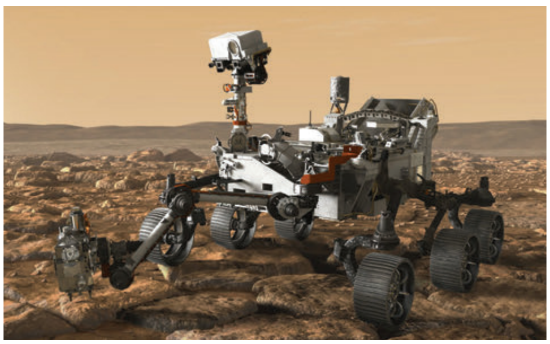
National Aeronautics and Space Administration

Mars 2020 Launch Nuclear Safety

NASA's Mars 2020 mission is scheduled to launch aboard an Atlas V rocket from Launch Complex 41 at Cape Canaveral Air Force Station in Florida in July 2020. The rover is designed to explore the geology of its landing site seeking signs of habitable conditions on Mars in the ancient past, search for signs of past microbial life itself, and—for the first time—collect and store the most promising samples of Martian rocks and soil for possible return to Earth by a future mission.

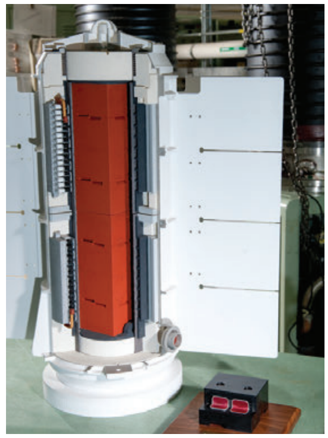
The design of the Mars 2020 rover is based on NASA's Curiosity rover, which was launched on a similar rocket and landed successfully on Mars in August 2012.



The Mars 2020 rover carries seven scientific instruments, plus a large robotic arm with a system to drill and collect samples of the Red Planet. The rover's radioisotope thermoelectric generator is located at the back of the rover, on the right of the image, with two of its flat, white radiator fins visible.

Similar to Curiosity, Mars 2020 receives its electrical power from a Multi-Mission Radioisotope Thermoelectric Generator (MMRTG). Built by the U.S. Department of Energy (DOE) for NASA, the MMRTG is an updated version of similar radioisotope power systems used for more than 40 years to safely and successfully provide electricity to numerous U.S. civil space exploration missions, including Galileo at Jupiter, Cassini at Saturn, and the ongoing Pluto-New Horizons mission. The MMRTG enables the range and productivity of the Mars 2020 rover—which needs to operate extremely efficiently to accomplish its prime mission—by allowing the rover to work free of limitations associated with solar panels, such as the daily and seasonal variations of sunlight on Mars and the accumulation of fine Martian dust.

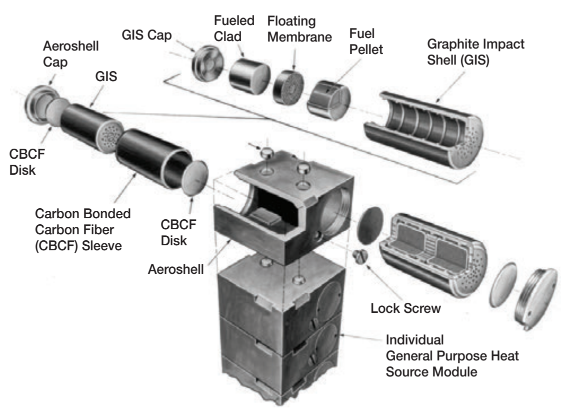
An MMRTG contains 10.6 pounds (4.8 kilograms) of plutonium dioxide as a dependable source of heat used to produce the electricity; the power system produces about 110 watts of electric power at the start of the mission, which charges a large battery inside the rover. The main type of plutonium used in a radioisotope power system, plutonium-238, is different from the material used for nuclear weapons, and it cannot explode like a bomb. The extra heat from the plutonium dioxide fuel in the MMRTG also warms the rover's internal systems during the sub-zero temperature Martian nights and winters.



Full-scale cutaway models of an MMRTG (left) and one of its eight General Purpose Heat Source modules (lower right); each of the modules contain four pellets of heat source plutonium dioxide protected inside several layers of protective material. An MMRTG is about 26 inches (66 centimeters) tall and has a mass of about 98 pounds (45 kilograms).

Although any type of launch accident is unlikely for the Mars 2020 mission, and an accident that results in a release of the plutonium dioxide fuel is more unlikely, analysis of a wide range of possible accident scenarios acknowledges that it is possible that some of the plutonium dioxide fuel inside the MMRTG could be released. In order for this situation to pose a potential health risk, the released fuel particles must be small enough to be carried away by winds into the atmosphere or onto food crops, and then inhaled or swallowed.

The General Purpose Heat Sources (GPHS) inside the MMRTG is designed specifically to prevent such an occurrence. The fuel inside each GPHS is surrounded by several layers of protective materials, including the type of tough material used in the nose cones of missiles designed to survive fiery conditions during re-entry into Earth's atmosphere. In addition, the radioisotope fuel is manufactured in a ceramic form (similar to the material in a coffee mug) that resists being broken into fine pieces, reducing the chance that hazardous material could become airborne or ingested.

