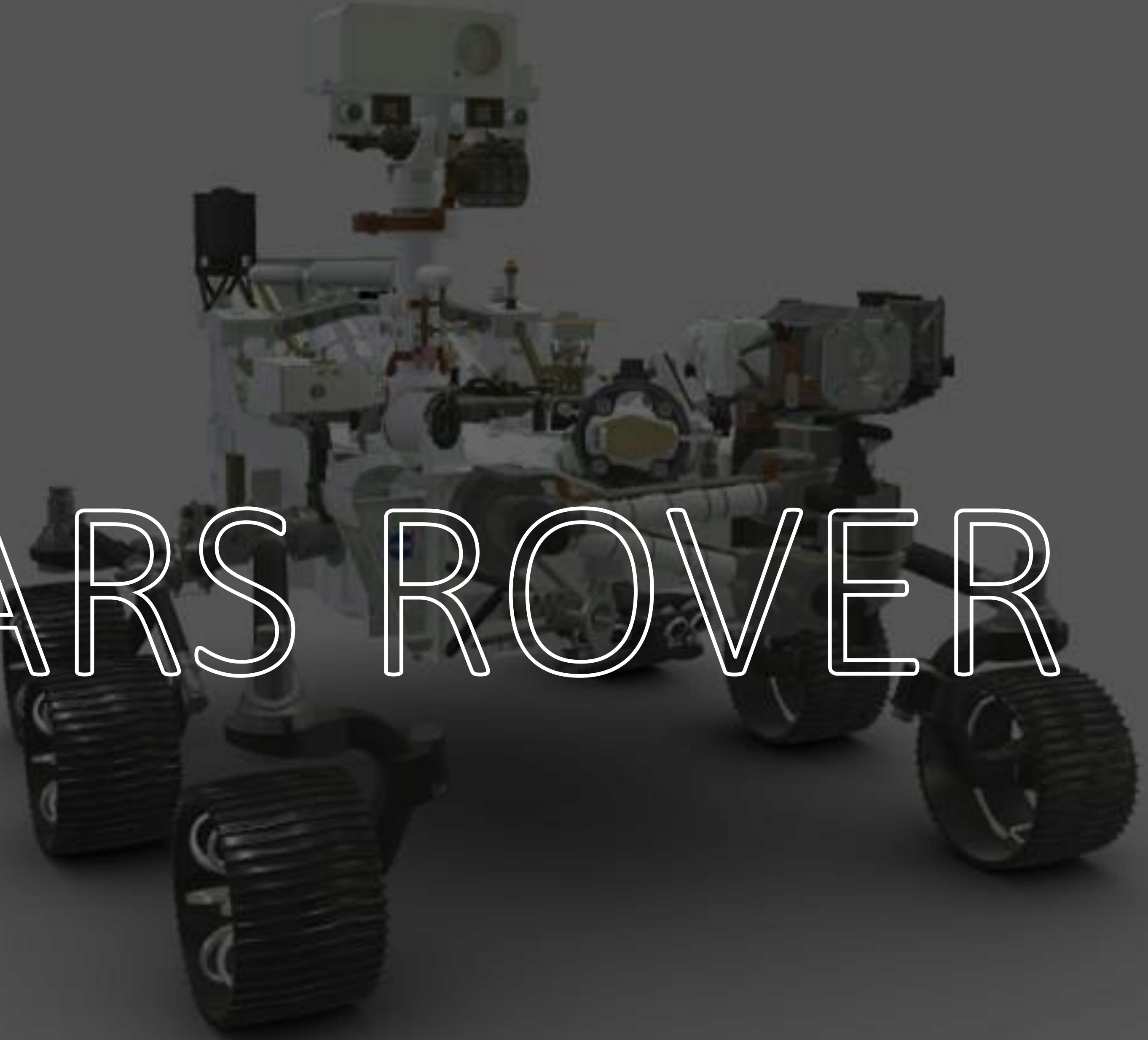
MARS ROVER



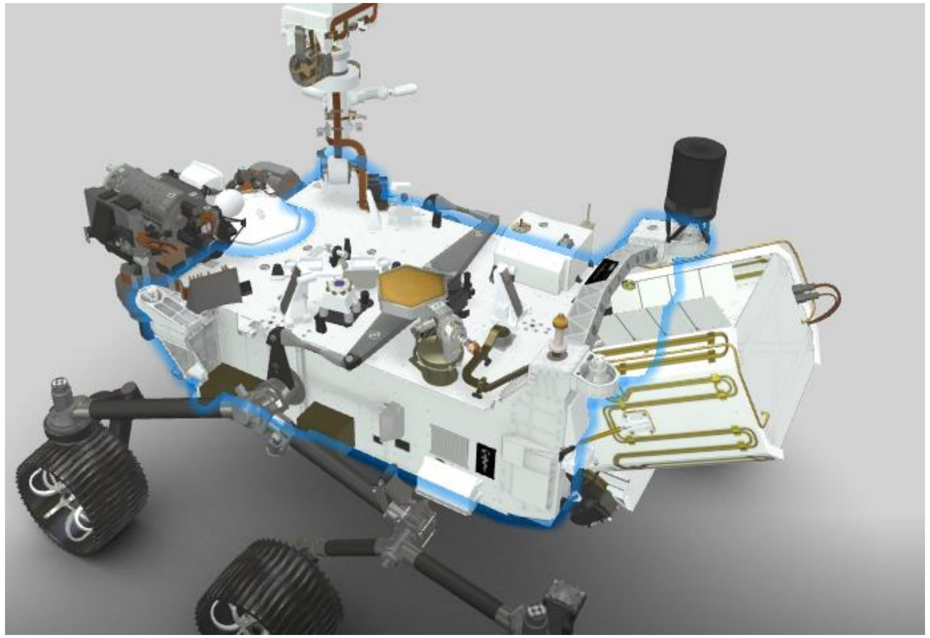
MAIN COMPONENTS

1. Design
2. Locomotion system
3. Navigation and Control System
4. Data Collection
5. Data Transmission
6. Power Management System

Design

Body

- Warm electronic box (WEB)
- Body is strong. Outer layer protects the rover’s computer and electronics.
- this rover can sample and cache minerals

