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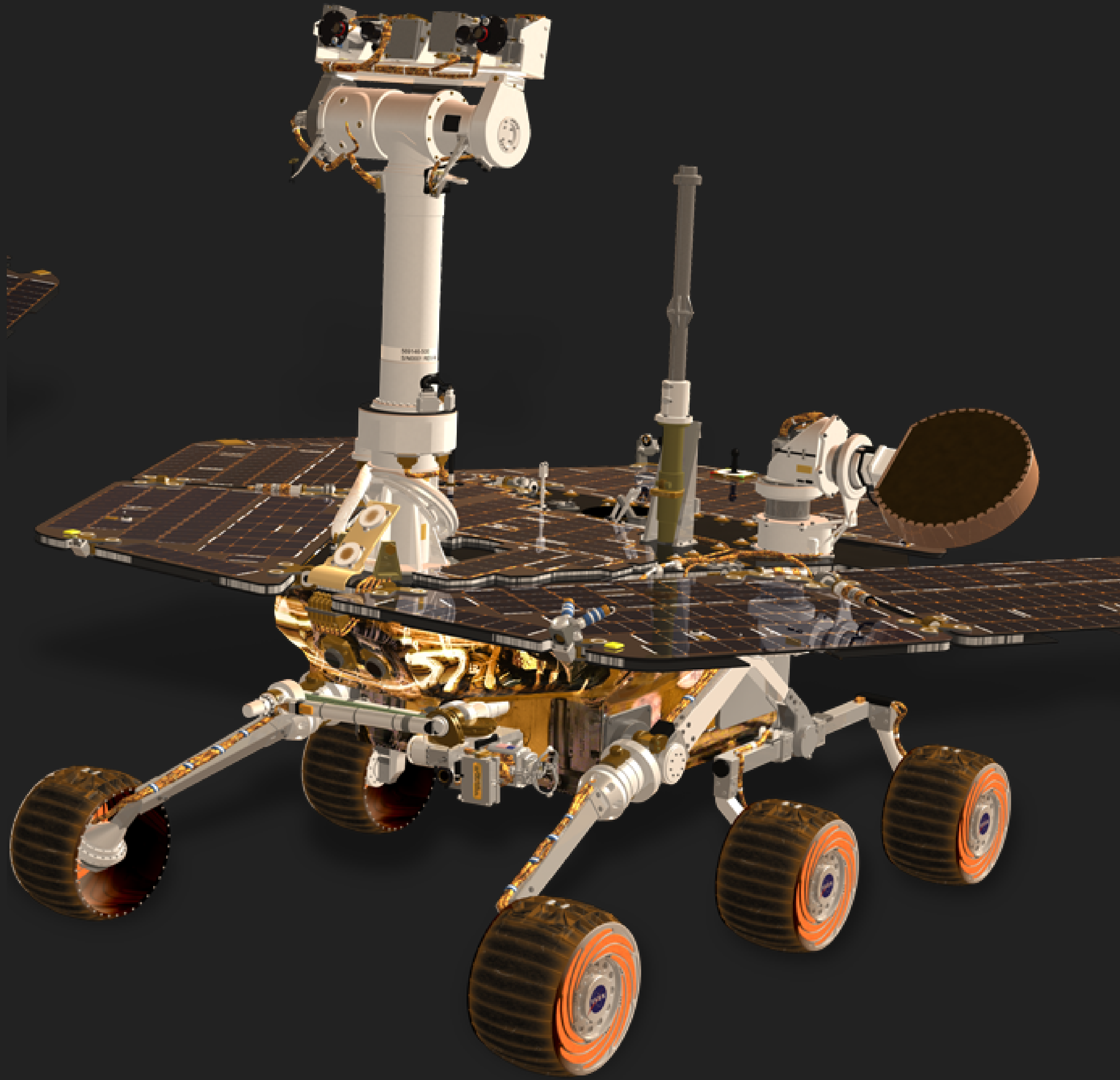
01

