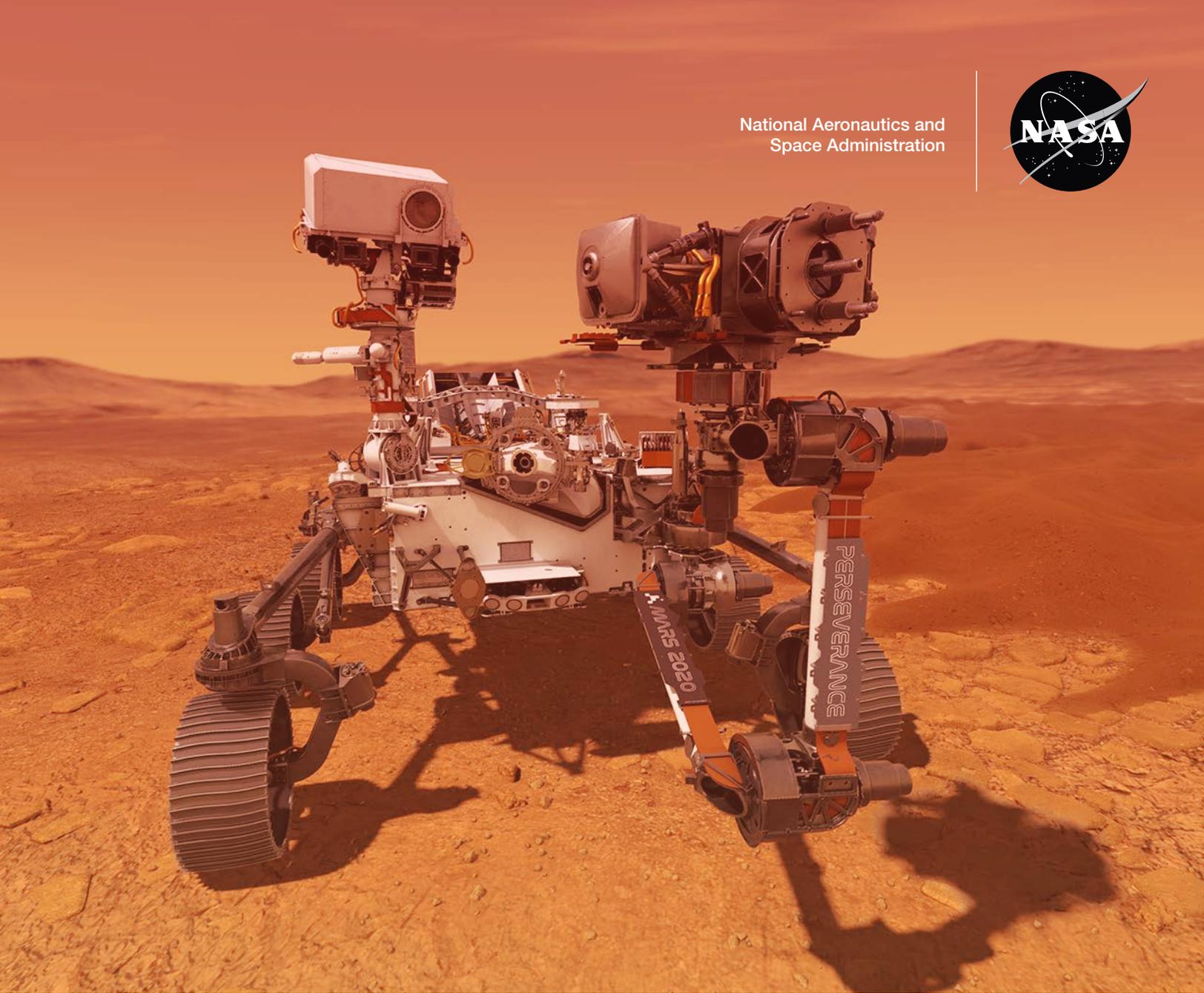


National Aeronautics and
Space Administration



MARS 2020 MISSION PERSEVERANCE ROVER

A CASE FOR SMALL BUSINESS



OFFICE OF **SMALL BUSINESS** PROGRAMS
...where small business makes a **BIG** difference



Members of NASA's Perseverance rover team react in mission control after receiving confirmation the spacecraft successfully touched down on Mars, February 18, 2021. Credit: NASA/Bill Ingalls