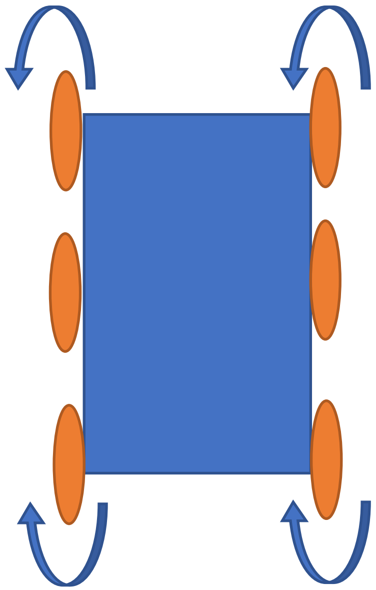


Body (Specs)

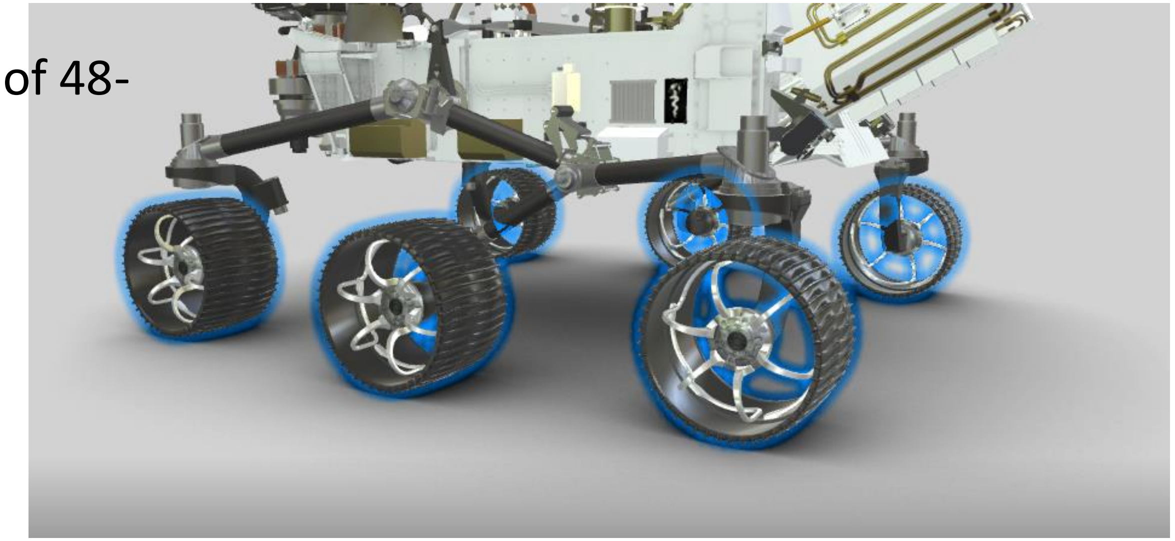
Main Job	Carry and protect the computer, electronic, and instrument systems
Length	10 feet (3 meters)
Width	9 feet (2.7 meters)
Height	7 feet (2.2 meters)
Weight / Mass	2,260 pounds / 1,025 kilograms
Structure	Bottom and sides are the frame of the chassis; top is the rover equipment deck (its "back"); 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

Wheels

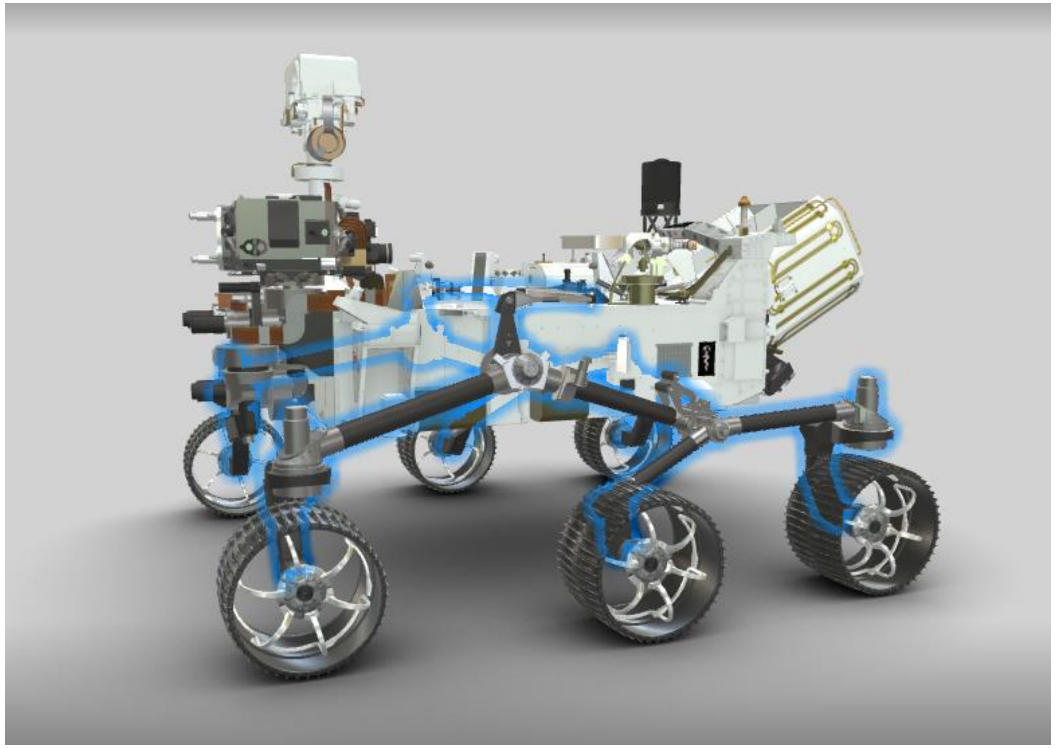


- Rover has 6 wheels, each with its own individual motor (6WD)
- 2 front and 2 rear also have individual steering motors. And allow turn full 360 degree
- The wheels are made of aluminium, with cleats for traction and curved titanium spokes for springy support.
- Each wheel has an aggressive tread composed of 48-grousers (or cleats), machined into its surface.
    - Able to drive in soft sand and hard rocks

