THE SHERLOC INVESTIGATION FOR MARS 2020. L. W. Beegle[1], R. Bhartia[1], B. Carrier[1], L. DeFlores[1], W. Abbey[1], S. Asher[2], A. Burton, M. Fries[3], P. Conrad[4], S. Clegg[5], K. S. Edgett[6], B. Ehlmann[7], W. Hug[8], R. Reid[8], L. Kah[9], K. Nealson[10], T. Nelson[5], M. Minitti[11], J. Popp[12], F. Langenhorst[12], P. Sobron[13], A. Steele[14], N. Tarcea[12], R. Wiens[5], K. Williford [1], R. A. Yingst[11]. [1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena Ca, 91109 (Brandi.L.Carrier@jpl.nasa.gov, Rohit.Bhartia@jpl.nasa.gov, Luther.Beegle@jpl.nasa.gov),[2]University of Pittsburgh, [3]Johnson Space Center, [4]Goddard Space Flight Center, [5]Los Alamos National Laboratory, [6]Malin Space Sciences, [7]California Institute of Technology, [8]Photon Systems Inc., [9]University of Tennessee, [10]University of Southern California, [11]Planetary Science Institute, [12]University Of Jena, [13]SETI Institute, [14]Carnegie Institute Washington

Introduction: SHERLOC is an arm mounted instrument that is part of the Mars 2020 payload. It combines imaging with UV resonance Raman and native deep UV fluorescence spectroscopy in order to identify potential biosignatures and understand the aqueous history of a site on Mars [1]. It utilizes a Deep UV laser (248.6 nm) to generate characteristic Raman and fluorescence photons from a target/area of interest. The DUV laser is co-boresighted to a context imager and integrated into an autofocusing/scanning optical system that allows us to correlate spectral signatures to surface textures, morphology and visible features. These spectral maps reveal more information than spectra alone by relating minerals and chemicals to textures in a way simple bulk analysis does not.

The goals of the SHERLOC investigation are to:

- *Assess the habitability potential of a sample and its aqueous history.*
- *Assess the availability of key elements and energy source for life (C, H, N, O, P, S etc.)*
- *Determine if there are potential biosignatures preserved in Martian rocks and outcrops.*
- *Provide organic and mineral analysis for selective sample caching.*

To do this SHERLOC does the following:

- Detects and classifies organics and astrobiologically relevant minerals on the surface and near subsurface of Mars
- Bulk organic sensitivity of 10^{-5} to 10^{-6} w/w over an 7 x 7 mm spot.
- Fine scale organic sensitivity of 10^{-2} to 10^{-4} w/w spatially resolved at <100µm
- Astrobiologically Relevant Mineral (ARM) detection and classification to <100µm resolution

The current CAD model of the SHERLOC instrument can be see in figure 1. Major subsystems include:

- A Photon Systems developed 248.6 nm NeCu laser that generates narrow line width laser light.
- An autofocus and context imager (ACI) that utilizes MAHLI heritage to obtain a gray scale image of a target and obtain optimum focus for the laser spot.
- An Aphere-Sphere Spectrometer system that utilizes a CHEMCAM heritage e2v CCD.
- A Wide Angle Imager that is MAHLI build to print.

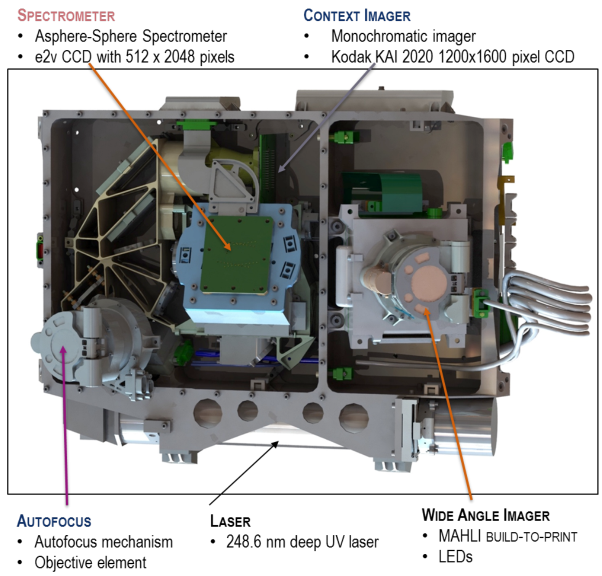

Figure 1. Current CAD model of the SHERLOC instrument.