ROBOTIC HARDWARE SYSTEM
MARS ROVER



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MARS ROVER

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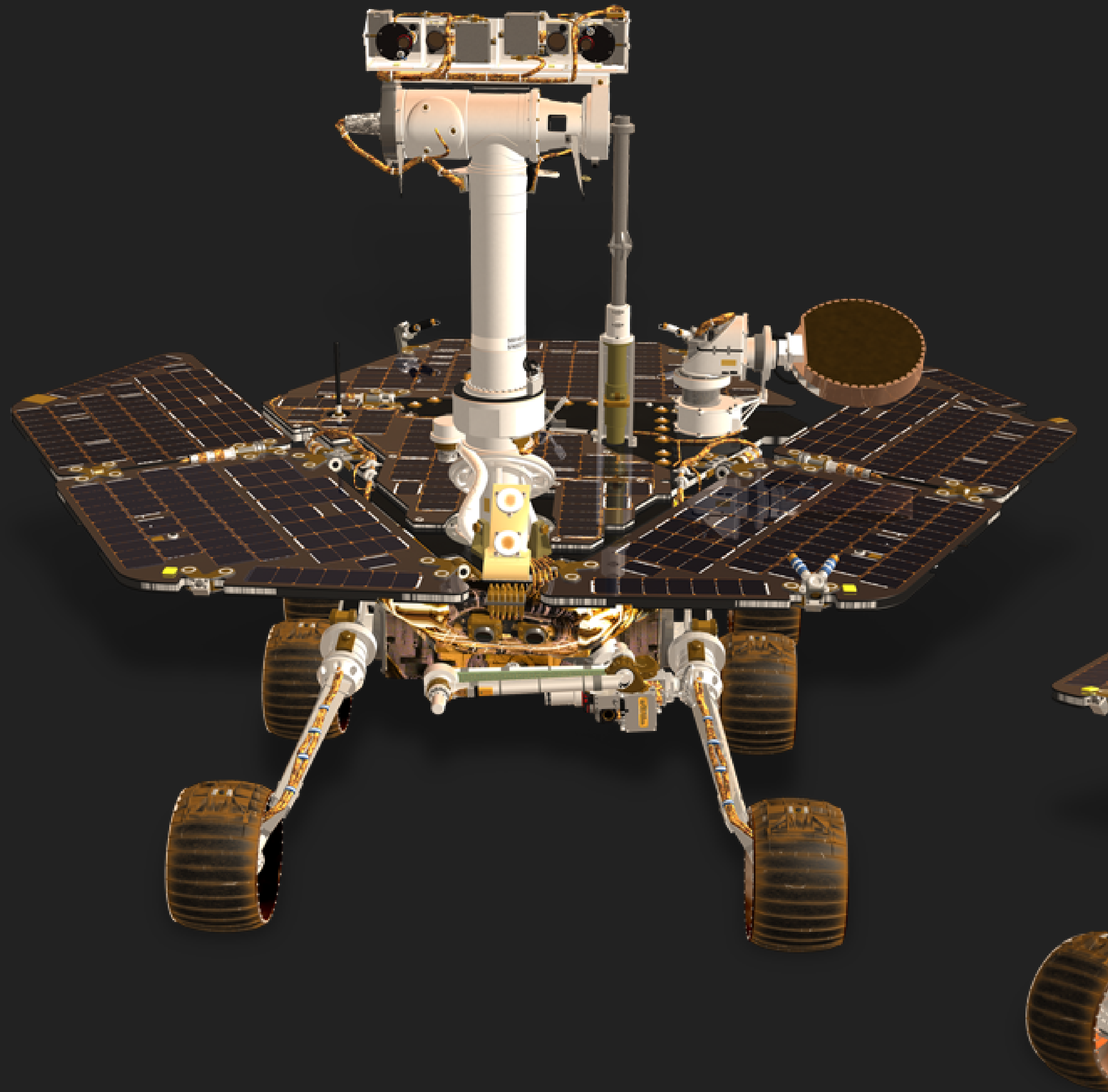
SPIRIT AND OPPORTUNITY LANDED ON MARS JANUARY 3 AND JANUARY 24, 2004 PST (JAN. 4 AND JAN. 25 UTC). BOTH ROVERS LIVED WELL BEYOND THEIR PLANNED 90-DAY MISSIONS. OPPORTUNITY WORKED NEARLY 15 YEARS ON MARS AND BROKE THE DRIVING RECORD FOR PUTTING THE MOST MILES ON THE ODOMETER.

