**SURFACE OBSERVATIONS FROM MARS 2020 EDLCAM CAMERAS AND MICROPHONE.** N. R. Williams[1], J. N. Maki[1], A. Culver[1], N. Ruoff[1], M. Lambert[1], D. Kessler[1], A. Nelessen[1], D. Gruel[1], T. Aranador[1], E. Ford[1], D. Hecht[1], A. Lidawer[1], A. Roth[1], J. Ryan[1], C. Wells-Weitzner[1], C. Moran[1], [1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, 91109, Nathan.R.Williams@jpl.nasa.gov.

**Introduction:** The Mars 2020 Perseverance rover carried a set of commercial off the shelf (COTS) cameras plus a microphone to record video and audio of its entry, descent, and landing (EDL) on Feb. 18, 2021. Four cameras were jettisoned with other hardware during EDL, while the Rover Uplook Camera (RUC), Rover Downlook Camera (RDC), and microphone (Mic) remained onboard the rover itself. Data from the cameras and microphone are stored on a 500 GB Data Storage Unit (DSU) and later downlinked. Stunning videos from EDL have previously been returned [1,2]. Only <7% of DSU storage capacity was utilized during EDL. Since landing, the team has performed additional low-cost opportunistic observations to both test extended functionality of the COTS hardware and provide additional science value. As of sol 668 (one full Mars year) of Perseverance's mission, EDLCAM has performed additional 55 recording sessions on the surface of Mars.

**Instrument Parameters:** The RUC and RDC are each 1280x1024 pixel color cameras, capable of recording still images or videos at a default rate of 30 frames per second. The RUC is located on the rover deck with a fixed boresight pointed ~up, with no hardware visible after the skycrane flew away. Conversely, the RDC is mounted on the rover's body near the rover's front-right wheel, with a boresight pointed ~down. No hardware is visible in the RDC either, but the rover's shadow and tracks are often visible. The cameras have a built-in autoexposure that takes <30 frames to converge for well-illuminated scenes. The MIC is located on the rover's port side.

**Results:** Four primary classes of EDLCAM observations have been recorded on the surface: audio, videos, single images, and time series. Microphone recordings comprise of 1-second clips that may be concatenated. Videos are recorded at a default 30 frames per second and saved onboard as a series of raw images, which may then be converted and compressed onboard into a movie file to minimize data volume for downlink while preserving raw data on the DSU. Each image frame of a video can optionally also be downlinked raw or compressed onboard into a jpeg. Due to short delays between command dispatch and completion, standalone images can be taken sequentially every 2 seconds or longer, and multiple of these individually-commanded images can be strung together to build up a time series movie. The RUC and RDC have used these time series to efficiently record 2 cloud movies and 14 "sidewalk" movies while the rover drives (e.g. Fig. 1). Over six hours of Mic audio has been cumulatively recorded. Five health checks have also been performed via short recordings with the RUC, RDC, and Mic to demonstrate continued viability.

A summary of recordings to date is provided in Table 1. Individual data is delivered to the Planetary Data System (PDS) [2,3] as part of the standard mission data release cadence. Audio is provided as 1-second clips and concatenated .wav files [2] and videos as .mp4 files [2], and calibrated image frames as .img files [3].

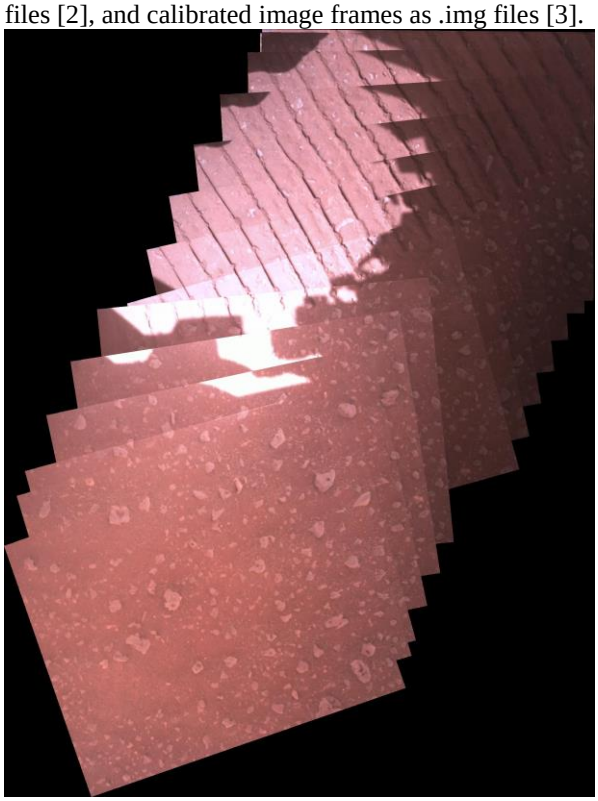

Figure 1: Mosaic of co-registered RDC sidewalk movie frames from session 40 (sol 387) showing rover tracks and regolith during a drive.

