Future Explorers™

www.futureexplorers.us

INSPIRED BY NASA's SPACE PROJECTS

PERSEVERANCE MARS ROVER

REFERENCE, USER AND ASSEMBLY MANUAL

- BUILD YOUR OWN ROVER TO EXPLORE CRATERS AND HILLS
- BASED ON REAL- LIFE NASA ROVERS
- DISCOVER HOW ROBOTS ASSIST IN THE STUDY OF MARS' SURFACE

71 PIECES

BUILD & LEARN

63 PAGES FACTBOOK MANUAL

STEM.ORG AUTHENTICATED EDUCATIONAL PRODUCT

DESIGNED BY Dr. Pablo SPACE RESEARCHER

8+

SEE PACKAGE BACK FOR PRODUCT DETAILS

ASSEMBLY VIDEO

Item No. 63801

DESIGNED IN THE USA

This kit will teach you how to build a rover mobility system similar to the ones employed NASA's Perseverance and Curiosity robots. Currently operating on the surface of Mars, they provide valuable information to scientists on Earth.

WARNING!
Not to be used by children except under adult supervision.

SAFETY INFORMATION

⚠ **WARNING:**
CHOKING HAZARD - Small parts. Not for children under 3 years.

This STEM toy has been designed for children of 8 years of age and older.

STEM.ORG AUTHENTICATED™ EDUCATIONAL PRODUCT

Concept, text and design by: Pablo de León, Kein Design, Martin Demonte and the team of Future Explorers LLC.

All images courtesy of NASA, except where stated.
Future Explorers ™ is registered by Future Explorers LLC, Cape Canaveral, Florida. United States of America.

Printed in China

PERSEVERANCE MARS ROVER

REFERENCE, USER AND ASSEMBLY MANUAL

INDEX

Meeting Dr. Pablo

My name is Pablo de León, but I am better known as Dr. Pablo. For the past thirty years, I have been working on what I consider to be the most fascinating topic of all time: human spaceflight. Human spaceflight is the study of how to send humans into space. It involves designing spacecraft, spacesuits, and all of the associated tools, equipment, and systems that astronauts need to explore space. It also includes the exploration of celestial bodies such as the moon and Mars.

Throughout my career, I have primarily focused on designing advanced spacesuits for returning to the moon and starting the human exploration of Mars. I have received several NASA awards, and the American space agency has funded my research to study ways to protect astronauts from the most hostile medium known to humanity, which is space.

I have always been passionate about space exploration, and in this new stage of my life, I want to share this enthusiasm with all of you. Even if you don't plan to become an astronaut, aerospace engineer, or rocket scientist, this knowledge will serve you well in the future.

Through these projects, we will learn and have fun together. We will be putting together experiments, models, and vehicles. My intention is to share my passion for space exploration with all of you.

Now, in a time of diminishing resources on Earth, it is imperative that we find ways to harvest the unlimited potential of energy and resources we have in space, and we need you to make it possible.

Dr. Pablo

Target Mars

Over the course of thousands of years, Mars has been the subject of dreams, philosophical musings, and literary works. Its distinct red color was associated with the god of war by the ancient Greeks and Romans. As science has progressed, we have learned a great deal about our red neighbor. And as we learn more, Mars becomes increasingly appealing to our human curiosity.

Science fiction writers and astronomers alike have imagined Mars with life, from green creatures to Earth invaders; many seem to have originated from the red planet. Thanks to science, however, we now know a great deal more about our distant companion. We know that there are no green Martians walking on its surface, nor are there any creatures attempting to invade Earth and steal our water, which is so scarce on the desert planet.

A Martian war machine from an early edition of The War of the Worlds from 1906.

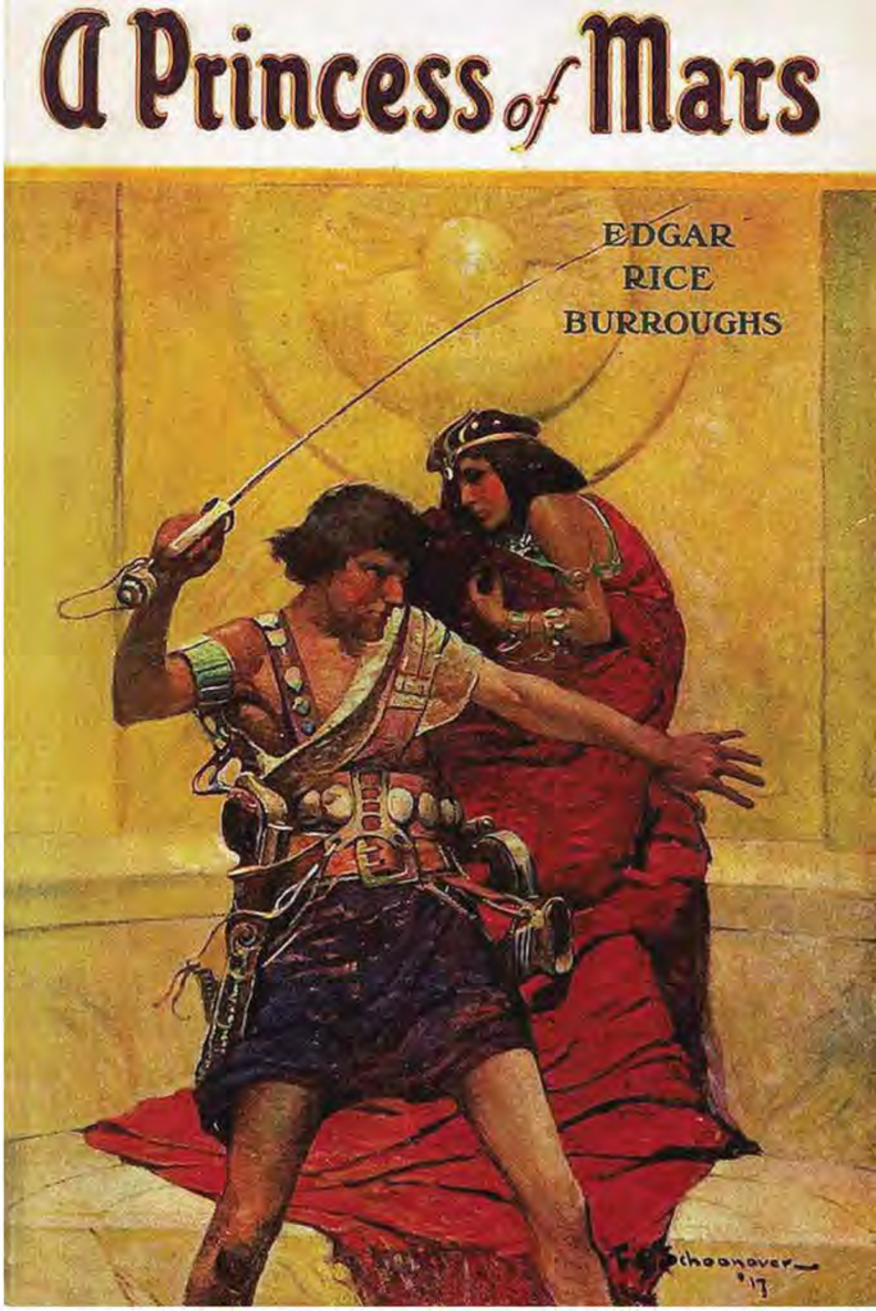


Illustration of The Princess of Mars from Burroughs' 1917.

So far, no astronaut has walked on Mars; that is reserved for the near future. But our robots, which have been sent to Mars since 1976, have explored many regions and sent back a wealth of information. In the last 20 years, NASA has started exploring Mars with moving robots that can "walk" on the planet, enabling them to explore wider areas and send us amazing pictures and videos. Recently, a small "helicopter" drone flew around the Perseverance rover, using artificial intelligence to avoid obstacles. These are incredible feats of science and technology, given that the distance to Earth is astronomical and it is impossible to control these robots in real time.

They must rely on their own "artificial intelligence" to prevent dangerous situations and correct orders from Earth.

Here, you will learn about the history of the exploration of our neighbor planet, Mars. There is a lot to learn, and it will take some time. However, if you prefer to begin assembling your rover now, that is ok. You can come back to learn more about the exploration of Mars a little bit later.

You can start the assembly now by turning to page 40 of this manual.

Initially, Mars drew attention to the astronomer Giovanni Schiaparelli in 1877 when he claimed to observe canals spread all over the planet. Later, the American astronomer Percival Lowell suggested that these canals were irrigation channels constructed by an intelligent civilization, and there was a possibility of life on Mars. This led to a series of speculations, and Mars became the focal point of the first science fiction novels and stories such as "The War of the Worlds" by H.G. Wells (depicting an alien invasion from Mars to Earth) and Edgar Rice Burroughs' series "The Martians," chronicling the adventures of John Carter on the planet Mars.

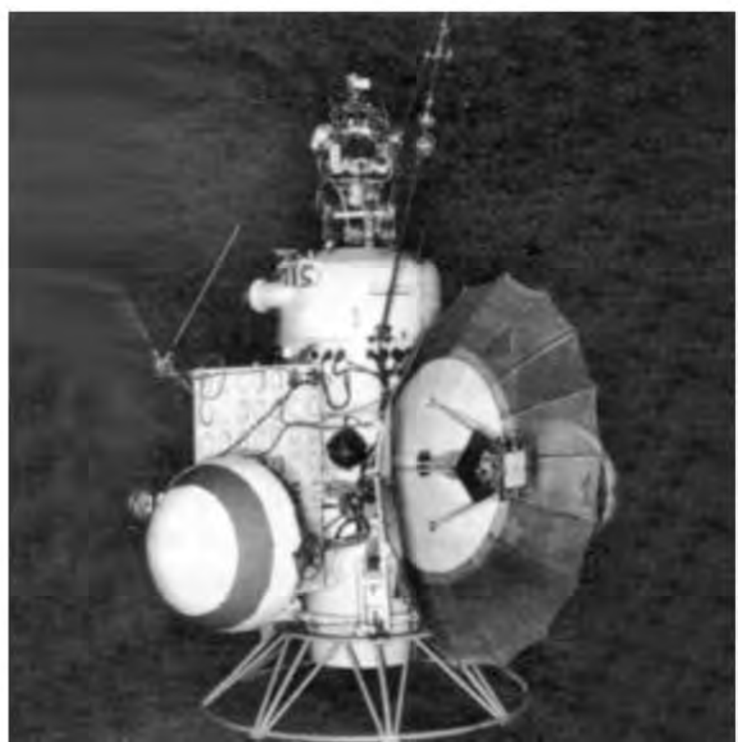
Mars 1962 A.

With time, the trip to Mars became a reality. The Soviet Union and the United States of America made a race to unlock the secrets of Mars. The exploration of Mars began with the first probes.

The Soviet Union sent the first probes to Mars in 1960. These were the Mars 1960 A and the Mars 1960 B, also known as Korabl 2 and 5 or Sputnik 22 and 25. Both probes were orbiters to take images while flying around the Red Planet, but both attempts failed.

In 1962, the Soviet Union sent the Mars 1962 A, which was lost during launch.

In the same year, Mars 1 (1962 Beta Nu 1) provided very little information as it was lost when the probe reached Mars. Also in 1962, Sputnik 24 (Mars 1962 B) was sent as a lander, but it failed to leave Earth orbit and was lost.

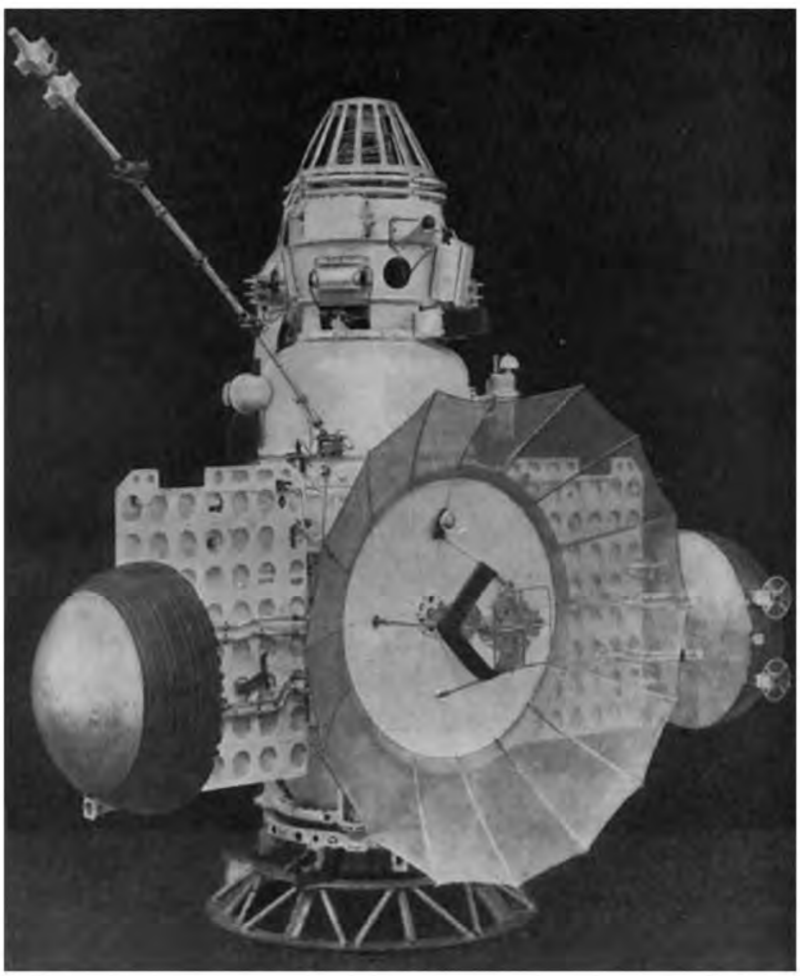


Sputnik 22.

Mariner 4

In 1964, the Zond 1964A, which was supposed to make a close flight to Mars, failed during launch.

The United States launched its first probe to Mars in the same year, the Mariner 3, but a failure in its trajectory put it in orbit around the sun, where it remains today. However, the Mariner 4 successfully arrived at Mars for a close flyby taking images of the planet.

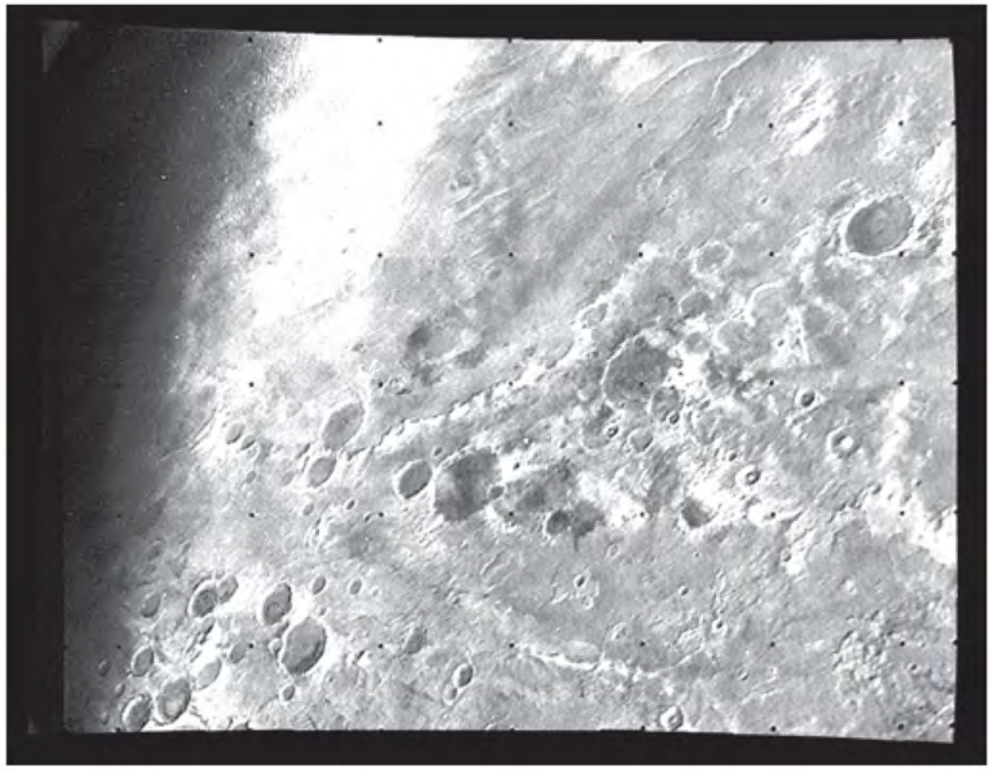


In 1964, a new orbiter probe, Zond 2, was launched for Mars, but communication with the probe was lost halfway.

Zond 2.

In 1969, the United States' Mariner 6 and 7, both twin orbiting probes, managed to orbit Mars and take better pictures of the Martian surface.

Mariner 6 and 7.



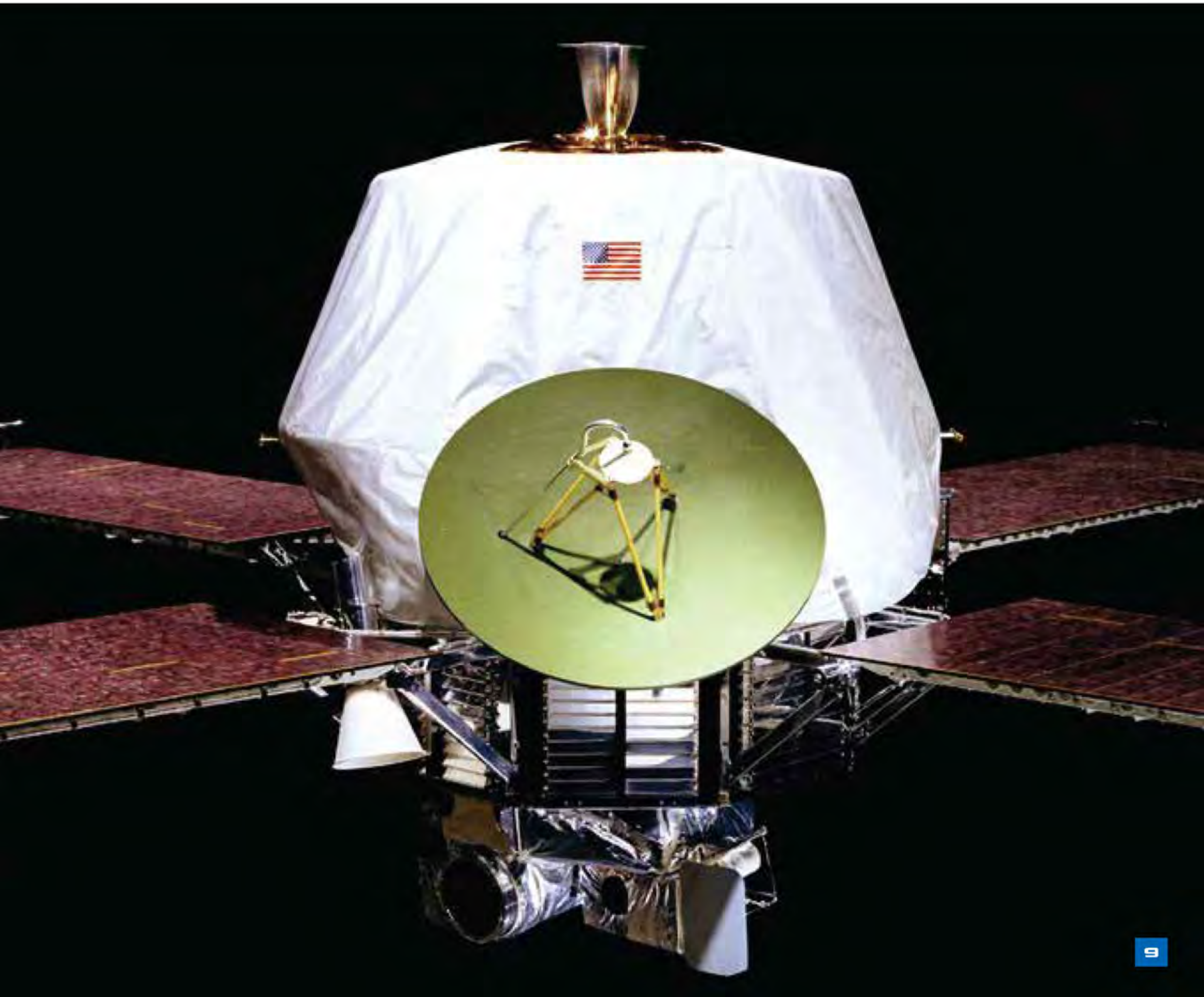
One of the black and white images taken by Mariner.

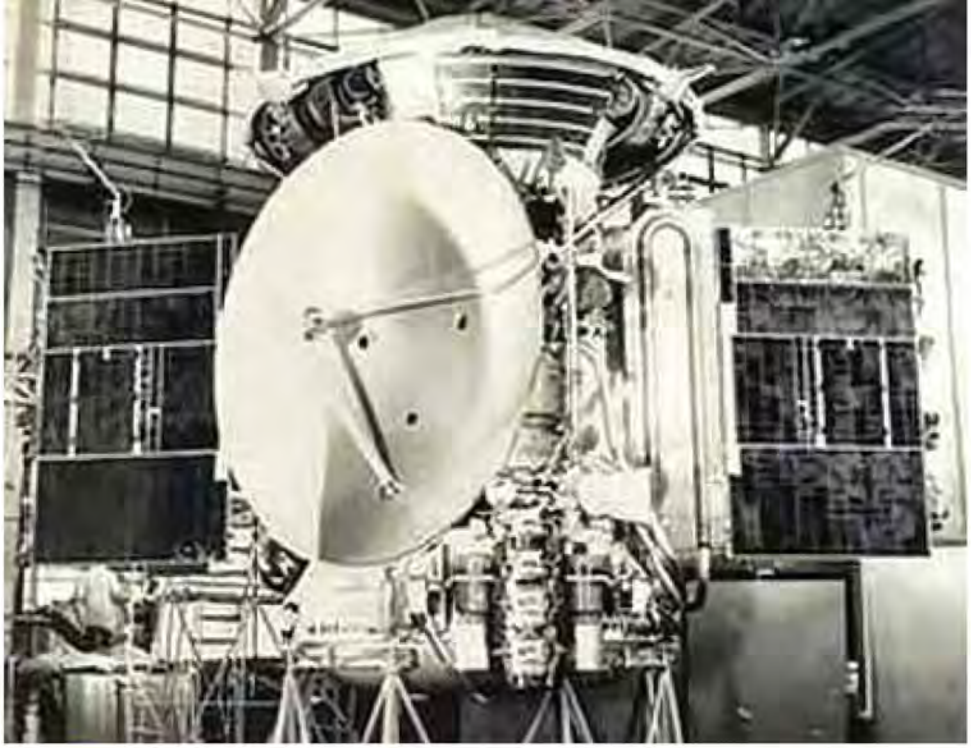
In the same year, the Soviet Union launched the Mars 1969A and B, but they were lost due to launch failures.

Mars 1969 B in the assembly building.

In 1971, the Cosmos 419 of the Soviet Union suffered the same fate as the United States' Mariner 8, with both probes failing to launch to Mars. But in the same year, the Mariner 9 orbiter achieved a successful mission, becoming the first probe to orbit Mars with total success, and mapping 70% of the surface of the Red Planet. Mariner 9 also made interesting studies on climate changes on Mars.

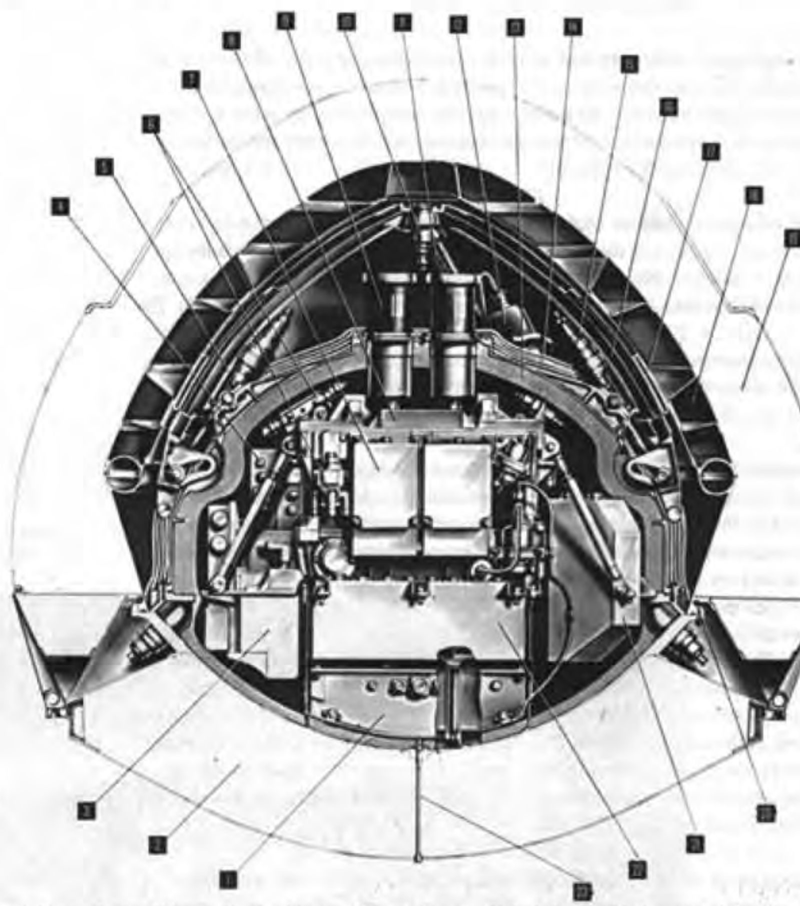
Mariner 9.





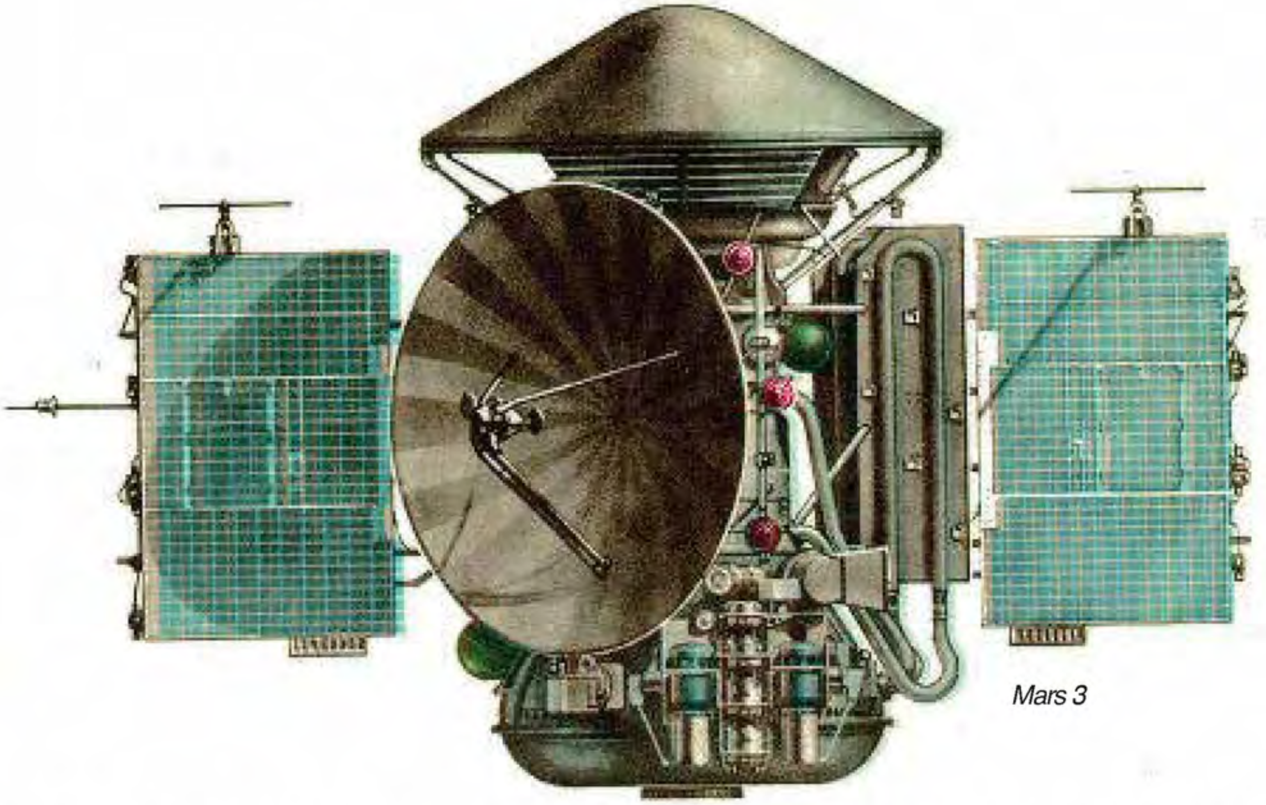
Mars 2.

The Soviet Union's Mars 2 was launched in 1971, consisting of an orbiter and a lander. The orbiter successfully achieved orbit around Mars, but the lander had a parachute failure and crashed. Despite the crash, it was the first terrestrial object to reach the Martian surface.