THE TWIN GEOLOGISTS, SPIRIT AND OPPORTUNITY, HAVE BOTH FOUND DRAMATIC EVIDENCE THAT:

- LONG AGO MARS WAS WETTER
- CONDITIONS AT MARS COULD HAVE SUSTAINED MICROBIAL LIFE, IF ANY EXISTED

WITH DATA FROM THE ROVERS, MISSION SCIENTISTS HAVE RECONSTRUCTED AN ANCIENT PAST WHEN MARS WAS AWASH IN WATER. SPIRIT AND OPPORTUNITY EACH FOUND EVIDENCE FOR PAST WET CONDITIONS THAT POSSIBLY COULD HAVE SUPPORTED MICROBIAL LIFE.



MAIN COMPONENTS

Presentation Outline

03

#1 Physical Design

#2 Propulsion System

#3 Navigation System (Sensors) & Control

#4 Data Collection

#5 Data transmission

#6 Power Management

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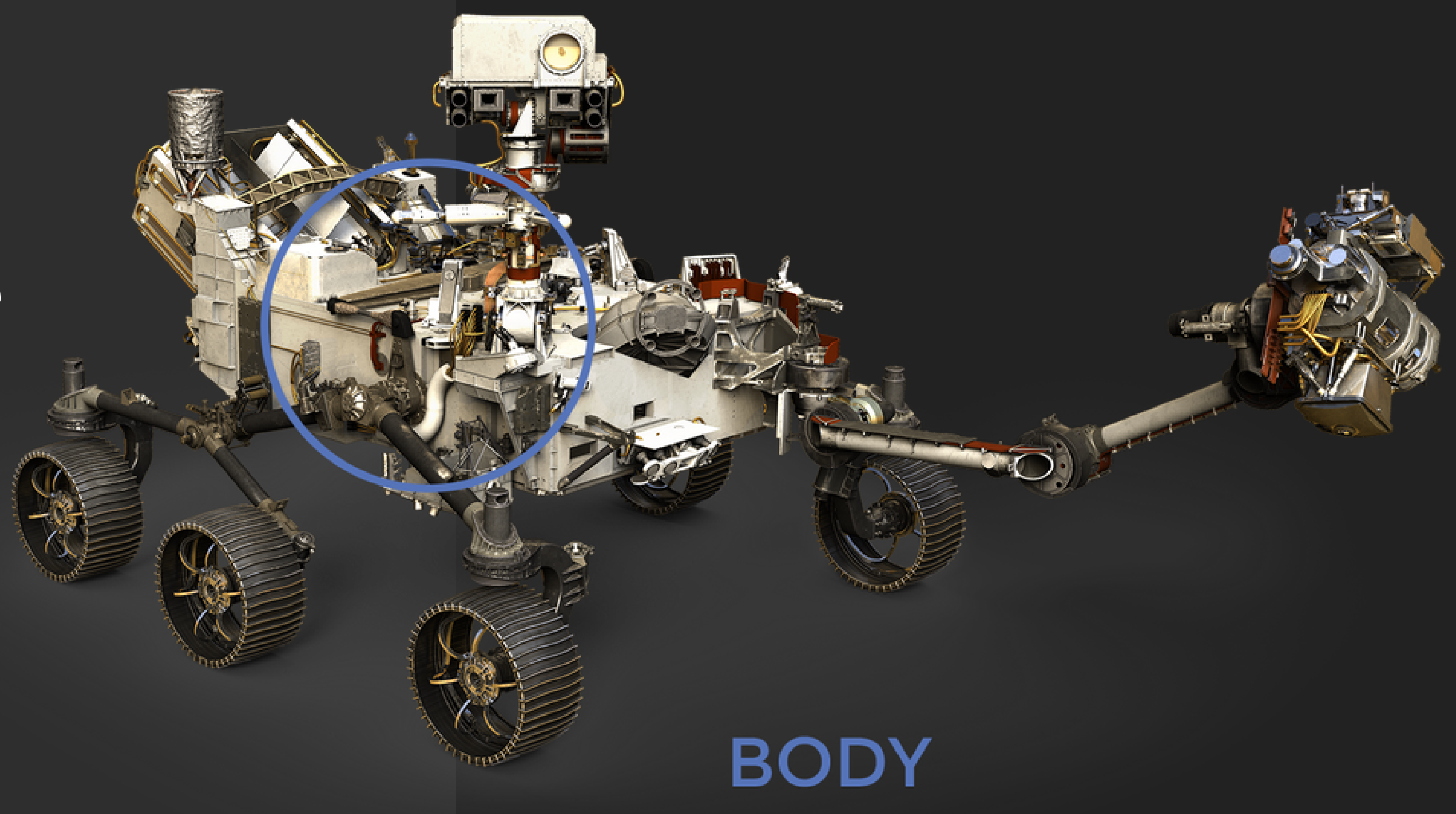
Physical **Design**