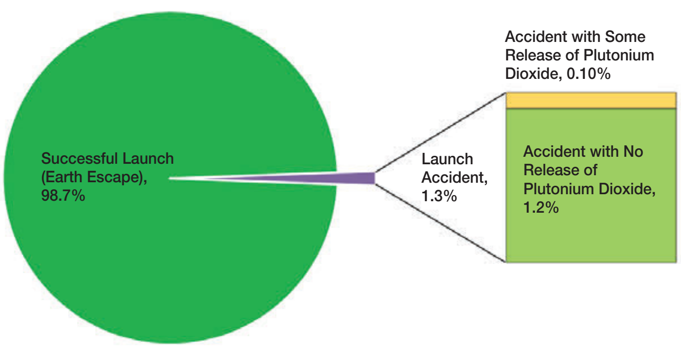


Each MMRTG heat source module includes several layers of protective material

NASAfacts

Extensive technical analysis and computer modeling of the planned launch of Mars 2020 has been conducted by NASA and DOE. This work includes review of all similar past expendable rocket launches and detailed studies of potential accident scenarios. The most recent technical analysis found that the most probable outcome for Mars 2020 is a successful launch, with a 98.7 percent probability. The chances of any launch accident are small—about 1.3 percent (a 1 in 80 chance). The overall chance of a launch accident that would be severe enough to release some amount of radioisotope fuel is smaller—about 0.1 percent (a 1 in 960 chance of a launch accident with some release).

NASA and DOE evaluated a wide range of accident scenarios across all phases of launch—starting from ones before or during the first few seconds of launch that could affect central Florida, to ones where the spacecraft reaches Earth orbit but cannot leave on its journey to Mars. There is about a 1 in 1,100 chance of an accident that would release some amount of plutonium dioxide in the region of influence in Florida (defined to be within 62 miles, or 100 kilometers, of the launch site). There is about a 1 in 12,000 chance of an accident outside the launch area that would release some amount of plutonium dioxide.



The chances of a Mars 2020 launch accident are small (1.3%) and the chance of an accident that would release any plutonium dioxide fuel are about 12 times smaller (0.1% of all launches). Image source: NASA Mars 2020 Draft Supplemental Environmental Impact Statement.

In the unlikely event of a Mars 2020 launch accident in the launch area with a release of some portion of its radioactive fuel, the estimated maximum dose of radiation an individual in the launch area might be expected to receive is about 210 millirem, which is equivalent to about eight months of natural background radiation exposure for a person living in the United States. (For context, U.S. residents receive an average of 310 millirem of radiation each year from natural sources such as cosmic rays from space, radon in Earth's soil, and certain foods, plus an additional equal amount from medical procedures and consumer products.)

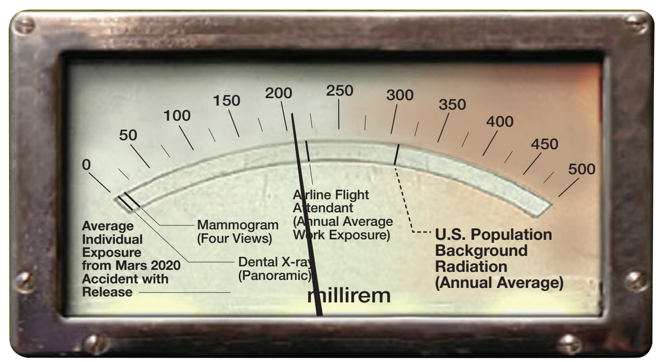
In the unlikely event of a Mars 2020 launch accident outside the launch area with a release of radioactive material, the estimated maximum individual dose that a person could receive is predicted to range from 48 millirem (late launch) to 2.4 rem (suborbital reentry case).

Even though the chances of launch accidents are small, NASA prepares contingency response plans for every launch that it conducts.

This contingency planning task takes on an added dimension when the payload being launched into space contains nuclear material. To manage the response to an accident with a release of radioactive material in the launch area, NASA establishes a radiological assessment and command center staffed by a variety of subject matter experts. This center deploys specialized monitoring equipment and field teams prior to launch, and it serves as a clearing house for information that forms the basis of easily accessible updates regarding accident conditions and any precautionary measures that might be recommended.

NASA's response plans for a mission using a radioisotope power system are developed and tested in accordance with the National Response Framework and the Nuclear/Radiological Incident Annex to the Response and Recovery Federal Interagency Operational Plans, with the combined efforts of the U.S. Department of Homeland Security (DHS), DHS's Federal Emergency Management Agency (FEMA), DOE, the U.S. Department of Defense (DOD), the U.S. Department of State (DOS), the U.S. Environmental Protection Agency (EPA), the State of Florida, and surrounding Florida counties.

NASA's emergency response team conducts exercises prior to launch to verify that the decision-making structure, communications channels, and field response organizations are prepared to respond in the unlikely event of a launch accident. Should a release of radioactive material occur in the launch area, the State of Florida and county and local governments would determine an appropriate course of action for any off-site areas (such as sheltering in place, exclusion of people from contaminated land areas, or no action required), and would have full access to the results of the coordinated Federal response.



The estimated maximum dose an individual in the launch area might be expected to receive from a Mars 2020 launch accident, about 210 millirem, is shown in comparison to other common radiation exposures. The total annual background exposure from natural sources for a person living in the United States (calculated using effective full-body dose, in millirem) is also shown. Data sources: Health Physics Society and the Mars 2020 Draft Supplmental Environmental Impact Statement.

The Mars 2020 mission is part of NASA's Mars Exploration Program. Major participants in the Mars 2020 mission include NASA's Science Mission Directorate, Space Technology Mission Directorate, and Human Exploration and Operations Mission Directorate, as well as contributions from numerous universities and several international partners.

Key Facts: Mars 2020 Launch

Launch Period: July 17–August 5, 2020
Mass of Rover: ~2,310 pounds (1,050 kilograms)
Launch Vehicle: Atlas V 541 from Cape Canaveral Air Force Station, FL
Arrival at Mars: February 21, 2021

For further information: ***mars.nasa.gov/mars2020***

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JPL 400-1673 Rev. 1 11/19