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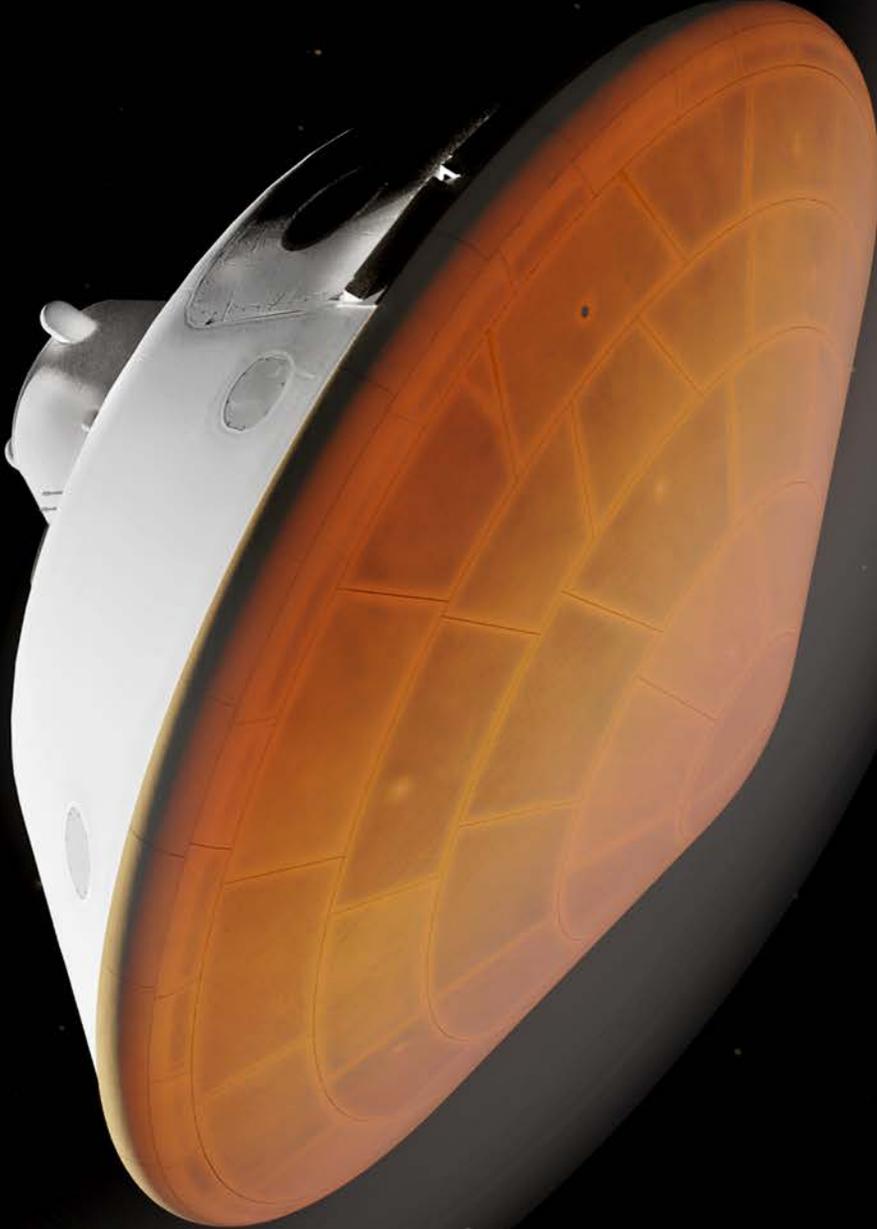
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**MARS
2020
PERSEVERANCE**



A United Launch Alliance (ULA) Atlas V rocket carrying the Mars 2020 mission with the Perseverance rover lifts off on July 30, 2020. Credit: United Launch Alliance



OFFICE OF SMALL BUSINESS PROGRAMS VISION AND MISSION

VISION STATEMENT

The vision of the Office of Small Business Programs (OSBP) at NASA Headquarters is to promote and integrate all small businesses into the competitive base of contractors that pioneer the future of space exploration, scientific discovery, and aeronautics research.

MISSION STATEMENT

- To advise the Administrator on all matters related to small business,
- To promote the development and management of NASA programs that assist all categories of small business,
- To develop small businesses in high tech areas that include technology transfer and commercialization of technology, and
- To provide small businesses maximum practicable opportunities to participate in NASA prime contracts and subcontracts.



MESSAGE FROM THE NASA OFFICE OF SMALL BUSINESS PROGRAMS ASSOCIATE ADMINISTRATOR

In this publication, I am pleased to highlight the significant contributions that small businesses made to the Perseverance Rover Mission. The main objective of the rover is to seek signs of ancient life and collect samples of rock and regolith (broken rock and soil) for a possible return to Earth.

I remember the exhilaration I felt on Thursday, February 18, 2021, when the Perseverance rover landed on Mars. The landing experience made me reflect on NASA's amazing achievements, and the amount of involvement from our small business partners.

More than 50 small businesses from across the nation demonstrated their innovative technology to support NASA's astounding accomplishments. Proudly, these companies provided an array of products and services such as lander engines, flight software development, testing support for the powered descent vehicle, and much more. The innovation generated by small businesses in this publication is a sampling of the dedication and ingenuity that industry provides

that enable NASA to complete its missions. All of the contributing small businesses have been able to perform during these unprecedented times, and due to their achievements, witnessed growth in revenue, personnel, and organizational capabilities. As evidenced in their development, these small businesses prove that when they get the opportunities to demonstrate their abilities, they can get the job done!