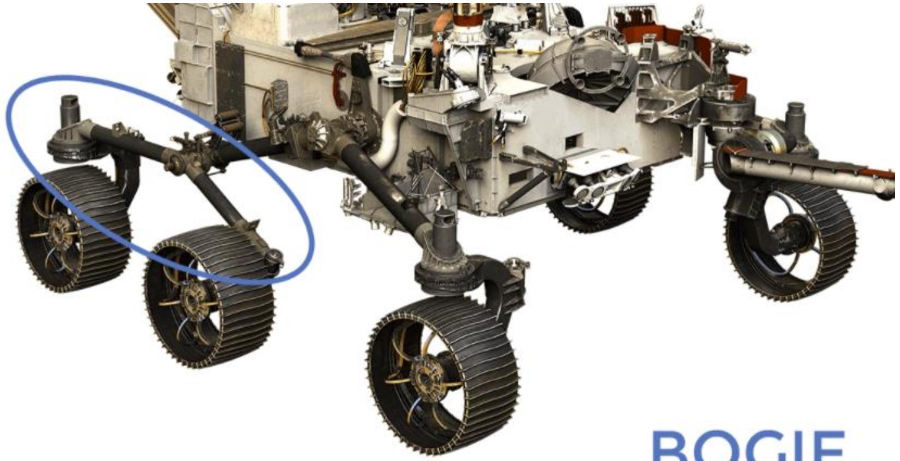


Suspension or legs

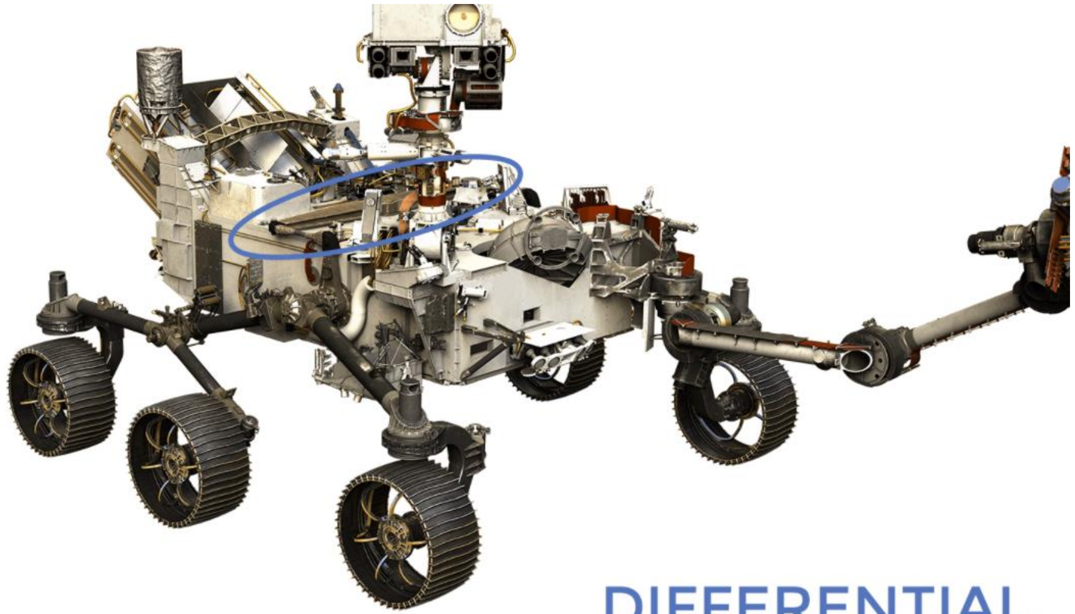
- Suspension system – “rocker-bogie” allows the wheels to go over obstacles (Mars terrain)
- 3 main components
  - **Differential** - Connects to the left and right rockers and to the rover body by a pivot in the center of the rover's top deck.
  - **Rocker** - One each on the left and right side of the rover. Connects the front wheel to the differential and the bogie in the rear.
  - **Bogie -** Connects the middle and rear wheels to the rocker.
- The suspension maintain weight and minimize rover tilt as it drives. Keeps more stable



