

# Three Mars Missions Will Create New Discoveries

by Marsha Freeman

Feb. 28—During the first two weeks in February, three visitors arrived at Mars. From the United Arab Emirates (UAE) came *Hope*, a small orbiter with a big mission. China's *Tianwen-1* arrived next carrying a lander/rover. And last, the American *Perseverance* rover made NASA's fifth successful rover landing on Mars.

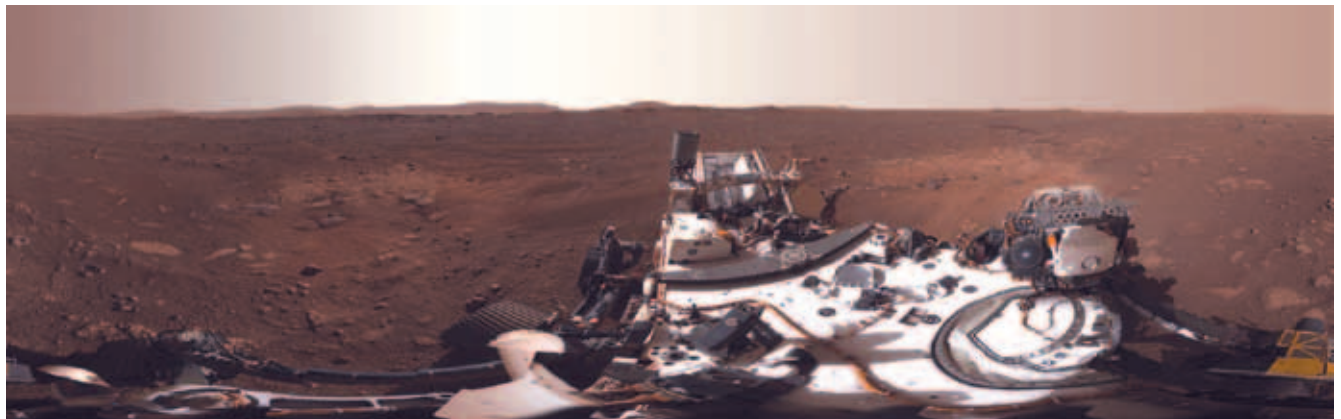
Each of the three space agencies that is carrying out a Mars mission is at a different level of development and experience. The UAE Space Agency is six years old, and has never sent a spacecraft beyond Earth orbit. Although China has extensive experience with landers and rovers on the Moon, and undoubtedly that will be useful, China has never been to Mars, but plans to land a rover on its first mission there. *Perseverance* will con-

Mars' orbit. The farthest distance between the two planets is 401 million km; the nearest distance is 56 million km.

## Hope for the Future

The UAE's *Hope* (in Arabic, *Al Amal*) Mars orbiter represents an intervention on the part of the government into three challenges facing the country.

As early as the 1970s, there were warnings that UAE's oil was a finite resource. Sheikh Zayed bin Sultan Al-Nahyan (1918-2004), the first leader of the United Arab Emirates after independence from Britain in 1971, always reminded the officials of the government that oil, although a great blessing, should not be



NASA/JPL-Caltech

Part of a 360-degree panoramic photo taken by the Perseverance Mars rover.

tinue NASA's series of increasingly capable roving laboratories, with a mission to address some of the most fundamental questions in science. All three missions will make new discoveries.

All three spacecraft were launched last July in a rush to be ready for the optimum launch window. (Unfortunately the European Space Agency did not make it on time, missed the launch window, and will have to wait for the next launch opportunity in two years.) The reason why some years are preferable to others for heading to Mars is that the distance between Mars and Earth varies due to the longer period and ellipticity of

the only source of wealth for the nation, and that future generations should have something to stand on.

To meet the first challenge, to diversify the economy, the country's leadership embarked on a modernization program, which centers upon creating high-technology industry and manufacturing industries, and the scientific and engineering talent that that requires. The UAE has under construction, by South Korea, four nuclear power plants, the only such plants in the Arab world. The push was to diversify the economy, to include industries such as satellite manufacturing. But it would be the space program, the government leaders

knew, that would capture young people’s imagination, and inspire them to participate in that grand endeavor, with hope for the future.

The second challenge was to become a spacefaring nation with a daring mission that creates new knowledge. The UAE Space Agency (UAESA) was established by federal decree in 2014 with the aim of creating a national space sector, and specifically to carry out a mission to arrive at Mars in 2021, which is the 50th anniversary of the founding of the United Arab Emirates. This was to include partnerships. The UAE took the approach that it would not take the time to reinvent the wheel, but would cooperate with more advanced states to gain access to aerospace technology. By 2015, the UAESA had a number of cooperation agreements, including with the United States, Japan, Russia, and China. The agreements included training for Emirati engineers and the transfer of technology.

For *Hope*’s mission, the major international partner is the Laboratory for Atmospheric and Space Physics at the University of Colorado. The program started with the training of 20 engineers. All told, there was a 45-person international team. By the final preparation for launch, 200 Emirati engineers, with an average age of 27, were working on the mission.