The NASA Small Business Program is supported by the Agency's Senior Management, the NASA Mission Directorates, Office of Procurement, other various acquisition personnel throughout the Agency, and the mission support offices. I would like to particularly recognize Administrator Bill Nelson's commitment to the program. In addition, I would also like to thank Mr. John McNamee, the Mars Perseverance Rover's Project Manager, and his team for their tireless efforts in ensuring that this mission continues to be a success. We appreciate Mr. McNamee for ensuring that companies like the ones in this publication have the opportunity to prove that small

businesses have the technical skills necessary to complete one of NASA's most highly anticipated and visible missions.

Our program would not be as successful without the dedication and hard work of the Agency's Small Business Specialists. The Small Business Specialists are devoted to locating small businesses around the nation and ensuring that they are provided with opportunities to participate in NASA's prime and subcontracts.

In closing, I want to take the opportunity to thank all of the small and large businesses that support NASA's various missions. NASA's industrial base provides continuous support in numerous capacities that enable the Agency to be successful. As the Associate Administrator of the NASA Office of Small Business Programs, I am proud to acclaim, that at NASA, "Small Businesses Makes a Big Difference."

Glenn A. Delgado
Associate Administrator
NASA Office of Small Business
Programs

With its heat shield facing the planet, NASA's Perseverance rover begins its descent through the Martian atmosphere in this illustration. Hundreds of critical events had to be executed perfectly and exactly on time for the rover to land on Mars safely on Feb. 18, 2021. Credit: NASA/JPL-Caltech



Did You Know?

NASA IS MAKING
OXYGEN ON
MARS



MESSAGE FROM THE MARS 2020 MISSION PERSEVERANCE ROVER PROJECT MANAGER

As with all NASA/JPL Mars missions, small businesses play an integral role in the development of the flight hardware, processes, and overall success of the project. The Mars Perseverance rover has several key components designed or built with the assistance of our small business partners, including the Perseverance robotic arm and the Mars Ingenuity helicopter. Small businesses were also involved in tracking the spacecraft during flight through NASA's Deep Space Network (DSN). Additionally, small businesses served as valuable partners in customization of spacecraft testing facilities, including cleanroom operations. Small businesses also provided thermal analysis and

telemetry monitoring support during entry to the Martian atmosphere. In addition, small business supported the Mars Perseverance project with design, analysis, and testing of the Perseverance Sample Caching System (SCS). In total, more than 500 small businesses supported the program resulting in over \$133M in expenditures toward NASA's small business objectives. As NASA continues to explore deep space and other planetary missions, we look forward to continued success with and support from our small business partners.

John B. McNamee

Mars 2020 Mission Perseverance
Rover Project Manager

 The payload fairing, or nose cone, containing the Mars 2020 Perseverance rover sits atop the motorized payload transporter that will carry it to Space Launch Complex 41 on Cape Canaveral Air Force Station in Florida. The image was taken on July 7, 2020. Credits: NASA/KSC

THE METRICS

SMALL BUSINESS ACHIEVEMENTS AT NASA

NASA FISCAL YEAR (FY) 2021 PRIME CONTRACT DOLLARS

Data generated November 16, 2021 from sam.gov

DOLLARS	CATEGORY
\$18,942,859,884	TOTAL DOLLARS
\$3,390,589,063	Small Business
\$1,502,469,537	Small Disadvantaged Businesses (SDB)
\$768,351,489	Woman-Owned Small Businesses (WOSB)
\$155,831,196	Historically Underutilized Business Zones (HUBZone)
\$302,463,166	Service-Disabled Veteran-Owned Small Businesses (SDVOSB)

▼ The heat shield (left) and back shell (right) that comprise the aeroshell for NASA's Mars 2020 mission are depicted at Lockheed Martin Space in Denver, Colorado. Credit: Lockheed Martin Space

\$3.2
billion

**NASA and its Prime
Contractors obligated
to Small Businesses
in FY 2020**





The Jet Propulsion Laboratory

is the Prime Contractor for the Perseverance Rover



In a clean room at NASA's Jet Propulsion Laboratory in Pasadena, California, engineers observed the first driving test for NASA's Mars 2020 rover on Dec. 17, 2019. Credit: NASA/JPL-Caltech



SMALL BUSINESS CONTRIBUTIONS TO THE MARS 2020 MISSION

When discussing scientifically advanced and historically significant NASA missions, it is a misconception to think that large businesses, with nearly unlimited resources, were the only ones to work on them. This is simply not the case. **Small businesses contribute a significant amount of research, development, manufacturing, and testing of mission-critical systems.**

From Perseverance's robotic arm, to the small but powerful propellers on Ingenuity, some of the most important scientific instruments designed to measure and navigate various parts of the Martian planet were created by small businesses.

It is important for NASA to extend its reach to small businesses for current and future missions, as it strengthens the economic opportunity for businesses that may not have the resources to directly compete with larger businesses for NASA contracts. We believe the more often small and large businesses work together for NASA missions, the more often innovation is fostered between them. This is exactly the mission of the NASA Office of Small Business Programs: to give small businesses a chance to contribute to the future of space exploration and aeronautics research.