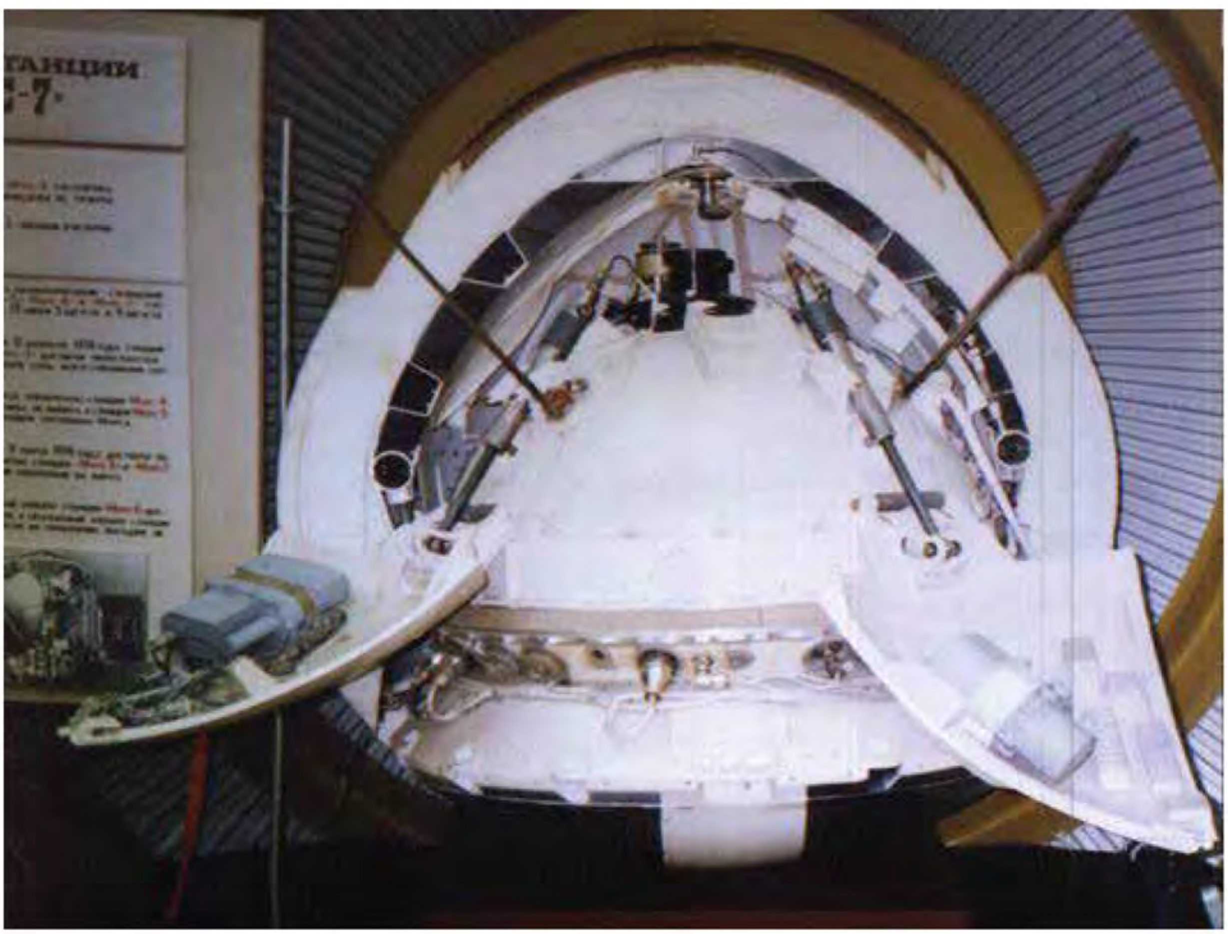
Automatic Martian Station of Mars 3--(1) radar-altimeters of the control system, (2) shock absorber of the lower part of the station, (3) telemetric units, (4) automatic radio system, (5) antennas of the radio system, (6) radio system, (7) blocks of the radio system, (8) modules with the scientific instruments (9) telephotometers, (10) lock of petals to place the station in a vertical position, (11) devices to move the scientific instruments outwards, (12) sensors of the scientific instruments, (13) thermo insulation system, (14) screen-vacuum thermo insulation system of the upper part of the station, (15) pyrocylinders to place the station in a vertical position, (16) petals, (17) displacing bag, (18) aeroshell cover, (19) shock absorber of the aeroshell cover, (20) expanded cumulative cartridge for the separation of the aeroshell cover, (21) automatic control system, (22) power system, and (23) receiver of the atmospheric pressure

Mars 2 lander diagram.



Mars 3

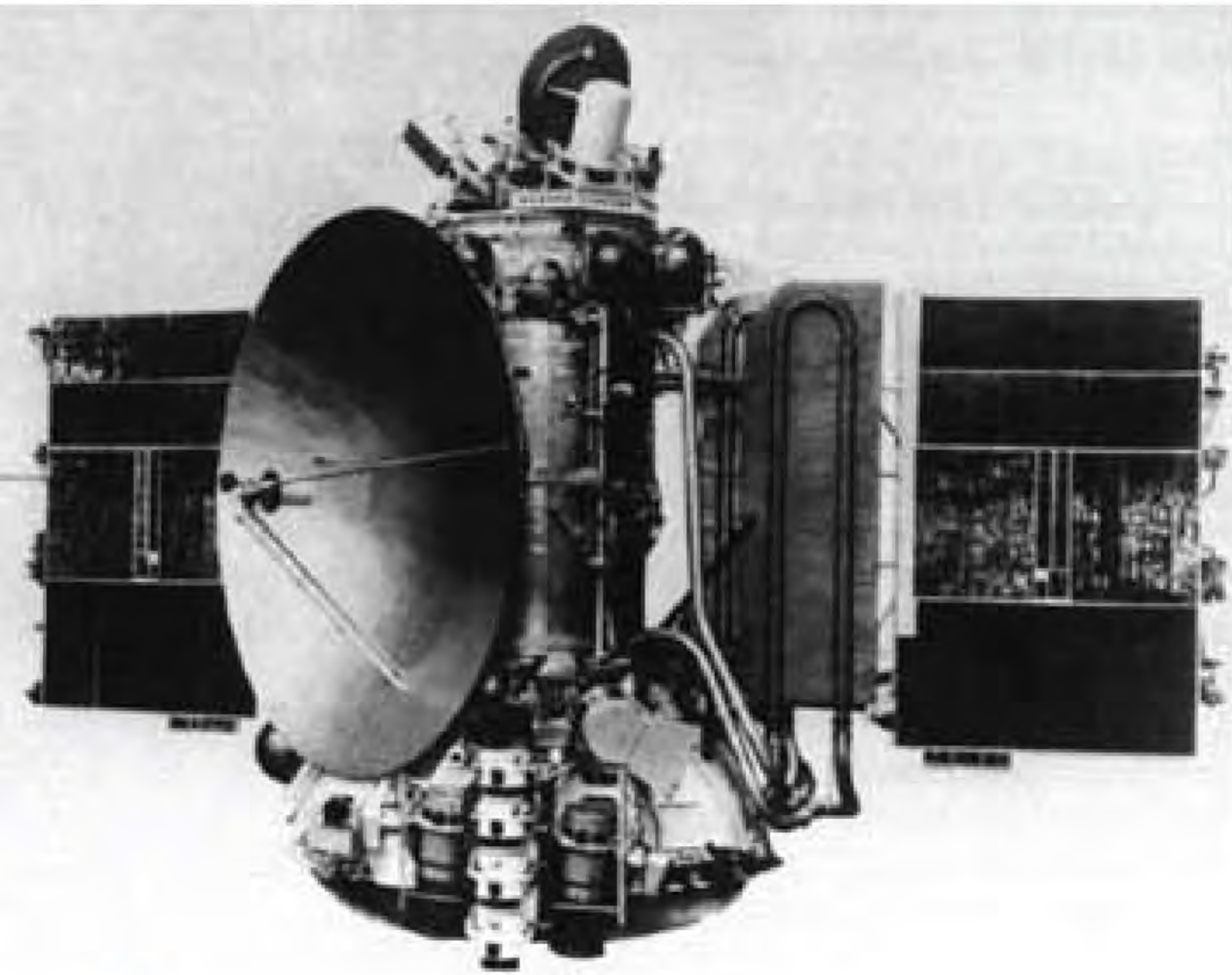
Mars 3, like Mars 2, had an orbiter and a lander. In 1971, the orbiter successfully entered orbit, and the lander landed perfectly, but they lost contact with the vehicle after a few seconds.

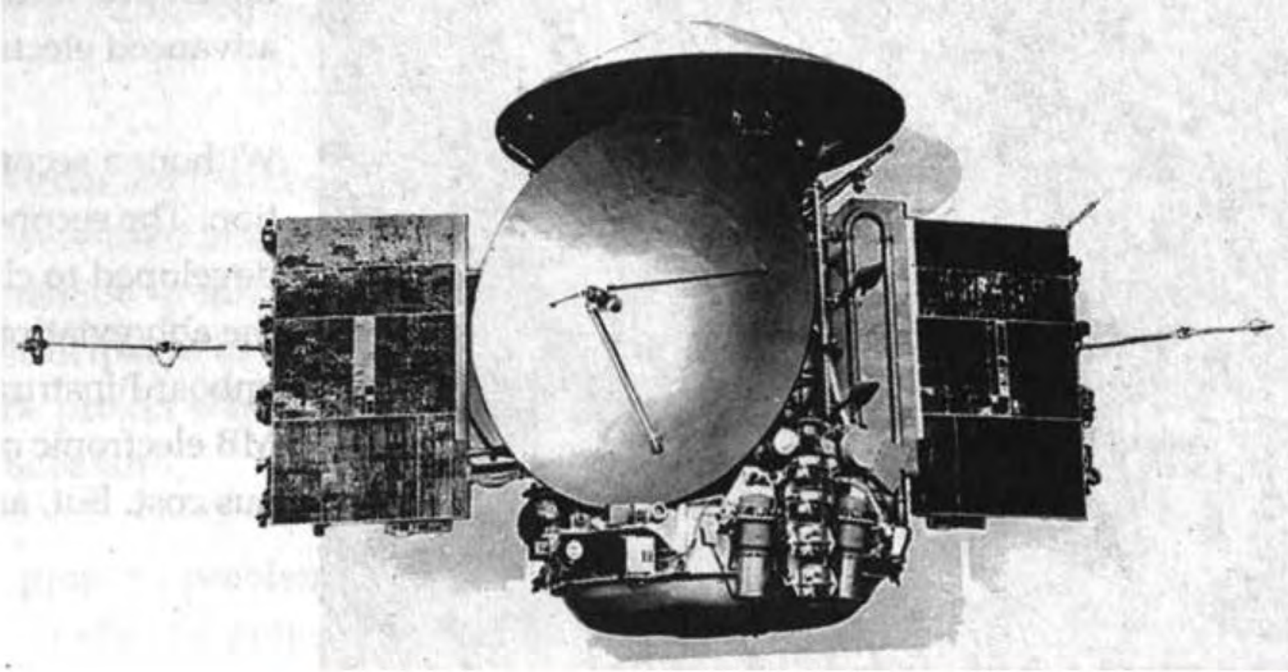


Mars 3 lander 2.

In 1973, Mars 4 and 5 reached Mars. However, Mars 4 failed to reach orbit but made a close flyby. On the other hand, Mars 5 successfully entered orbit and sent information to Earth, but communication was lost after nine days (see Fig. 17). In the same year, Mars 6 had no problems during descent on Mars. However, contact with the lander was lost (see Fig. 18). Mars 7, also launched in 1973, had an orbiter and a lander. However, the lander encountered a problem during descent and grazed the atmosphere, causing it to bounce off and remain in an elliptical orbit. This was the last probe of the Soviet Mars program (see Fig. 19).

Mars 4 and 5





Mars 6

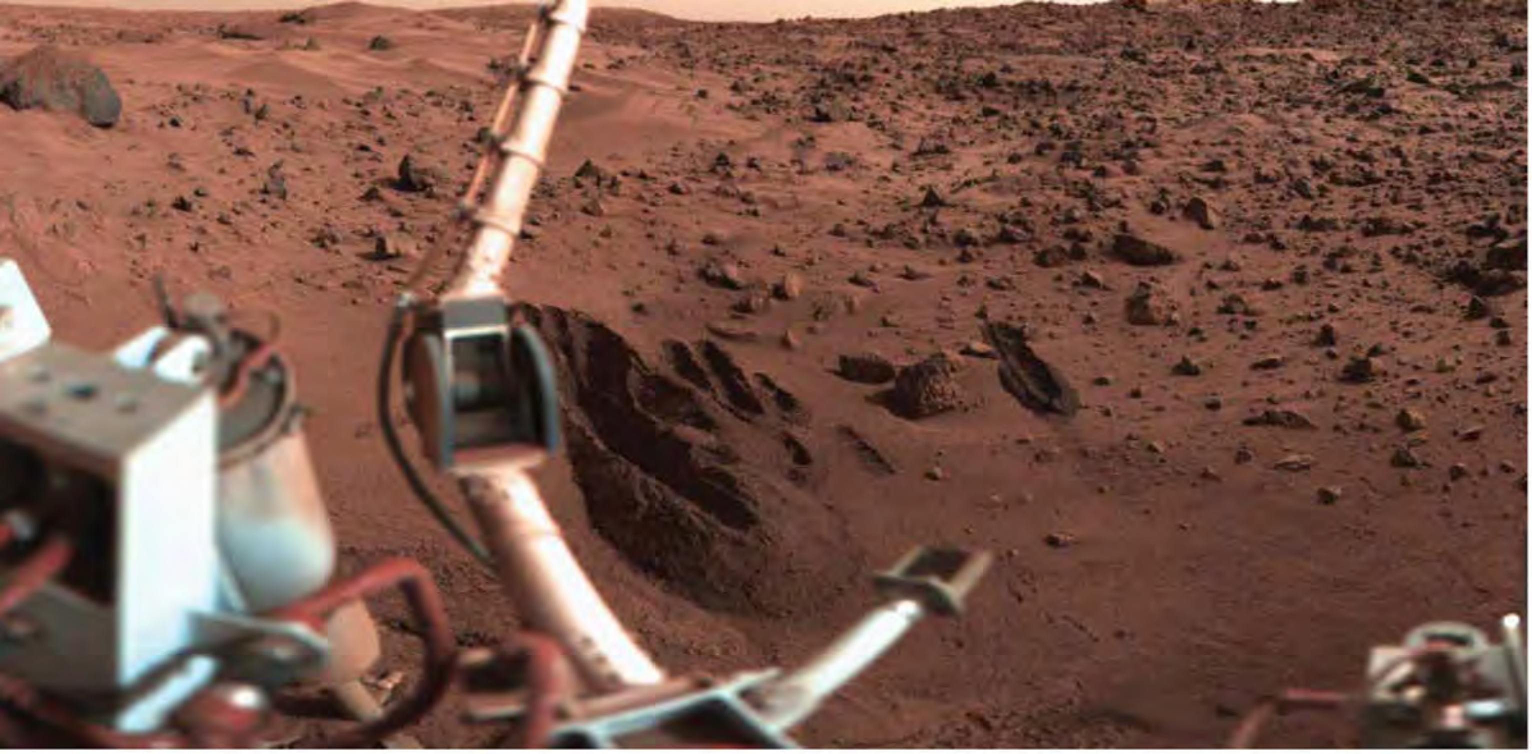
Mars 7

Viking 1

On August 20, 1975, aboard a Titan III rocket, the Viking 1 was launched from the USA to Mars. The probe consisted of an orbiter and a lander. Viking 1 arrived at Mars on July 20, 1976, and with more instruments on board, it was able to choose a better landing spot for the lander. The lander made a perfect landing at Chryse Planitia, and the amount of data sent to Earth was much greater than before. The Viking 1 orbiter sent more than 57,000 photos, making the mission a complete success (see Figs. 20-23). However, the VL1 ceased operations on November 13, 1982, due to human error in a software update.

Viking 1 and lander.

Next page:
Photo of the surface of Mars
Taken by Viking 1.



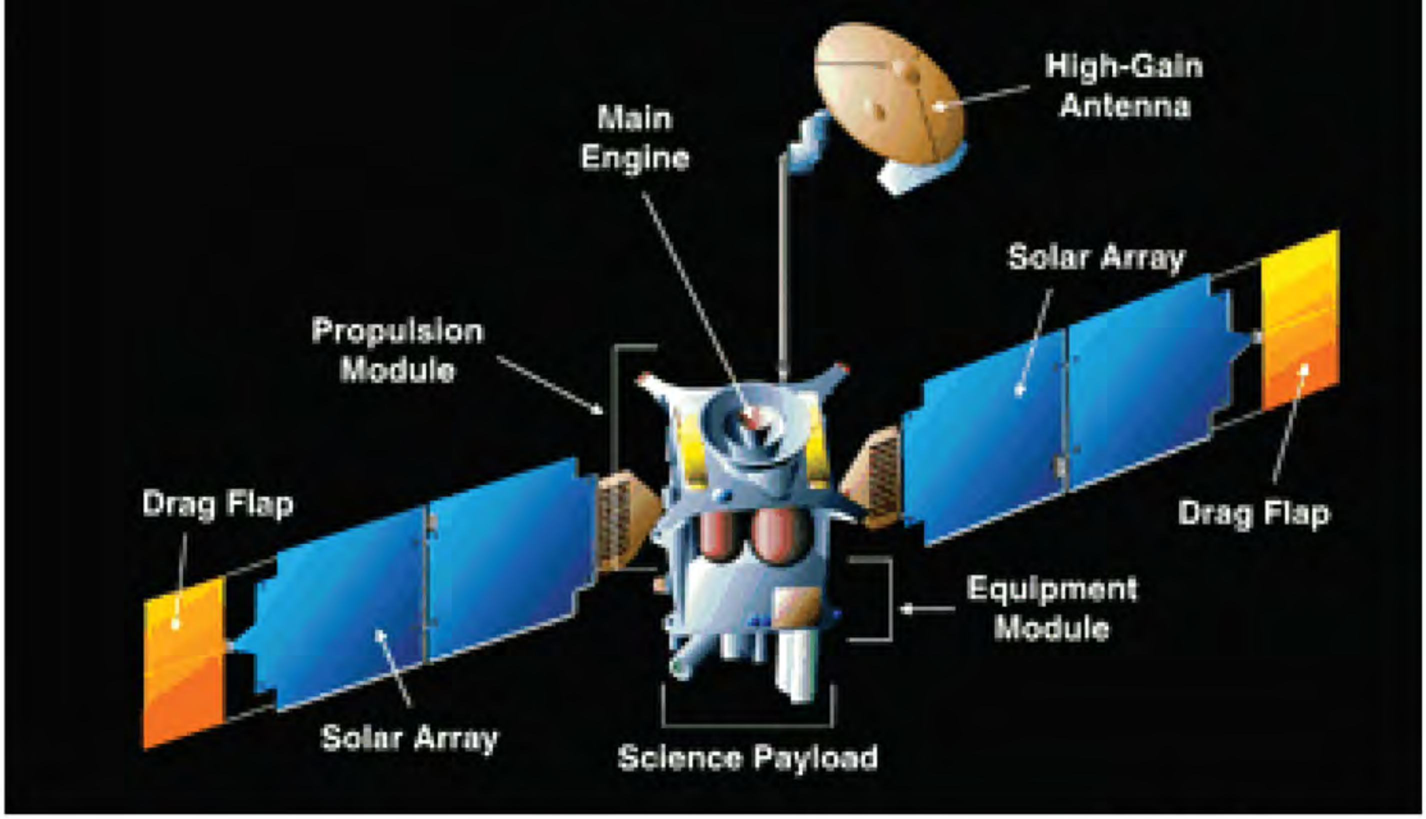
In this photo you can see the marks made by the Viking 1 mechanical shovel.

Viking 1 was the first human-made vehicle to successfully land on the surface of Mars.
One month after Viking 1, NASA launched Viking 2 on September 9, 1975. This probe successfully completed its mission, just like Viking 1. In addition, microbiology studies were carried out in the Viking program. In a particular photo (see Fig. 24), you can observe frost on Mars at the base of the rocks.

In this photo you can observe a frost on Mars at the base of the rocks.

In 1988, the Soviet Union sent two probes, Phobos 1 and Phobos 2, to carry out studies of the moons of Mars. The landers were intended to land on the moon Phobos, but Phobos 1 lost contact on its journey to Mars and Phobos 2 lost contact with Earth shortly after arriving at its destination and deploying the lander. The missions failed.
In 1992, NASA launched the Mars Observer with the goal of orbiting Mars for one year. However, contact with the probe was lost three days before it arrived at its destination.

Mars Observer

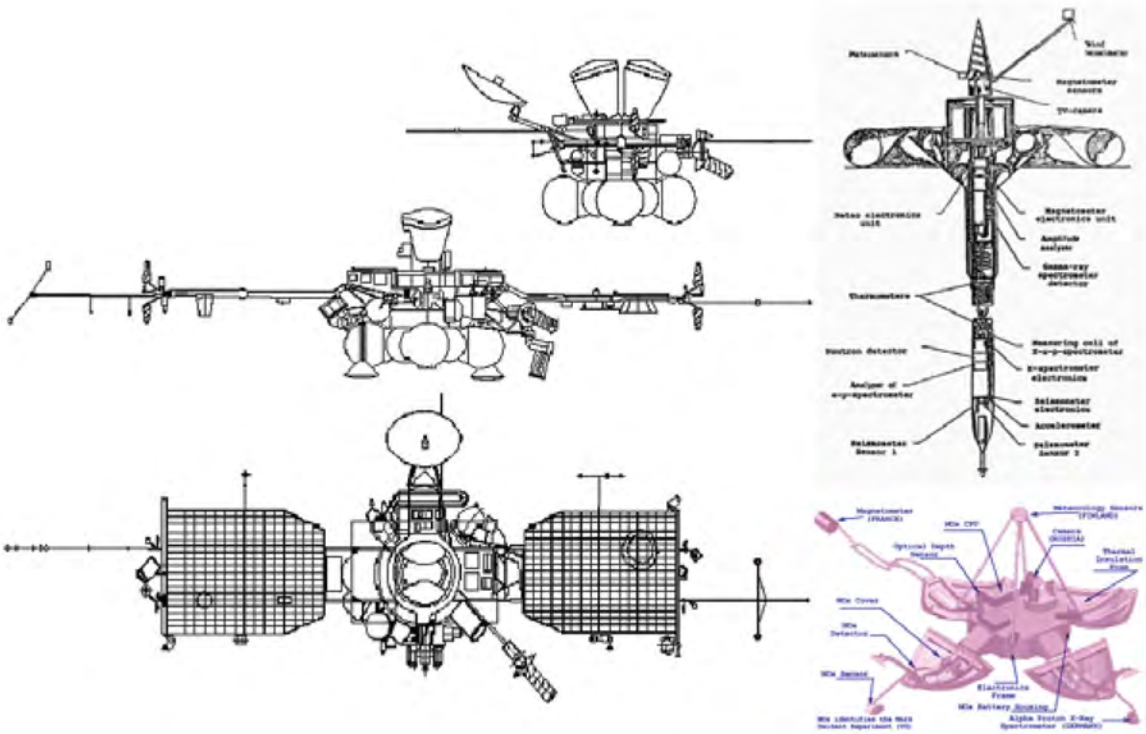


Mars Global Surveyor

In 1996, NASA launched the Mars Global Surveyor, which successfully mapped Mars.

On November 16, 1996, Russia launched Mars 96, an ambitious project consisting of an orbiter, two landers, and two penetrators. It was the heaviest probe ever sent into space, but it failed to launch and crashed in the Pacific Ocean.

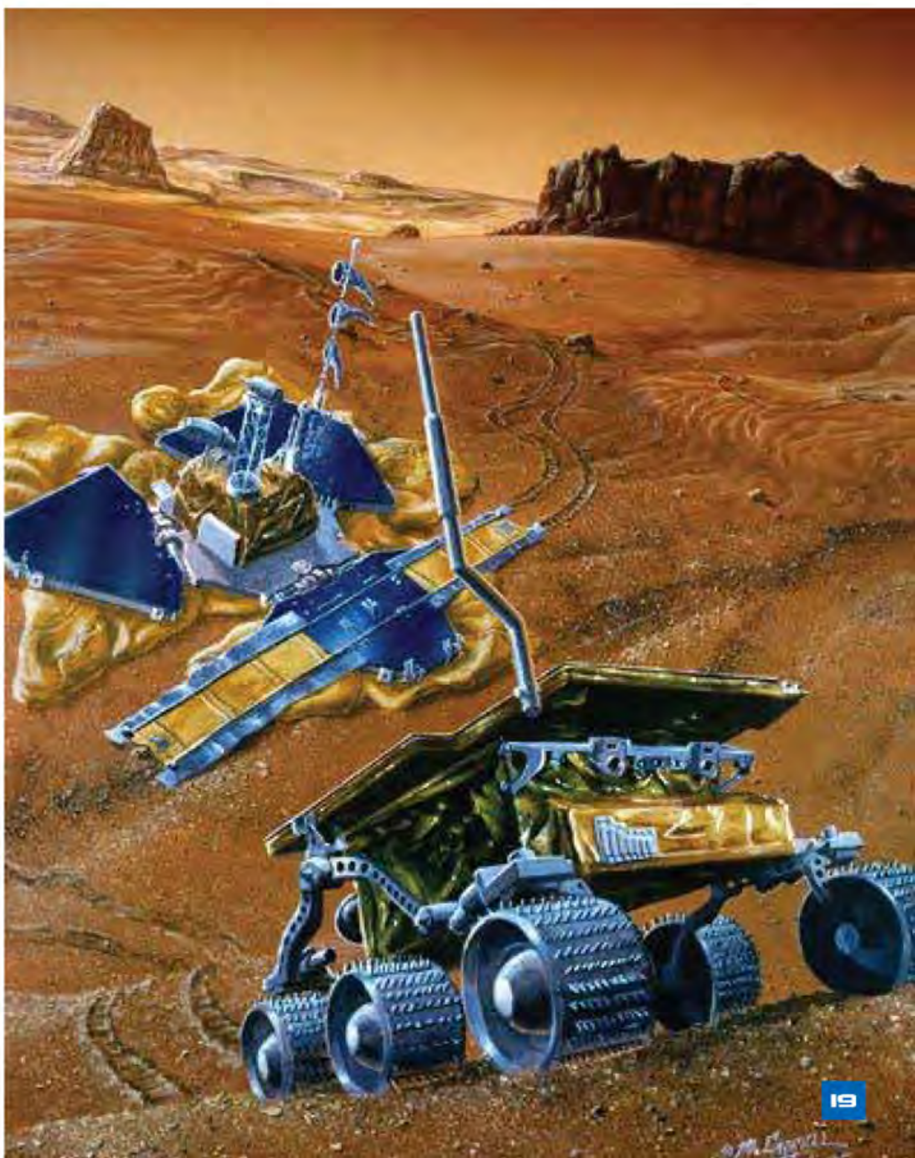
Mars 96



Here you can see how complex the Mars 96 probe was.

The Mars Pathfinder, composed of a lander named Carl Sagan Memorial Station and a rover named Sojourner, was launched on December 4, 1996, by NASA. It was the first rover to work outside the Earth-Moon system and was a probe designed to carry out a series of tests of new technologies. The Pathfinder successfully conducted a series of scientific experiments and was a complete success, working for almost three months.

