THE SUPERCAM MAST UNIT ON THE NASA MARS2020 MISSION. M. Deleuze[1], P. Bernardi[2], Ph. Caïs[3], R. Perez[1], J.-M. Reess[2], L. Pares[4], B. Dubois[4], Y. Parot[4], B. Quertier[3], S. Maurice[4], K. Maccabe[5], R. Wiens[5] and F. Rull[6], [1]CNES, 18 avenue Edouard Belin, 31401 Toulouse cedex 4, France, [2]LESIA, Observatoire de Paris, 5 place Jules Janssen 92195 Meudon Cedex, France, [3]LAB, Université de Bordeaux, Allée Geoffroy Saint-Hilaire, 33615 Pessac Cedex, France, [4]IRAP, Observatoire Midi-Pyrénées, 14 avenue Edouard Belin, 31400 Toulouse France, [5]LANL, P.O. Box 1663, Los Alamos, NM 87545, USA., [6]Uva, Universidad de Valladolid, Spain

Introduction: The Mars 2020 rover mission is part of NASA's Mars Exploration Program, a long-term effort of robotic exploration of the Red Planet. The Mars 2020 mission addresses high-priority science goals for Mars exploration, including key questions about the potential for life on Mars. The mission takes the next step by searching for signs of past microbial life. The Mars 2020 rover introduces a drill that can collect core samples of the most promising rocks and soils and set them aside in a "cache" on the surface of Mars. The mission also provides opportunities to gather knowledge and demonstrate technologies that address the challenges of future human expeditions to Mars. These include testing a method for producing oxygen from the Martian atmosphere, improving landing techniques, and characterizing weather, dust, and other potential environmental conditions that could affect future astronauts living and working on Mars.

SuperCam Instrument: The SuperCam instrument is an evolution from the successful ChemCam (CCAM) instrument on MSL-Curiosity. SuperCam is an instrument package capable of five different remote-sensing techniques: Laser-Induced Breakdown Spectroscopy (LIBS), Raman and time-resolved fluorescence (TRF), passive visible and infrared (VISIR) reflectance spectroscopy, remote micro-imagery (RMI) and a sound recording device (MIC).

The SuperCam package consists of three separate major components: the SuperCam Body Unit (SCBU), the SuperCam Mast Unit (SCMU) and the SuperCam Calibration Target (SCCT). The SCMU is provided by IRAP (Toulouse, France, funding from CNES), while LANL (Los Alamos, NM) is building the SCBU. The IRAP and LANL subunits are entirely separate mechanically, greatly simplifying development across international boundaries. The University of Valladolid (UVa, Spain) is primarily responsible for the SuperCam on-board calibration target assembly.

SuperCam Mast Unit : The SuperCam Mast Unit (SCMU) combines several functions: it focuses the telescope, generates the laser beam to trigger the LIBS plasma and Raman scattering, it collects LIBS/Raman/VISIR light which is redirected to the spectrometers, reads RMI images and records sound. The SCMU consists of 2 units which are thermally separated: the Electronics Box (EBOX) and the Optical Box (OBOX). Within the SCMU; four modules are identical or minimally adapted from CCAM (LIBS Laser, Red Line optical path, Telescope, Focus), one is improved from CCAM (color imager), and three are completely new (InfraRed Spectrometer, Green line optical path and microphone).

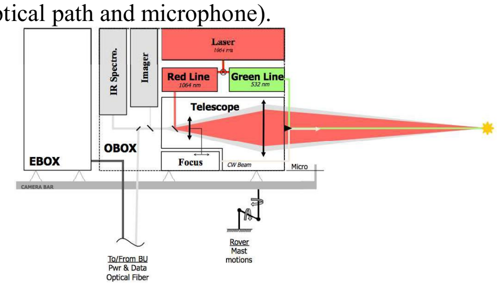

Figure 1: SCMU functional block diagram

Laser. The laser is the heart of the LIBS and Raman experiments. It has CCAM laser heritage but differs in a couple of important ways: a new Nd:YAG crystal to support higher firing rates (10 Hz/1000 shots). Simultaneously, the beam quality is improved for a better focus quality and a doubling crystal (KTP) is added to convert the 1064 nm line in 532 nm on demand.

Red Line. The 1064 nm laser beam is expanded to 1 cm diameter by a compact Galilean telescope and injected into the main Cassegrain telescope, which is unchanged from CCAM.

Green Line. The 532 nm laser beam is also expanded to 1 cm diameter by a compact Galilean telescope, but it remains collimated and is co-aligned along the telescope axis by a 2-mirrors periscopic system.

Telescope. The Cassegrain telescope has high CCAM heritage : it focuses the laser red beam onto the target and collects the photons through the laser dichroic. Then light below 950 nm is fed into a 300 µm-core fiber for LIBS/Raman/Vis reflectance analysis while longer wavelengths are diverted to the IRS. Moreover, light from a 20 mrad cone around the analysis spot goes to the color camera (RMI).

