

Mars Perseverance & Ingenuity

Launch – July 30, 2020 Landing – February 18, 2021



Mission Goals:

- Perseverance will explore an area on Mars that is interpreted to be an ancient river delta, and it will also select and prepare samples of Mars for return to Earth by a future mission.
- The Perseverance mission is planned to last a year and a half, but if the rover is functional after that, the mission will continue. The Opportunity Rover was only designed to last 90 days, but the mission continued for almost 15 years.

Previous Mars rovers:



- NASA's first rover on Mars was modest: Sojourner, in the lower left of the photo, is the size of a microwave oven; and it demonstrated in 1997 that a robot could move across the surface of the Red Planet.

- NASA's next Mars rovers, Spirit and Opportunity, upper left, were each the size of a golf cart. After landing in 2004, they discovered evidence that the planet once hosted running water before becoming a frozen desert. Spirit roamed for 6 years and was the first to climb a mountain on Mars.

Opportunity roved the planet for 14 and a half years, traveled a Marathon distance, and discovered gypsum, hematite nodules, evidence for long-lasting water in the past, and explored the rim of a large impact crater.

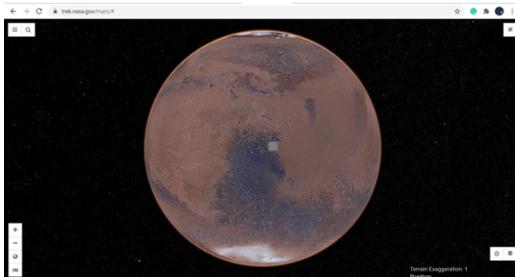
- The car-sized Curiosity rover landed in 2012. Curiosity, right side of the photo above, discovered that its landing site, Gale Crater, hosted a lake billions of years ago and an environment that could have supported microbial life. Each rover mission learns from the previous ones and the science, technology, and rover designs are increasingly advanced.

- Once every 26 months, Earth and Mars move into orbital positions that allow for the shortest duration trip. This is why two other Mars explorers launched at around the same time as Perseverance, in summer 2020, and are due to arrive within a week of Perseverance.

- The *Hope* Mars Mission from the United Arab Emirates, launched on July 19, 2020 and successfully went into orbit around Mars on February 9, 2021. The mission goal is to orbit for at least one Mars year to study Mars' climate and atmosphere. On July 23, 2020 China launched *Tianwen-1*, which includes an orbiter and rover. It entered orbit on February 10, 2020 and will orbit for some months before the rover is sent to a selected site on Mars. The other nations that have had successful Mars missions, in addition to the US and USSR, are ESA, and India.

Spacecraft Design:

- The Mars 2020 mission spacecraft design is based on the Curiosity Rover mission – with improvements.
- The Cruise Stage, for travel between Earth and Mars, includes an aeroshell consisting of a backshell and heat shield, in which the rover and its landing system are enclosed.
- The Entry, Descent, and Landing System (EDL) protects Perseverance as it enters into the Martian atmosphere. It includes the aeroshell, a parachute, a descent vehicle, and a sky crane that will lower the rover to the Martian surface on tethers.
- This is the first mission to have cameras and microphones that will record the descent and landing on Mars and enable us to see the landing! There are cameras mounted on the backshell that look up to the parachute, on the descent stage looking down at the sky crane, and on the rover looking up at the sky crane and down at the surface.
- There are two new technologies that will help with landing since it is a difficult landing site. The parachute is not a timed event, it will take place when the spacecraft is at the optimum time and elevation; this is called a “range trigger.” Then the descent stage will actually fly over the terrain looking for a safe place to land and lower the rover to the surface at the proper place; this is called “terrain relative navigation.” No other Mars lander has ever done this before.

**Landing Site - Jezero Crater:**

- The landing site on Mars is Jezero Crater, an old impact crater. Billions of years ago, it was filled by a lake, about the same size as Lake Tahoe, fed by a river. The river deposited material into the lake that formed a delta. Life is often present in similar areas on Earth.

The outline of river delta material that flowed into Jezero Lake is shown in the image to the right (Image: <https://mars.nasa.gov/resources/22475/jezero-crater-mars-2020s-landing-site/>)

- The rover will study sediments that were once under water in the river delta and along the lake shore. Samples of rock in these regions might contain evidence of ancient, microscopic life.

- 2/3 of Mars’ northern hemisphere was once covered in liquid water. Something happened about 3 billion years ago that caused the water to freeze or evaporate into space. Go to this site for an artist drawing of what Mars might have looked like with water and an article on the subject: <https://www.nasa.gov/press/2015/march/nasa-research-suggests-mars-once-had-more-water-than-earth-s-arctic-ocean>



The Mission Plan



- Perseverance is a car-sized rover. It will go on a traverse that includes studying the delta sediments at different levels. At geological units of interest, it will be directed to drill into the surface, collect samples, and seal them in tubes. Once a diverse set of samples have been gathered, Perseverance will place them on the surface of Mars to await being collected and returned to Earth by a future mission.