Pathfinder

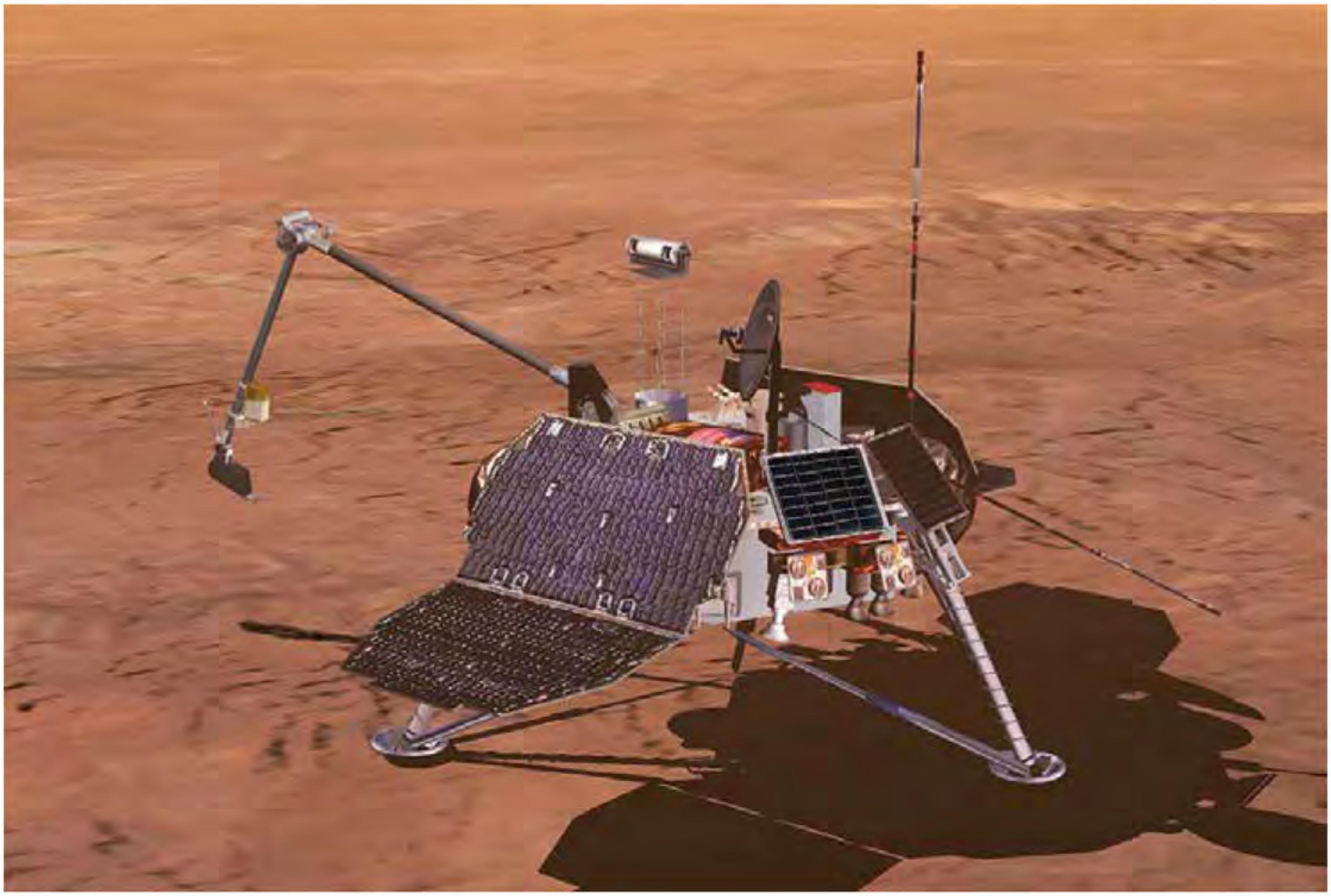


Rover being photographed by Pathfinder.

In July 4, 1998, Japan launched Nozomi, which was meant to carry out studies of the Martian atmosphere, but it had complications on the trip to Mars and could not enter orbit.

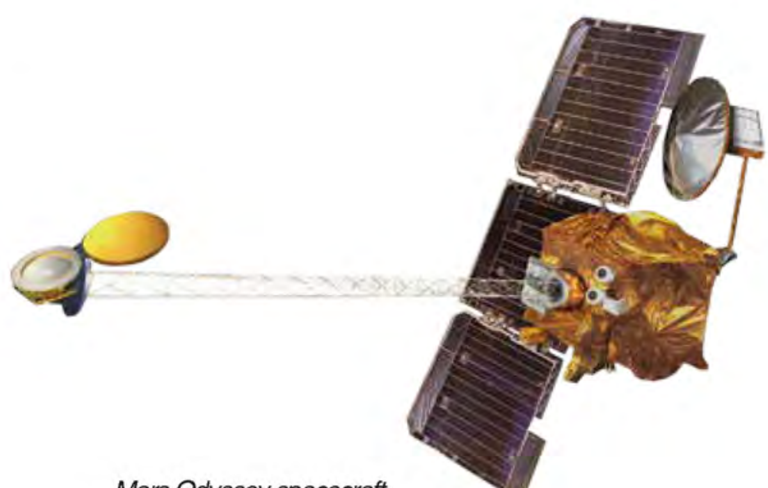
Nozomi

On December 11, 1998, NASA launched the Mars Climate Orbiter, which was intended to study atmospheric variables but crashed while descending due to metric unit complications.
On January 3, 1999, NASA launched the Mars Polar Lander and Deep Space 2 (DS2). The lander and two microprobes lost contact upon arrival at Mars.



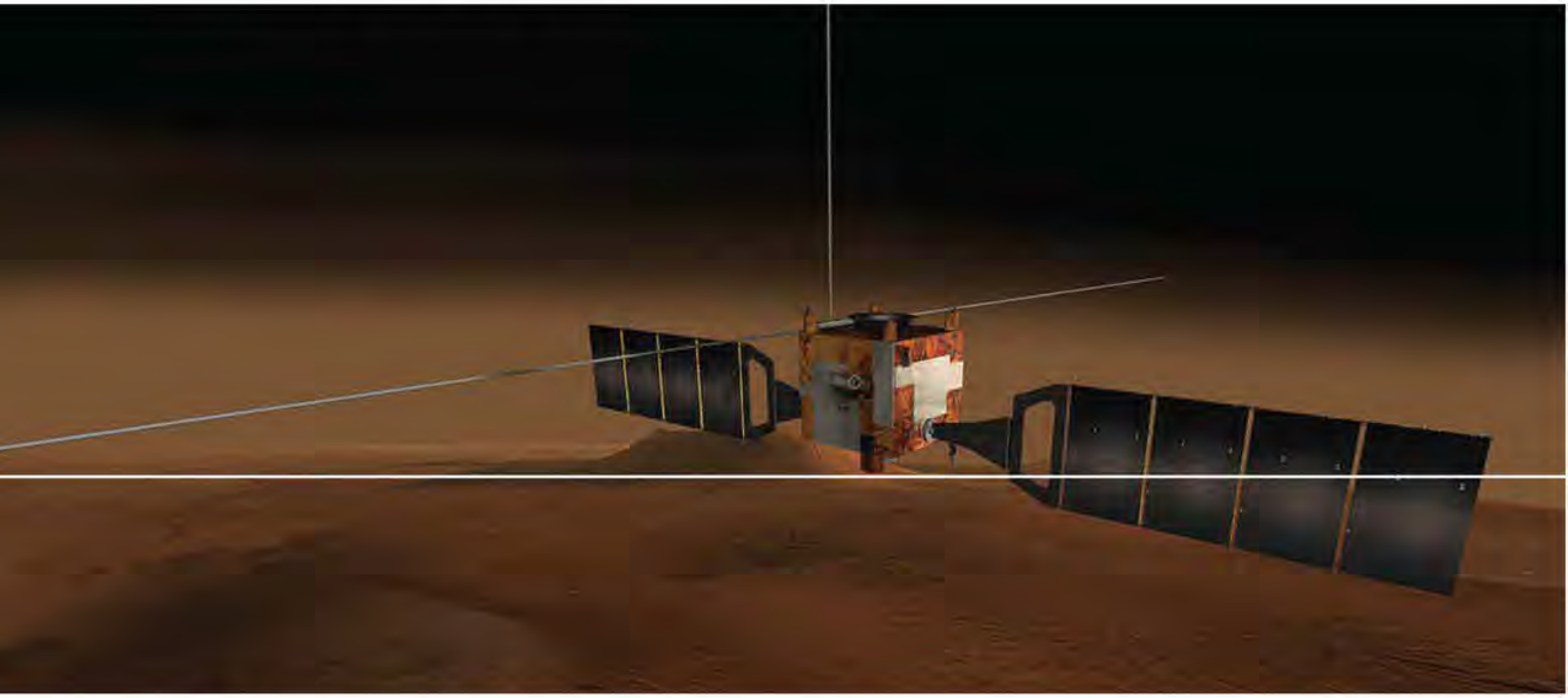
Mars Polar Lander.

Mars Odyssey, a space probe launched by NASA on April 7, 2001, successfully mapped the surface of Mars and is also used as a communications link with robots on the ground.



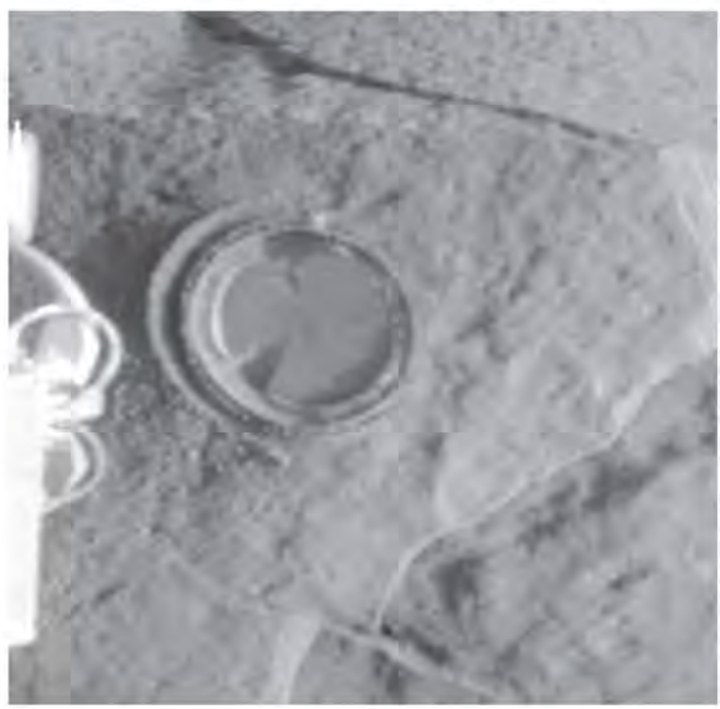
Mars Odyssey spacecraft

In June 2, 2003, the European Space Agency launched the Mars Express, the first European interplanetary mission. The Mars Express carried the Beagle 2 lander, which lost contact on landing. However, the Mars Express orbiter continues to operate today.



Mars Express

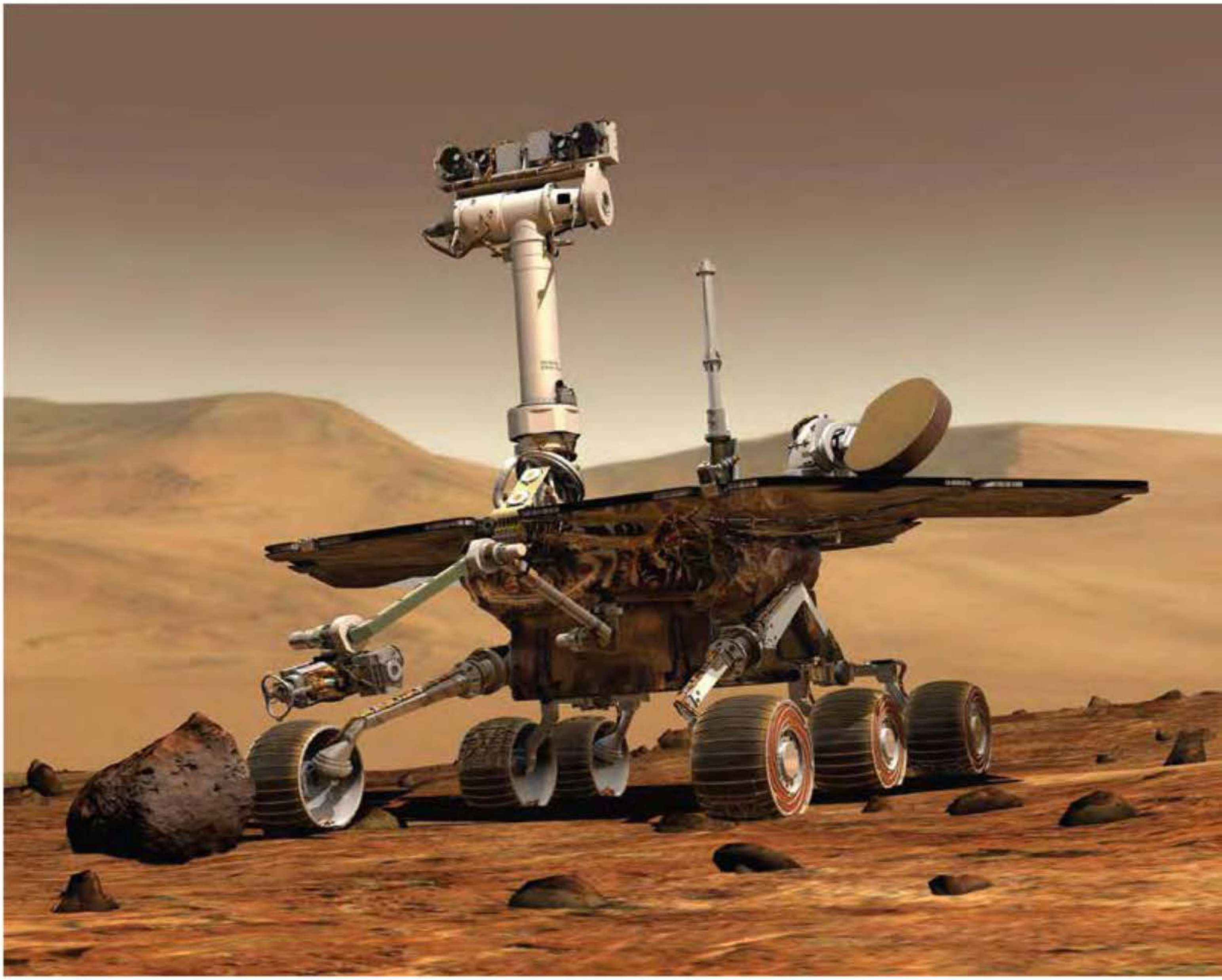
On July 10, 2003, NASA launched the Rover Spirit, which reached Mars on January 4, 2004. For the first time, a rock was drilled on Mars. Spirit made three important discoveries: evidence for ancient boiling springs, evidence for a dense atmosphere and fresh water, and evidence for an active water cycle. All of these discoveries contribute to future missions for the colonization of Mars. The Spirit was designed to work for three months, but it worked for seven years before being declared over by NASA on May 25, 2011, after not having received any signal from it since March 22, 2010, due to numerous mobility problems that trapped it in a sandy area.

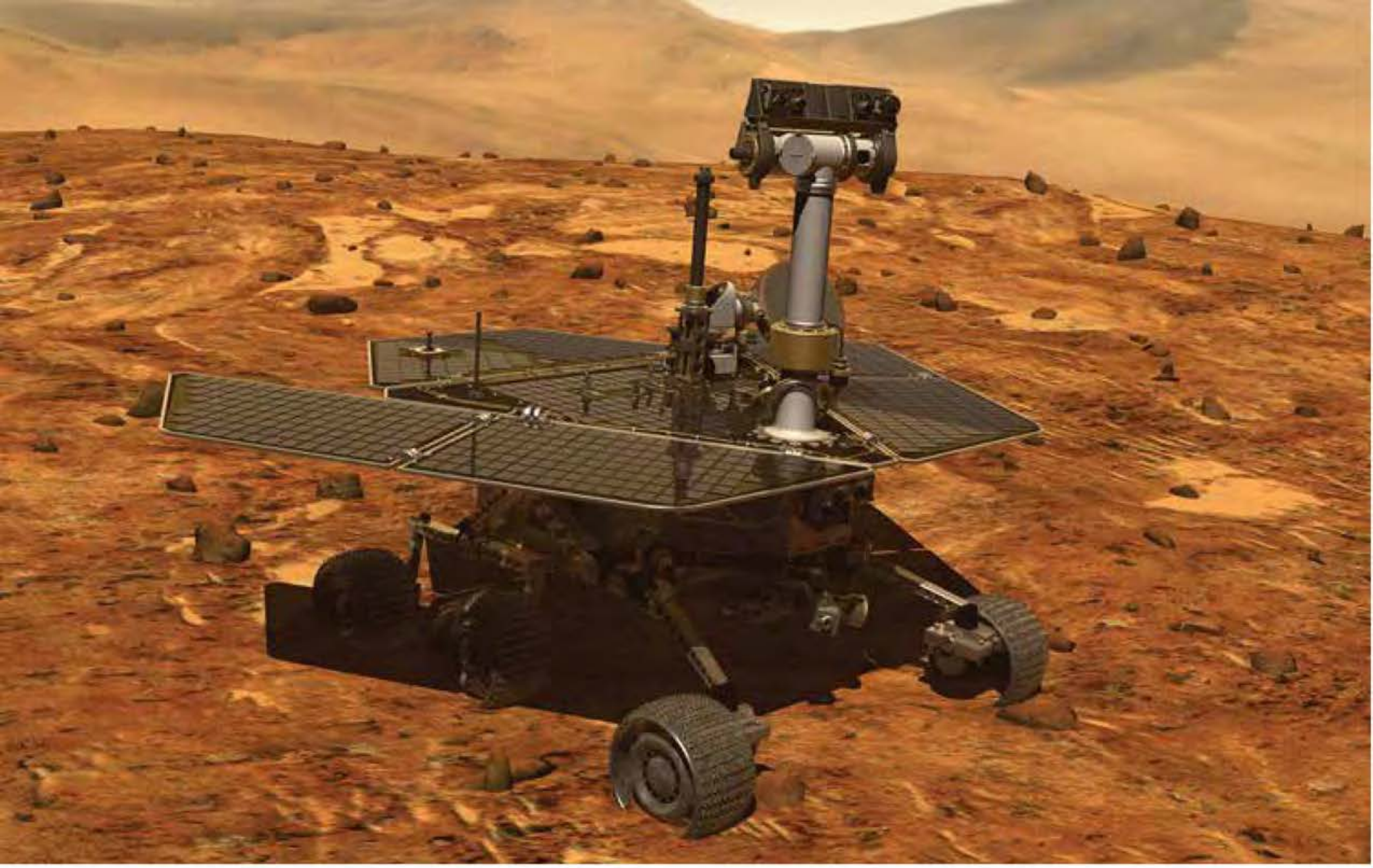


First rock drilled on Mars

Lahontan Crater

Spirit





Opportunity

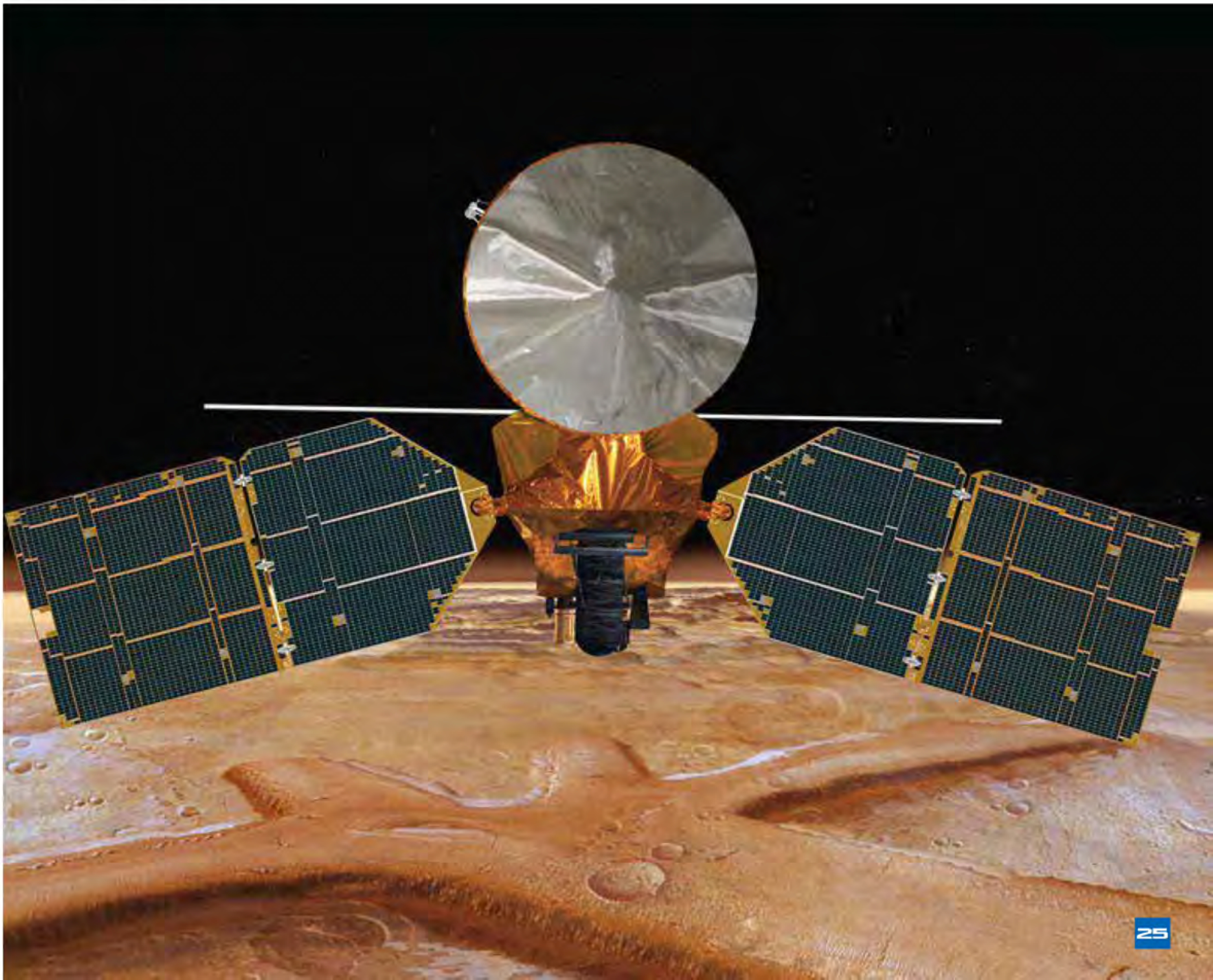
The Opportunity rover, Curiosity's twin, arrived on the planet Mars on January 26, 2004, after being launched on July 7, 2003. Opportunity landed at Meridiani Planum and conducted examinations of extramartian meteorites, two years of research in Victoria Crater, and two more years of research in Endeavor Crater, surviving many sandstorms and holding the distance record for a rover of more than 45 km. Although the mission was supposed to last only 90 Martian days, it was extended to 13 years thanks to the funds provided by NASA. However, on June 10, 2018, after a strong sandstorm that covered Opportunity's solar panels, NASA terminated the mission with total success.

Opportunity airbag system

Rosetta was a space probe launched by the European Space Agency (ESA) on March 2, 2004, which made a close flight to Mars and then left for comet 67P/Churiumov-Guerasimenko.

The Mars Reconnaissance Orbiter (MRO) is a multipurpose spacecraft that was launched on August 12, 2005, to advance human knowledge of Mars through detailed observation, in order to examine potential landing zones for future surface missions. The HiRISE camera mounted on board the MRO spacecraft obtained high-definition images during an orbital passage. The MRO is currently in operation, as shown in the picture below.

Mars Reconnaissance Orbiter

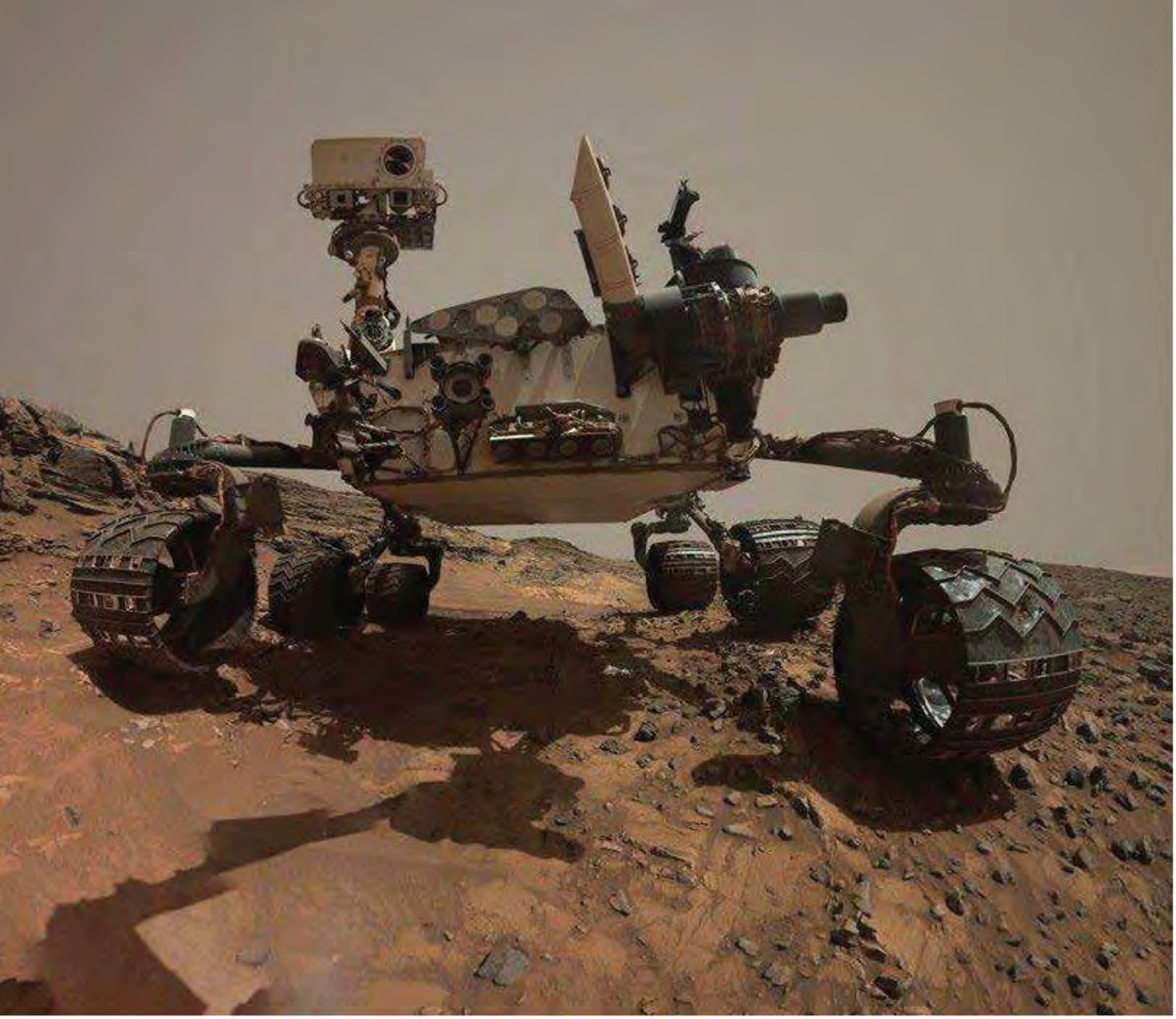


The Phoenix Mars Lander was a space probe built by NASA, launched on August 4, 2007, and arrived on Mars on May 25, 2008. Its mission was to determine if there was or could be life on Mars, characterize the climate of Mars, study the geology of Mars, and carry out studies of the geological history of water, a key factor in deciphering the past of climate changes on the planet. The main mission was supposed to last 92 days, but after the discovery of water ice, it was extended for five more weeks and finally ended on November 10, 2008, with a successful mission.

A rendition of the Phoenix landing.

Model of Phobos Grunt.

On November 8, 2011, Russia launched the Phobos-Grunt & Yinghuo-1 mission, carried out by Russia and China, with the objective of studying Phobos. The idea was to send a lander to collect samples from the Martian moon and return to the ship to bring the samples to Earth. However, the ship failed after launch and remains orbiting the Earth, eventually crashing days later.



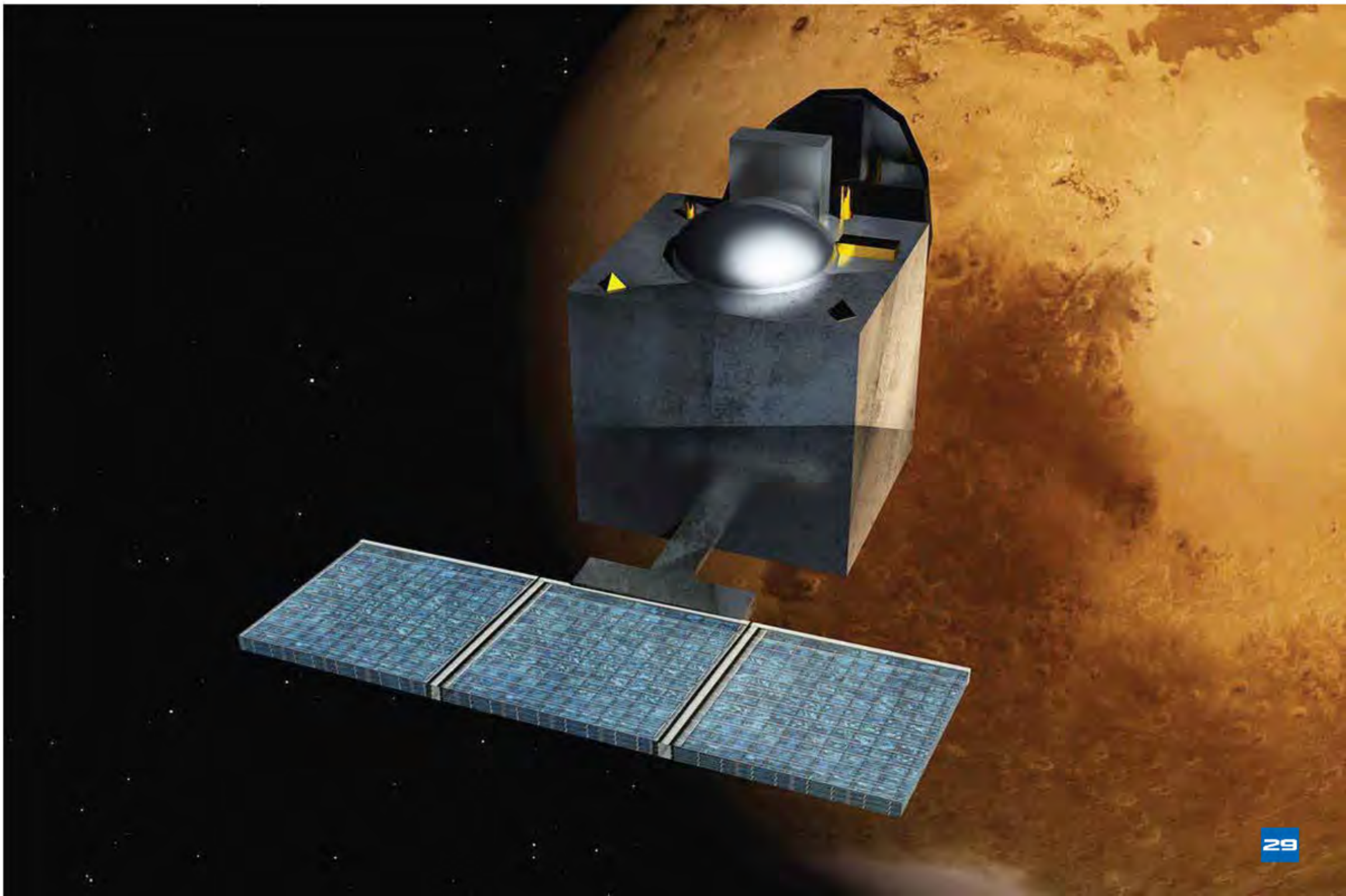
Mars Curiosity Rover in Mount Sharp.