04

The Perseverance rover's body is called the warm electronics box, or "WEB" for short. Like a car body, the rover body is a strong, outer layer that protects the rover's computer and electronics (which are basically the equivalent of the rover's brains and heart). The rover body thus keeps the rover's vital organs protected and temperature-controlled.

The warm electronics box is closed on the top by a piece called the Rover Equipment Deck. The Rover Equipment Deck makes the rover like a convertible car, allowing a place for the rover mast and cameras to sit out in the Martian air, taking pictures with a clear view of the terrain as the rover travels.



Tech Specs

Main Job	Carry and protect the computer, electronic, and instrument systems
Length	10 feet (3 meters)
Width	9 feet (2.7 meters)
Height	7 feet (2.2 meters)
Weight / Mass	2,260 pounds / 1,025 kilograms
Structure	Bottom and sides are the frame of the chassis; top is the rover equipment deck (its "back"); bottom is the belly pan. Note that for new Sampling and Caching interior workspace, the belly pan in that front end of the rover (about first 1 1/2 feet from front end) is dropped soon after the rover lands. This exposes the workspace to Martian atmosphere and makes more room for sample handling operations within that workspace.

LOCOMOTION SYSTEM AND ACTUATORS

The IDD is mounted towards the front of the rover and is capable of reaching out approximately 0.75 meters in front of the rover at full extent. The IDD weighs approximately 4 kg and carries a 2 kg payload mass

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MER Instrument Positioning System