- As sophisticated as Perseverance is, it can't do the kind of analysis that we can on Earth. That's why the rover will prepare samples for return to Earth from Mars. The craft that will retrieve and launch the samples is still in the planning stages, but can hopefully get the samples to Earth by 2031.
- Later, Perseverance will explore Jezero Crater's rim to examine and study rocks once deep within Mars brought to the surface by the asteroid that impacted and created the crater.
- The rover will look at minerals at the microscopic level. It will try to identify organic elements that form life on Earth that might be indicators of past life during the time of the delta formation.

Instruments and Design of Perseverance:

- Go here for a 3D Model!: <https://mars.nasa.gov/mars2020/spacecraft/rover/>
- The initial design of the rover started on paper almost 10 years ago. Based on the Mars Science Laboratory's Curiosity rover configuration, Perseverance is car-sized, about 10 feet long (not including the arm), 9 feet wide, and 7 feet tall. But at 2,260 pounds (1,025 kilograms), it weighs less than a compact car.

Perseverance Scientific Instruments:

- All the rover's instruments complement each other and many are specifically designed to look for evidence of life. There are spectrometers, cameras, a radar instrument, and a weather station.

- SHERLOC (The Scanning Habitable Environments with Raman & Luminescence for Organics & Chemicals) is on the end of the rover's arm and can detect organic matter. A spectrometer will provide close-up imaging and use an ultraviolet (UV) laser to determine fine-scale mineralogy and detect organic compounds. SHERLOC will be the first UV Raman spectrometer to fly to the surface of Mars and will provide complementary measurements with other instruments in the payload.



- PIXL (Planetary Instrument for X-ray Lithochemistry) is also part of the instrument package on the arm and measures the composition of rocks and soil. An X-ray fluorescence spectrometer contains a high-resolution imager to determine the fine-scale elemental composition of the Martian surface. PIXL will provide capabilities that permit more detailed detection and analysis of chemical elements.

- Mastcam-Z is an advanced camera system on the mast with panoramic and stereoscopic imaging capability with the ability to zoom. The instrument also will determine mineralogy of the Martian surface and assist with rover operations.

- SuperCam is the large camera on the mast and is usually represented as the rover’s eye. It can provide imaging, chemical composition analysis, and mineral identification. It will also be able to detect the presence of organic compounds in rocks and dust from a distance. Roger Wiens from Los Alamos National Laboratory here in NM is the principal investigator for this instrument.

- MEDA (Mars Environmental Dynamics Analyzer) is the rover’s weather station that will provide measurements of temperature, wind speed and direction, pressure, relative humidity, and dust size and shape through a number of sensors.

- MOXIE (Mars Oxygen ISRU Experiment) is a technology investigation that will attempt to produce oxygen from Martian atmospheric carbon dioxide. This is a requirement for sending humans to Mars in the future. Mars explorers can use oxygen to breath and make rocket fuel.

- RIMFAX (Radar Imager for Mars' Subsurface Experiment) is a ground-penetrating radar that will provide centimeter-scale resolution of the geologic structure down to about 30 feet below the surface, depending on what’s under the rover at the time.



- The drill on the arm can only penetrate down to about 5 centimeters below the surface, but previous missions showed that’s deep enough to get to some of the sediments we’re interested in.

- Perseverance will enjoy greater autonomy than any previous rover with the ability to travel up to 200 meters without any commands from Earth. NASA’s programming language is C.

- The rover is powered by a Multi-Mission Radioisotope Thermoelectric Generator (MMRTG). It makes about 110 W of electricity with thermocouples from heat radiated through the natural decay of plutonium. The plutonium is surrounded by a form of iridium as part of the protective casing.

- Part of the unit was developed at Los Alamos National Labs here in NM. The power produced by the MMRTG drops steadily over time, but Perseverance’s unit is expected to continue providing enough power to the rover for about 14 years.

<https://www.energy.gov/ne/articles/nuclear-power-system-delivered-florida-nasa-s-perseverance-rover>

- Power for the Spirit and Opportunity rovers was provided by solar panels. The end of Opportunity rover’s mission came when a dust storm on Mars cover the panels so that the batteries could not be recharged. Solar power cannot provide enough electricity for the instruments on Curiosity and Perseverance, and that’s why they need RTGs. They also don’t have to worry about dust storms.

