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NEXT MONTH, THREE COUNTRIES HEAD OFF TO THE RED PLANET.

BY TONY REICHHARDT

EVERY 26 MONTHS OR SO, when the planets are favorably aligned, spacecraft can be sent to Mars at a discount—in terms of the rocket fuel required. NASA, which has a lot of experience in this area, rarely misses the chance. U.S. spacecraft have been dispatched to Mars during six of the last eight biennial launch windows.

This summer, two newcomers are ready to hop on the Mars train: China and the United Arab Emirates, the first Arab country to attempt a planetary mission. Meanwhile, NASA will up its game with the first half of a two-part campaign to collect Martian samples and return them to Earth.

Another launch had been on the schedule, but the European/Russian Exomars mission was forced to miss this year's window due to technical delays and, finally, the coronavirus. The global pandemic still hangs like a cloud over everyone's plans, complicating the logistics of final testing and transport to the launch pad. But as of late April, spacecraft from three different countries were still scheduled to leave this planet for Mars in July, with arrival next February.

Here's what they hope to accomplish.

HOPE FOR A NEW GENERATION

The rulers of the United Arab Emirates do love their technology. Whether it's drone taxis or Jetson-esque skyscrapers, the Emirati regime embraces risky inventions and prides itself on being technically progressive. In 2020, that means having a space program that goes beyond launching satellites into Earth orbit.

Last September the UAE sent its first astronaut on an eight-day trip to the International Space Station. Now the young, oil-rich country aims to do something few other space agencies have even tried: orbit a spacecraft around Mars.

The mission is called Hope, or EMM (for Emirati Mars Mission). Its goals are modest. Onboard the spacecraft will be three cameras for studying the Martian atmosphere at visible, infrared, and ultraviolet wavelengths. Hope will travel a high orbit specially designed to observe different loca-

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tions at different times of day, over the course of a Martian year. From there it will take first-time measurements of the lower atmosphere, where the Martian weather, including dust storms, develops. It's a scientific niche, but an important one.

At the start of the project, Emirati scientists and engineers were given marching orders by Prime Minister Sheikh Mohammed bin Rashid Al Maktoum (for whom the country's space center is named): Hope was to arrive at Mars before the 50th anniversary of the UAE's founding, in December 2021. The team also was instructed—as project manager Omran Sharaf recounted in a 2018 TED talk—that Hope was to make a significant contribution to science, not just repeat what others had done. And the engineering would be done, at least partially, in the UAE. "You're not going to buy it, you're going to build it," said the prime minister, according to Sharaf.

The UAE space agency partnered with three U.S. universities, all veterans of NASA planetary missions, and will launch Hope on a Japanese rocket. Mike McGrath of the University of Colorado's

➡ A technician at the Mohammed Bin Rashid Space Centre in Dubai applies finishing touches to Hope.

ESA/DLR/FU BERLIN/JUSTIN COWART; INSET: WAM/NOUR SALMAN/MOHD AAMIR

Last November, Chinese space engineers checked out their new Mars lander's ability to hover and avoid obstacles on a test range in Hebei province, not far from Beijing.

Laboratory for Atmospheric and Space Physics, the former U.S. program manager and now senior advisor on the project, moved to Dubai three years ago and has only praise for his Emirati colleagues. "Everybody I work with is in their early to mid-30s," he says. He singles out Sharaf and the project's science manager, Sarah Amiri, particularly. "I have never seen people of their capability at this point in their career. It's quite stunning."

That hints at another project goal, even more important than reaching Mars. In his 2018 talk, Sharaf (who got his undergrad degree from the University of Virginia and cut his engineering teeth working in Korea on an Earth-observing satellite for the UAE) emphasized that the Hope project is meant to inspire the 100 million young people in the Arab region, boost their interest in science and engineering, and point them to a future beyond oil, which cannot carry the country's economy forever. "Failure [at Mars] is an option," he said. "But failure to progress is not."

CHINA EXTENDS ITS REACH

For more than 40 years, ever since the Viking missions of the 1970s, the Martian surface has been exclusively American territory. The moon, though, belongs to China—at least in the early years of this century. Two landers, Chang'e 3 and Chang'e 4, set up small research stations on the lunar surface after touching down there in 2013 and 2019 respectively. Both carried small rovers called Yutu (Jade Rabbit), capable of exploring the immediate surroundings with cameras, spectrometers, and other instruments.

Now China's sights are set on Mars. The nation's space program is as ambitious as it is methodical, progressing in carefully planned steps that often check off more than one milestone at a time. So, rather than starting off with a simple orbiter—the way other space agencies have—China is sending both an orbiter and a rover on its first try.