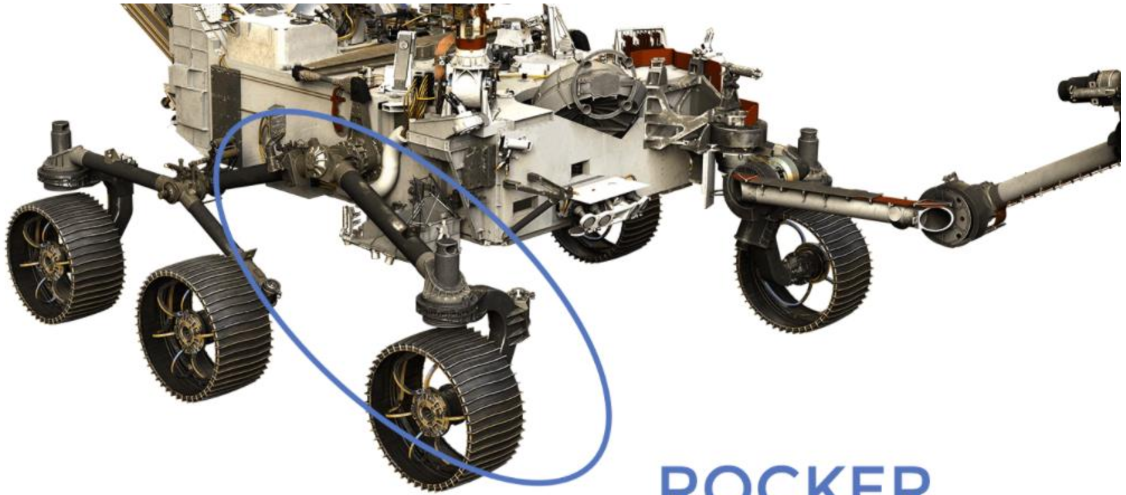
Suspension or legs



BOGIE



DIFFERENTIAL



ROCKER

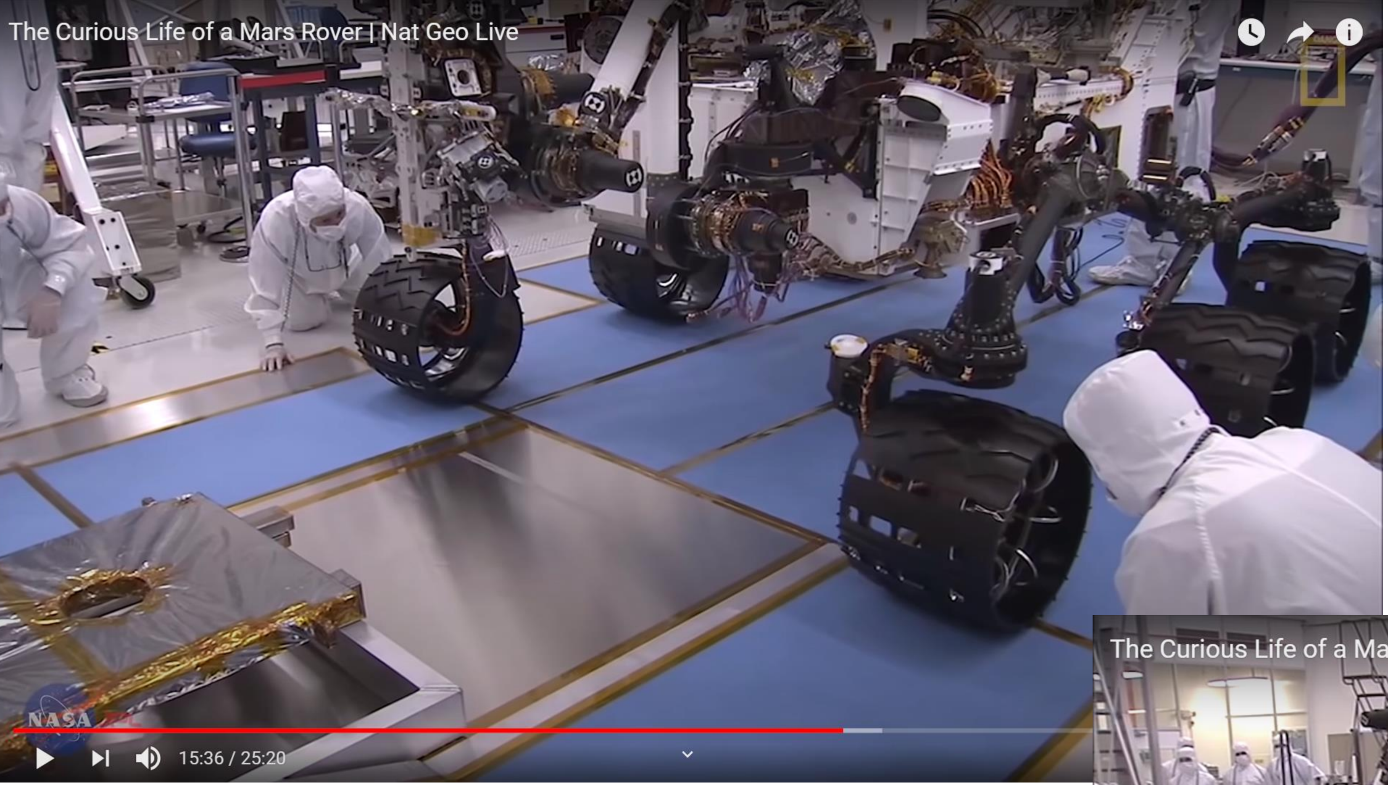
Legs and wheels specs

Legs

Materials	Made of titanium tubing formed with the same process used to make high-end mountain bike frames.
Other	Enable the rover to drive over knee-high rocks as tall as 40-centimeters (15.75-inches).

Wheels

Materials	Made of aluminum, with cleats for traction and curved titanium spokes for springy support.
Size	52.5 centimeters (20.7-inches) in diameter
Other	One full turn of the wheels with no slippage drives the rover 1.65 meters (65-inches).