The rover Curiosity was launched by NASA on November 26, 2011, and successfully landed on Mars in Gale Crater on August 6, 2012. The mission focuses on placing a rover-type vehicle on the Martian surface, three times heavier and twice as large as the vehicles used in the Mars Exploration Rover mission, with more advanced science instruments. Over the course of the mission, Curiosity took dozens of samples of Martian soil and rocky dust. Although the planned duration of the mission was one Martian year, it is still operating, having found clues about the watery past of Mars, a very important discovery. The mission has four objectives: determining if life ever existed on Mars, characterizing the climate of Mars, determining the geology of Mars to prepare for human exploration of the Red Planet, and examining the possibility of future human missions.

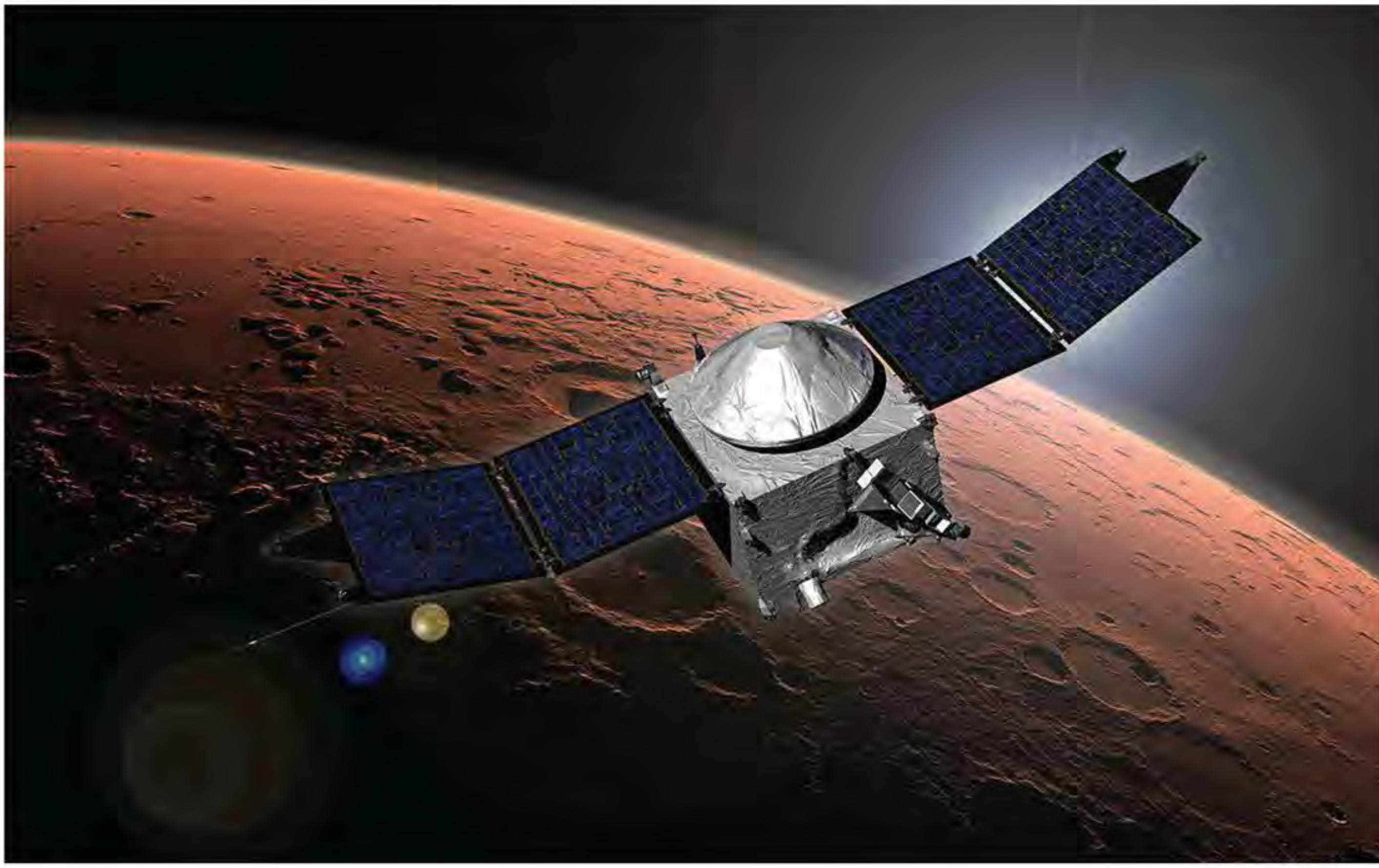
Mount Sharp.

The Mars Orbiter Mission was launched by India on November 5, 2013, with the main objective of raising awareness of India's rocket launch systems, spacecraft construction, and operation capabilities. It arrived in the orbit of Mars on November 24, 2014, but the mission ended due to a loss of signal, with the last contact made on April 2022. However, the mission was considered a success.

Mars Orbiter Mission by India (Artist Concept)



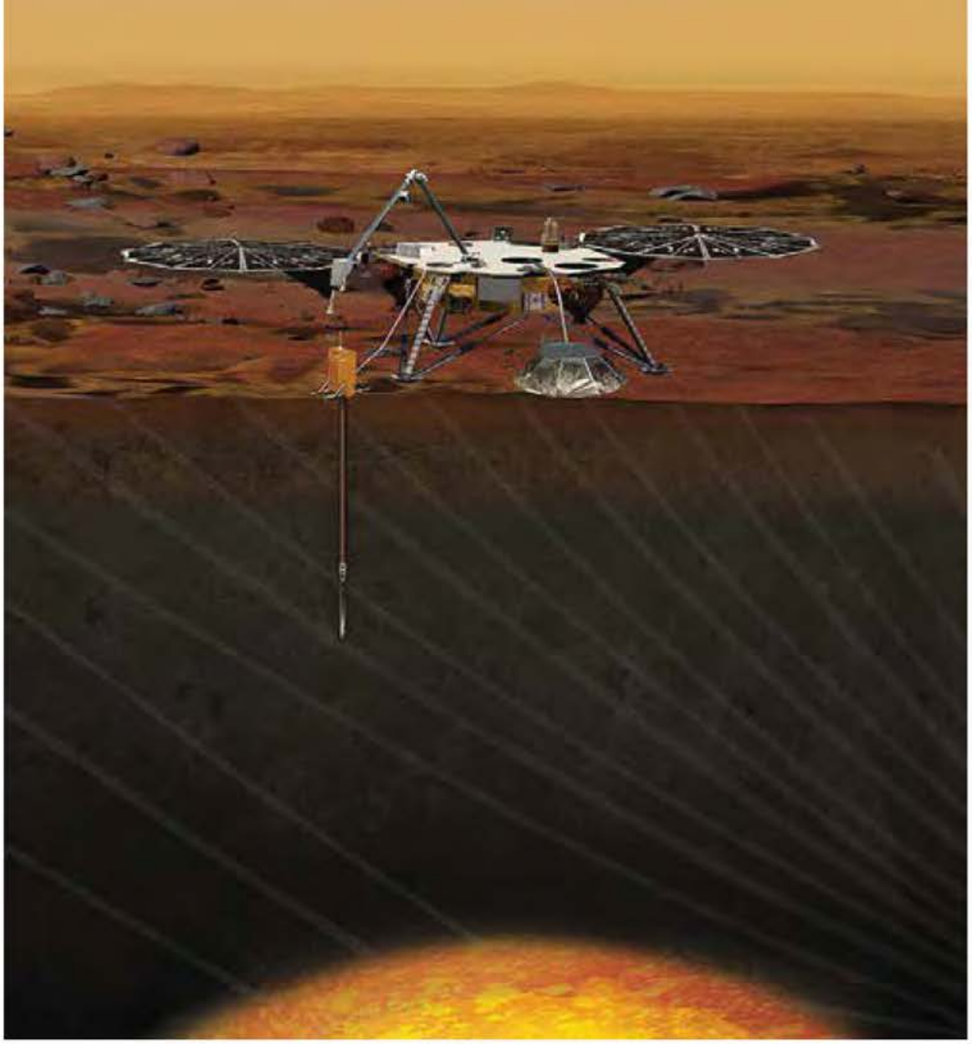
MAVEN (Mars Atmosphere and Volatile Evolution) is an orbiter launched by NASA on November 18, 2013, with the goal of studying the Martian atmosphere and determining how the atmosphere and water on Mars disappeared. It arrived in Martian orbit on October 21, 2014, and the mission is still in progress.



Mars MAVEN Orbiter

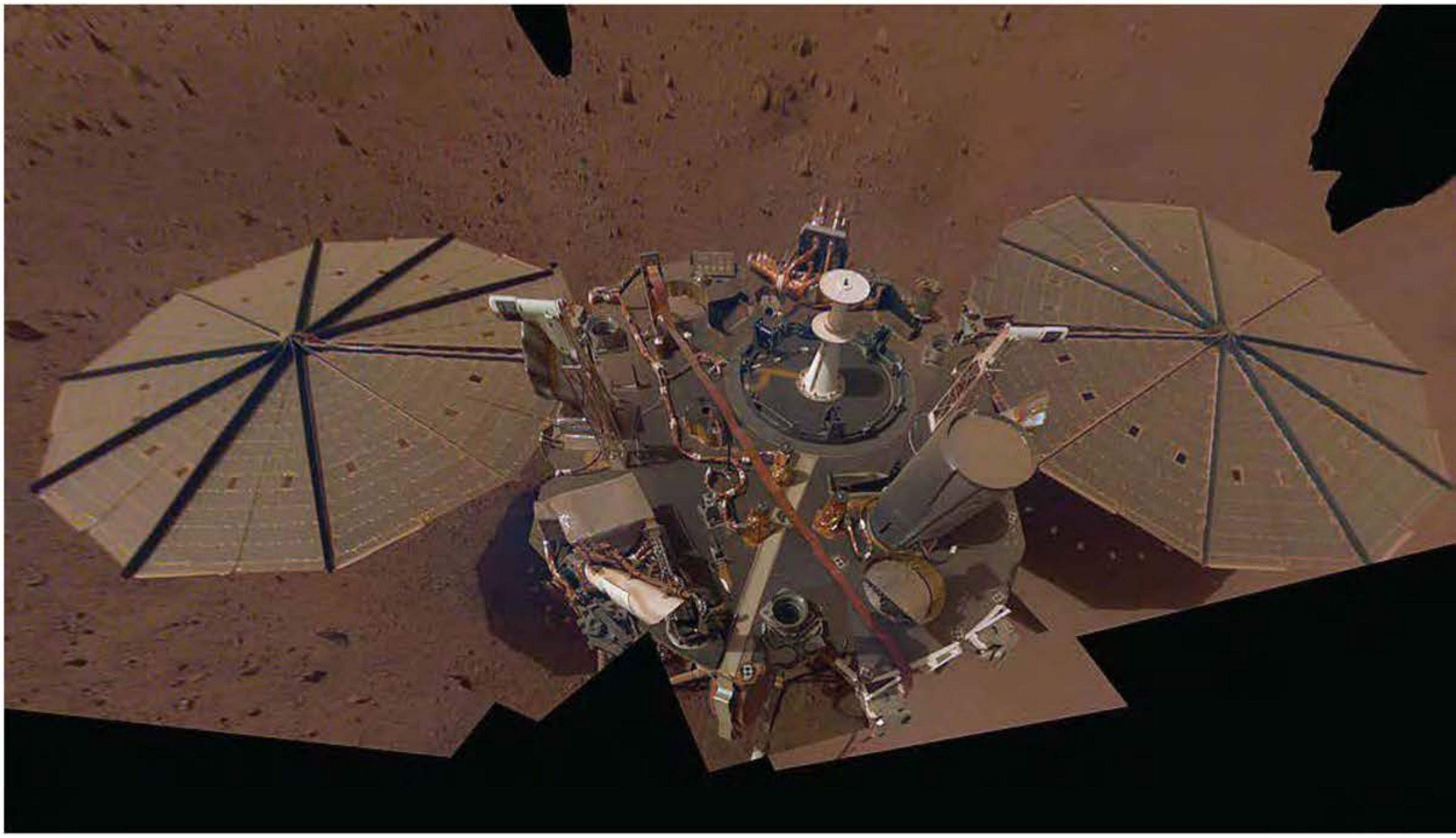
ExoMars (Exobiology on Mars) is a space mission to search for life on Mars. It consists of an orbiter, a lander, and a rover. The first stage of the mission was launched on March 14, 2016, and arrived on October 19, 2016. However, the lander crashed on the surface of Mars, and plans to send the rover to Mars in 2028 are being made due to a break in the partnership with Russia over the Ukraine war.

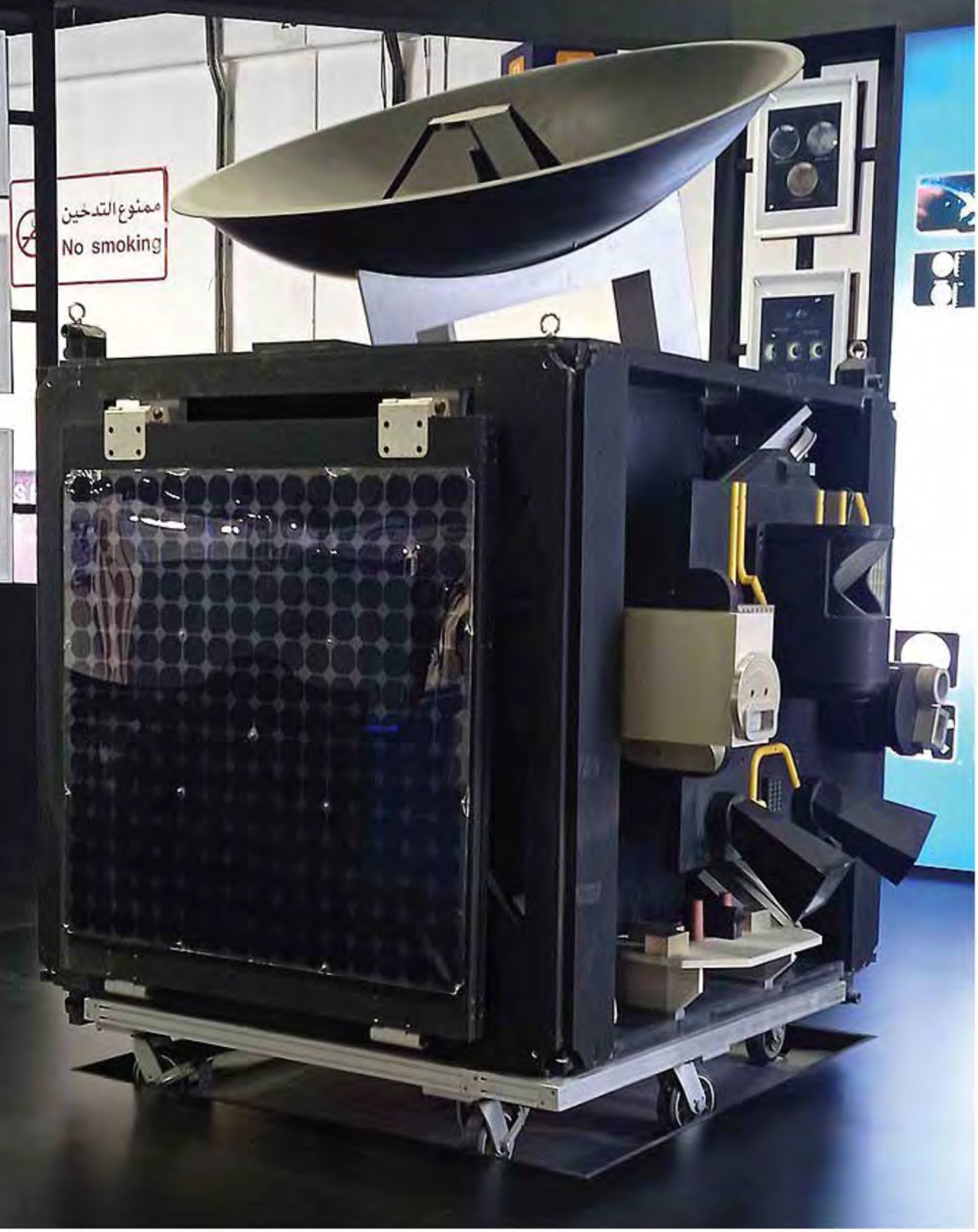
InSight was launched by NASA on May 5, 2018, and successfully landed on Mars on November 26, 2018. During its stay on the surface, InSight investigated and studied the internal structure of the planet and detected "marsquakes." To May 2022, 1,313 marsquakes had been recorded, but the last contact with the lander was made on December 15, 2022. Although a reconnection was attempted on December 18, InSight did not respond, and NASA decided to conclude the mission on December 21, 2022. The mission was partially successful, as the drill failed to penetrate the surface.



Artist´ concept of the InSight Lander

Mars Insight Lander Selfie



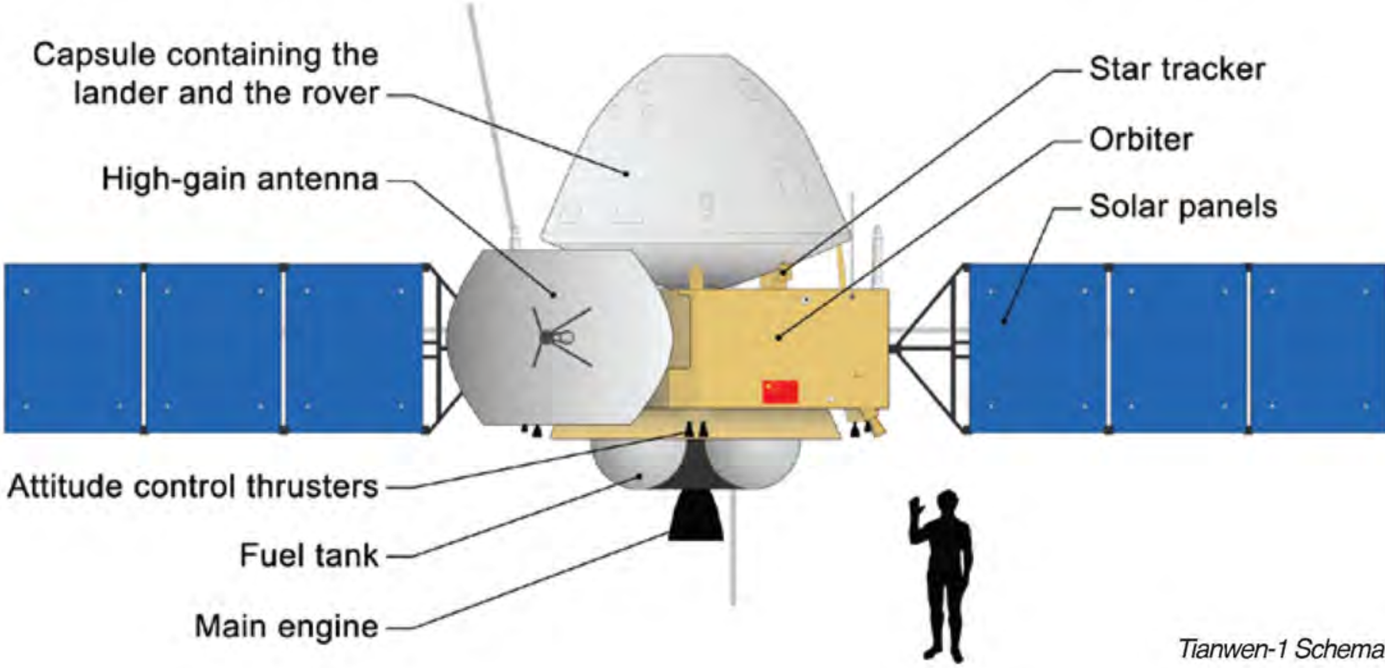


United Arab Emirates Hope Mars Spacecraft

The Hope Mars mission is a space exploration mission towards the orbit of Mars, launched on July 19, 2020, by the United Arab Emirates. It was built by the Mohammed bin Rashid Space Center, as well as the University of Colorado Boulder, Arizona State University, and the University of California, Berkeley. On February 10, the probe arrived at Mars with a successful Orbital Insertion. The mission is still in development, with the spacecraft orbiter studying the Martian atmosphere and climate.

Tianwen-1 is a Chinese space mission that aims to deliver an orbiter, a lander, and a rover, Zhurong, to the planet Mars. The mission was launched on July 23, 2020, with a Long March 5 rocket. It entered Martian orbit on February 10, 2021, while the Zhurong rover landed on May 15, 2021. The mission is still in progress and has been successful so far.

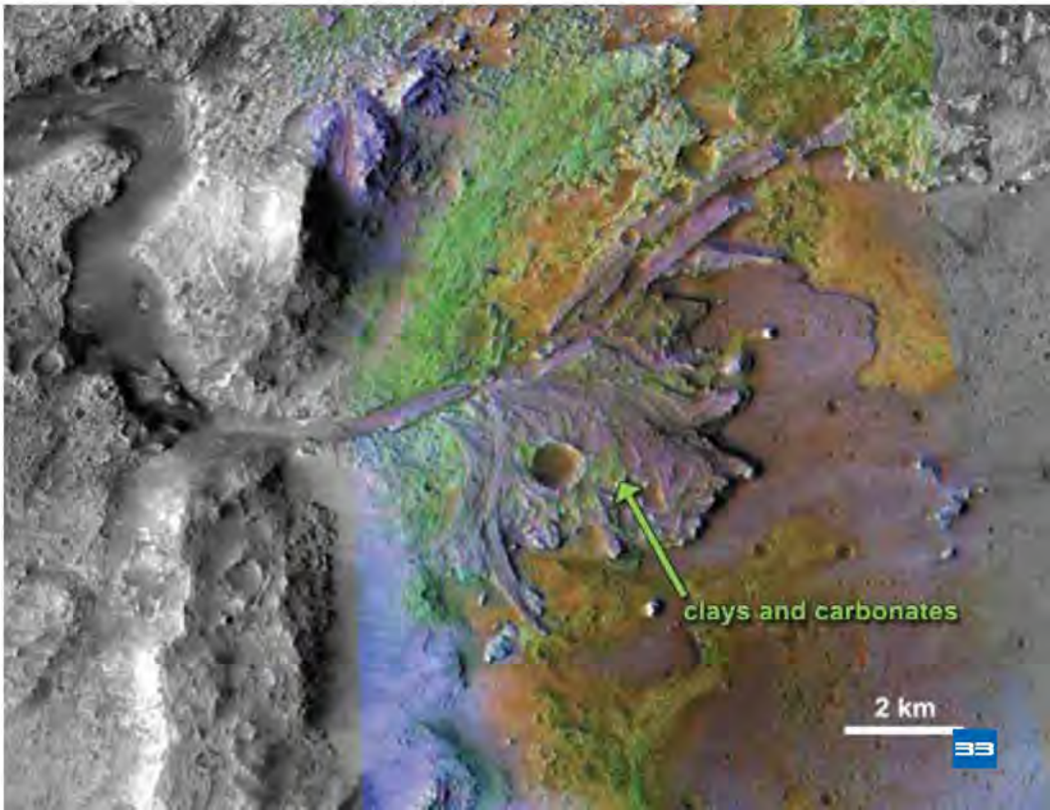
With this mission, China became the second country to land successfully on Mars.



Tianwen-1 Schematic

Perseverance's primary mission is to determine whether there is evidence of past life on Mars and whether it would be possible to establish human settlements on the Red Planet for further exploration. To accomplish this task, Perseverance was sent to the Jezero crater, which is believed to be an ancient river delta or lake on Mars.

Jezero Crater Delta

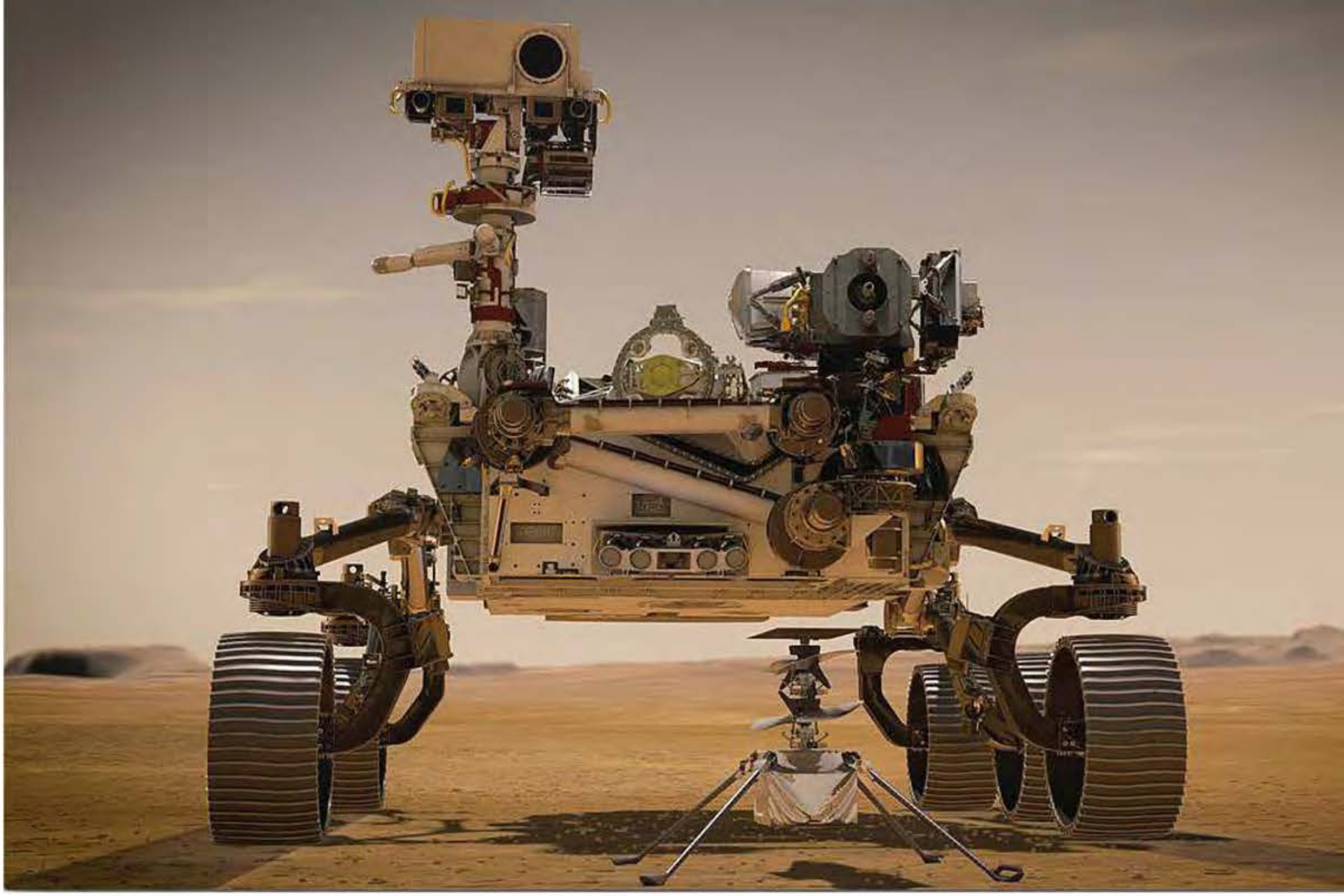


Perseverance Landing using Skycrane

Perseverance, is equipped with special instruments mounted on a robotic arm (parts D19, E17, E18, E20, E22, and F21) that can drill into rocks or shoot them with a laser for analysis. Perseverance also has various types of cameras (parts E8 and E9) that capture images of the Martian surface for further study, and the helicopter Ingenuity provides a unique aerial perspective to help Percy choose exploration sites.