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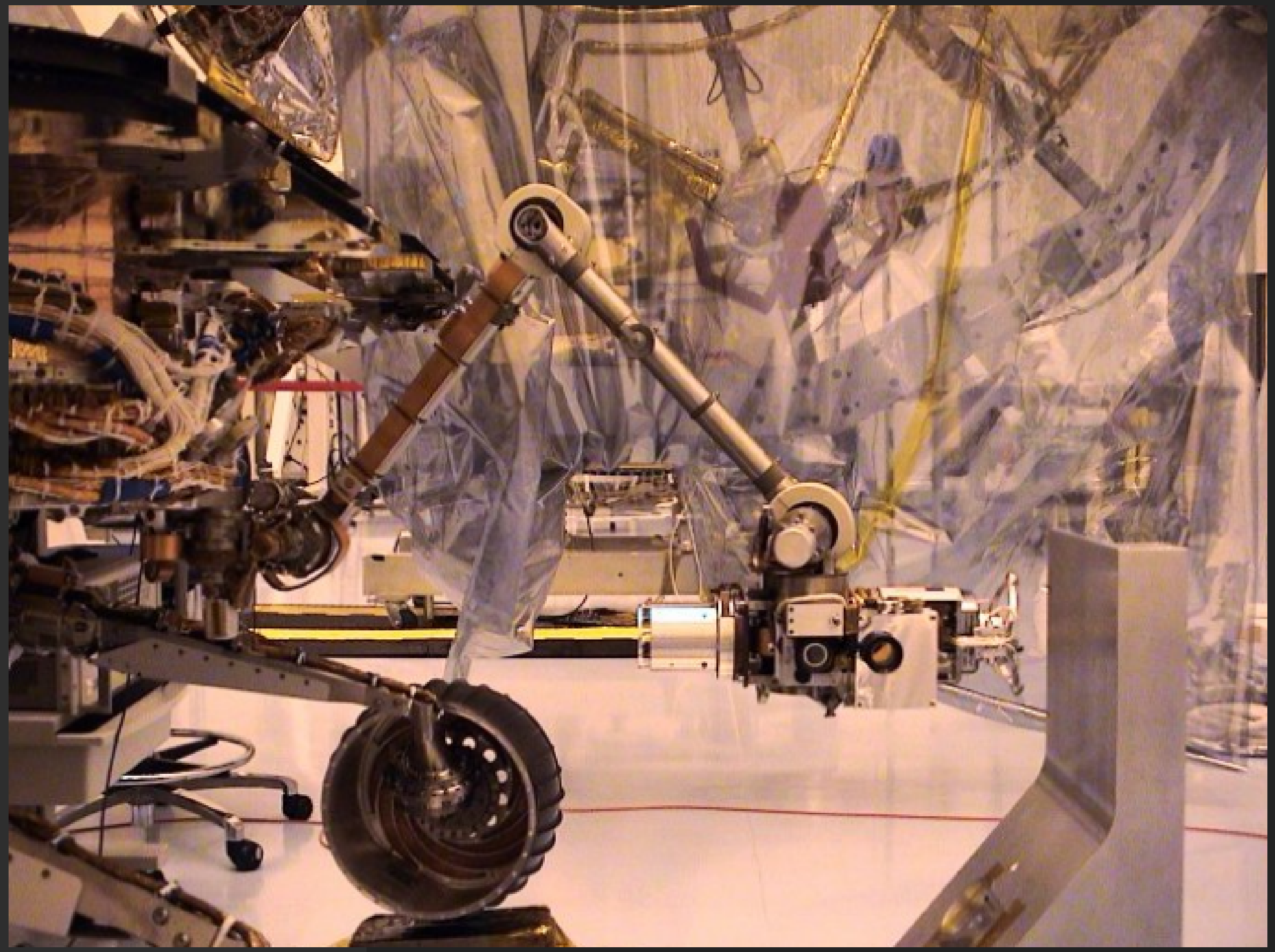
The IPS includes the 5 degree-of-freedom (DOF) Instrument Deployment Device that is utilized to place and hold the in situ instruments on rock and soil targets located within the IDD work volume and the rover-mounted targets such as the dust collecting magnets and instrument calibration targets.

https://www-robotics.jpl.nasa.gov/publications/Eric_Baumgartner/IPS_IEEE_Aerospace_2005_final.pdf



Navigation System (Sensors) & Control

The guidance, navigation, and control subsystem controlled the orientation of the orbiter (the direction in which it was pointed). To perform its functions, the guidance, navigation and control subsystem uses several types of:

Sensors

Control Devices

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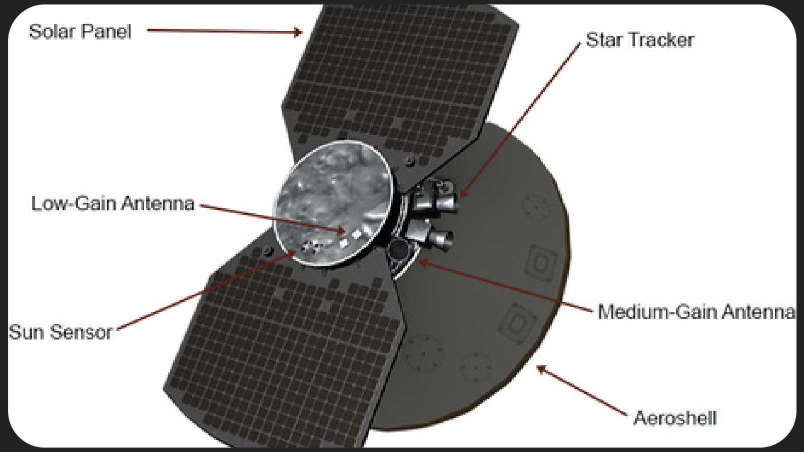
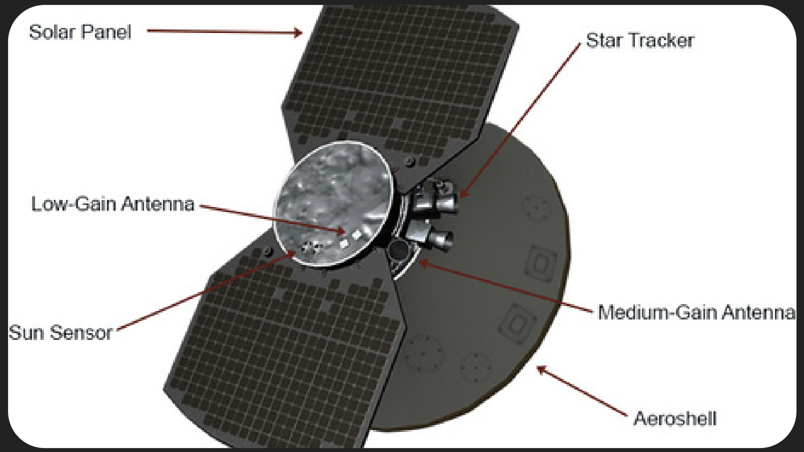
Sensors