The Curious Life of a Mars Rover | Nat Geo Live
NASA
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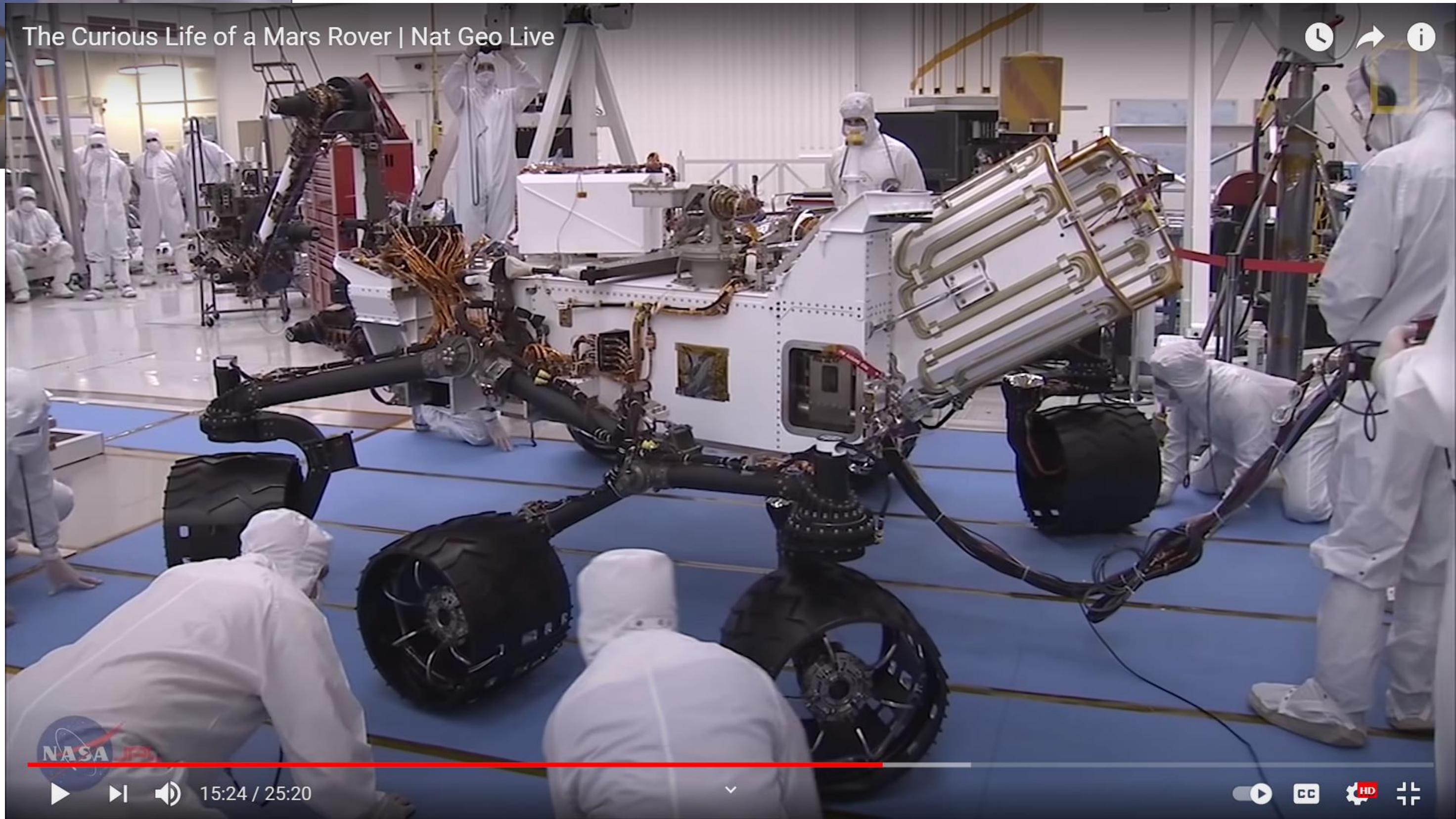
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NASA
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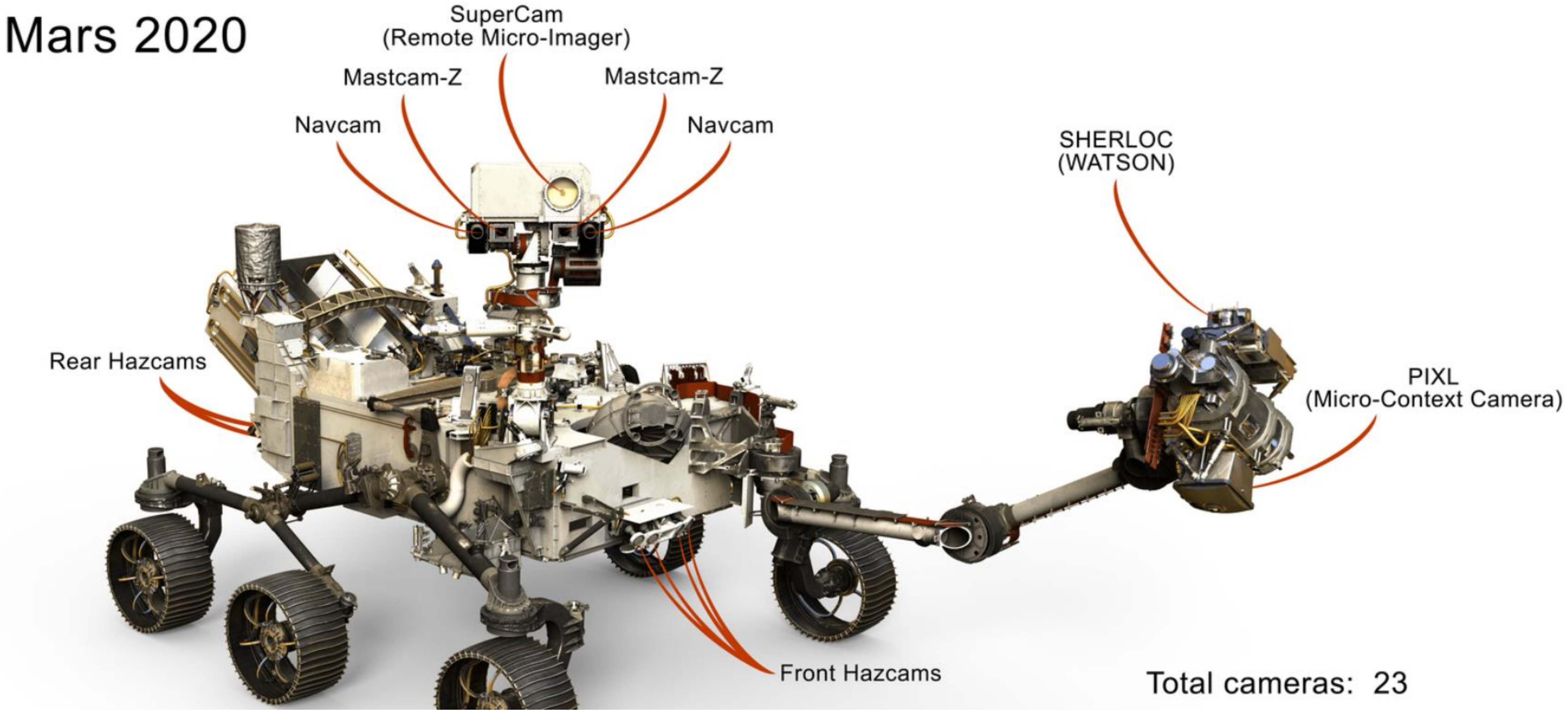
Speed

- Rover is slow
- Top speed on flat, hard ground – 4.2 cm/s or 152 meter/h
- The slow pace is energy efficient consuming less than 200-watts.