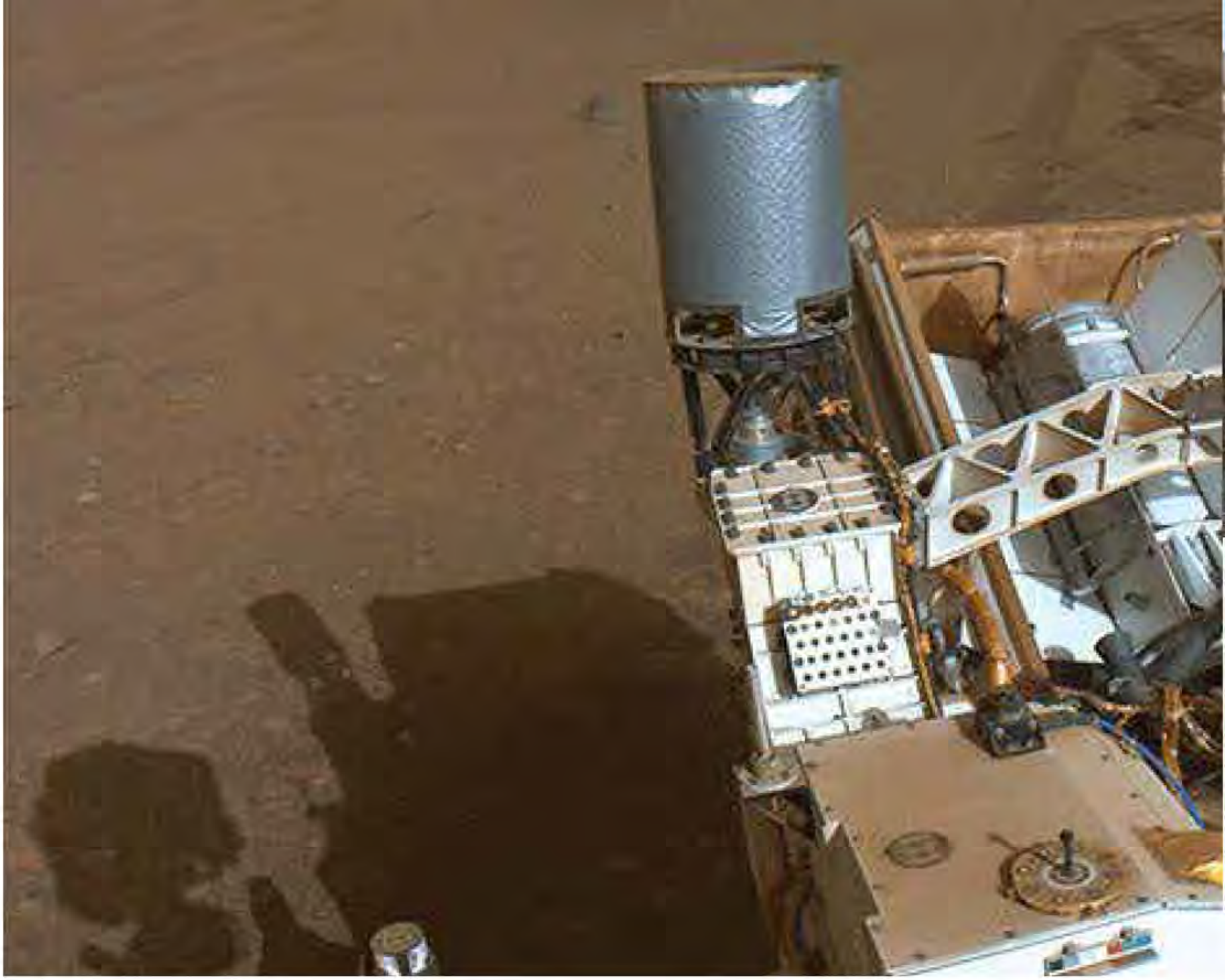
A critical aspect of the mission is for Perseverance to help prepare samples that future missions can collect and bring back to Earth. The rover will test technology to produce a small amount of pure oxygen (O2) from Martian atmospheric carbon dioxide (CO2) and search for groundwater.

Perseverance's mobility is essential for exploration, and our model of the Mars Rover includes a similar system to the actual one. The original rover has a radioisotope thermoelectric generator that provides energy for vehicle transfer and experimentation operations, including movement. Our model will use commercial batteries to simulate the nuclear engine, and the suspension (rocker-bogie) in parts D23, D23, D25, and D26 gives Perseverance the freedom to adapt to the terrain and avoid obstacles.



Perseverance, rover and Helicopter Ingenuity

Perseverance takes a selfie of its robotic arm



The original Perseverance rover, weighing just under 2,300 pounds (1,043 kilograms), is on a mission to search for signs of past microbial life and characterize the climate and geology of Mars. It also collects samples of Martian rocks and dust for a future Mars Sample Return mission to Earth and serves as a steppingstone for human exploration of the Red Planet.

For the first time, this rover is equipped with a drill to collect core samples of Martian rock and soil, which will be stored in sealed tubes for pickup by a future mission for detailed analysis. It also features the Mars Helicopter, Ingenuity, a technology demonstration that made history by achieving many successful powered flights on the Red Planet, becoming the first aerial vehicle of its kind to do so.

The mission also tests new technologies such as producing oxygen from the Martian atmosphere, identifying subsurface water and other resources, improving landing techniques, and characterizing weather and dust.

55 Perseverance, as seen from the MastCam.

The mission utilizes technological innovations that have been successfully demonstrated before, particularly for entry, descent, and landing, and includes new entry, descent, and landing (EDL) technologies like Terrain-Relative Navigation (TRN) that allow the rover to avoid hazardous terrain by diverting around it during its descent through the Martian atmosphere.

The Perseverance rover's design is largely based on the engineering design of the previous Curiosity rover, with improvements such as a new, more capable wheel design and a drill for coring samples from Martian rocks and soil. The rover also demonstrates a new capability of gathering, storing, and preserving samples, potentially paving the way for future missions to retrieve them for laboratory analysis.

Furthermore, the rover tests a technology for extracting oxygen from the Martian atmosphere, which helps in planning ways to use Mars' natural resources to support human explorers and improve designs for life support, transportation, and other vital systems for living and working on Mars. The rover also monitors weather and dust to better understand daily and seasonal changes on Mars and help predict Martian weather for future human explorers.

The Perseverance rover has four science objectives that support the Mars Exploration Program's science goals:

Looking for Habitability: Identify past environments capable of supporting microbial life.

Seeking Biosignatures: Seek signs of possible past microbial life in those habitable environments, particularly in special rocks known to preserve signs of life over time.

Caching Samples: Collect core rock and "soil" samples and store them on the Martian surface.

Preparing for Humans: Test oxygen production from the Martian atmosphere.

In the next few years, governments and private space agencies will be busy as we approach a new era of space exploration. Competition drives technological advancements, and space exploration has already led to many inventions that we now use in everyday life. Our thirst for exploration and knowledge has driven us to the brink of human-crewed missions to Mars, and all the previous probes were our eyes and senses preparing the way for humans to explore Mars.

Exploring a celestial body brings new ideas and opportunities, and private companies and space agencies are preparing for the first human missions to the Red Planet. NASA has an excellent partnership with the private sector, exemplified by Elon Musk´ SpaceX and NASA's international collaborations on Mars missions. As human beings, we seek to explore as we have a natural curiosity to know what is beyond our reach and to learn more about the universe that surrounds us.

As we discussed before, Curiosity and Perseverance are brothers. These Mars robots were designed and built at the Jet Propulsion Laboratory (JPL) in Pasadena, California. A few years ago, I was fortunate enough to visit the JPL when the Perseverance rover was being manufactured, and I was truly amazed by the level of complexity of all its systems.

Dr. Pablo (left) with his friend, Dr. Parag Vaishampayan, a NASA scientist at JPL.
who worked on keeping Perseverance clean. This is done to prevent the contamination of planet Mars by Earth microbes and bacterias.

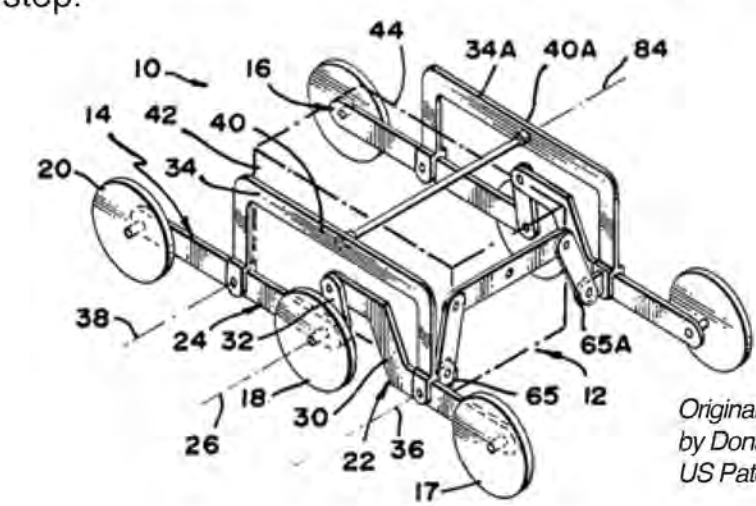
PERSEVERANCE MARS ROVER

STEP BY STEP BUILDING GUIDE

One of the systems that amazed me was the suspension system used by the robot to avoid obstacles. Mars' terrain is covered with rocks and uneven ground, and Mars robots need to be able to cross these obstacles without major issues. In 1988, the JPL designed this incredible suspension system called the "rocker-bogie," with the main inventor being Donald Bickler. This system allows the robots to climb over obstacles that are up to twice the diameter of the wheels. It was first used by the Mars rover Sojourner, but since then, it has become the chosen design for Mars rovers. It has been used by Spirit and Opportunity, as well as Curiosity and Perseverance.

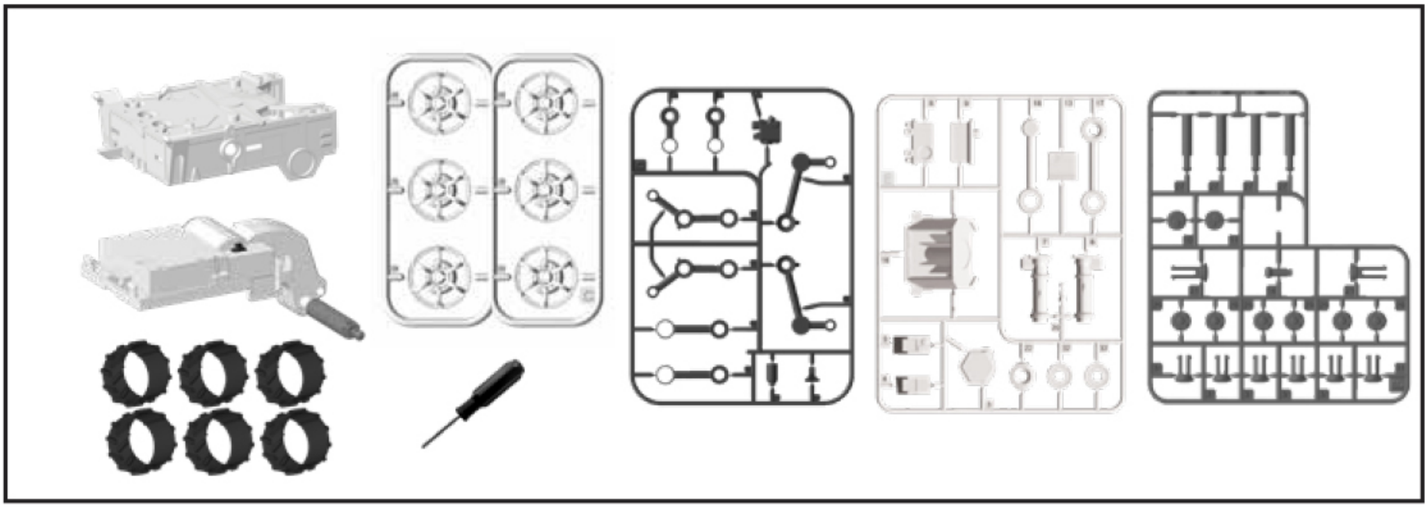
Therefore, as part of today's project, we will build a working "rocker-bogie" suspension system, similar to the one used in Mars rovers. In fact, we will build a Mars robot prototype and test it in the field to see how it works. We will then report our results, just as any test engineer or scientist would.
And now that we have learned enough about the exploration of Mars, let's start our project.

Let's build together our Perseverance Mars Rover!
Our first task will be to find and identify all the pieces of our rover.
Check each plastic bag and find the parts numbers to be sure you have everything. Our artists took great care on trying to make each figure self-explanatory, but I will also bring some guidance here, so you are sure of each step.

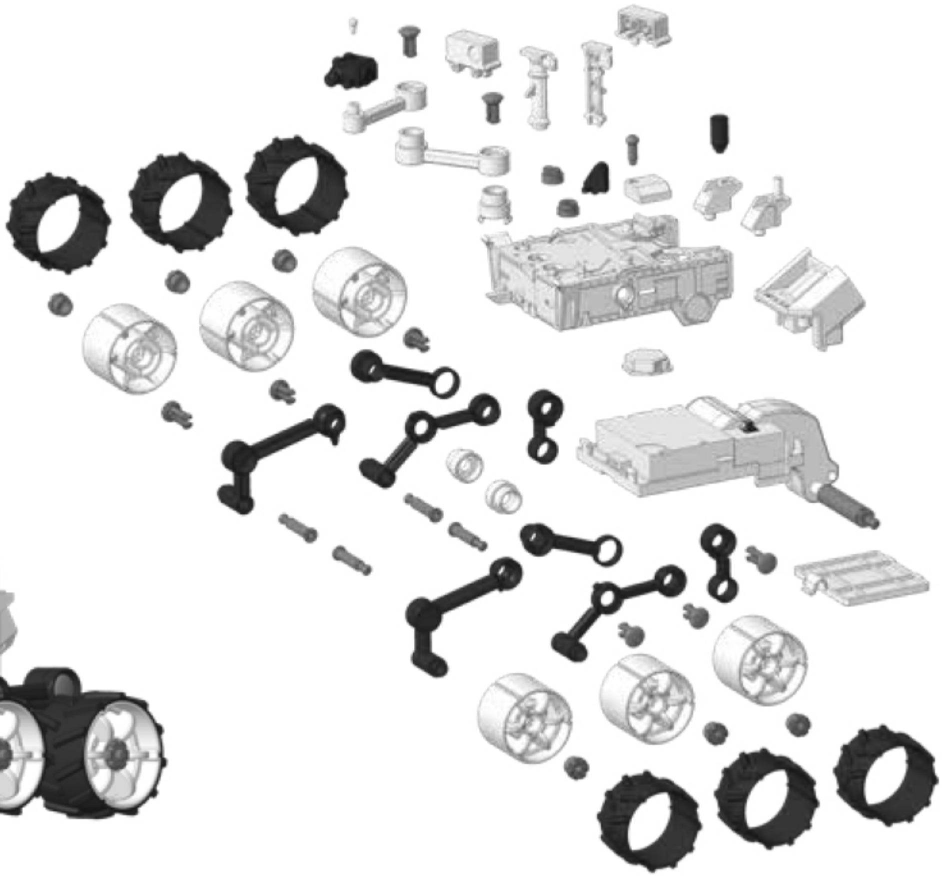


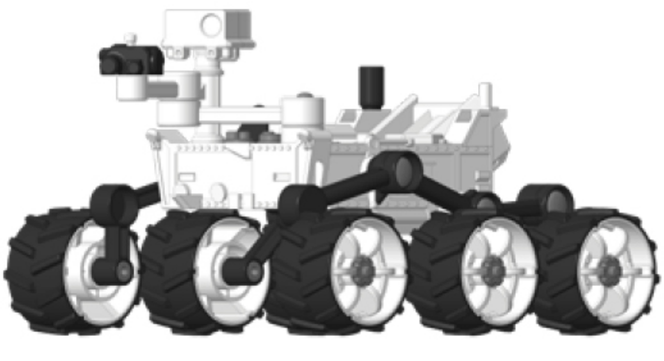
Original drawing of the Rocker-Bogie System, by Donald Bickler, US Patent US4840394. Credit: USPTO

1. Inside the box, you will find two larger white parts, which serve as the main body of the rover, six rubber tires, and four plastic frames with parts. Dispose of the plastic bags properly, as they pose a choking hazard.



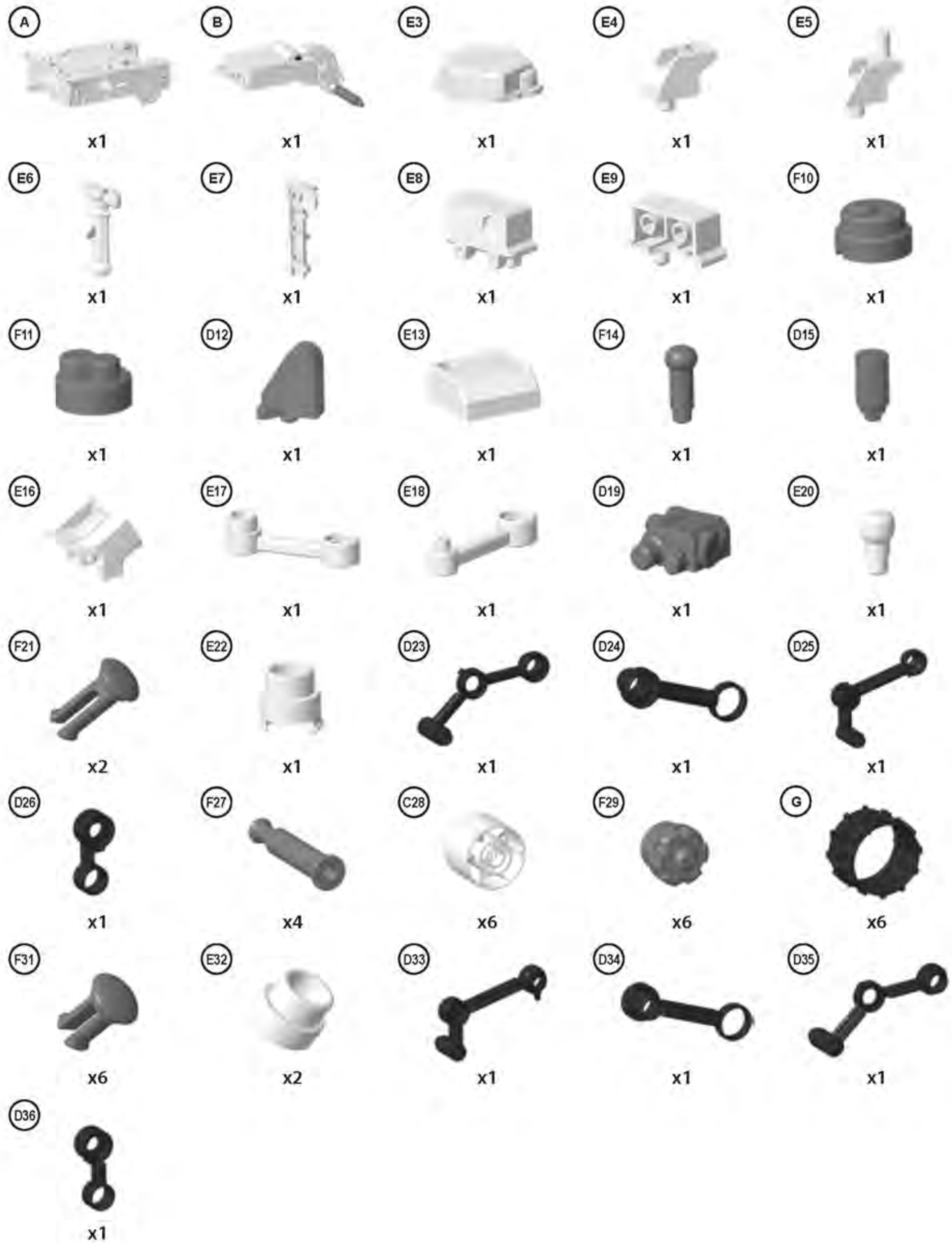
2. Separate all the pieces from the plastic frames and group them by type on a large table. The small parts you´ll be separating are also a choking hazard, so be cautious if there are small children or pets around. Below is a detailed exploded view of all the parts inside the box. Familiarize yourself with all of them before starting the assembly.





This is what our rover should like once it´s finished. This is our goal!

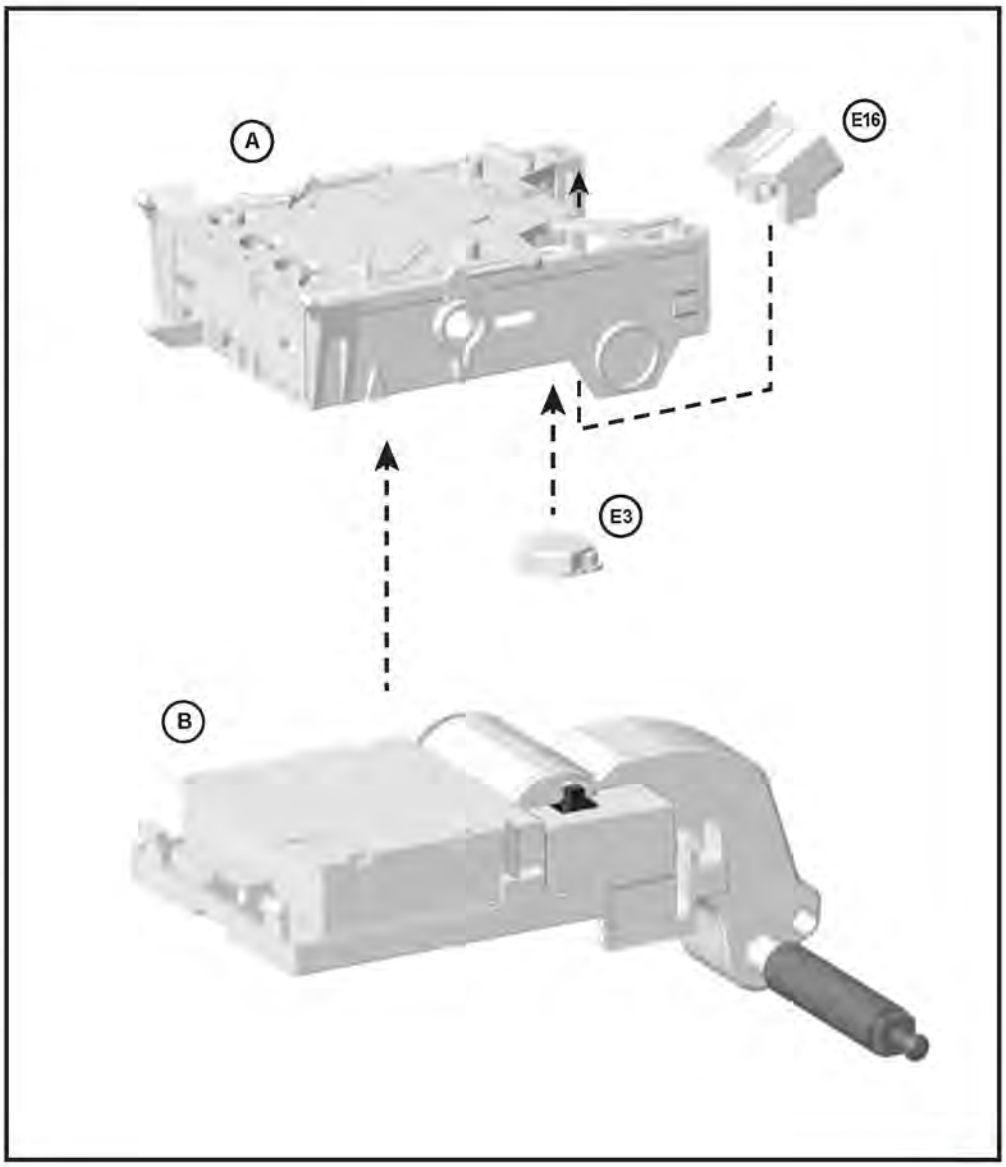
3. In the drawing below, you will identify each part using a letter and number. Find each part in your groups. The ¨x¨indicates the total quantity of each piece you should find.



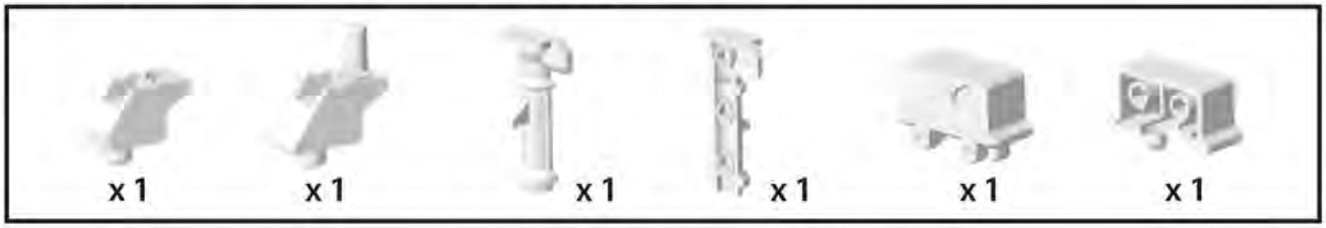
4. In this step, we will locate the two larger pieces marked as A and B, as well as the hexagonal flat button (which will start and stop our rover) and the E16 piece, which we will use soon.

5. Begin with part A and slide in part E16. Simultaneously, slide the E3 button on top of the electrical switch. Once they are in position, slide in part B, which contains the electric motor, demultiplication mechanism, and axes. They should click into place when properly assembled.

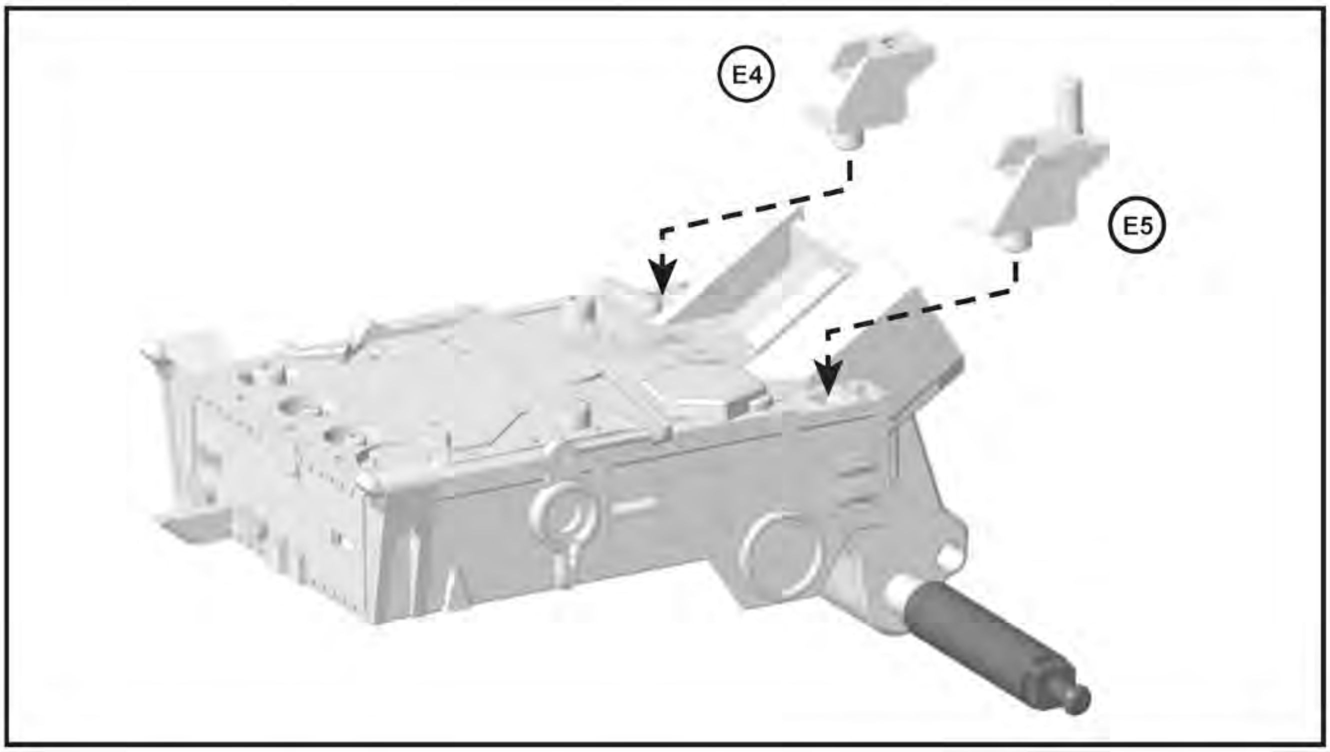
Part E16 represents our power source, which in the case of Perseverance is nuclear. However, don´t worry! We are not providing you with a nuclear battery. Our Perseverance will use regular AAA batteries.