The third challenge, which faces the whole region, is the younger population. It is estimated that the region has over 100 million youth, with over 35% unemployment. The leadership sees the optimism in the space program as a way to uplift the region.

Omran Sharaf, the *Hope* mission’s project manager, told AFP, “The UAE wanted to send a strong message to the Arab youth and to remind them of the past, that we used to be generators of knowledge.” Sharaf told *Nature* magazine that the Mars mission was designed to cause “a big shift in the mindset” especially of young people.

### Mars’ First Weather Satellite

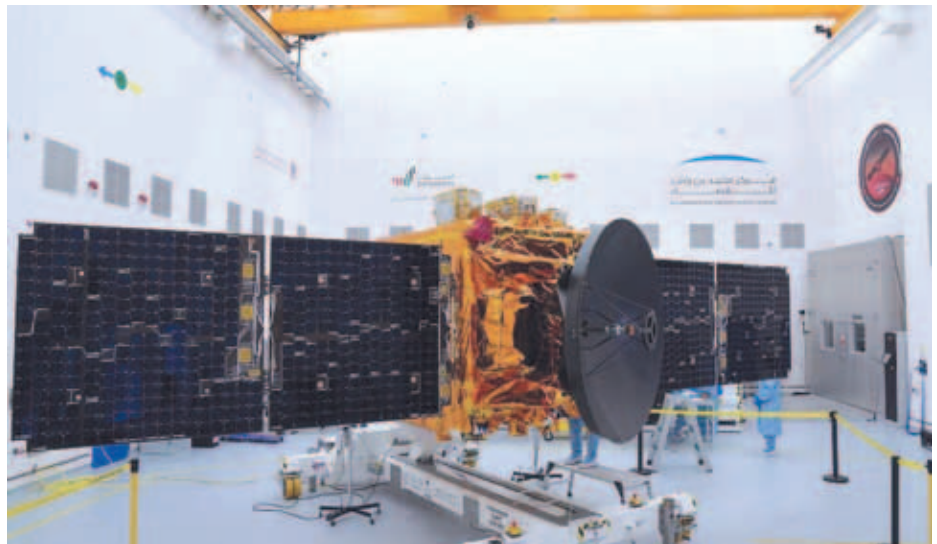
Upon *Hope*’s reaching the orbit of Mars on February 8, Sarah Al-Amiri, the 34-year-old chairwoman

of the Space Agency, told the press:

The Emiratis’ Mars mission has ... inspired the nation to look to the future and look to the skies. It has shown that collaboration across nations, geographies, creeds, in the face of remarkable challenges can forge brilliant outcomes for the benefit of us all.

Al-Amiri has assembled a team of planetary scientists who are “reprogrammed” engineers. Women make up 34% of the team. Recently, the top universities in the UAE have started to offer courses in physics, astronomy, and other fundamental sciences.

*Hope* will orbit Mars for at least one Martian year.



UAE Space Agency

*Hope, the UAE’s first spacecraft to leave Earth orbit.*

Three instruments mounted on *Hope* will provide a picture of the Martian atmosphere. Unlike every previous measurement in which only the upper atmosphere is observed, *Hope* will provide information about the atmosphere from top to bottom. An infrared spectrometer will measure the composition of the lower atmosphere. A high-resolution imager will provide information about ozone levels. And an ultraviolet spectrometer will measure oxygen and hydrogen levels from a distance of 43,000 kilometers from the surface. This will add information as to how Mars is losing its atmosphere to space. *Hope* will observe dust storms, and measure temperature, water vapor, and other gases.

*Hope* is now in a temporary orbit as it powers on its instruments. It will be relocated to its science orbit in May. The science orbit will have the spacecraft circling

high over the planet's equator every 55 hours. And then—as the head of the UAE Space Agency, chairwoman Sarah Al-Amiri, proudly says—*Hope* “will be the very first weather satellite for Mars.”

### China's Daring

China's *Tianwen-1* (*Questions of Heaven*) spacecraft reached the orbit of Mars a day after *Hope*. China National Space Agency (CNSA) reported on February 23 that *Tianwen-1* had entered a temporary parking orbit around Mars. The spacecraft will remain in the new orbit for about three months, CNSA said, before the lander/rover attempts to land. The orbiter, during this time, will be mapping the surface of Mars in preparation for the lander's mission.

This is the first time any nation visiting Mars for the first time has taken along a second craft to deploy. In the Chinese lunar program, each mission stretched the technology and introduced new capabilities, such as the landing on the far side of the Moon by *Chang'e-4*. China does not repeat any mission that was successful; each mission is unique. The lunar program has been planned as a campaign, with multiple missions planned at the start.

That this approach is being applied to the Mars missions is indicated by the designation of this first mission as number “1.”

