The Mars 2020 Mission One Month After Landing. K.A. Farley[1], J. Trosper[2] and the Mars 2020 Science and Engineering Teams [1]Caltech Pasadena, CA (farley@caltech.edu), [2]Jet Propulsion Laboratory Pasadena, CA (jennifer.h.trosper@jpl.nasa.gov).

Introduction: The Mars 2020 mission was successfully launched on July 30, 2020, and as of this writing has completed 85% of its cruise to Mars with no significant unexpected events. Shortly after 12:30 PM Pacific time on February 18, 2021, the spacecraft is expected to transit the Martian atmosphere and deposit the Perseverance rover on the planet's surface. This abstract summarizes the mission and its expected activities, focusing on the first 90 sols and the linkage of the mission to a possible joint NASA-ESA Mars Sample Return campaign. Immediate post-landing science results will be described at the Conference.

Mission Goals: The central objectives of the Mars 2020 mission are to seek the signs of ancient life and to collect a cache of rock and regolith samples for possible return to Earth by a follow-on mission. Using its scientific payload, the mission will characterize the geology of its exploration environment, identify any habitable paleoenvironments, and search for biosignatures [1]. These activities are essential to the identification and documentation of samples that, if returned and analyzed in terrestrial laboratories, may answer key questions about the evolution of Mars, its climate, and the potential existence of life beyond Earth [2]. The mission will also enable future exploration by characterizing modern weather conditions and by demonstrating new technologies including the first rotorcraft to attempt flight on another planet.

Mission Design and Science Instruments: Mars 2020 inherits most of its designs from the Mars Science Laboratory (MSL) mission and its *Curiosity* rover, with a few important modifications. Most notably, *Perseverance* has seven new science instruments selected to achieve the mission's unique goals. These include the ground-penetrating radar RIMFAX that will characterize shallow subsurface structure, the MEDA instrument to document the modern environment, and MOXIE, a device that demonstrates an important ISRU capability: the conversion of atmospheric CO_2 into O_2. Mastcam-Z and Supercam are mast-mounted instruments that provide high resolution color imagery and elemental chemistry and mineralogy at the outcrop scale, while the turret-mounted instruments SHERLOC (and its associated WATSON imager) and PIXL provide similar data, including organic compound measurements, at the microscopic scale on natural or abraded surfaces or drilled rock tailings. The ability to coregister and map geochemical data to textural observations is an important advance and an essential component of *Perseverance's* search for biosignatures.

The mission's most sophisticated new element, the Sampling and Caching System, allows *Perseverance* to collect and store samples for possible Earth return. To take a sample, this system selects one of the 38 ultraclean sample tubes from a storage assembly inside the rover and transfers the tube to the robotic arm that then cores ~15 g of rock or regolith directly into the tube. Once returned to the rover interior, the tube is assessed for acquired volume, a picture looking down the bore is acquired, and the tube is hermetically sealed and returned to the storage assembly. *Perseverance* also carries 5 "witness tubes" that can be collected at different times to document the evolving rover contamination environment. After acquisition, sample tubes are transported within the rover until deployed to the martian surface for possible retrieval at a later date.

Mars 2020 carries a new EDL capability that was enabling in landing site selection. While previous Mars landers required landing zones almost completely free of hazards such as boulders, cliffs, craters, and sand dunes, Terrain Relative Navigation (TRN) allows the Mars 2020 spacecraft to acquire real-time positional awareness during descent, and to deflect away from previously mapped localities that would otherwise be mission-ending. After landing, the computational hardware implementing TRN is repurposed to expedite autonomous rover navigation.

Mars 2020 has upgraded its operations system to shorten the operations tactical timeline, ultimately to ~ 5 hrs, to reduce the number of sols that are constrained or lost due to Earth-Mars time phasing. This shortened tactical timeline is enabled by ground software and operational process improvements. The upgraded ground software includes more than 30 interoperable tools utilizing cloud-based technologies, data analytics, intuitive interfaces, and best practice cyber security standards. This software enables secure collaboration of hundreds of scientists and JPL engineers to make decisions efficiently through fast data processing, collaborative targeting and automated command expansions. The tactical timeline duration is reduced further through the formalization of the decision-making effort that occurs out of the tactical timeline in parallel meetings with longer time horizons, termed Strategic, Campaign Planning, and Campaign Implementation. Additional details of the Mars 2020 mission, its capabilities, and its instrument suite can be found in a recent collection of publications in Space Science Reviews [3].