Focus. The focus capability relies on fine displacements of the secondary mirror. With high CCAM heritage, the table focus is used in autofocus mode at distances lower than 12 m and manual focus at greater distances.

Remote Micro-Imager. The RMI is a context imager of the laser pits on targets. It is located at the rear of the telescope. The optical path to the camera is unchanged from CCAM but the panchromatic 1 Mpx CCD is replaced by a color CMOS. The CMV4000 device constituted of 2048 x 2048 5.5µm pitch pixels, with a Bayer filter from CMOSIS was selected. RGB pixels of the Bayer filter are illuminated, providing color images with the same resolution as for CCAM. The RMI will benefit from the High Dynamic Range (HDR) mode.

InfraRed Spectrometer. The IRS is a compact and independent subsystem, linked to the telescope objective with a periscope. The band pass lies between 1.3 µm and 2.6 µm. The IRS concept is based on the scan of an Acousto-Optical Tunable Filter (AOTF). Applying a Radio Frequency (RF) signal on a transducer mounted on the AOTF, the crystal will transmit a zero order and diffract two useful orders (e-ray and o-ray) at the same wavelength depending on the excitation RF frequency. The zero order is trapped in a light trap while the e-ray and o-ray are focused on the two different HgCdTe (MCT) photodiodes. The photodiodes are embedded in a TO66 package including a triple-stage Thermo-Electric Cooler (TEC) to decrease the photodiode temperature up to 70°C below the spectrometer temperature. Only one of the two photodiodes is powered at the same time, the other one is carried as a cold redundancy. Considering the simplicity of the design, the IRS provides extremely valuable science using minimal resources.

Microphone. The MIC primary science objective is to support the LIBS investigations to obtain unique properties of Mars rocks and soils through their coupling with the LIBS laser. In addition, the MIC can monitor various artificial sounds of the rover and contribute to basic atmospheric science. The MIC assembly is composed of two parts: the microphone finger mounted on the RWEB window bracket and the front-end electronics fixed on the OBOX. The microphone is a Commercial Off-The-Shelf (COTS) unit, but has heritage from Mars Polar Lander (MPL) and Phoenix missions. The microphone has been implemented lately in the SCMU and is designed to add no risk on the developments, and to be plug-and-play up to ATLO.

EBOX. The EBOX is mechanically independent of the OBOX, and isolated from the baseplate, using fiberglass mounting feet. Four electronics boards are interconnected with a wiring flex and outer connectors (data, power, safety) to the SCBU.

LVPS board. The Low Voltage Power Supply (LVPS) board is connected to the rover +28V via the SCBU, to allow on/off switching of the SCMU and to distribute digital and analog secondary power lines.

DPU board. The Digital Processor Unit (DPU) board communicates with the SCBU, controls and monitors all the SCMU subsystems and hosts some operational algorithms. The DPU incorporates a re-programmable FPGA.

Laser board. The Laser board drives the Laser with high current (up to 230A) for lasing, and then triggers the Pockels cell with a high voltage signal (1450V) for firing. Another Pockels cell is triggered to switch the laser from red to green color.

IR board. The IR board functions are to power the AOTF with adequate frequency (from 33.8 to 68.7MHz), to control the TEC cooler and to sample the IR photodiodes signal. The RF frequency range covers the 1.3-2.6 µm range at 30 cm^{-1} resolution.

Development and Test Approach of the SCMU: The overall philosophy maximizes heritage and focuses strong attention on the few lower-heritage areas to ensure success. The plan is rich in development models :

EDU Model: The SCMU Engineering and Development Unit (EDU) Model was built to be fully functional, but not fully form and fit. All the functions are present and characterized at ambient. During last spring, the SCMU EDU has been shipped temporarily to LANL for a coupling test with SCBU EDU, for a successful first Raman end-to-end check.

TU Model : The SCMU EDU will be refurbished to be the SCMU Testbed Unit (TU) and delivered to JPL after being integrated with the SCBU for Mars 2020 Vehicle System TestBed purposes.

STM Model: The SCMU STM (Structural and Thermal Model) was built last spring and passed successfully the environemental tests (vibration, shock, thermal vacuum).

EQM Model: A fully representative SCMU Engineering and Qualification Model (EQM) model will be built and tested at Qualification level in 2016/2017. Performance will be verified and characterized. The EQM model will be delivered to LANL, for tests at Instrument level, then, for Calibration. This model will stay at LANL, as a ground model, during the mission.

Flight Model: This model, for flight, will be very similar to the EQM, but with screened EEE parts. The FM model will go through Acceptance tests campaign and will be delivered to LANL and then to JPL in 2018.

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