.2.2.18447.00165. [3] Edgett, K.S. et al. (2015) doi:10.13140/RG.2.1.3798.5447. [4] Moeller, R.C. et al. (2021) *SSR,* **217**, 5, doi:10.1007/s11214-020-00783-7. [5] Herkenhoff, K.E. et al. (2019) *JGR-Planets*, **124**, 528–584, doi:10.1029/2018JE005774. [6] Wiens, R.C. et al. (2021) *SSR*, **217**, 4, doi:10.1007/s11214-020-00777-5.