Landing Site and Science Mission Plan: *Perseverance's* intended landing site in Jezero crater was a several-hundred-meter deep, 40 km diameter open-system lake in the late Noachian or early Hesperian. During the community workshops that led to selection of this site, it was recognized that studies of this lacustrine habitable environment would be complemented by studies of a distinct potentially-habitable subsurface paleoenvironment, in the very ancient rocks of the Nili Planum region upon which Jezero crater is superposed. The final site selection recognized the value of combining exploration of these two very different environments through a traverse from the Jezero floor, up the crater rim and across Nili Planum (subject to an appropriate level of confidence in rover health and capabilities) .

Over the last several years the *Perseverance* Science Team undertook a detailed study of Jezero and its surrounding with the goal to develop a Science Mission Plan that identifies promising outcrops in Jezero, the crater rim, and in Nili Planum, and maps those locations to specific science questions they could inform, what in-situ observations could be undertaken there, and what sample collection targets they contain. Notional traverses connecting these targets were then generated with realistic and well-informed constraints such as time required for commissioning, driving, science observations, and sols that are unproductive for various reasons. The resulting traverses explore Jezero crater in a period of 2 to 3 Earth years and then ascend the crater rim and explore Nili Planum through ~2027. While *Perseverance's* actual traverse will undoubtedly be modified from these initial plans by facts on the ground, this activity provides important insights to where effort is likely to be focused, how mission time will likely be spent, and signals what types of rocks the Mars 2020 sample cache may ultimately include [2]. Mars 2020's parallel goals of in situ exploration and sample collection are extremely ambitious, and this exercise informs team-internal and stakeholder expectations.

First 90 sols: The first ~3 months of mission operations will be focused on the transition from Cruise, Entry, Descent and Landing to Surface Operations. Critical events during this period include assessment of rover health, transition to surface flight software, and functional check-outs. The latter includes the Sampling and Caching system, which may be used to acquire a first witness blank sample. Towards the end of this period *Perseverance* will seek out and drive to an appropriate landscape in which to deploy and operate the *Ingenuity* helicopter. The helicopter will nominally operate for 30 sols and five test flights, during which limited science data collection will occur. During the ~90 sol period we expect to acquire one or more high resolution panoramas that will provide the first on-the-ground insights to the geology of the landing site and will inform development of the first science campaign. Downlink of the rich dataset acquired by the EDL cameras and microphone is also expected in this period.

Most or all of the first 90 sols of Mars 2020 operations will be undertaken on Mars time. Owing to COVID, a bare minimum of staffing will occur on-site at JPL with most work done remotely. In particular the science team will not co-locate until the Fall of 2021 at the earliest. The science and engineering teams have been working and practicing to minimize the impact of distributed operations on mission productivity.

Linkage to Mars Sample Return: An animating feature of the Mars 2020 mission is its linkage to Mars Sample Return, and the choreography this necessitates. Although still nascent, current thinking is that a Sample Return Lander (SRL) may arrive to pick up the samples Mars 2020 collects as early as 2028. This leads to the expectation that Mars 2020 should acquire a full complement of samples by late 2027. Samples would be transferred to the SRL in one of two ways: a cache of samples deployed to the martian surface could be picked up by a fetch rover delivered by SRL, or Mars 2020 could itself deliver samples directly to SRL. Stakeholders are investigating how to maximize the scientific value of the sample cache will simultaneously maintaining appropriate risk tolerance. As one example, *Perseverance* could deposit one cache of samples on the martian surface towards the end of its qualified lifetime (3 Earth years, so sometime early in 2024) and before beginning the ascent of the Jezero crater rim. Once deployed, this initial cache, rich with samples from the promising outcrops within the crater, guarantees a target for SRL pickup regardless of what happens to *Perseverance* thereafter. A second cache (or direct delivery to SRL) could then occur "just on time" about 3 years later. To ensure maximum science value of this second cache, *Perseverance* could acquire duplicates of the best (or even all) samples from the Jezero environment, depositing one copy in the initial cache and transporting the duplicate to the second depot. It is reasonable to expect that these types of considerations and plans will steadily evolve as the design of SRL matures, as the health and capability of *Perseverance* become better known, and as the team obtains a better understanding of its exploration environment and of the scientific value of the sample cache.

References: [1] Williford et al., LPSC 2021; [2] Herd et al., LPSC 2021; [3] Farley, K.A. Space Sci Rev 216, 142 (2020) and companion papers in same issue.