Sun Sensors

Sixteen sensors (eight of them backups) deployed around the spacecraft body provide knowledge of where the Sun is located. The Sun sensors provide enough information so the spacecraft can continue to get power from the Sun,



Star Trackers

Two star trackers provide full knowledge of the spacecraft's orientation, allowing the spacecraft to know not only where the Sun is, but also where Earth and Mars are and how to point in any direction in the sky

Inertial Measurement Units

Two inertial measurement units are on board (the second for backup purposes). Each is a combination accelerometer and ring laser gyroscope. The accelerometer measures acceleration (changes in speed) so the spacecraft can know things like when it has fired its rocket engines for long enough.

Control Devices

Reaction Control System Thrusters

These thrusters change the speed of the spacecraft's rotational (spinning) motion. They are unlike the other larger thrusters, which are used to change the linear velocity of the spacecraft -- that is, its speed along a line. The reaction control system thrusters are good at making quick turns, and are used for getting to new orientations quickly. They also work with the reaction wheels in a special operation described below.

Reaction Wheels

While the reaction control system thrusters allow the spacecraft to turn quickly, they're not good at slow and steady turns. Slow and steady turns are required to take high-resolution images of Mars from orbit. Mars Reconnaissance Orbiter therefore has devices called reaction wheels. These are literally spinning wheels -- four in total: one for each rotational axis plus a spare in case one of the three isn't working.