**Discussion:** EDLCAM's COTS hardware remains healthy and operating after a full Mars year on the surface (668 Mars sols or 687 Earth days), and is ready for additional observations. EDLCAM has weathered several coronal mass ejections that passed by Mars without any observable issues. Two RUC dust cloud searches show subtle variations possibly due to clouds, although out of focus and/or with indistinct clouds. RDC sidewalk movies are more in focus and distinguish rock and regolith textures at an average 0.335 mm/pixel resolution. EDLCAM's Mic occasionally experiences

high gain that may be linked to intermittent connectivity observed infrequently before launch, yet nonetheless provides useful data that is still being analyzed by rover teams. 88.5% of DSU storage capacity remains available for use as the mission continues.

**Acknowledgments:** We gratefully acknowledge the broader Mars 2020 Perseverance rover engineering and science teams.

**References:** [1] Maki J.N. et al. (2020) LPS LII, 1004. [2] Maki J.N. et al. (2022) M2020 EDLCAM Raw Video and Audio Bundle, PDS Imaging Node, https://pds-imaging.jpl.nasa.gov/data/mars2020/m2020_edlcam_raw/. [3] Maki J.N. et al. (2022) Mars 2020 Entry, Descent, and Landing (EDL) and Lander Visual System Cameras Bundle, calibrated products, PDS Imaging Node, https://pds-imaging.jpl.nasa.gov/data/mars2020/mars2020_edlcam_ops_calibrated/.

| Sol | Session | Activity Description | Received Data |
|---|---|---|---|
| **2** | 6 | First audio of wind and rover sounds | Mic: 60 s |
| **3** | 7 | Audio of rover sounds | Mic: 60 s |
| **16** | 8 | Audio of rover drive | Mic: 1012 s |
| **45** | 9 | Audio of arm motions for selfie part 1, wind | Mic: 576 s |
| **46** | 10 | Audio of arm motions for selfie part 2, wind | Mic: 2909 s |
| **55** | 11 | (Failed) Audio of MOXIE compressor sweep | No audio retrieved |
| **121** | 12 | Health check of RDC, RUC, and mic | RUC: 1 image; RDC: 1 image; Mic: 30 s |
| **152** | 13 | Health check of RDC, RUC, and mic after coronal mass ejection passed Mars | RUC: 30 frame video + last frame raw<br>RDC: 30 frame video + last frame raw<br>Mic: 30 s |
| **200** | 14 | Parallelism test between EDLCAM Mic and SuperCam Mic | Mic: 167 s |
| **217-233** | 15-29 | (High gain in 15, 18, 23) EDLCAM Mic in parallel with SuperCam Mic during conjunction | Mic: 167 s per session |
| **316** | 30 | Dust Cloud Search | RUC: 13 frame time series, ~10 s apart |
| **319** | 31 | Dust Cloud Search | RUC: 65 frame time series, ~30 s apart |
| **331** | 32 | Parallelism Test between EDLCAM Mic and SuperCam Mic and LIBS | Mic: 270 s |
| **346** | 33 | Audio of abrasion | Mic: 1904 s |
| **346** | 34 | Audio of Gaseous Dust Removal Tool | Mic: 846 s |
| **360** | 35 | Sidewalk movie | RDC: 30 frame autoexposure video<br>+ 85 frames of time series |
| **375** | 36 | Health check of RDC, RUC, and Mic | RUC: 30 frame video + last frame raw<br>RDC: 30 frame video + last frame raw<br>Mic: 30 s |
| **382-455** | 37-49 | Sidewalk movies | RDC: 30 frame autoexposure video (not downlinked) + ≤901 frames of time series |
| **568** | 50 | Audio of abrasion | Mic: 750 s (716 s with valid data) |
| **575** | 51 | (High gain for first 10 minutes) Audio of coring | Mic: 1628 s (1602 s with valid data) |
| **579** | 52 | Audio of coring | Mic: 1732 s (1701 s with valid data) |
| **584** | 53 | Audio of witness tube assembly processing | Mic: 2795 s (2758 s with valid data) |
| **610** | 54 | Audio of HRS/RIPA pump maintenance, part 1 | Mic: 120 s |
| **610** | 55 | Audio of HRS/RIPA pump maintenance, part 2 | Mic: 120 s |
| **612** | 56 | Audio of abrasion | Mic: 512 s |
| **616** | 57 | Health check of RDC, RUC, and Mic | RUC: 30 frame video + last frame raw<br>RDC: 30 frame video + last frame raw<br>Mic: 30 s |
| **623** | 58 | (High gain for first 10 mins) Audio of coring | Mic: 1041 s |
| **633** | 59 | Audio of HRS/RIPA pump maintenance | Mic: 3720 s |
| **649** | 60 | Health check of RDC, RUC, and Mic | RUC: 30 frame video + last frame raw<br>RDC: 30 frame video + last frame raw<br>Mic: 30 s |

Table 1: Summary of EDLCAM recordings on the surface of Mars through sol 650 (excludes EDL see [1,2])