Next, you will discover just a sample of the highlights of small business participation that made the Perseverance rover and Ingenuity helicopter possible!

◀ NASA's Perseverance rover deploys a supersonic parachute from its aeroshell as it slows down before landing, in this artist's illustration. Hundreds of critical events had to be executed perfectly and exactly on time for the rover to land safely on Feb. 18, 2021. Credit: NASA/JPL-Caltech

ABOUT THE MARS 2020 MISSION PERSEVERANCE ROVER

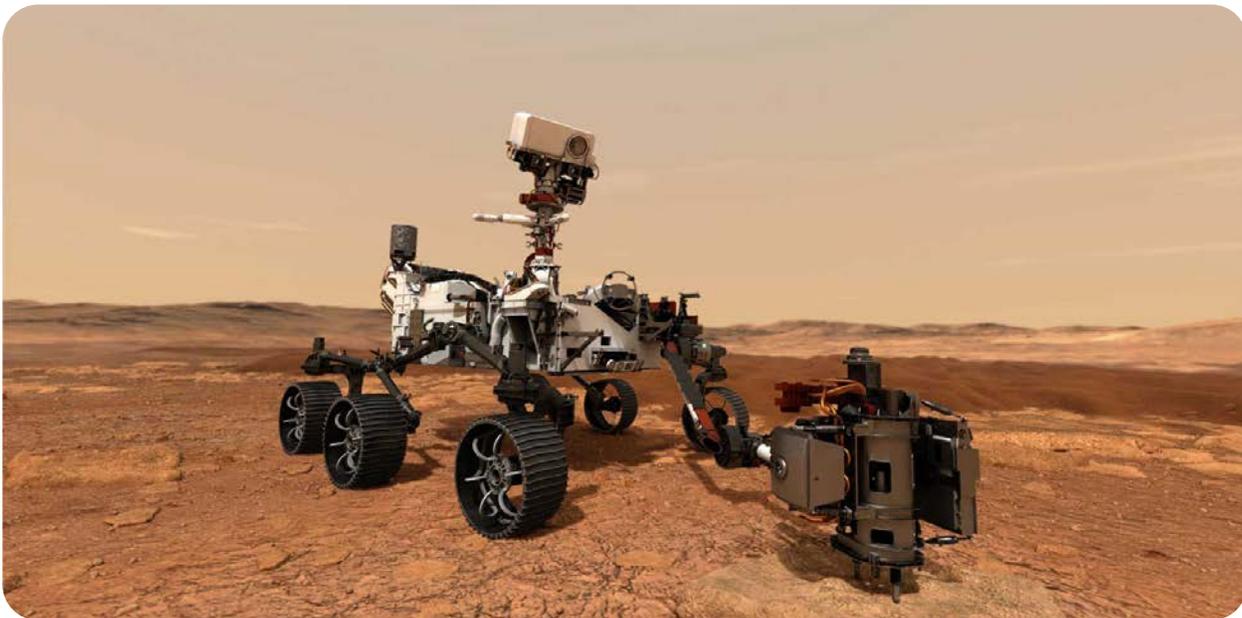
Over the past two decades, missions flown by NASA's Mars Exploration Program have shown us that Mars was once very different from the cold, dry planet it is today. Evidence discovered by landed and orbital missions point to wet conditions billions of years ago. These environments lasted long enough to potentially support the development of microbial life.

The Mars 2020/Perseverance Rover mission is designed to better understand the geology of Mars and seek signs of ancient life. The mission will collect and store a set of rock and soil samples that could be returned to Earth in the future. It will also test new technology to benefit future robotic and human exploration of Mars.

KEY OBJECTIVES

- Explore a geologically diverse landing site
- Assess ancient habitability
- Seek signs of ancient life, particularly in special rocks known to preserve signs of life over time
- Gather rock and soil samples that could be returned to Earth by a future NASA mission
- Demonstrate technology for future robotic and human exploration

*Text reprinted from NASA's Mars 2020/Perseverance fact sheet dated March 2020.



Artist rendering of the Perseverance Mars rover.

HIGHLIGHTS OF SMALL BUSINESS PARTICIPATION



Prototype test at Ames Research Center's Arc Jet Complex



Perseverance's robotic arm is shown outstretched in Jezero Crater on the surface of Mars.

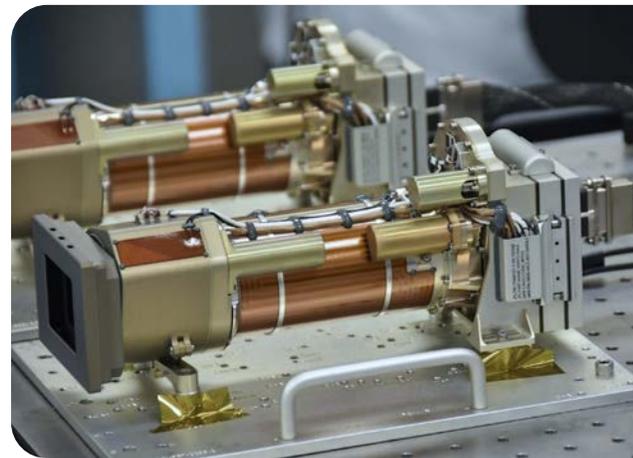
The Mars 2020 Mission Perseverance Rover provided NASA small business contractors an opportunity to do what they do best—provide creative and innovative solutions! Listed on these pages is a brief sampling of the capabilities of the small businesses that supported the mission.