DATA TRANSMISSION AND COLLECTION

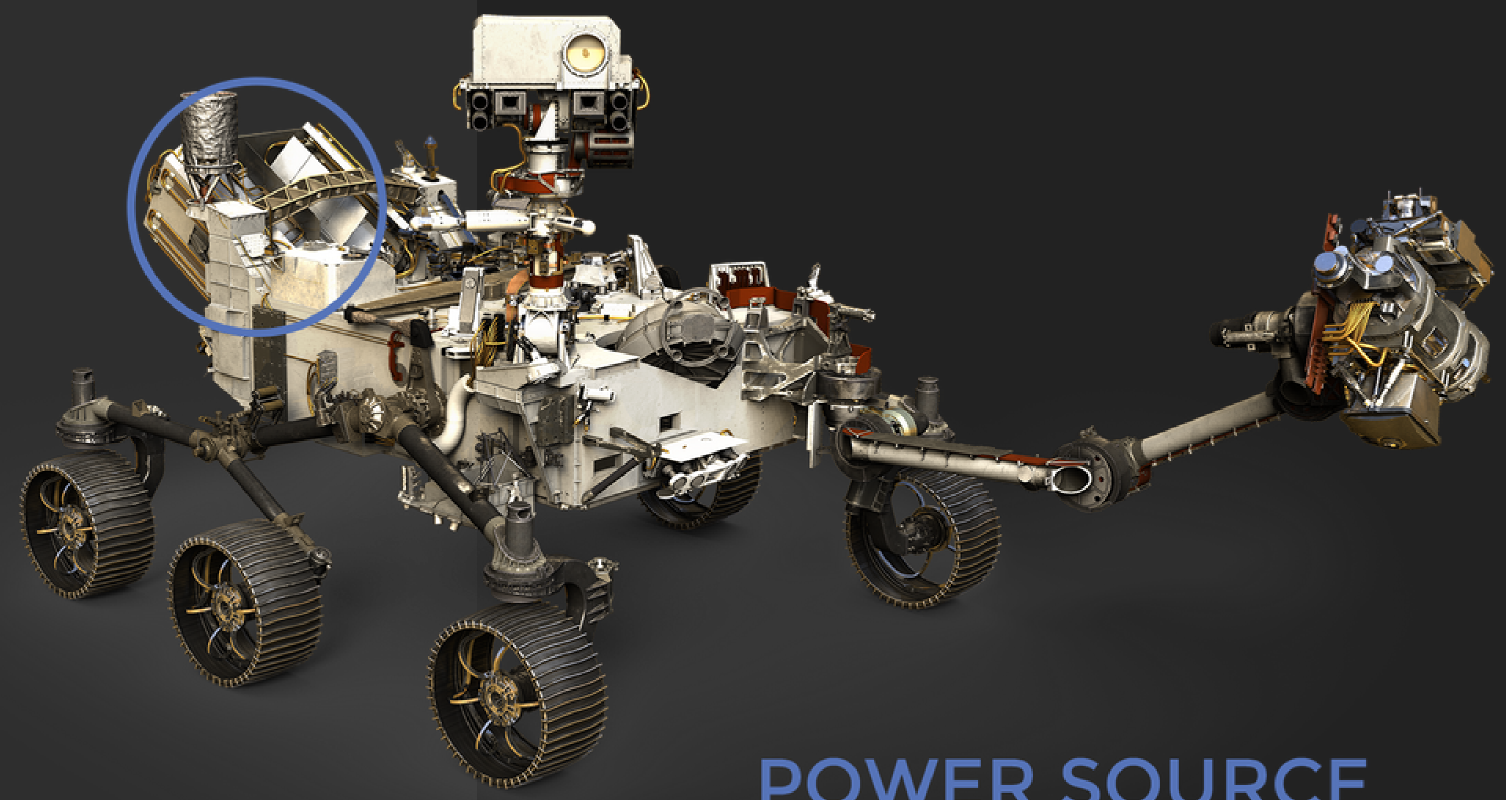
The NASA Deep Space Network (DSN) is an international network of antennas that provide the communication links between the scientists and engineers on Earth to the missions in space and on Mars.
The DSN consists of three deep-space communications facilities placed approximately 120 degrees apart around the world: at Goldstone, in California's Mojave Desert; near Madrid, Spain; and near Canberra, Australia. This strategic placement permits constant observation of spacecraft as the Earth rotates on its own axis.

Preventing Busy Signals

During critical mission events, such as landing on Mars, multiple antennas on Earth and the Mars Reconnaissance Orbiter track the signals from the spacecraft to minimize risk of loss of communication. During the landed operations phase on the martian surface, the Mars Science Laboratory utilizes the Multiple Spacecraft Per Aperture (MSPA) capability of the DSN, which allows a single DSN antenna to receive downlink from up to four spacecraft simultaneously, as well as using the relay capabilities of the Mars Odyssey (ODY) and Mars Reconnaissance Orbiter (MRO) spacecraft.

Power Management

The Perseverance rover requires electrical power to operate.
Without power, the rover cannot move, use its science instruments, or communicate with Earth.
Perseverance carries a radioisotope power system. This power system produces a dependable flow of electricity using the heat of plutonium's radioactive decay as its "fuel."
The power source is called a "Multi-Mission Radioisotope Thermoelectric Generator" or MMRTG for short. The MMRTG converts heat from the natural radioactive decay of plutonium into electricity.



MMRTG multi-mission radioisotope thermoelectric generator

This power system provides several advantages:

- The 14-year operational lifetime of an MMRTG provides significant reserve for Mars 2020 prime mission duration of 1.5 Mars years (three Earth years)
- It gives the rover greater mobility over a large range of latitudes and altitudes
- It allows scientists to maximize the capabilities of the rover's science instruments
- It provides engineers with a lot of flexibility in operating the rover (e.g., day and night, and through the winter season)