Called Tianwen-1 (Questions to Heaven) after a Chinese poem, the five-ton orbiter-plus-lander will launch on a Long March 5 rocket. At Mars, the two parts will separate, and after a high-speed entry inside an aeroshell, the lander—basically just a platform for the rover—will parachute to the surface and make a soft touchdown using retro-propulsion. The Chang'e lunar missions used an impressive array of LIDAR and optical sensors to navigate and avoid hazards like large boulders during the landing. Tianwen has similar capabilities, although landing in the Martian atmosphere is trickier than coming down on the moon and may be the biggest hurdle for newcomers to Mars exploration.

Once on the surface, the Yutu-like wheeled vehicle (as yet unnamed) will roll down a ramp from the landing platform and begin its site investigation. One of the Tianwen instruments—a ground-penetrating radar of the kind used on Earth for everything from archaeology to finding buried utility lines—builds on the success of a similar device flown on China's moon missions. Nobody has ever placed such a tool on Mars, but NASA has one on its 2020 lander, as did the postponed European mission. The idea is to look tens of meters under the ground to help reveal the local geology and the distribution of rocks, dirt, and ice.

For the record, Tianwen isn't strictly China's first shot at Mars. In 2011, a would-be orbiter called Yinghuo-1 rode piggyback on a Russian Mars-bound spacecraft that, following a launch

ANDY WONG/AP/SHUTTERSTOCK

mishap, ended up in the Pacific Ocean instead. It was a setback, to be sure. But that was a younger, less confident Chinese space program.

A ROCK COLLECTOR ON MARS

In 2011, when U.S. planetary scientists were asked what big-ticket projects should receive federal funding over the next decade, a Mars sample-return mission came out as their top choice. Actually, they needed two missions. The first would collect rocks and soil and cache them on Mars, and the second would retrieve the samples at some later date and return them to Earth where they could be studied in far more detail than they could be on Mars. NASA's Perseverance rover constitutes Part One of that plan. Now scheduled for a July 17 launch from Cape Canaveral, it's the most advanced Mars mission yet.

Having established from past investigations that Mars was once a habitable place, scientists now want to know if the planet was, in fact, ever inhabited. That's a more difficult question, as there currently are no definitive "biosignatures" for identifying life, short of spotting a kangaroo bounding across the Martian surface. More likely, a tentative answer will come from multiple lines of evidence showing that a particular rock's chemistry and physical characteristics *probably* resulted from biology. Perseverance's job is to find the rocks that look most promising for containing that fossil evidence.

At first glance, the 2020 mission looks like a repeat of Curiosity, now in its eighth year of exploring Mars. The one-ton rover is of the same general size and design, and the same (slightly scary) helicopter-like sky crane system will be used to lower it to the Martian surface.

But there are many improvements, starting with the landing site, Jezero Crater. All the scientific wisdom gathered from the last 20 years of robotic Mars exploration went into choosing this location, an ancient river delta where rocks of many different kinds, from different geologic settings, should all have washed into the same (now dry) lakebed.

Perseverance will use a number of techniques to get more quickly to its destination, including one called "range trigger," which alters the timing of the parachute release during atmospheric entry based on proximity to the target. Most of the instruments onboard the rover are improved versions of those on Curiosity. The navigation cameras are sharper and will "see" in color instead of black-and-white. Even the wheels have been modified to improve their traction in sand.

The biggest advance is the intricate Sample Caching System. After rolling to a promising site and identifying some bit of rock or soil that on close inspection looks like a keeper (a spectrometer called SHERLOC and another instrument can spot organic compounds), the rover will use its seven-foot robot arm and a drill to collect up to half an ounce of material in an ultra-clean, metal, coring tube/sample container. At least 30 of these tubes will be left on the ground in a designated "depot" area, like so many messages in bottles, awaiting pickup. The tubes are designed to remain tightly sealed on the Martian surface for at least 10 years.

Perseverance also will deploy a tiny helicopter that, if it works, will make the first powered flights on another world (see "A Helicopter Dreams of Mars," April/May 2019). And a tech demonstration called MOXIE will attempt to draw oxygen from the Martian atmosphere, previewing the kind of device Mars astronauts might someday use to make rocket fuel and breathable air.

There's a lot riding on this risky $2.5 billion mission—and no guarantee of proving or disproving that Mars was once alive. Part Two of the sample-return campaign is penciled in for a 2026 launch. It's sure to be much more expensive, and funding is far from assured. But it's NASA's plan, and they're sticking to it. Maybe that's why they call it Perseverance. ◻

NASA/JPL-CALTECH

⬆ The Perseverance rover, seen here in an artist's conception, may look like the Curiosity robot now on Mars, but underneath its belly is a complicated mechanism for storing samples collected on the Martian surface.