- Provided Deep Space Network personnel support.
- Developed prototypes of the helicopter propulsion and structural systems, including landing legs, motors, blades, and control mechanisms. We refined these prototypes through testing and analysis, which led to the fabrication of two Engineering Development Model (EDM) helicopters, EDM1 and EDM2.
- Analyzed all aspects of the vehicle environments during the high-speed entry at Mars, including the expected convective heating and infrared radiation transferred to the vehicle heat shield and backshell which carries the parachute and several components used during later stages of entry, descent and landing.
- Performed thermal modeling and analyses for several subsystems.
- Analyzed and tested support for the powered descent vehicle, rover, and robotic arm.
- Supported numerous Perseverance design teams with analysis and pre- and post-testing efforts to ensure that the rover's structures and mechanisms would perform as expected while exposed to challenging environments and operations such as entry, descent, and landing (EDL).

- Provided expert analysis for specific aspects of the materials testing process, such as testing requests for elemental analysis, including organic components and metals.
- Provided several key components for the Mars Perseverance rover, including the Rover's Robotic Arm, the Mastcam-Z Zoom and Focus Mechanism, the robotic arm's 6-Degree of Freedom (DOF) Force Torque Sensor, and the Mastcam-Z Filter Wheel.
- Developed and manufactured the deep UV laser that powers the rover-arm-mounted Perseverance SHERLOC instrument, which performs deep UV Raman and fluorescence detection and chemical/mineralogical imaging of targets on Mars surfaces or in bore holes.
- Led design development of the EECAM (Enhanced Engineering Cameras) and related electronics, mechanical ground support equipment, computer-aided design, drawing generation, and FEA (finite element analysis).
- Produced electronic ground support equipment units to interface with the flight EECAMs.
 - **EDLCAM (Entry Descent Landing Camera):** Designed the imager brackets; delivered flight hardware.
 - **MOXIE (Mars In-Situ Resource Utilization Experiment):** Provided mechanical design, analysis of the sensor panel, and flight hardware.
 - **SHERLOC (Scanning Habitable Environments with Raman & Luminescence for Organics and Chemicals):** Design, drawing generation for the structure, optical/optomechanical system, electronics packaging, ground support equipment, integration/test support.
 - **Mechanical Ground Support Equipment:** Design, analysis, fabrication, and testing of mechanical ground support equipment.



Engineers install the robotic arm on the Perseverance rover.



Mastcam-Z flight cameras prior to installation on the rover offering revolutionary imaging capability on Mars.

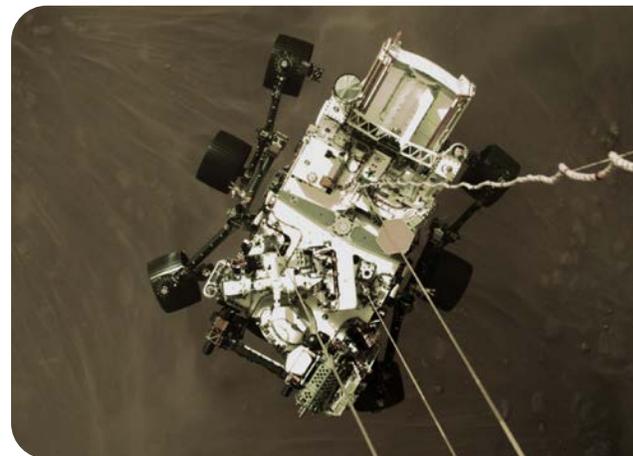


Image taken by EDL cameras. Engineers designed and analyzed the camera and data-storage unit brackets.