6. Now, locate parts E3, E5, E6, E7, E8 and E9.

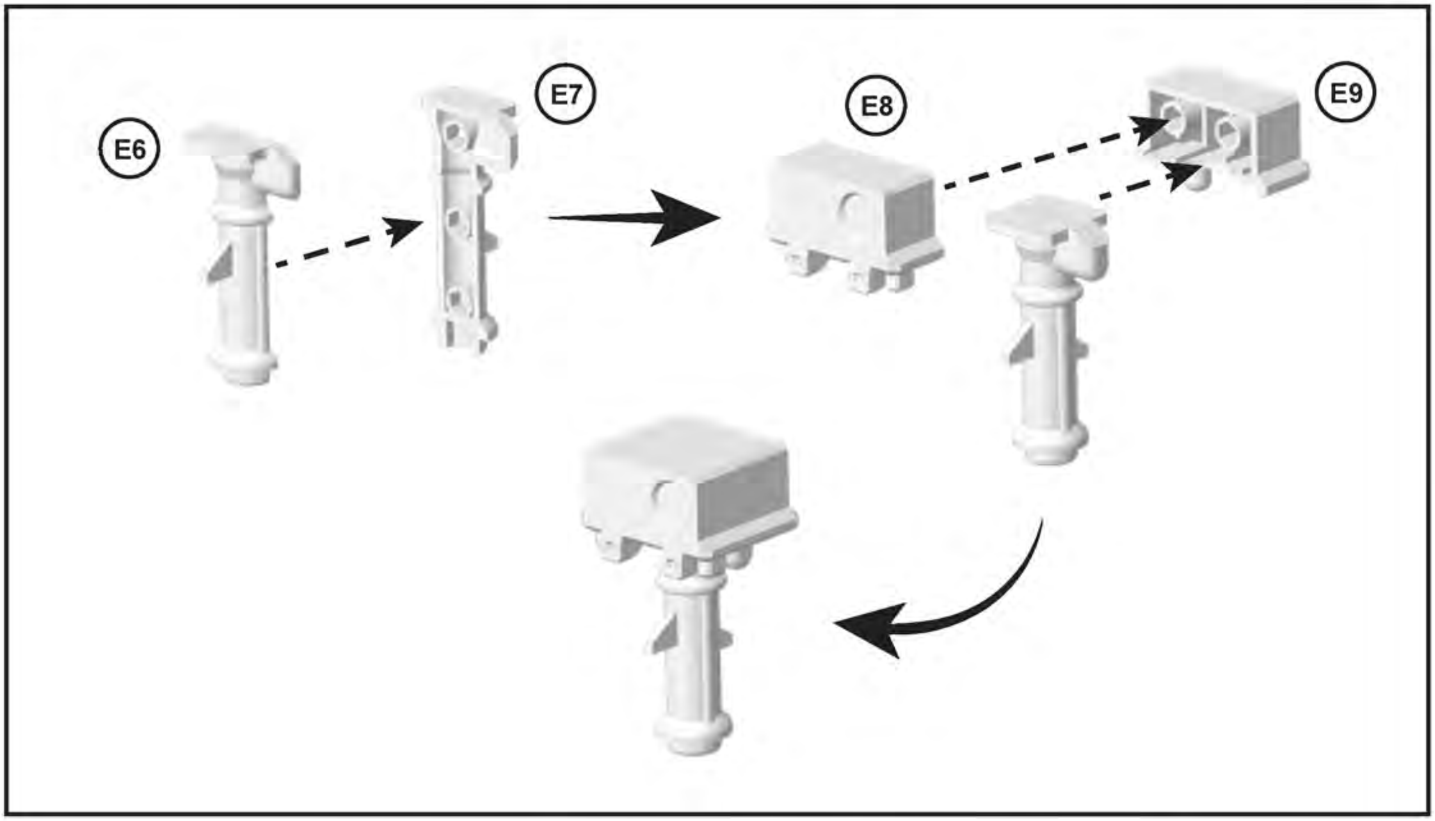


7. Connect parts E4 and E5 as shown in the figure below. These represent the instruments at the back of the Perseverance.

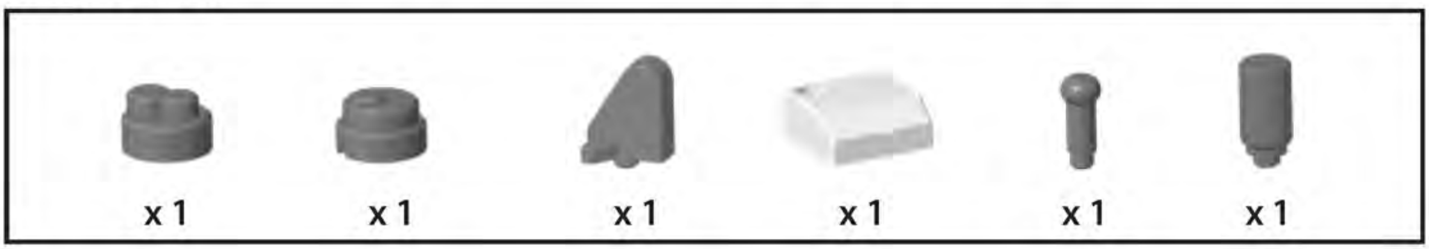


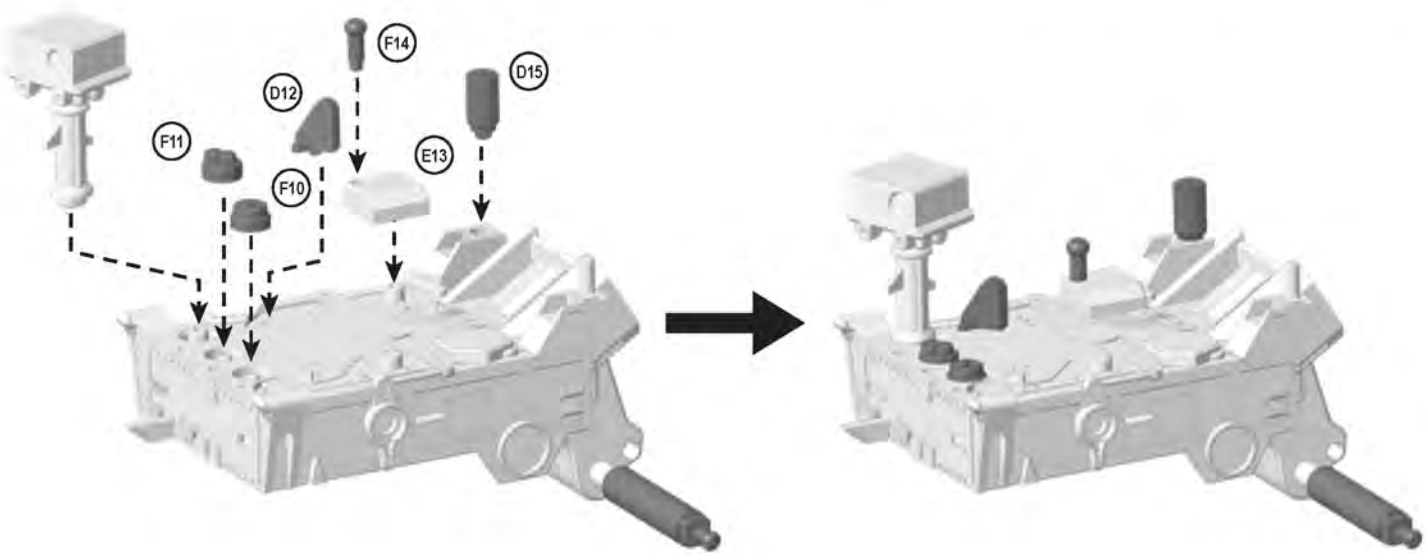
8. Our next task is to assemble the powerful camera system and its mast. It is called ChemCam, and with it, Perseverance can study rocks using a laser beam and analyze their components with a spectrometer. The mast also has optical cameras.

Connect the mast parts E6 and E7, and then secure the camera parts E8 and E9, anchoring the mast in he middle.

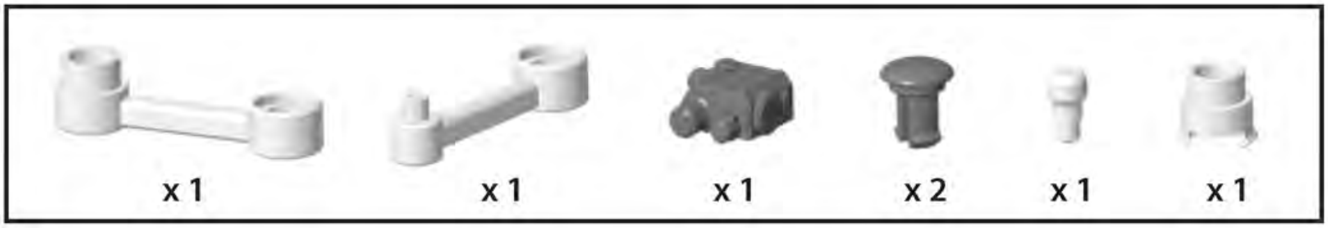


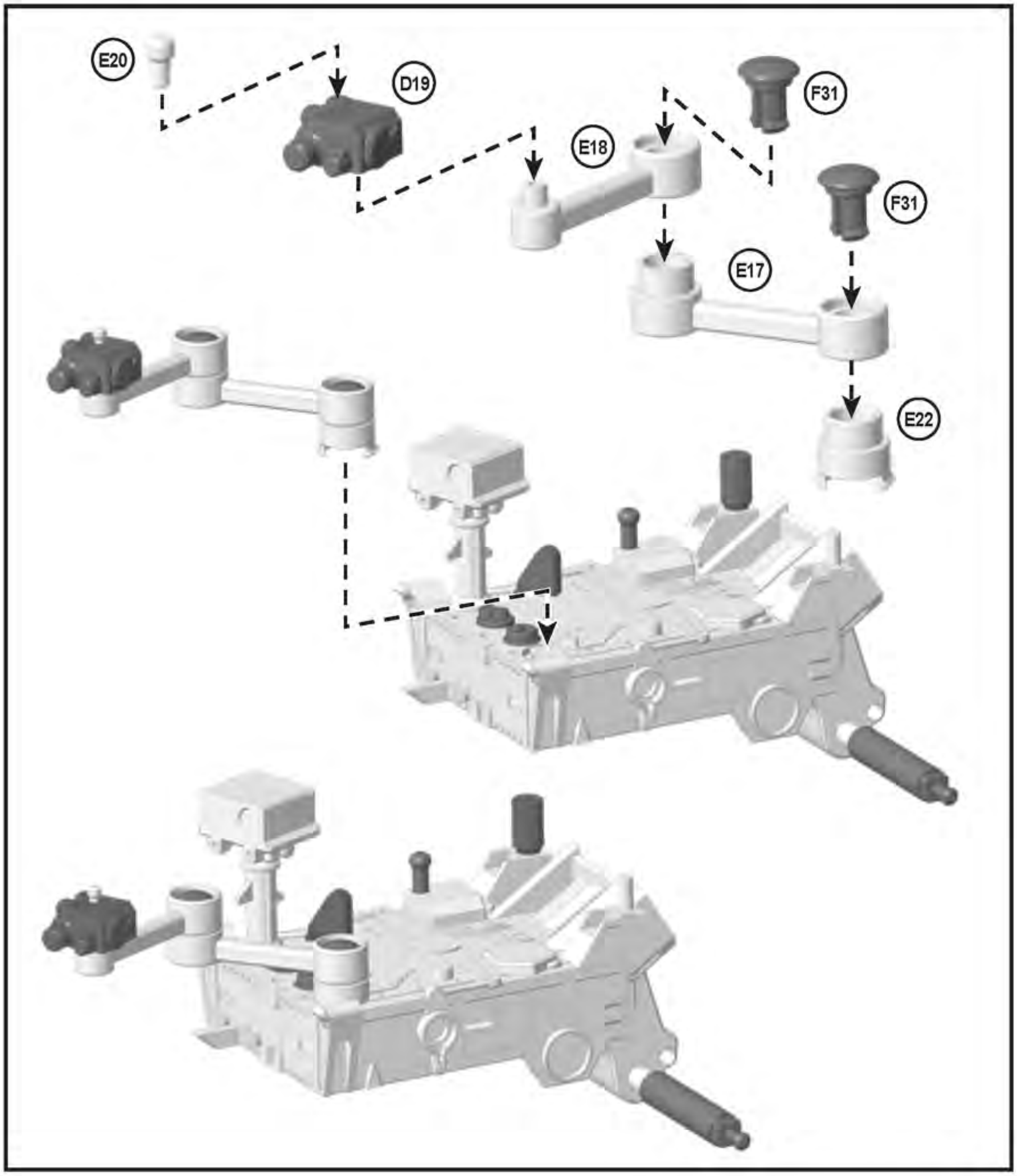
9. Next, identify the following parts: D12, D15, E13, F10, F11 and F14. Insert them as shown below.



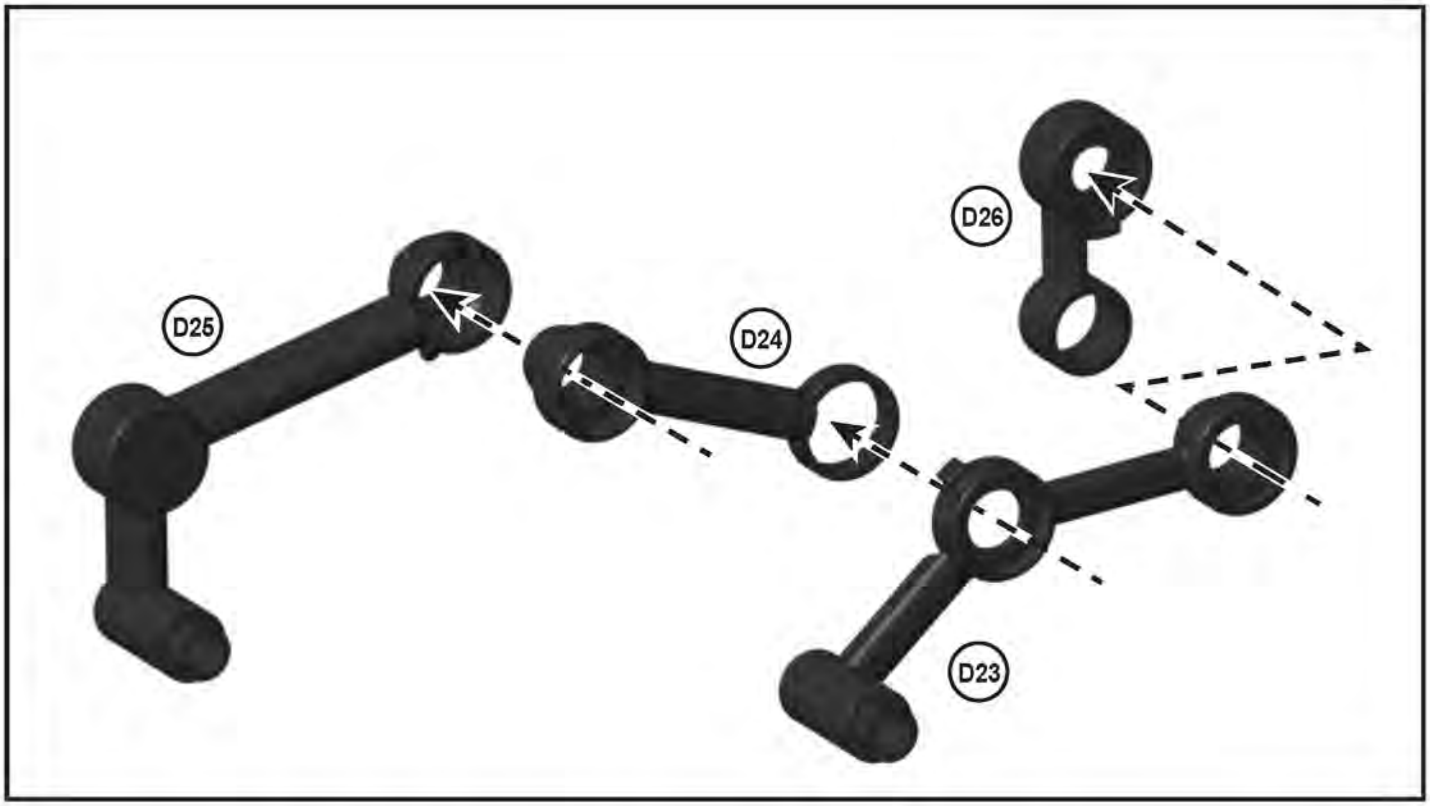


10. Find parts E20, D19, E18, E17, F31, and E22, and assemble them carefully following the sequence below. The F31 parts act as pegs to secure our assembly. This represents the robotic arm of our rover, which in the original Perseverance includes powerful tools and instruments for scientific tasks in the terrain.

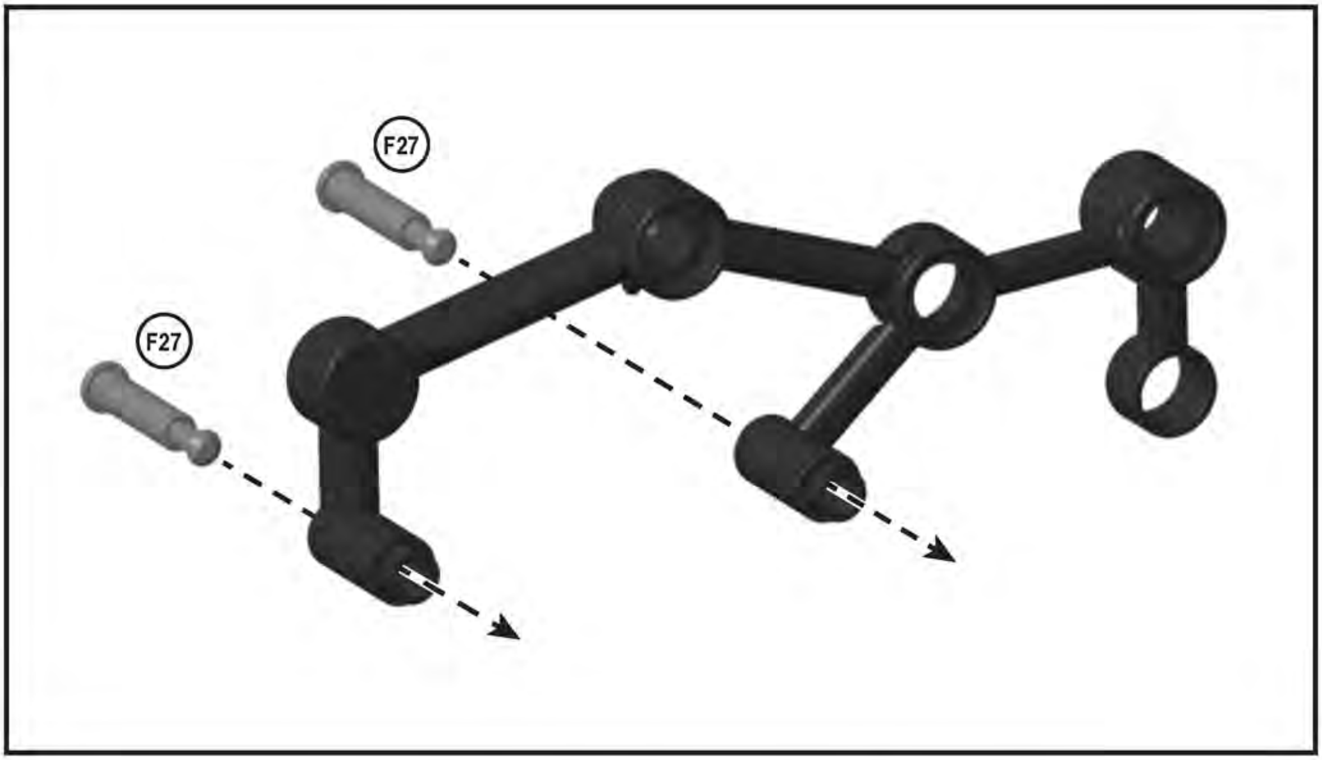




11. Now. let´s begin assembling the Rocker-Bogie mechanism to provide movement to one side of our rover. This part is very delicate, so please follow the drawings carefully. We will start with one side first. Identify parts D25, D24, D26, D23 and two F27 pegs. Assemble the D parts together first and then insert the F27 pegs. Having an extra set of hands will be helpful here, so ask for assistance.

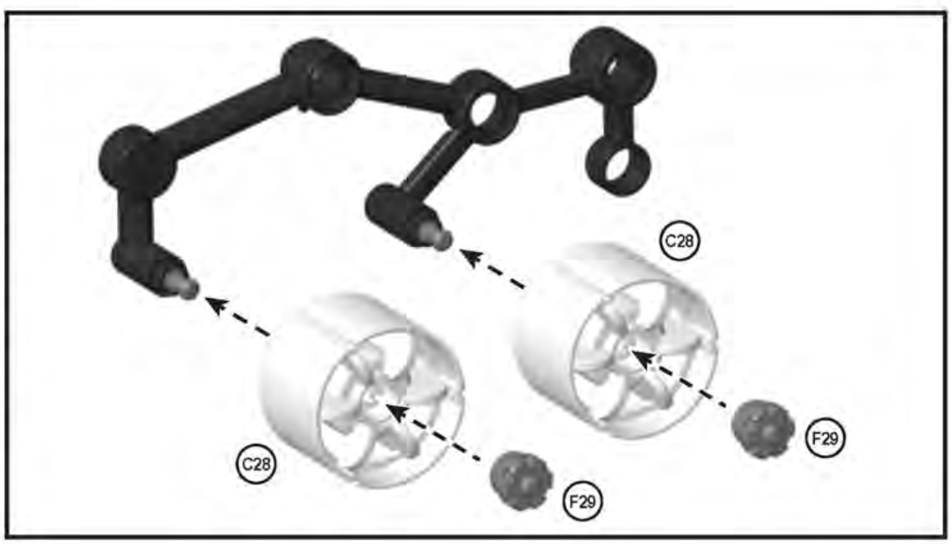


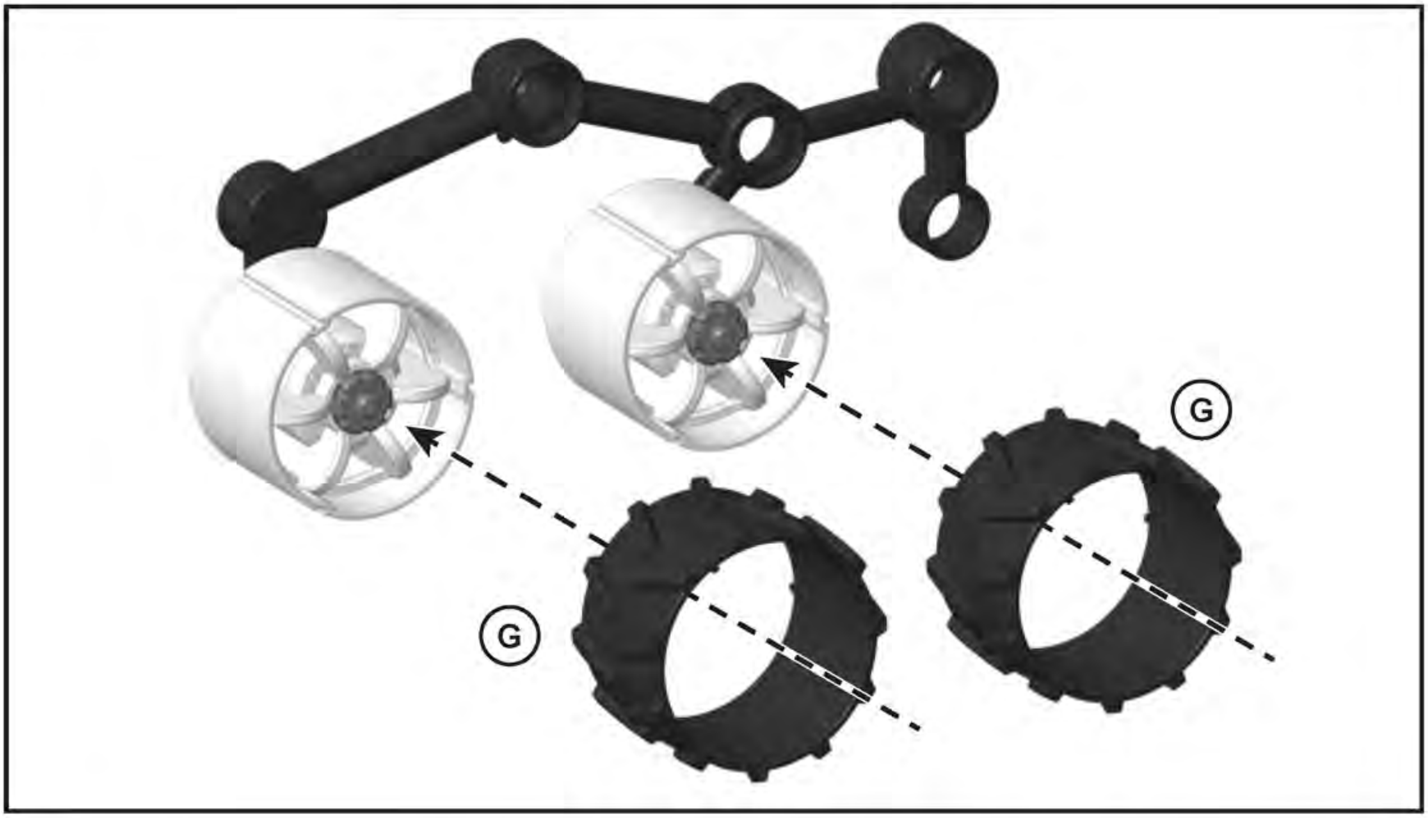
12. Double-check the next drawing to ensure you have correctly assembled this side.



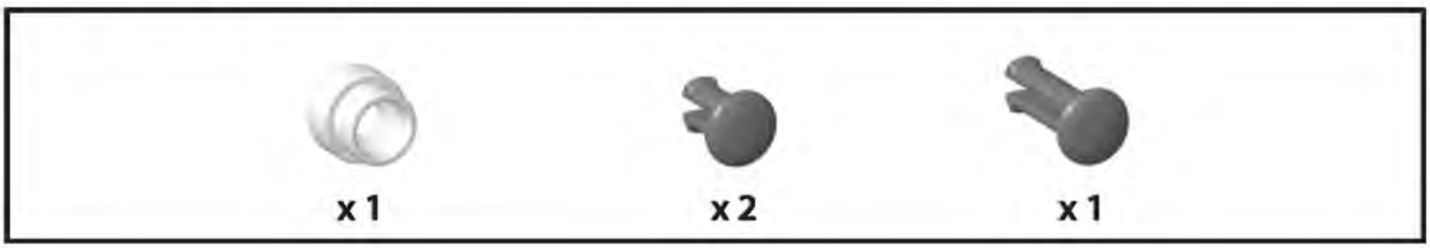
13. Next, let´s focus on the tires. Identify parts C28, G, and F29.

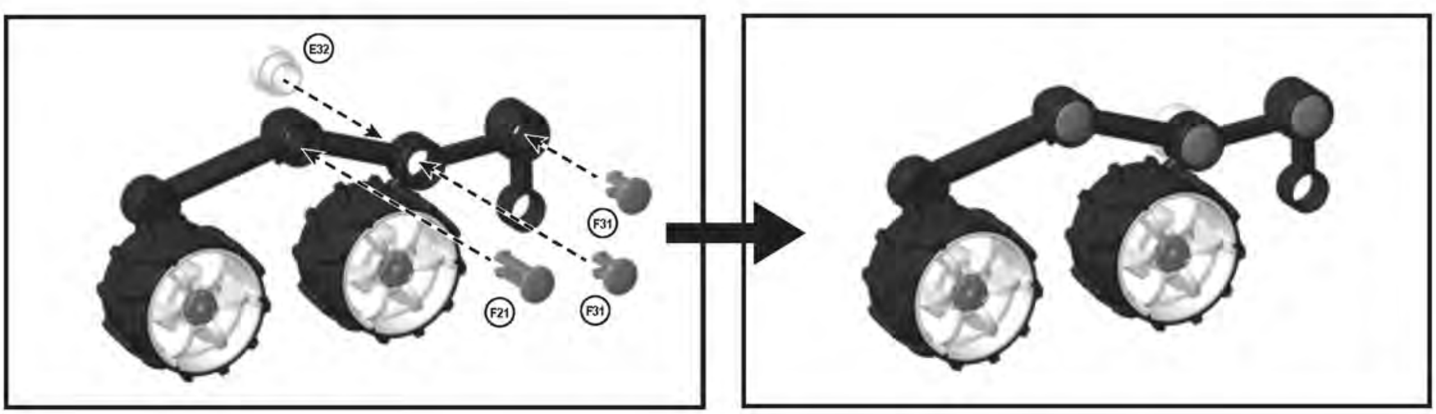
14. Using the side of the Rocker-Bogie mechanism you assembled earlier, attach the wheel rims C28 and secure them in place with F29. They should click and remain in place. Then, slide on the rubber tires, G.