Scientific Operations: SHERLOC performs both spectroscopy and co-boresightedd microscopic imaging for scientific investigations. For wide field imaging and sample documentation, the Wide Angle Topographic Sensor for Operations and eNgineering (WATSON) imager provides images that document the sample at distances of 2 to 25 cm. These images allow for co-located results from other payload images to the SHERLOC spectroscopy results.

For spectroscopy, operations are planed around a single arm placement, 48 mm above the target. Through the use of an internal scanning mirror, autofocusing lens, and a depth of focus of ±500 µm, the 100 µm laser spot can be systematically scanned over a 7x7 mm area with a fine-scale spatial resolution on natural or abraded surfaces, with the additional capability of investigating boreholes to a depth of at least 13 mm without further arm movement. The spectroscopic side of SHERLOC has a gray scale contextual imager. The gray scale contextual imager is easily matched to the color images from the WATSON camera. While the instrument is being designed to be flexible with respect to operations, the nominal activity includes two opsmodes that allow “survey” of a 49 mm^2 area followed by and automated “detailed” analysis of regions of interested. Both of these modes will be performed in a typical operational scenario and can be done without ground-in-the-loop.

Survey mode. Initial observations will be performed on an abraded patch in survey mode. The laser will fire raster over a 7x7 mm area with 200µm spacing to generate 1225 spectra arranged in a 35x35 point grid. A Raman/fluorescence spectrum is acquired within 1 sec at each point. These spectra can be averaged together to get bulk organic/mineral abundances over the entire scanned area.

Detailed mode. In a typical operational scenario, survey mode would be used to identify an area of interest to be analyzed using detail mode. The internal SHERLOC computer will analyze the acquired spectra from survey mode for Raman and/or fluorescence signatures and determine a region of high interest to perform a detailed analysis. During detailed mode, a denser map is generated over a 1x1mm areas. This consists of rastering the 100µm laser beam at 100 µm steps to generate 100 Raman/fluorescence spectra in a 10x10 grid. Each spectrum is acquired in <12 sec.

Imaging for engineering: SHERLOC has a built to print version of the MAHLI camera that was flown on MSL. This system, called the Wide Angle Topographic Sensor for Operations and eNgineering (WATSON) was added to satisfy engineering and scientific needs that the SHERLOC autofocus and contextual imager was unable to provide, including color images of targets beyond 7 cm from the lens. It is controlled by the same Digitial Electronics Assembly (DEA) that operates the autofocus and contextual imager (ACI) for SHERLOC spectroscopy. It does this with minimal resource requirements by use of a MUX switching board developed by Malin Space Science Systems (MSSS). Engineering uses include wheel imaging, hardware inspection and inspection of the instruments on the mast.

Conclusions: The two distinct operational modes in a nominal surface operation are designed to identify organics and ARM’s on the 100 micron spatial scale and on a scale >1 mm x 1 mm. Because of the built in FPGA, other modes of operations, including line scans, are possible depending on the evolution of operations on Mars 2020.

By bringing to bear multiple scientific instruments on a single sample, our ability to assess the habitability of ancient environments and search for poten-tial biosignatures preserved within the geologic rec-ord will be greatly enhanced, making possible the selection of high-priority samples for caching.

Acknowledgement: This work was carried out at the Jet Propulsion Laboratory, The California Institute of Technology under a contract from NASA.

References: [1] Beegle, L. W. et al. (2015) *IEEE, 90,* 1-11.

Survey Mode	
# of Spectra	1225
Area Scanned	49 mm^2
Duration of Ops	8.8 min
Avg Power (CBE)	~41 W
Data Volume	~50 Mbits (3:1)
Laser Pulses	9600
Aromatics (<1e-6 w/w)	✓ Spatially resolved
Aliphatics (1e-4 w/w)	✓ Bulk
Minerals (ARM)	100 µm grains

Detailed Mode	
# of Spectra	100
Area Scanned	Up to 1 mm^2
Duration of Ops	23 min
Avg Power (CBE)	~54 W
Data Volume	~7 Mbits (3:1)
Laser Pulses	40,000
Aromatics (<1e-6 w/w)	✓ Spatially resolved
Aliphatics (1e-4 w/w)	✓ Spatially resolved
Minerals (ARM)	<50 µm grains