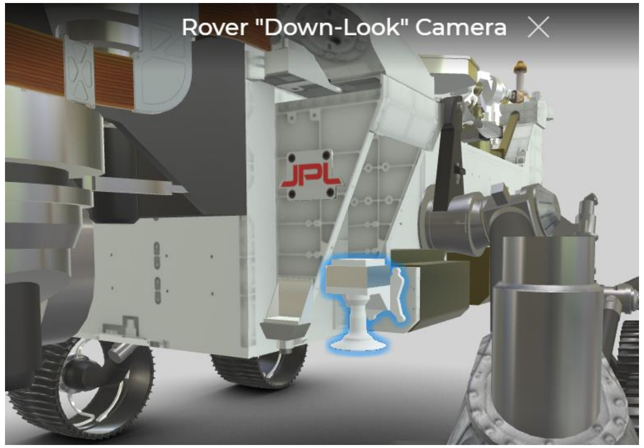
Navigation and control system

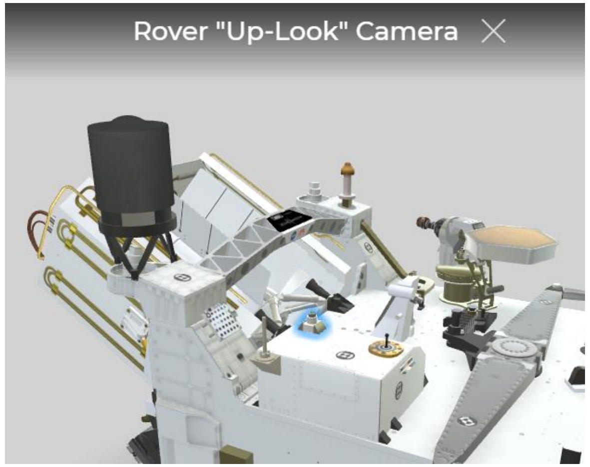
Cameras

Engineering cameras: 9
Science camera: 7
Entry, descent and landing (EDL): 7



Cameras





- (only use on landing) EDL Cameras:
  - Parachute “up look” camera
  - Descents-stage “down look” camera
  - Rover “up look” camera
  - Rover “down look” camera
- Engineering cameras:
  - Main job: Used for driving around on Mars and for positioning the tools on the robotic arm
  - engineering cameras give much more detailed information, in color, about the terrain around the rover
  - Fx:
    - measure the ground around the rover for safe driving
    - check out the status of rover hardware
    - support sample-gathering
    - help determine the best way to move closer to scientific targets.
  - For driving:
    - wider field-of-view gives the cameras a much better view of the rover itself
    - for checking on the health of various rover parts
    - measuring changes in the amount of dust and sand that may accumulate on rover surfaces

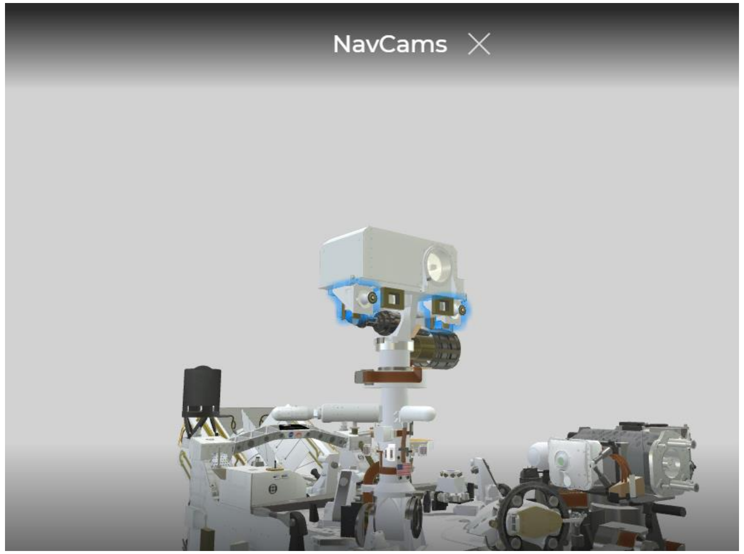
Engineering camera

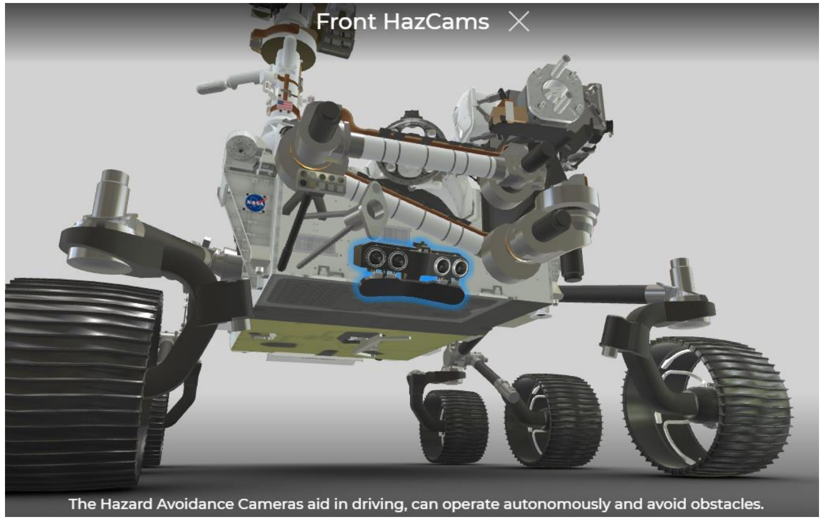
- **Hazard Avoidance Camera (HazCams)**
  - four on the front and two on the rear of the rover body (pointing down)
  - detect hazards to the front and back pathways of the rover
  - Some front HazCams – to see the movement of robotic arm to take measurement, photos, collect samples

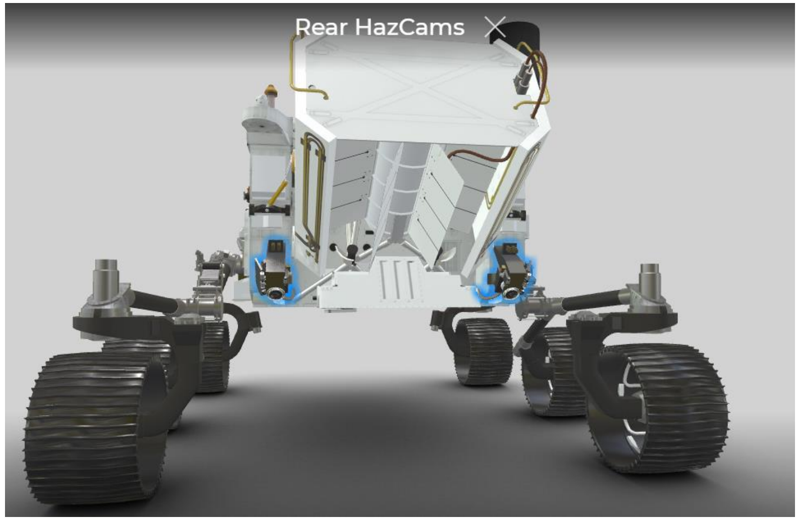
- **Navigation Camera (NavCams)**
  - help engineers to navigate when Rover operates autonomously
  - Mounted high on the rover's mast; left and right "eyes"

For navigation

- **CacheCam**
  - To see down into the top of a sample tube after the sample is gathered; to take microscopic pictures of the top of the sample material before the tube is sealed.