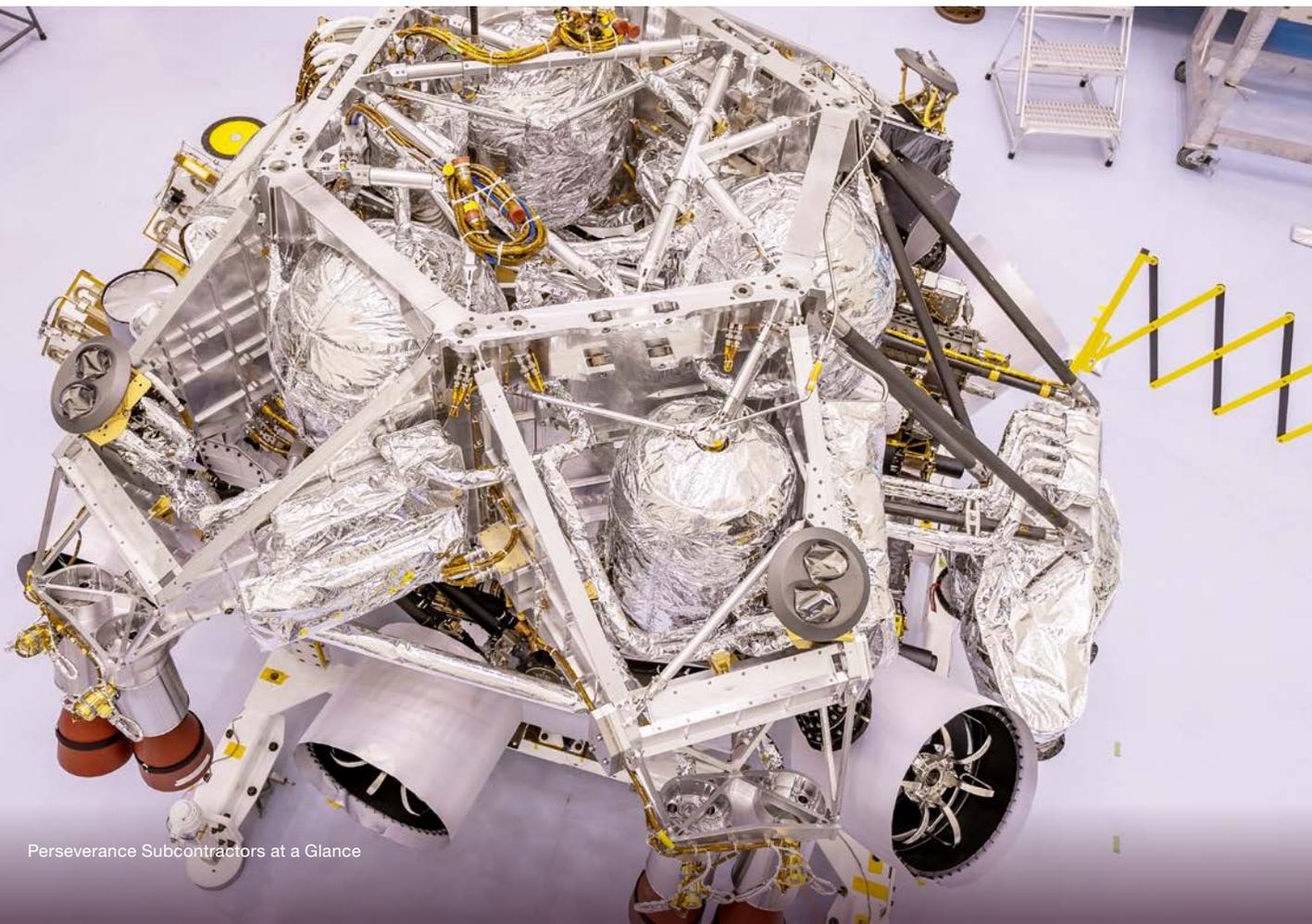
PERSEVERANCE SUBCONTRACTORS AT A GLANCE

TEN BIGGEST LARGE BUSINESS SUBCONTRACTS

Aeroflex Plainview, Inc.	High Gain Antenna (HGA), Wheel and Steering Actuator (WSA), Remote Sensing Mast (RSM) Actuators
Aerjet Rocketdyne, Inc.	Lander engines
Airborne Systems North America of CA, Inc.	Parachute assemblies
Arizona State University Tempe	Mastcam-Z
General Dynamics Ordnance	Mortar deployment subsystem
Honeybee Robotics, LTD	Witness plate assemblies
Lockheed Martin Corp	Aeroshell
Raytheon FY14 Agency-level SBIA Winner	Flight software development
Sierra Nevada Corporation	Gearboxes and actuators
SSL Robotics, LLC	Sample handling assembly



This image of the rocket-powered descent stage sitting on top of NASA's Perseverance rover was taken in a clean room at Kennedy Space Center on April 29, 2020. Credit: NASA/JPL-Caltech