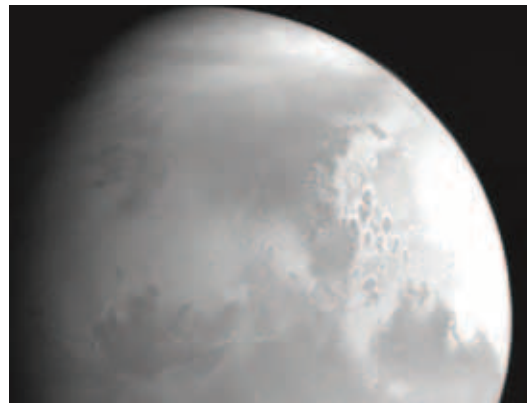
Although China has extensive experience landing spacecraft on the Moon, the airless Moon poses many fewer challenges than Mars, which has an atmosphere. There are short-term daily and seasonal weather variations, and longer-term climactic changes on Mars. In order to increase the chances of a successful deployment of the lander/rover, China will use the full range of technologies that have been developed to softly set it down—a parachute, rocket firings, and airbags. The current plan is for the lander to touch down in Utopia Planitia. This is where a *Viking* lander set down in 1976.

Both the orbiter and the rover have arrays of scien-



CNSA

*Above, an artist's concept of Tianwen-1 on its way to Mars. It will deploy its rover in a few weeks.*



CNSA

*The black and white image of Mars, at left, is the first photo received from Tianwen-1, 3.54 million kilometers from Earth.*

tific instruments that cover a broad range of scientific disciplines. A sub-surface radar aboard the orbiter will be used to study structures below Mars' polar ice caps. The orbiter has

five scientific goals encompassing a dozen scientific disciplines. These include topography, geomorphology, and geological structure of the global area of the whole planet, and of the potential landing area for the rover; the thickness, composition, and distribution of soil, planet-wide and in the landing zone; ground water distribution and water ice data; detailed investigation of key candidates for landing areas, in case a back-up site needs to be chosen. The orbiter has medium- and high-resolution cameras, a magnetometer, a mineral spectrum analyzer, an ion and neutral-particle analyzer, and an energetic particle detector.

The rover weighs 240 kg. It is expected to operate for three months and can move at 200 meters an hour. The rover is equipped with cameras, ground-penetrating radar (which has been very successful on the Moon), a magnetometer, a weather station, and instruments to measure the chemical composition of the dust and rock.

All of these tools will be used to search for pockets of liquid water and ice, a main task of the mission. Three of NASA's Mars orbiters have indicated there is

subsurface water ice under the northern hemisphere at mid-latitudes. It would seem that this could make it likely that the Chinese rover will find ice underground.

The next big step in China's progression of Mars missions will be to bring samples of Martian rocks and soil back to Earth. Eventually, China plans to carry out manned missions to Mars; and if the resources, such as water, can be extracted economically, perhaps a research station and living quarters will be built on Mars.



NASA/JPL-Caltech

*This still photo of the Perseverance landing vehicle with its rover and helicopter, touching down on Mars, was taken from a camera mounted on the rocket-powered sky crane. February 18, 2021.*

### **Perseverance—A Multi-Tasking Mars Robot**

The last of the trio to reach Mars was the American rover *Perseverance*. Her job is to search for signs of ancient life. She will also demonstrate new technologies to be used on future missions, and release a 1.8 kg helicopter named *Ingenuity*.

The mission scientists are not expecting *Perseverance* to find fossils of past microbial life. The sophisticated equipment needed to do that does not fit on a rover. So NASA is teaming up with the European Space Agency (ESA) to carry out a sample return mission, and deliver rocks and soil from Mars to scientists in laboratories on Earth. *Perseverance* landed in Jezero Crater. There is evidence that three or four billion years ago at Jezero, a river flowed into a body of water the size of Lake Tahoe, perhaps creating the conditions for life. The sample return mission is being planned for later this decade.

One of the technologies that will be tested by *Perseverance* for later use by astronauts is MOXIE—the Mars oxygen *in situ* resource and utilization instrument. MOXIE will separate the oxygen from carbon dioxide, producing oxygen for breathing and for use with chemical rocket fuel.

Without a doubt, the demonstration that will garner the most attention and excitement will be the flight of *Ingenuity*. This will be the first flight of any vehicle in the atmosphere of a planet other than Earth. The helicopter weighs 1.8 kg, with propellers so large they seem

out of proportion to the body. That is due to the thinness of the Martian atmosphere as compared to that of Earth.

Although *Perseverance*'s frame is the same as her predecessor, *Curiosity*, the technology is much more advanced. For the entry into Mars' atmosphere, descent, and landing, NASA mobilized orbiters already on station to get video and still photographs of the descent. Cameras on the rover and on the "sky crane" that lowered it down, took photos as well. Within just a few hours of landing, *Perseverance* sent

back photographs of its surroundings at Jezero Crater. Dramatic video footage of the descent and landing came soon after.

Each of the three Mars missions has specific tasks and goals. When they complete their assignments, we will know considerably more about Mars than we now know. That will be important for the move of human civilization to a new venue, the deployment of scien-



NASA/JPL-Caltech

*The most exciting activity on the Perseverance mission will be the test flight of the first powered vehicle to ever fly on another planet. Scientists hope to make at least three flights with Ingenuity, shown here on Mars in an artist's representation.*

tific instruments for a better look at the Universe, and the revitalization of life on Earth from the mission to do that.

But along the way, there will be exciting developments—they started a few weeks ago with the landings—and will continue with new discoveries.