NavCams


Front HazCams
The Hazard Avoidance Cameras aid in driving, can operate autonomously and avoid obstacles.


Rear HazCams

Brains - "Nerves" for balance and position

- Rover carries an Inertial Measurement Unit (IMU) – provides 3-axis information on its position
    - enables the rover to make precise vertical, horizontal, and side-to-side (yaw) movements.
    - to support safe traverses and to estimate the degree of tilt the rover is experiencing on the surface of Mars.

Data Collection

CacheCam and Science Camera (sight)

- **CacheCam**
  - To see down into the top of a sample tube after the sample is gathered; to take microscopic pictures of the top of the sample material before the tube is sealed.

Mastcam-Z

- takes color images and video, three-dimensional stereo images, and has a powerful zoom lens.

SuperCam

- fires a laser at mineral targets, then analyzes the vaporized rock to reveal its elemental composition
- Its camera and spectrometers then examine the rock's chemistry.

PIXL

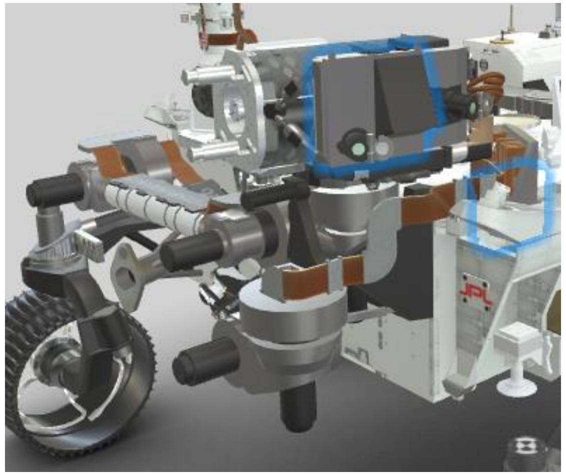
- uses X-ray fluorescence to identify chemical elements in target spots

SHERLOC Context Imager

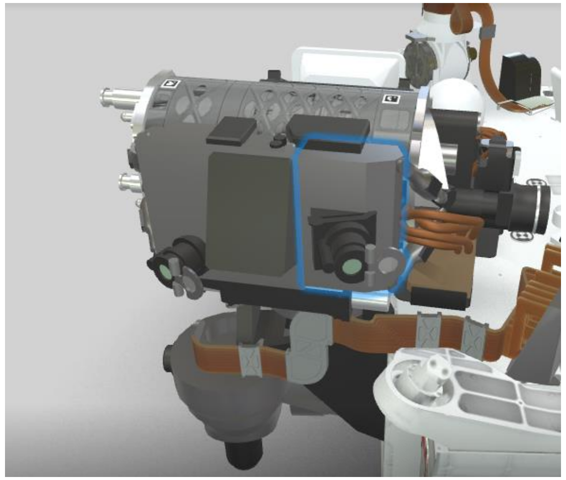
- main tools are spectrometers and a laser
- it also uses an integrated “context” macro camera to take extreme close-ups of the areas that are studied

WATSON

- WATSON (Wide Angle Topographic Sensor for Operations and eNgineering) captures the images that bridge the scale from the very detailed images and maps
- helps identify targets of interest for the other rover instruments
- provides images of instruments and rover parts



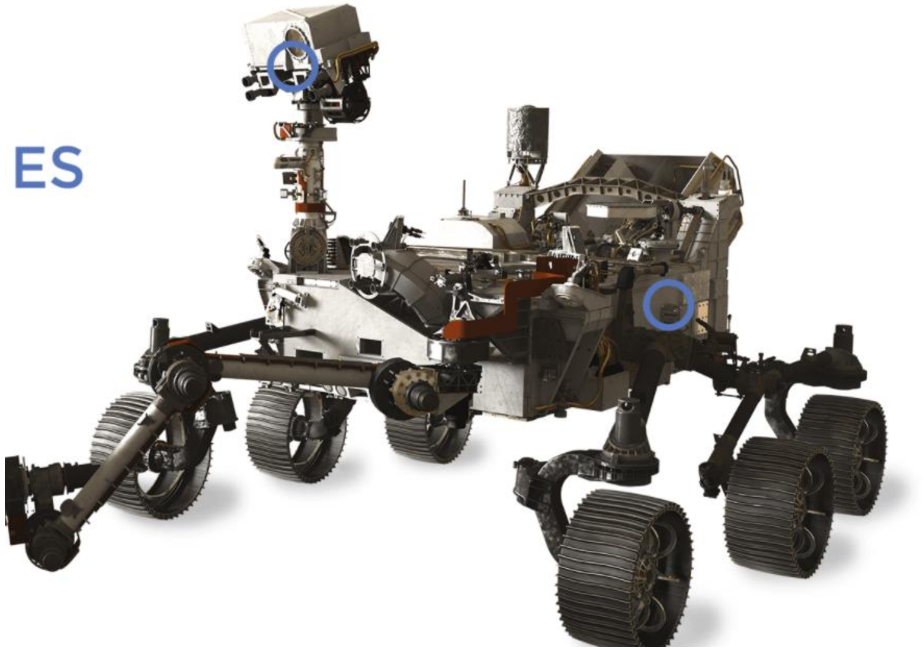
SHERLOC



WATSON

Microphone (hear)

- SuperCam Microphone
  - To help study Mars rocks
  - Listen when the SuperCam instrument is on, for a few milliseconds at a time. Or to listen to wind and for rover sounds for about 3.5 minutes at a time.
  - It can hear the staccato pop caused when the laser studies rock, wind, and rover noises
- EDL Microphone
  - To record the sound of landing
  - Operate when landing on Mars
  - Record the sound of descent, friction from atmosphere, dust blown up by the thrusters .