SUPPORTING SMALL BUSINESSES

A+J Product Solutions	Wire support bracksts, sealing flange (program and machine)
Aerodyne Industries, LLC Cape Canaveral, FL	ATOM small business teammate
Aerospace Computing, Inc.	<i>Information not provided</i>
AeroVironment Inc. Simi Valley, CA	Prototypes of the helicopter propulsion and structural systems, including landing legs, motors, blades, and control mechanisms
Analytical Mechanics Associates Hampton, VA	Analyzed vehicle environments during the high speed entry at Mars
Applied Sciences Laboratory, Inc. Baldwin Park, CA	Thermal modeling and analyses
Aremco Products, Inc.	Ceramabond for model construction, materials
ATA Engineering, Inc. San Diego, CA	Analysis and testing support for the powered descent vehicle, rover, robotic arm, remote sensing mast, mobility system, skycrane, and sample caching system
Black Rock Technology Group, LLC	Membrane box, materials
California Fine Wire Company	Wiring materials
Edmund Optics Worldwide	Infrared (IR) bandpass filters
FKI Spacestructures	<i>Information not provided</i>
Galbraith Laboratories, Inc. Knoxville, TN	Mars Entry, Descent, and Landing Instrumentation 2 (MEDLI2) thermal protection system (TPS) material char analysis
Hadland Technologies Inc.	Computerized tomography (CT) scanning for MEDLI2 heat flux sensors
Hardware, Inc.	Membrane box, materials
Lascar Electronics Inc.	Calibration services
Malin Space Science Systems	<i>Information not provided</i>
Masten Space Systems	Testing of JPL lander vision system used on the perserverance lander
Medtherm Corporation	Heat flux transducer Gardon gage sensor and recalibration support of Gardon gage
Motiv Space Systems Pasadena, CA	Rover's Robotic Arm, the Mastcam-Z Zoom and Focus Mechanism, the robot arm's 6-DOF Force Torque Sensor and the Mastcam-Z Filter Wheel
Pacific Design Technologies Inc.	<i>Information not provided</i>
Pelican Wire Co., Inc.	Calibration services and certificate of conformance
Photon Systems, Inc. Covina, CA	Deep UV laser
Precision Control Systems, Inc.	Lamp support tube and retainer, materials
Sierra Lobo, Inc. Fremont, OH	EECAM (Enhanced Engineering Cameras), EDLCAM (Entry Descent Landing Camera), MOXIE (Mars In-Situ Resource Utilization Experiment), SHERLOC (Scanning Habitable Environments with Raman & Luminescence for Organics and Chemicals), and MGSE (Mechanical Ground Support Equipment)

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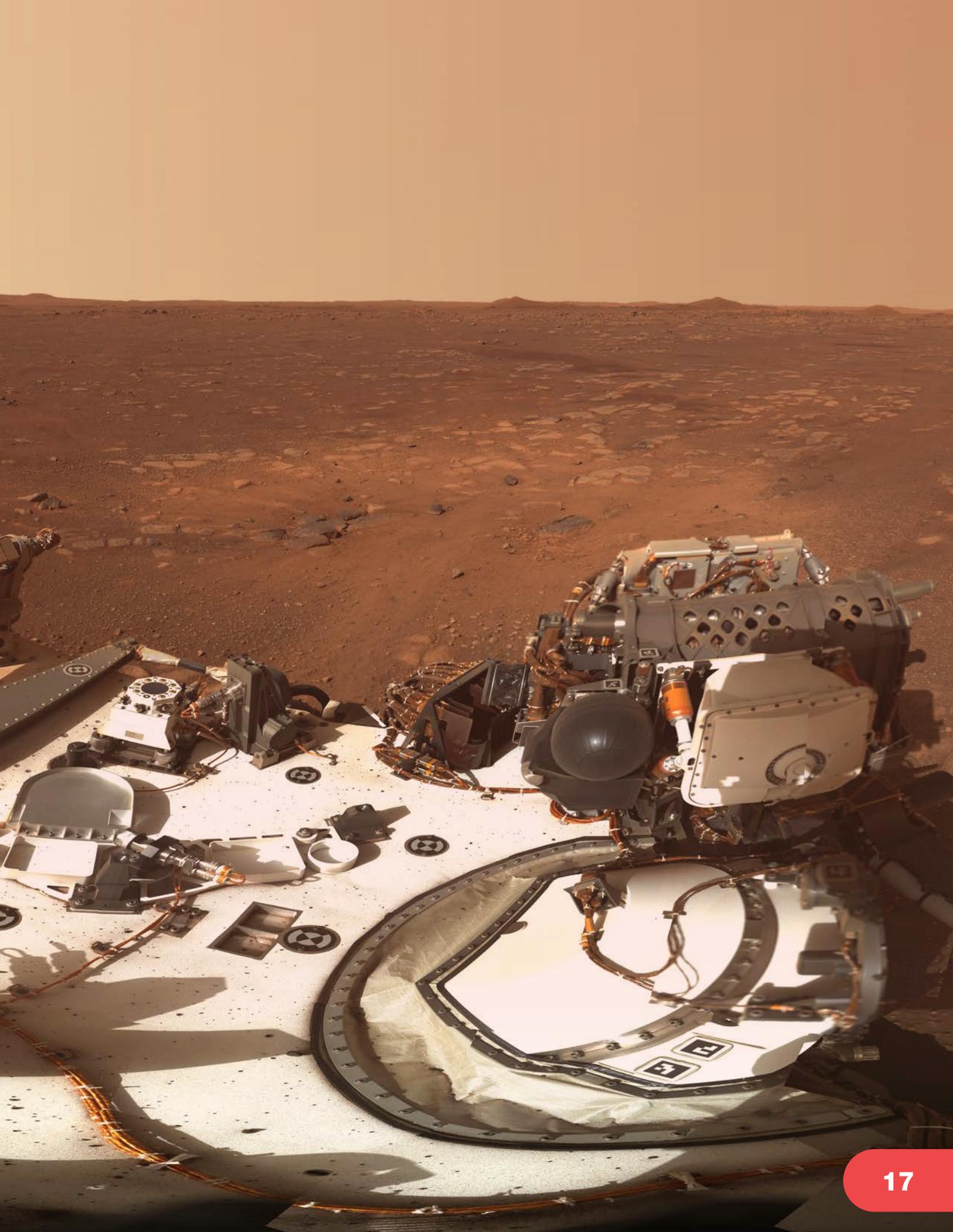