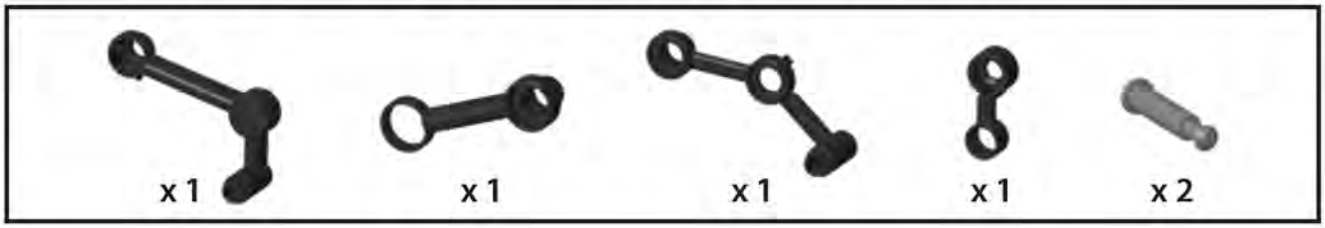


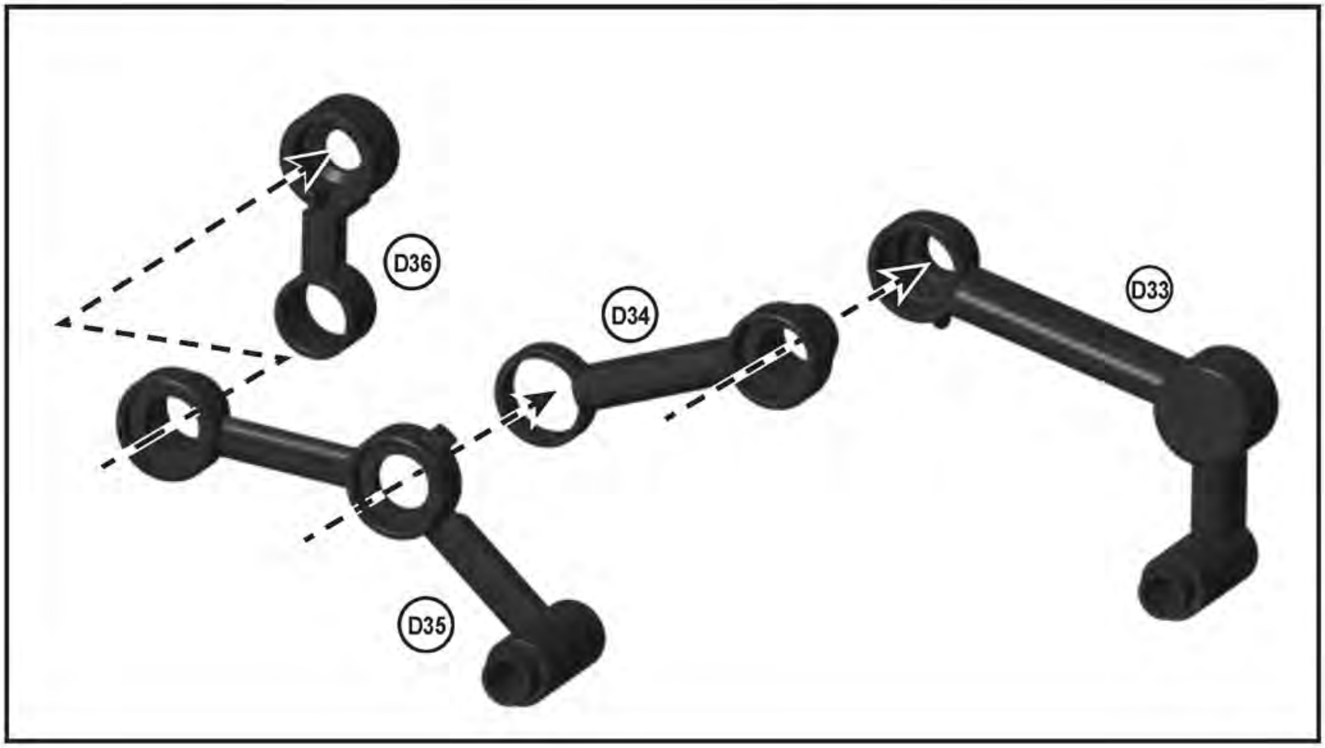
15. Find parts E32, and pegs F31 and F21 (be careful not to confuse them, as they have different lengths).

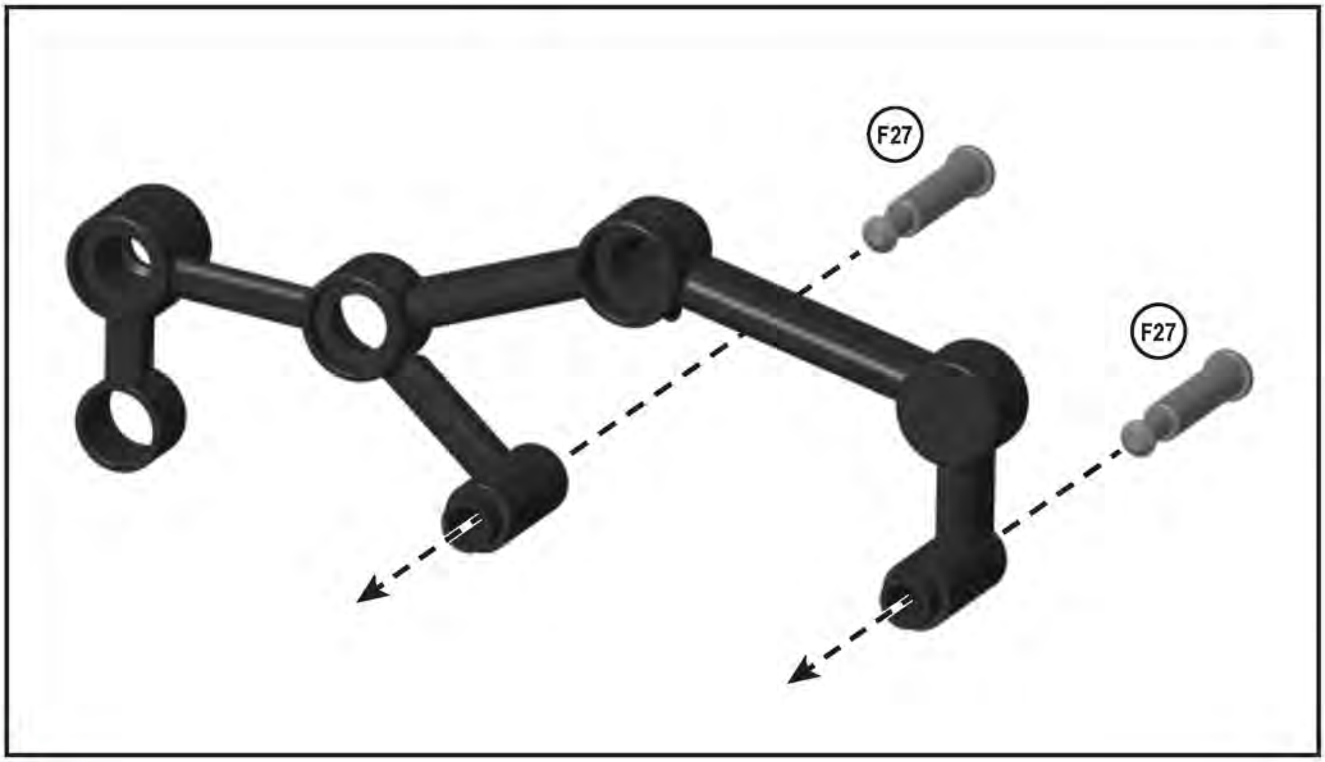




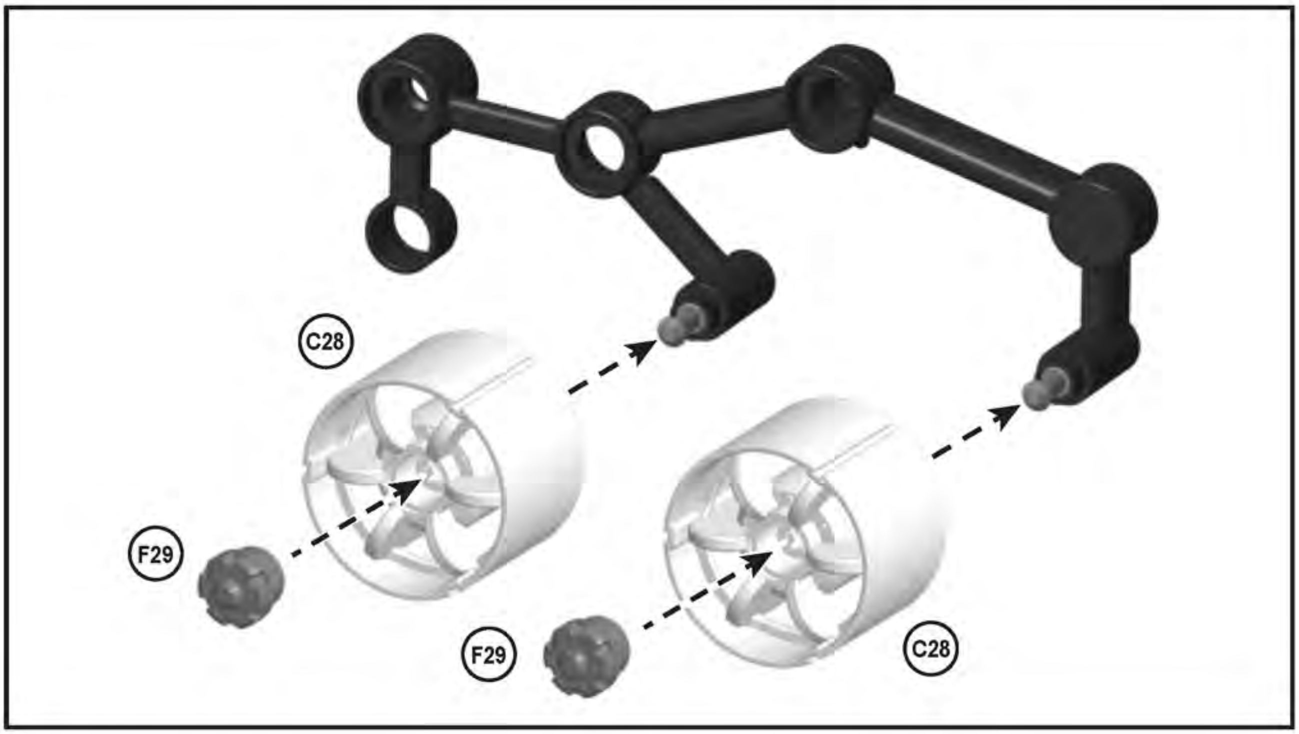
16. Now, let´s assemble the other side in the same manner as before.

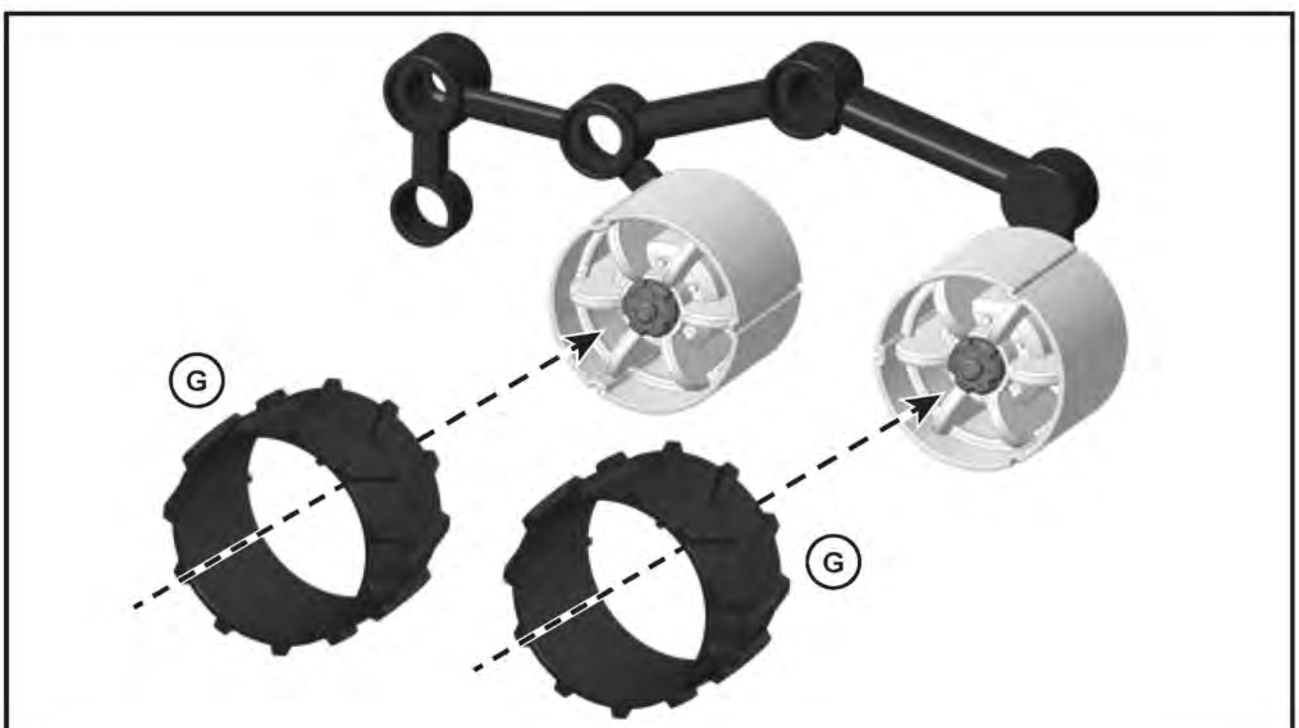


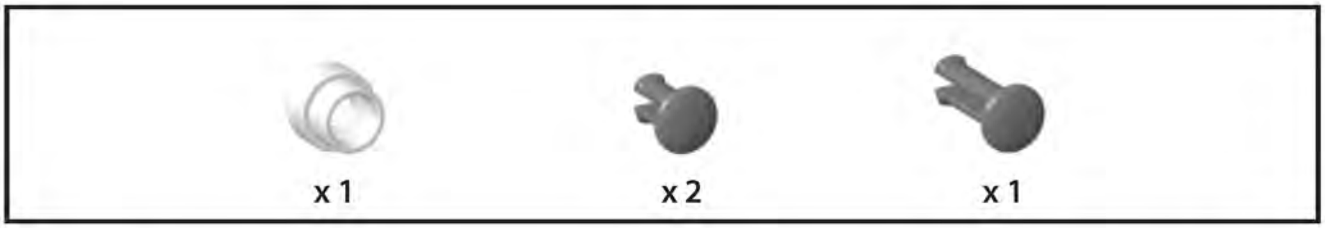


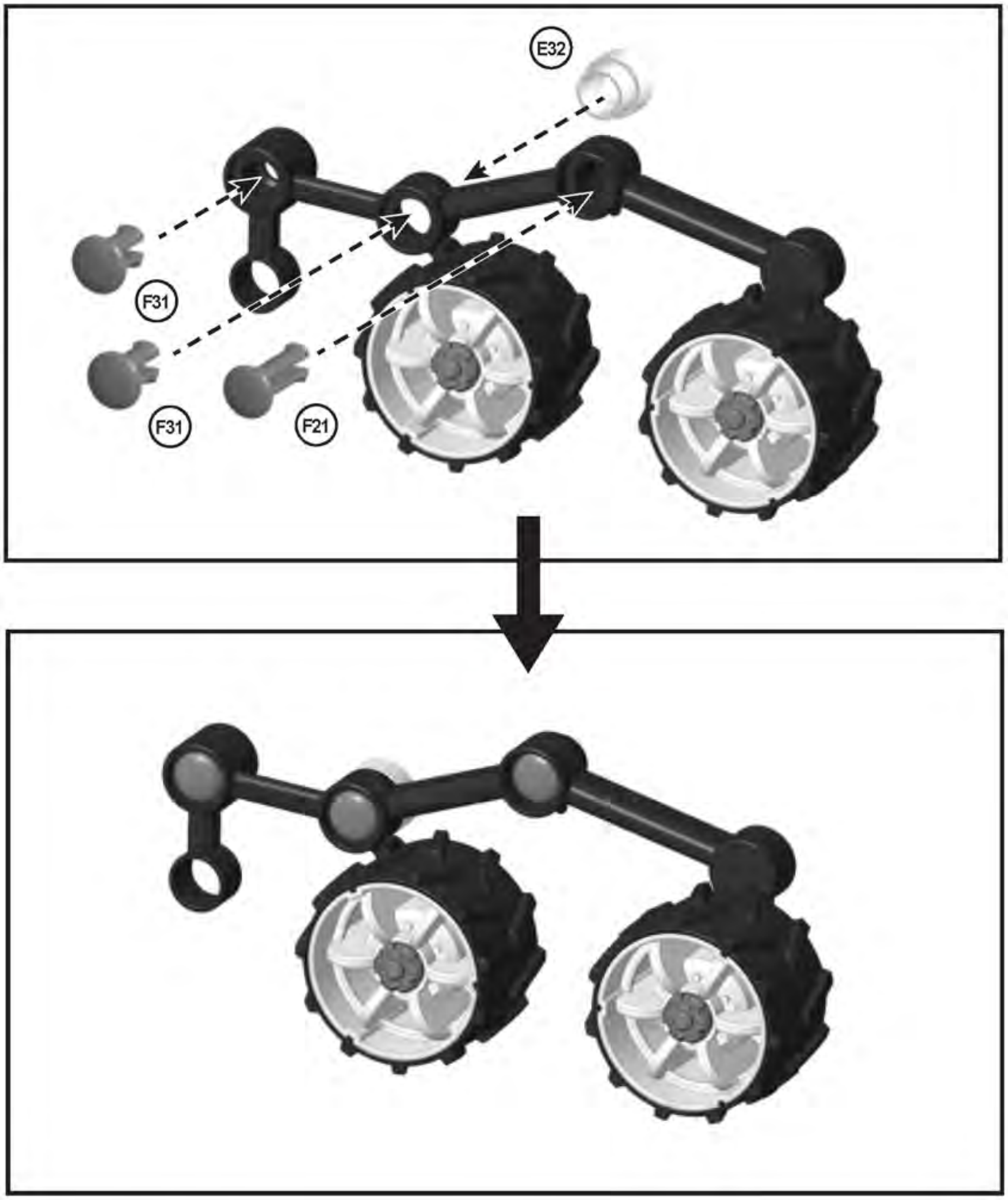


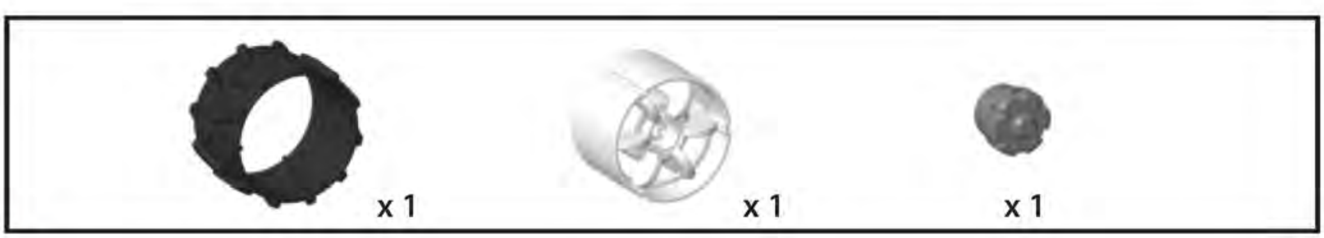
17. Repeat the process of assembling the wheels for the other side.



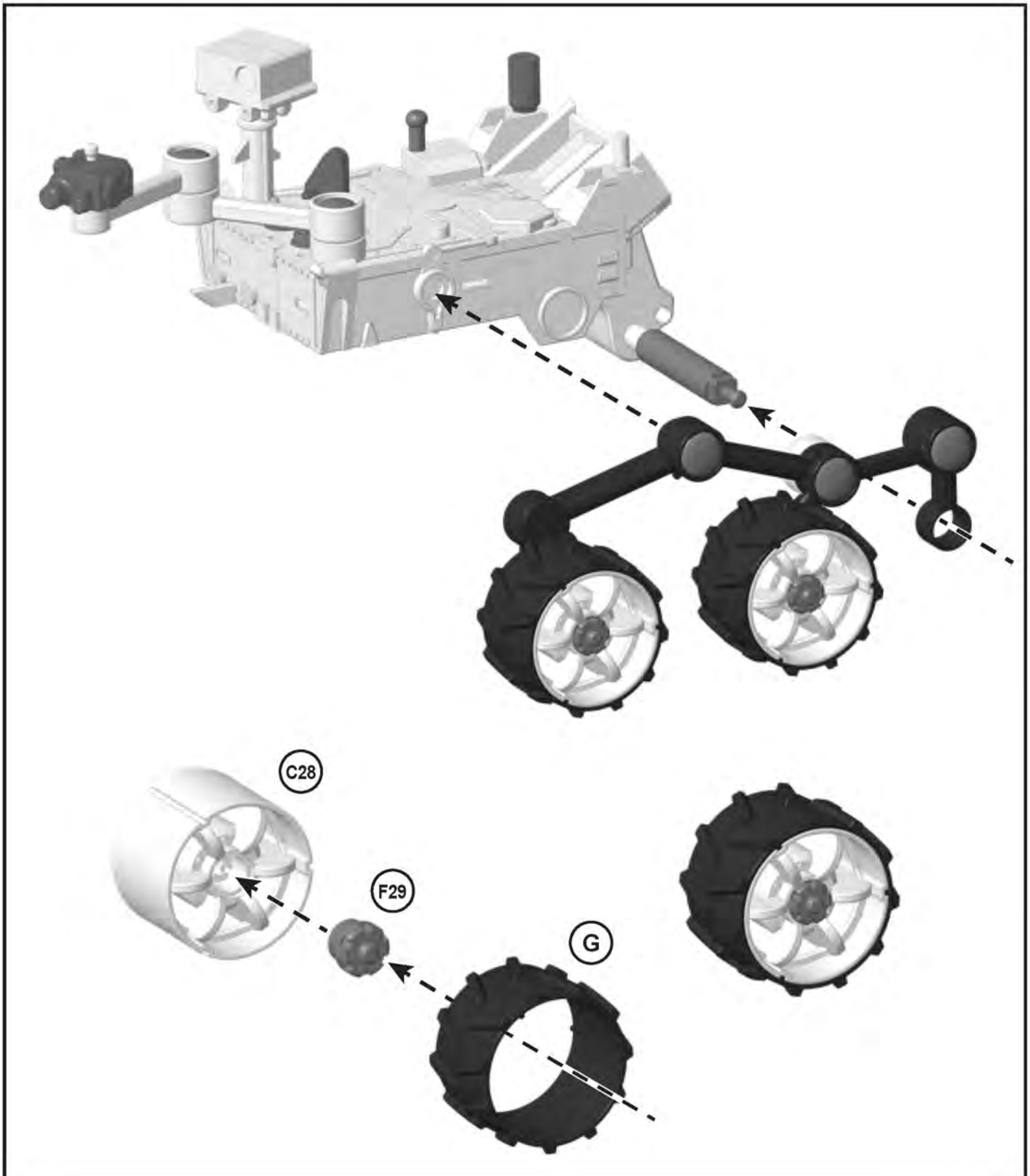


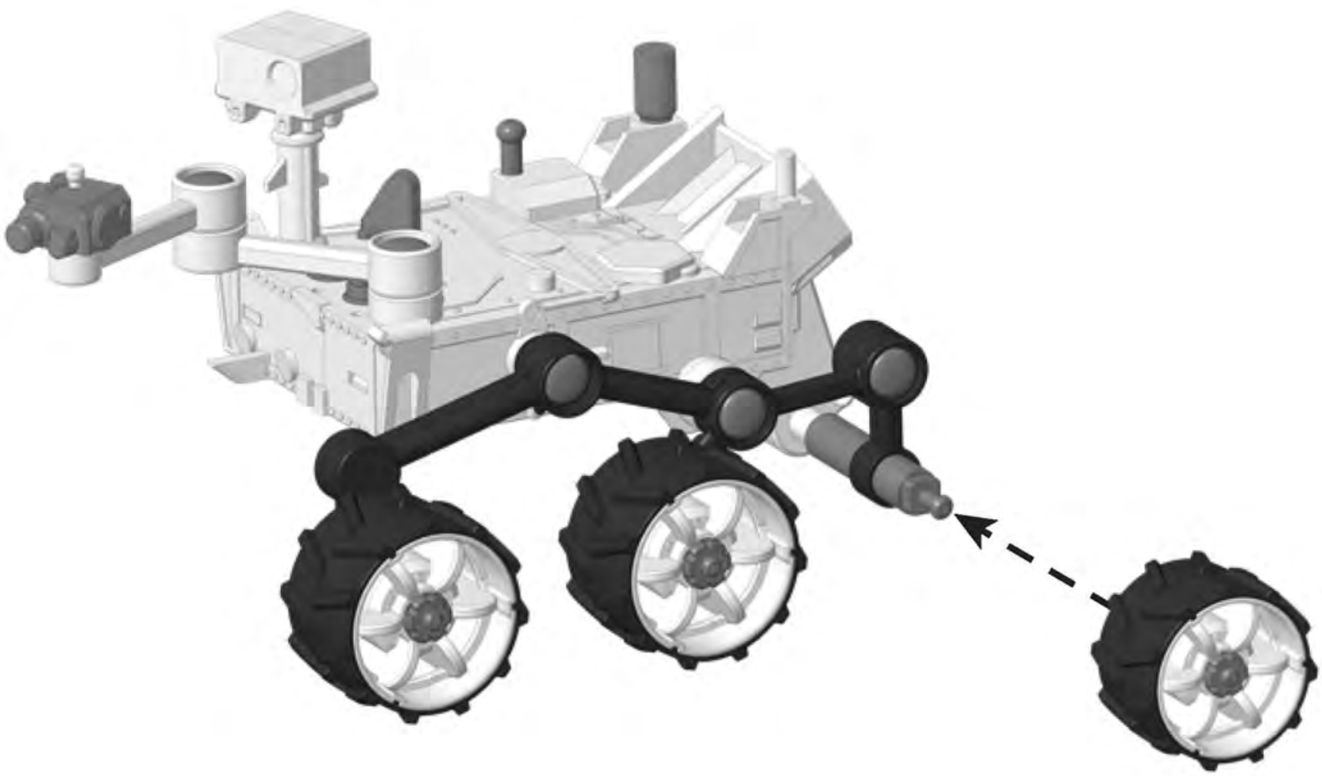

x 1
x 2
x 1

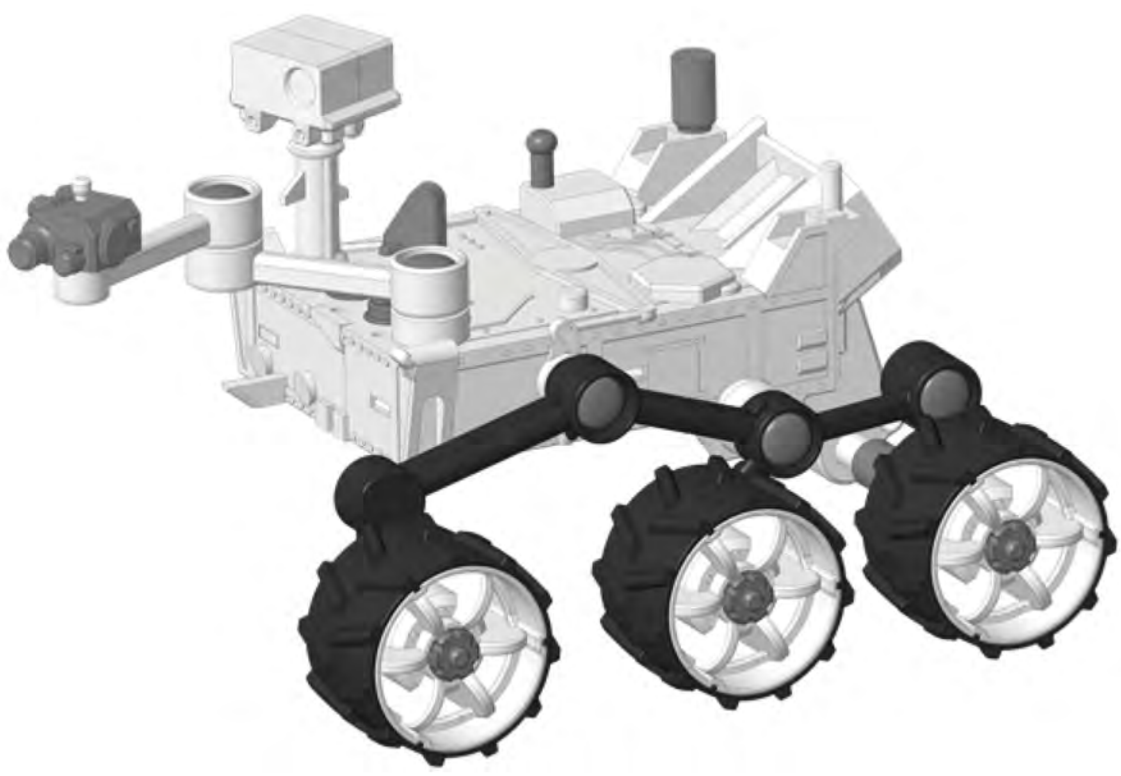

E32
F31
F31
F21


x 1
x 1
x 1

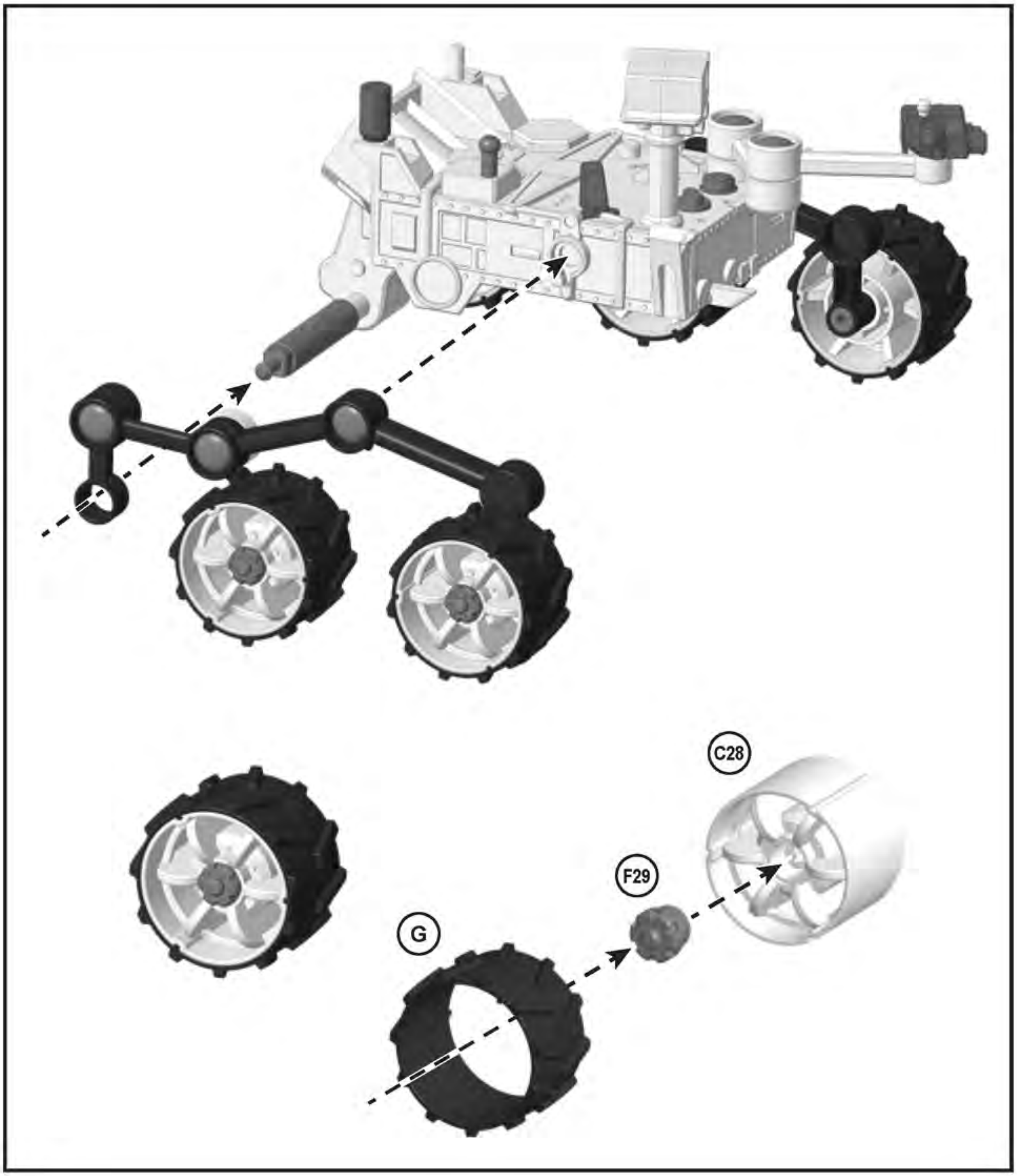
18. It's time to give our rover a complete look! Assemble the Rocker-Bogie mechanism on the left side, as shown in the figure below. Once it's done, attach the last wheel, which will secure the left portion of the three wheels.