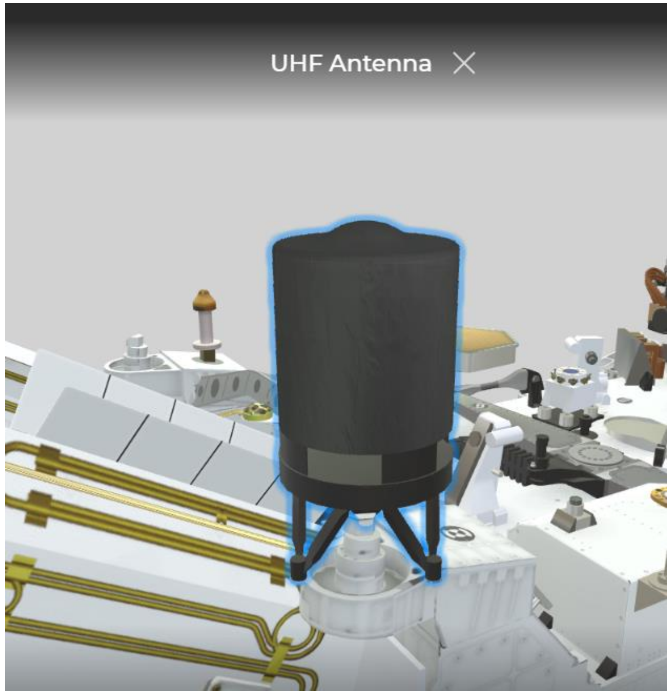
Communication (antenna)

- **X-Band Low Grain Antenna**
  - Receiving Data
  - the entire rover doesn't need to change position to talk to Earth
  - the rover can save energy and keep things simple by moving only the antenna
  - 10 bps from the Deep Space Network’s 34 meter-diameter antennas
  - 30 bps from the Deep Space Network’s 70 meter-diameter antennas
  - Radio frequency: X band (7 to 8 GHz)

Data Transmission

Communication (antenna)

- **Ultra-High Frequency Antenna (UHF)**
  - to communicate with Earth through NASA's orbiters around Mars
  - Rover and orbiter antennas act like walkie-talkie
  - takes about 5 to 20 minutes for a radio signal to travel the distance between Mars and Earth
  - Mass and power constrained rover can achieve high data rate up to 2 Mbps
  - Radio frequency: UHF about 400 MHz

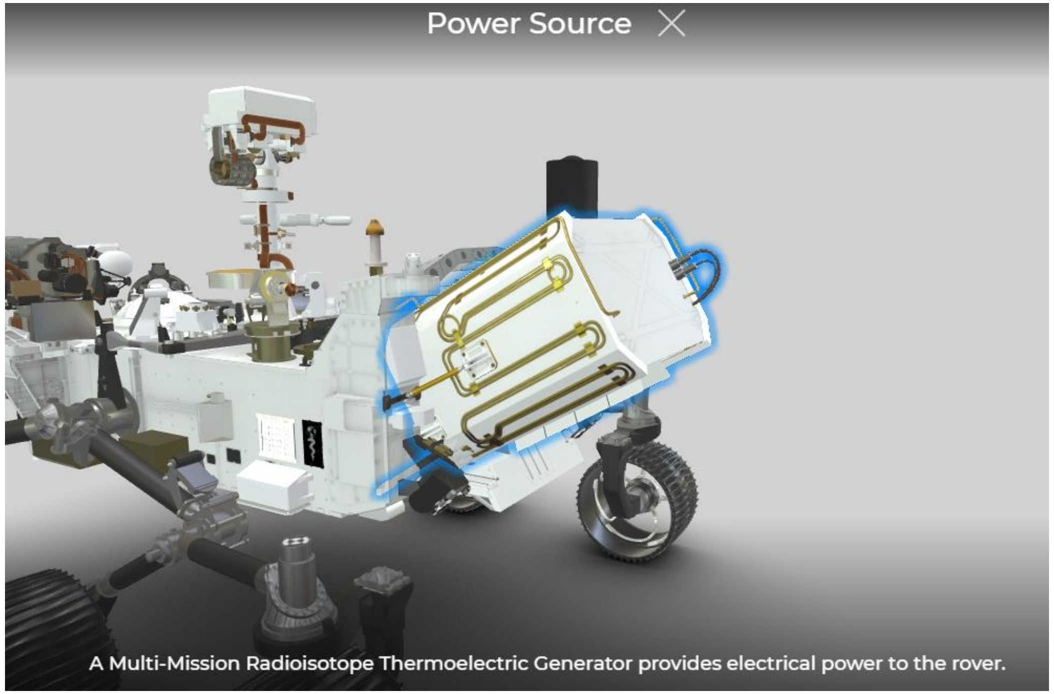


- **X-Band High Grain Antenna**
  - Transmitting data directly to and from Earth
  - the entire rover doesn't need to change position to talk to Earth
  - the rover can save energy and keep things simple by moving only the antenna
  - 160/500 bps to/from the Deep Space Network’s 34 meter-diameter antennas
  - 800/3000 bps to/from the Deep Space Network’s 70 meter-diameter antennas
  - Radio frequency: X band (7 to 8 GHz)

Power System

Electrical Power (Radioisotope Power System)

- This power system produces a dependable flow of electricity using the heat of plutonium's radioactive decay as its "fuel.“
- Multi-Mission Radioisotope Thermoelectric Generator (MMRTG) converts heat from the natural radioactive decay of plutonium into electricity.
- It charges the rover's two primary batteries.
- The heat from MMRTG is used to keep the rover's tools and systems at their correct operating temperatures.
- Electrical power produced: -About 110 watts at launch, declining a few percent per year
- Battery used:- Two lithium-ion rechargeable batteries



- **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)