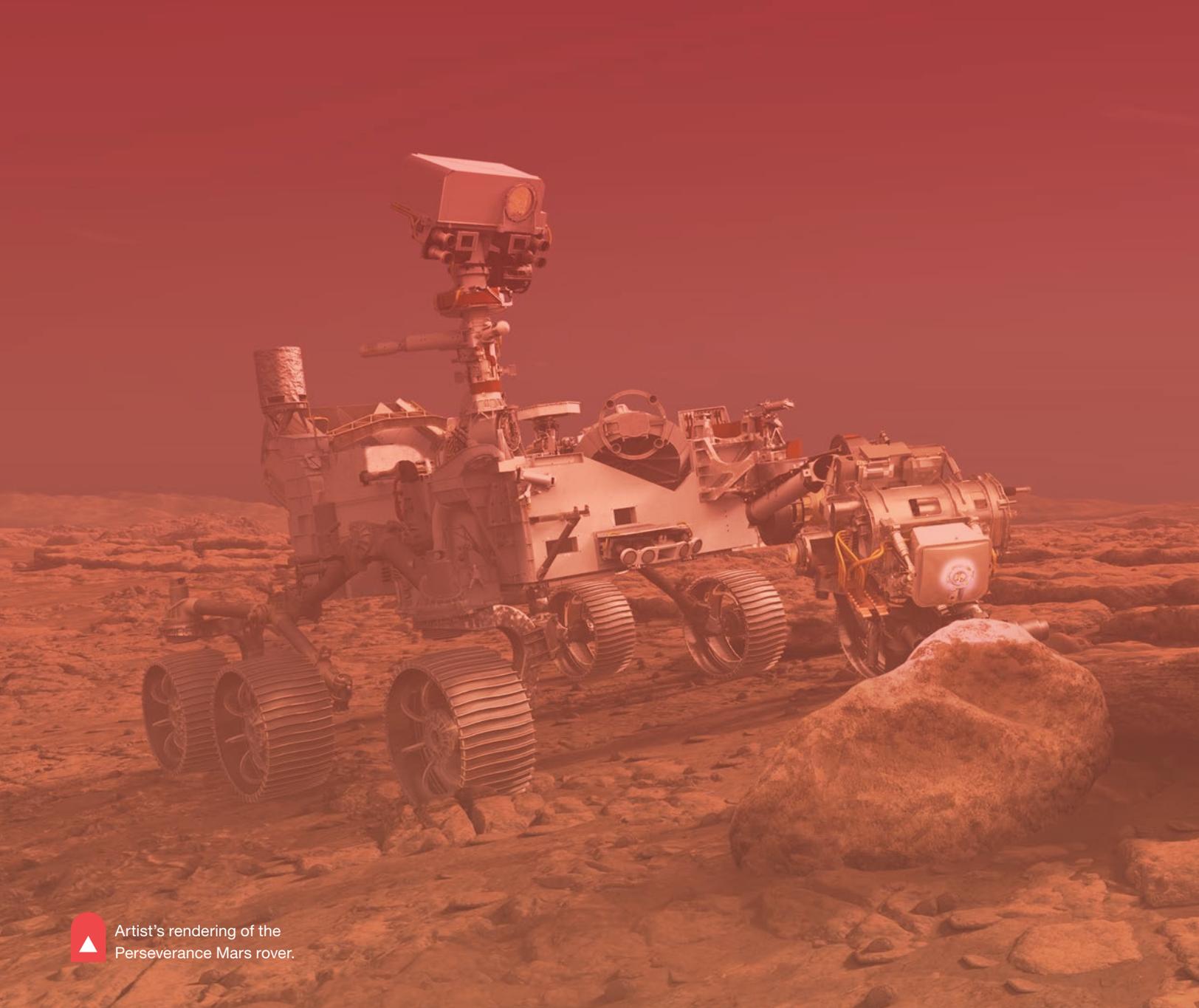
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This is the first 360-degree panorama taken by Mastcam-Z, a zoomable pair of cameras aboard NASA's Perseverance Mars rover. The panorama was stitched together on Earth from 142 individual images taken on Sol 3, the third Martian day of the mission (Feb. 21, 2021). Credits: NASA/JPL-Caltech/MSSS/ASU







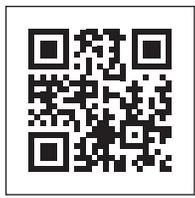
▲ Artist's rendering of the Perseverance Mars rover.

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-  NASA Vendor Database

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