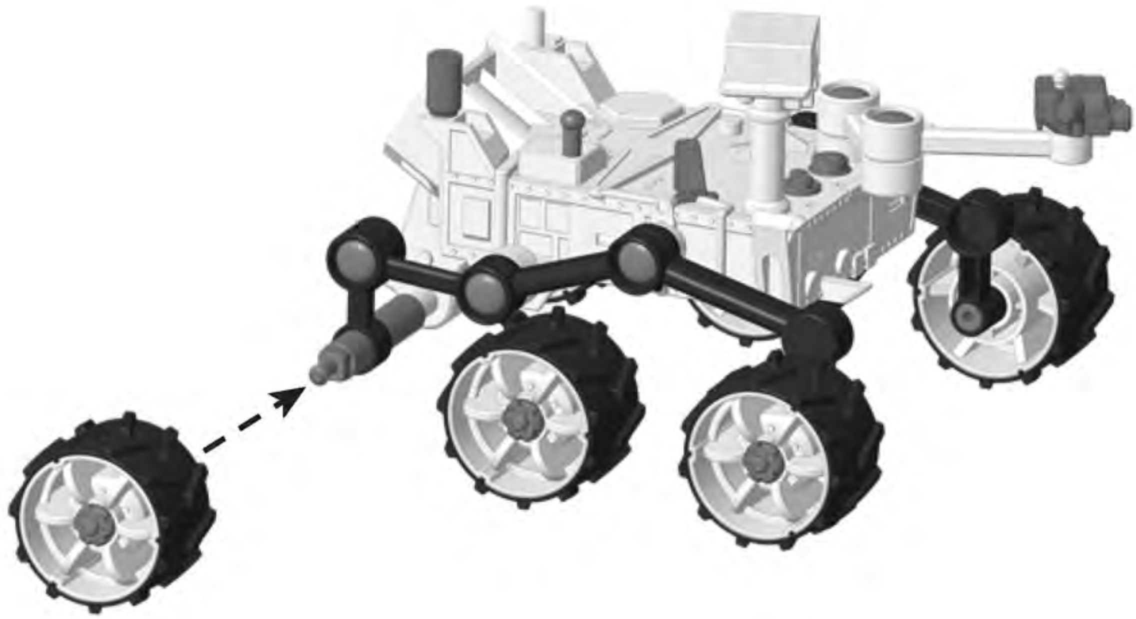




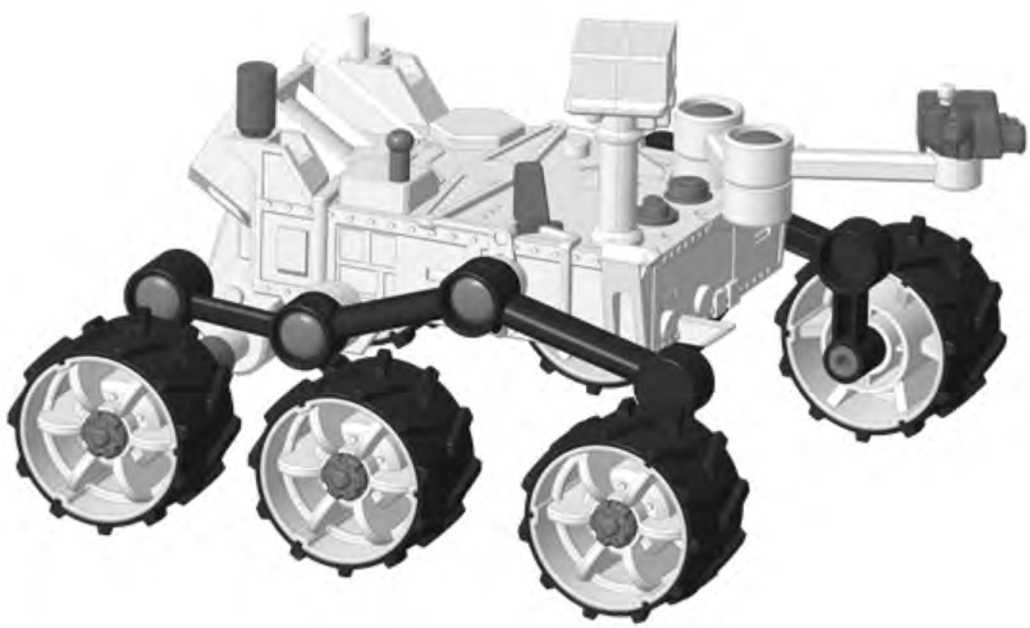


19. Now, repeat the same procedure for the right side. The last wheel will secure the Rocker-Bogie system.

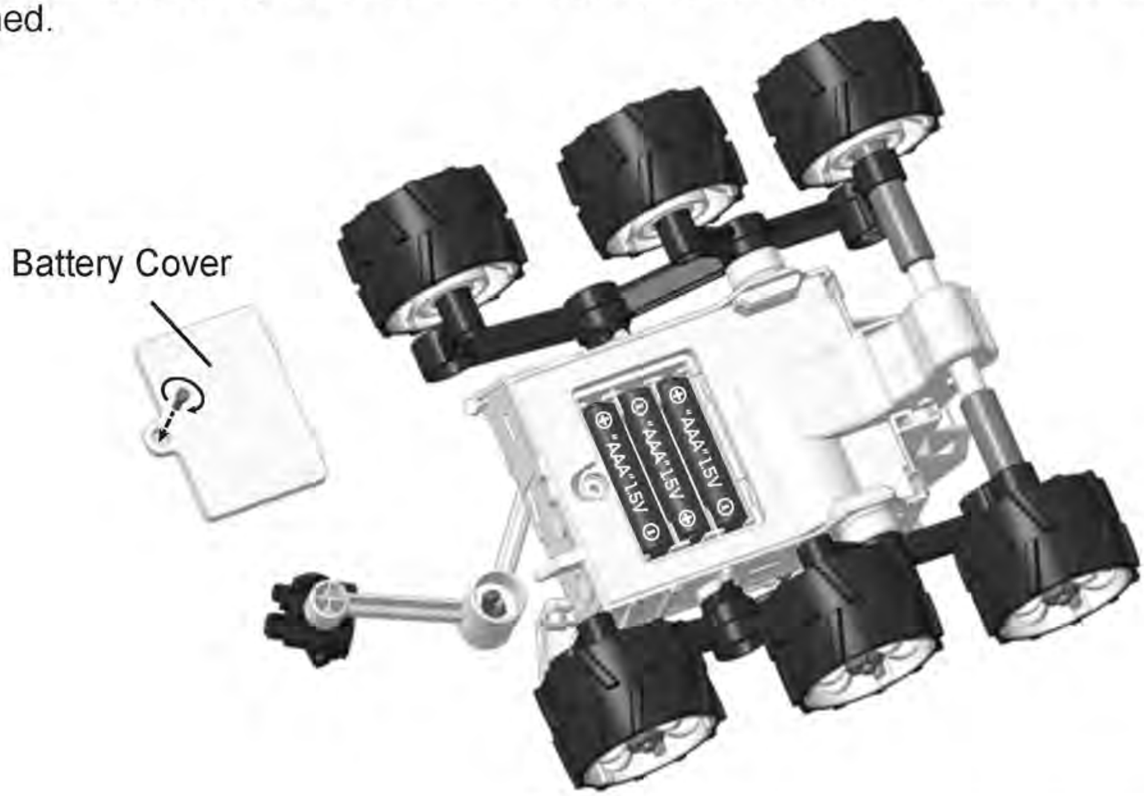




20. Now, our rover is almost complete!



21. At the back of the rover, you will find the battery compartment. You will need 3 AAA batteries. Use Alkaline batteries and install them as shown below. Seek assistance from an adult to help you with the batteries and to close the cover. You will need a small Phillips screwdriver (included) to secure the battery cover after the batteries are properly attached.



Use 3 x 1.5V AAA LR03/R03 batteries (Not Included)

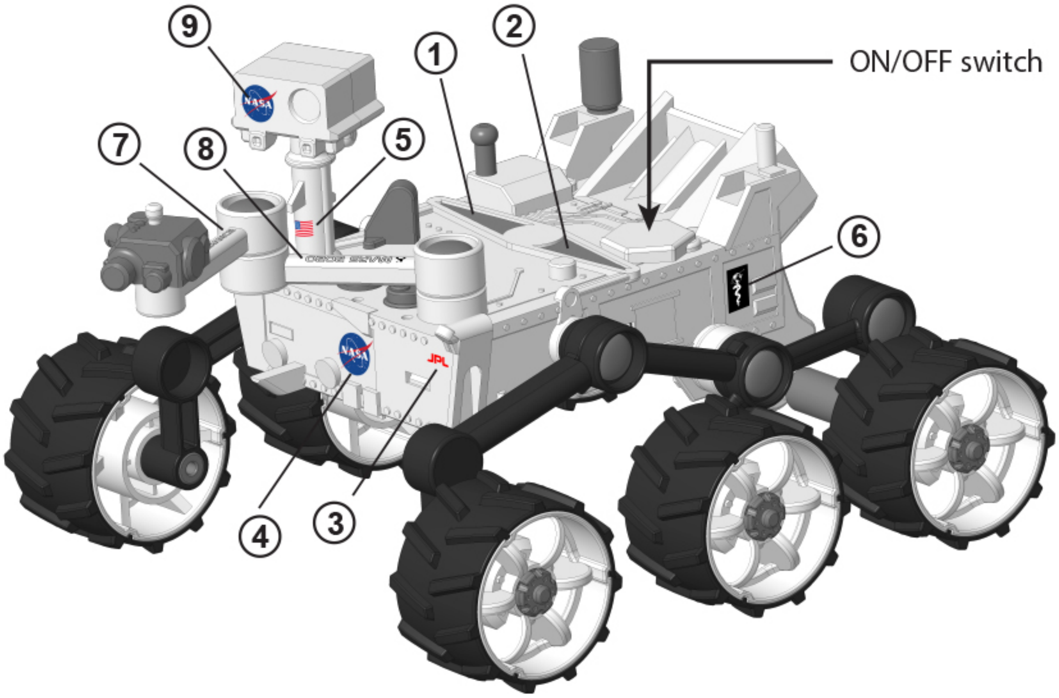
Battery Instructions

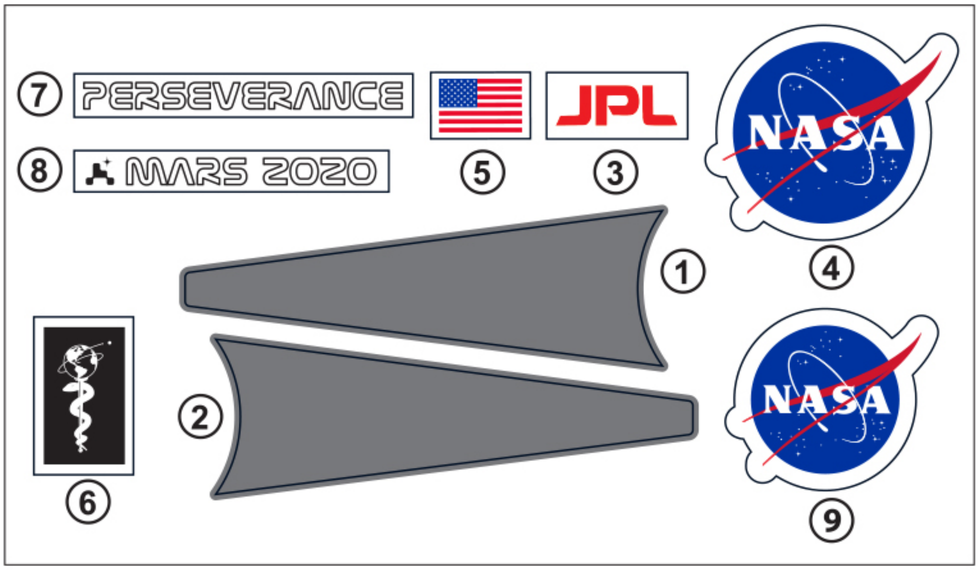
Unscrew and remove the battery compartment cover.
Insert three 1.5V AAA LR03/R03 batteries as shown.
Replace the cover and screw it down securely.

Battery Caution

- It is recommended to use alkaline batteries.
- Do not use rechargeable batteries.
- Use only the recommended batteries.
- Do not mix old and new batteries.
- Do not mix alkaline, standard (carbon-zinc), or rechargeable (nickel cadmium) batteries.
- Non-rechargeable batteries should not be recharged.
- Only use batteries of the same or equivalent type as recommended.
- Ensure the batteries are inserted with the correct polarity.
- Do not short-circuit the battery terminals.
- If the batteries are loose, bend out the contacts for a tighter fit.
- Remove exhausted batteries from the toy immediately and dispose of them properly; never dispose of batteries in fire.
- If storing the toy for long periods of time, make sure to remove the batteries.
- Periodically check the product for signs of damage to electrical parts; do not play with the product until any damage has been properly assessed.
- Batteries should be charged under adult supervision.
- Please keep this manual for future reference.

22. You will find some stickers to install on your rover. Please adhere them as shown below.





STICKERS

23. It's time to test your rover! Verify that everything is well connected and secure. Inspect your vehicle one final time and find a suitable place to perform your first test run. I suggest starting on a flat surface without obstacles, such as the floor. Once everything is ready, push the on/off switch (the hexagonal button we installed at the beginning) and be prepared to see your rover move! Once you become more familiar with its speed, you can do some testing.

24. Time to test our Perseverance!
Just like actual space scientists and engineers, it's time for us to test our rover. Since this robot can move, we need to test it in various situations and scenarios that closely resemble the conditions our rover will face on Mars.
Mars has a variety of terrains, although not as diverse as those on Earth. There are areas with more sand, hilly landscapes, and rocks. To perform our testing, we can try our rover in different areas. You may need to adapt since you might not have access to all the terrains I describe here, but as a future space designer, improvisation and adaptation are key. If you can't find the exact terrains, try to find something similar. Also, make sure you are in a safe place when testing. As most of your testing may be done outside, avoid construction zones or places with cars and streets. A playground can be the safest place to test your rover since you can find a variety of terrains there for your tests.

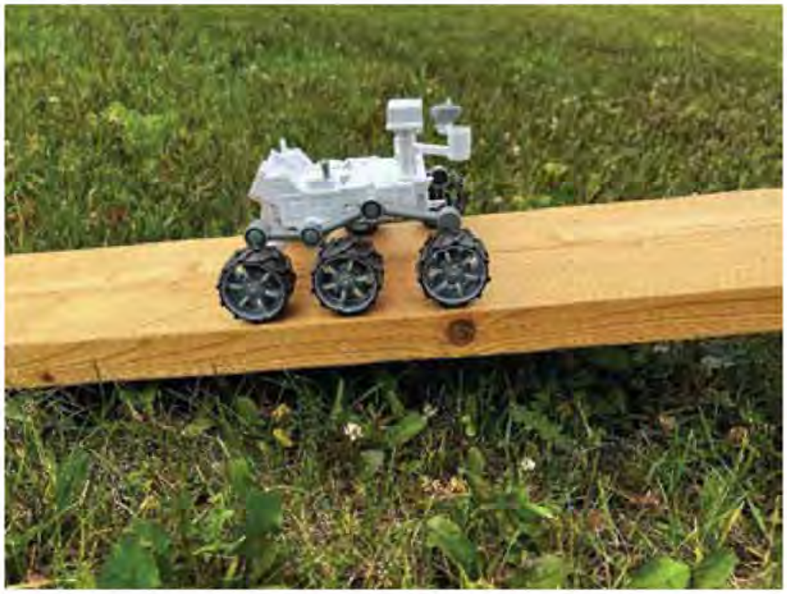
First, let's try our rover on a flat concrete terrain. Find any flat solid terrain made from concrete. Check the speed. An adult can help you measure the distance versus time. Use a watch, a cellphone with a stopwatch function, or a chronometer to time a few seconds. Then, use a measuring tape to measure the distance your rover covered in, let's say, 5 seconds. Write down the results and the type of material you tested the rover on. Also, note any additional observations, such as whether the wheels skipped during movement or if the rover veered to the side or moved in a straight line.

Second, let's move to a pavement. This can be any paved surface, typically black and hard. Once again, make sure you are not on a public road or in an area with cars, as you could accidentally get hit while testing. Turn on your rover and check the speed and record any other observations for later analysis.

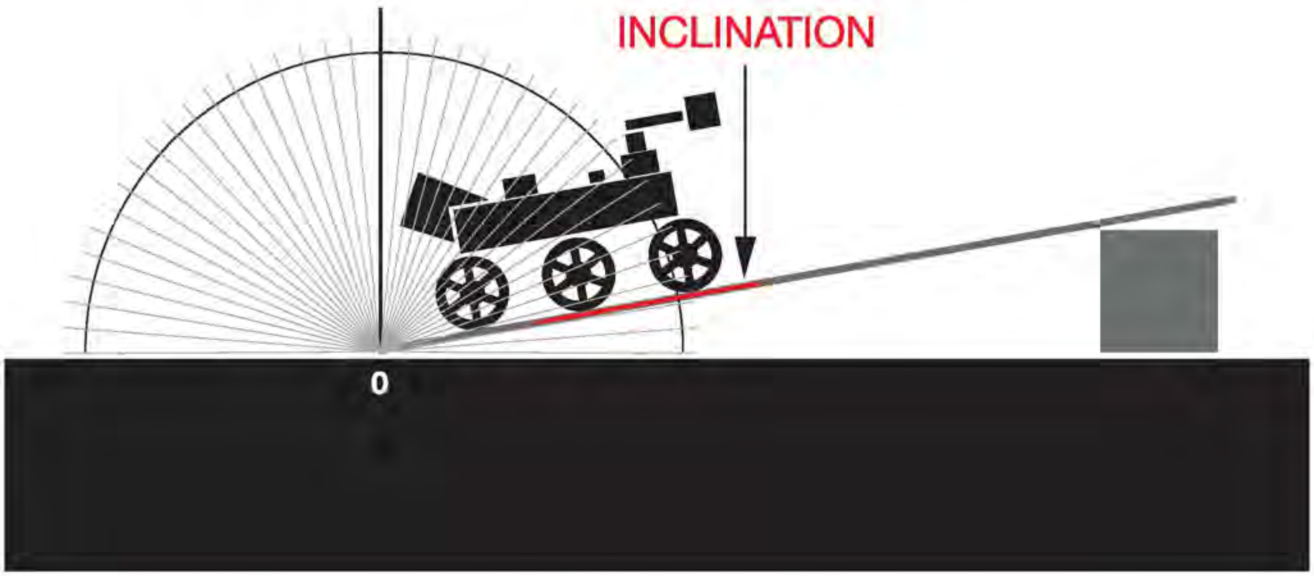
Third, let's find some sand. A children's playground is an ideal place for this test. Turn on your rover and observe and compare its performance with the previous surfaces. Is the sand making it easier or harder to move? Since Mars is mostly sandy, this experiment is extremely important.

Fourth, let's try a rocky terrain. The rocks can be pebbles or other types, but make sure they are small enough for our rover to climb. Large rocks won't work. Also, avoid rocks that are near water! Our rover will not get along well with water. The real Mars Perseverance can maneuver around rocks to find a path forward, but in our case, we need to find the right terrain for our rover. Compare how difficult or easy it is for our rover to move in a straight line on top of the rocks.

For our fifth and final test, let's try our rover on an inclined plane. Since Mars is not entirely flat and often has hills, we want to determine the maximum slope our rover can handle. To do this, use a wooden plank as shown in the picture below. You can use a different material such as hard plastic or sturdy cardboard. Place a box at one end to create an incline, and test it at different angles. Start with a small angle and gradually increase the inclination until the rover can no longer move forward (be careful not to let your rover fall off the plank!).



If you have a protractor from school, you can use it to measure the angles precisely. Align the 0 on the protractor with the start of the inclined plane. If you don't have a protractor, you can visit our website for a printable protractor that you can use for this experiment. Remember to write down your results.



Now that you have some results, it's time to draw conclusions. Which terrain performs better for Perseverance? How about the inclined plane? How steep of an incline can your Perseverance climb? You could even prepare a report on the history of Mars rovers, the assembly of Perseverance, and how your testing went. Your science teacher might appreciate seeing it!

I hope you enjoyed learning about the history of Mars exploration and building and testing your Perseverance. There is much more to learn about space!

For more space educational toys, please visit our website at **www.futureexplorers.us**

Para instrucciones de armado en su lenguaje, por favor visite nuestro sitio web: **https://www.futureexplorers.us/**

Per le istruzioni di montaggio nella vostra lingua, vi preghiamo di visitare il nostro sito web: **https://www.futureexplorers.us/**

Für die Montageanleitung in Ihrer Sprache besuchen Sie bitte unsere Website: **https://www.futureexplorers.us/**

Para as instruções de montagem no seu idioma, por favor, acesse o nosso site: **https://www.futureexplorers.us/**

Pour les instructions de montage dans votre langue, veuillez vous rendre sur notre site Web : **https://www.futureexplorers.us/**

للحصول على تعليمات التجميع بلغتك، يرجى زيارة موقعنا على الإنترنت:

https://www.futureexplorers.us/

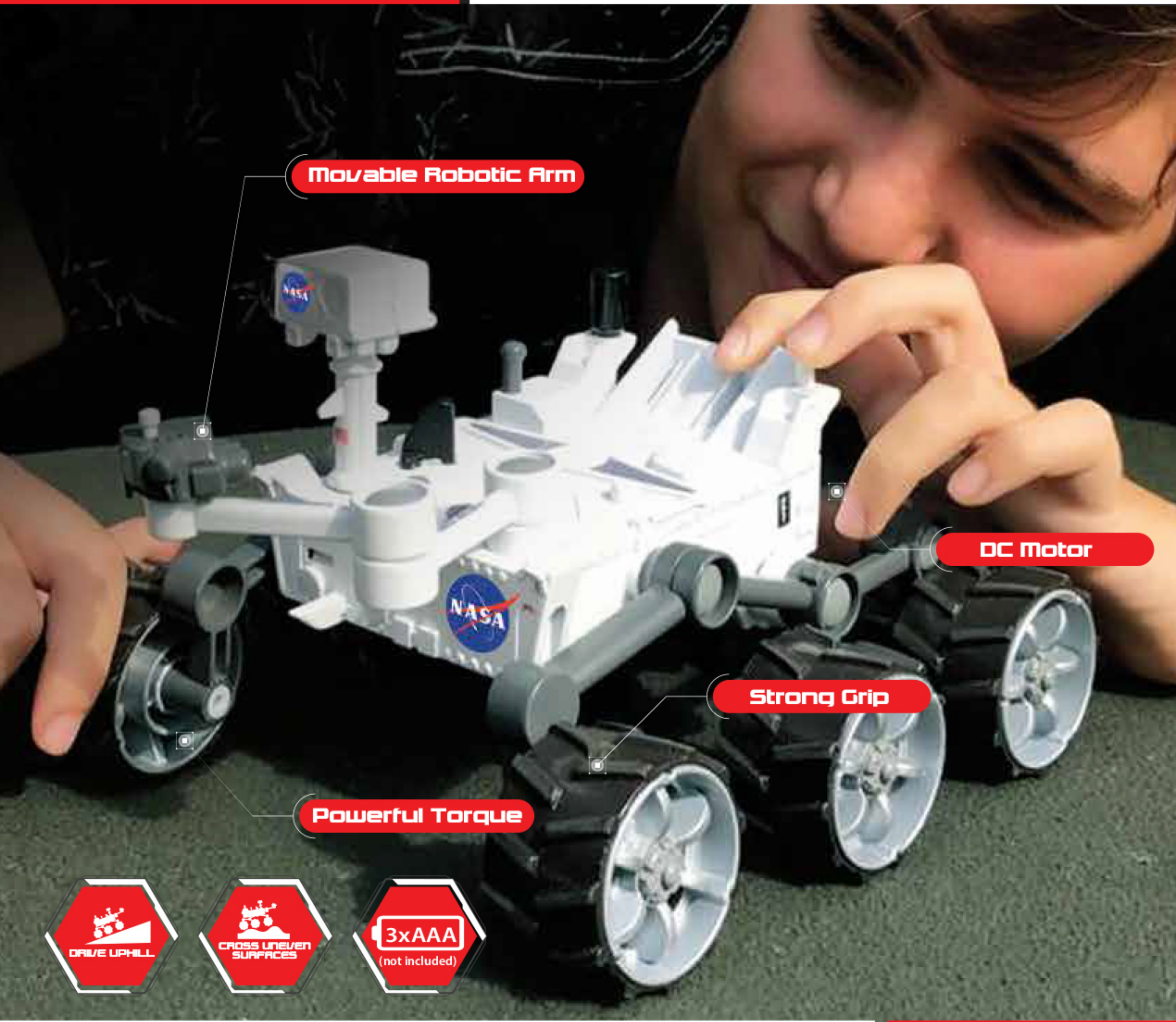
Future Explorers™

www.futureexplorers.us

INSPIRED BY NASA's SPACE PROJECTS

PERSEVERANCE MARS ROVER

REFERENCE, USER AND ASSEMBLY MANUAL



STEM.ORG AUTHENTICATED EDUCATIONAL PRODUCT

DESIGNED BY Dr. Pablo SPACE RESEARCHER

DESIGNED IN THE USA

MADE IN CHINA

0-3

PLAY MIND®