Ingenuity

- Ingenuity is the first helicopter designed to fly in Mars' thin atmosphere, weighing only 4 pounds! The fuselage just 0.45 feet by 0.54 feet by 0.64 feet.
- The density of Mars' atmosphere is about 1% that of Earth's. With air that thin, the rotors must spin from 2,000 to 3,000 RPM – many times faster than a passenger helicopter on Earth. If all goes well, they'll be at least 5 experimental flights.
- Ingenuity features four specially made carbon-fiber blades, arranged into two rotors that spin in opposite directions for stability. The payload consists of batteries, avionics hardware, and sensors to determine how the craft flies. Power comes from innovative solar cells above the blades. The only instrument that could be used for science is a camera.



This illustration shows the Mars Helicopter Ingenuity on the surface of Mars.

Ingenuity is a flight test:

- Ingenuity is not considered to be a science instrument on Perseverance ... it is an engineering test to prove that the concept will work. It is what is known as a technology demonstration – a project that seeks to test a new capability for the first time, with limited scope. It will be the first aircraft to attempt controlled flight on another planet. Previous groundbreaking technology demonstrations include the [Mars Pathfinder](#) rover Sojourner and the tiny [Mars Cube One](#) (MarCO) CubeSats that flew by Mars in 2018. Ingenuity is a separate experiment from the Mars 2020 Perseverance rover. Future Mars missions may have helicopters as science instruments...if Ingenuity is successful.
- It can be bone-chillingly cold at [Jezero Crater](#), where Perseverance will land with Ingenuity attached to its belly in February 2021. Nights there dip down to minus 130 degrees Fahrenheit (minus 90 degrees Celsius). While Ingenuity's team on Earth has tested the helicopter at Martian temperatures and believes it should work on Mars as intended, the cold will push the design limits of many of Ingenuity's parts.
- Flight controllers at JPL won't be able to control the helicopter with a joystick. Communication delays are an inherent part of working with spacecraft across interplanetary distances. Commands will need to be sent well in advance, with engineering data coming back from the spacecraft long after each flight takes place. In the meantime, Ingenuity will have a lot of autonomy to make its own decisions about how to fly to a waypoint and keep itself warm.

The Ingenuity team will count success one step at a time.

The helicopter will need to:

- 1) Survive the launch from Cape Canaveral, the cruise to Mars, and landing on the Red Planet
- 2) Safely deploy to the surface from Perseverance's belly
- 3) Autonomously keeping warm through the intensely cold Martian nights by Autonomously charging itself with its solar panel

- 4) Make its first flight attempt. The first test flight is expected to take place between the first 30 and 60 sols after landing. The helicopter could fly as high as 15 feet (5 meters) in altitude and as far as 160 feet (50 meters) downrange. The longest that engineers will try to fly the helicopter on each flight will be 90 seconds.
- 5) If the helicopter succeeds in that first flight, the Ingenuity team will attempt up to four other test flights within a 30-Martian-day (31-Earth-day) window.



Links to New Mexico

•This will be the second rover mission to have a direct connection to the New Mexico Museum of Natural History & Science through a science team member on the mission!



•Dr. Larry Crumpler, NMMNHS, was a science team member on the Mars Exploration (Spirit and Opportunity) mission and part of the original science team for Ingenuity during its development and is currently a member of the Perseverance science team. The NMMNHS is one of only two museums nationwide with a direct connection to Mars rover missions.

•Dr. Crumpler's role on the mission will be to make geologic context maps of the terrain as the rover follows its traverse. This will be on the ground geologic mapping, using the rover's cameras and instrument data, and it is especially important for determining the best geologic samples to select and cache.

•Los Alamos scientists are team members on ChemCam on Curiosity and the SuperCam instrument on Perseverance. Dr. Roger Wiens, LANL, is Principal Investigator on both instruments.

•Scientists have already studied Martian rocks here on Earth; over 126 meteorites found on Earth are from Mars (<https://www2.jpl.nasa.gov/snc/>). Mars meteorites on public display include one at the NMMNHS. The Institute of Meteoritics at UNM is one of the major sites for the study of Martian meteorites and has a meteorite museum that is open to the public by appointment. Why do we still need samples returned to Earth? We do not know where the meteorites came from on Mars so they do not tell us about the general geology of the planet.

•For more information about Perseverance and Ingenuity, go to the museum's website www.Naturalhistory.org. Go to the Perseverance page for links to NASA websites and activities: <http://www.nmnaturalhistory.org/exhibits/space-science/mars-perseverance-mission>

•Follow "Field Reports from Mars" entries by Dr. Crumpler as the mission proceeds: <http://www.nmnaturalhistory.org/exhibits/space-science/mars-perseverance-mission>

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