Mars towards the future

Three spacecraft from three different nations arrived at Mars in February 2021. Two of those nations are newcomers to Mars and the third successfully set out the path for a Mars sample return.

Despite regular launch opportunities every 26 months, every mission to Mars invariably captures headlines in the news and huge interest from the public. The 2020 launch window, however, actually had several novelties that distinguished it from the others — even without considering that it happened in the midst of a global pandemic.

First of all, this year has been unusually busy. Mars has not seen so much incoming traffic since 2003. Moreover, all three missions were successful, showing that we are getting more confident in delivering probes to Mars without glitches. Mars has long enjoyed the reputation of being a spacecraft-eating ghoul, but maybe it is time to bury this cliché: only one of the 15 missions sent to Mars since 2000 fully failed by not leaving Earth's orbit.

One of the most significant features of the 2020 launch window is the appearance of new actors. The United Arab Emirates (UAE) and China have respectively become the fifth and sixth countries ever to reach Mars. Like the European Space Agency (ESA) and India, they succeeded at the first attempt. The widening of the exclusive club of nations exploring beyond the Earth–Moon system is always welcome, although we are far from the 'democratization of deep space' that we are experiencing for Earth's orbit and have started to glimpse for the Moon.

Interestingly, the two nations opted for very different approaches to their Mars debut. The Mars Hope Probe from the UAE was conceived to answer very specific scientific questions linked to the vertical connections within the atmosphere, from the troposphere to atmospheric escape. In this sense, it has some overlap with NASA's Mars Atmosphere and Volatile Evolution (MAVEN) orbiter, and indeed the UAE has worked closely with members of the MAVEN team in the United States. International collaboration and knowledge exchange have been key points of the Hope mission. Tianwen-1 is instead all Chinese and also a very ambitious first attempt, consisting of a full orbiter–lander–rover package. The lander–rover composite is planned to land in Utopia Planitia in May 2021 after a thorough reconnaissance of the area by the orbiter aimed at identifying the best landing site according to scientific and technical criteria. Its scientific objectives are very different from — and complementary to — Hope's, focusing on surface and shallow sub-surface processes and environment.

Compared to the UAE and China, NASA is the big veteran of Mars exploration. However, the Perseverance rover marks a distinct change in perspective for the US space agency. The 'follow the water' mantra that drove NASA's Mars exploration since the 1990s is becoming obsolete, as we 'follow habitability' now. The Curiosity rover started this new trend, and Perseverance is consolidating it. But above all, while the science is surely going to be exciting, Perseverance has a clear forward-looking concept that distinguishes it from NASA's previous rovers. The most important innovation by far is the first step towards a Mars sample return.

Actual projects for a Martian sample return have struggled to materialize due to the magnitude of its technical challenges. Now we have a clear plan: a three-step sequence (of which Perseverance carries out the first) that spans the whole decade and involves a tight collaboration between NASA and ESA. Much of Perseverance's design revolves around sample return. The rover will drill and collect samples that will be stored in cylinders and left on the Martian surface. Cleverly, the rover will carry these samples from the different acquisition points over to a single caching area, ready for collection by the future 'fetch' rover. The scientific payload is also tailored for this purpose: a suite of cameras and spectrometers will allow the identification of the most interesting rocks to sample, and in situ sample analysis facilities were sacrificed to make space for the tube collection and storage. Mars sample return has always been considered at risk of being bypassed because of its high costs, but now that it is in motion it will be much harder to stop.

Perseverance's look to the future goes beyond sample return, containing as it does a rather unprecedented set of technology experiments. First, the Ingenuity helicopter will try to perform the first controlled flight on another planet as a standalone and autonomous system. Considering the extremely thin and dust-laden atmosphere of Mars, success is not a given and Ingenuity will be a crucial test for any future airborne technology. In addition, the rover contains MOXIE (the Mars Oxygen In-Situ Resource Utilization Experiment), which is designed to release oxygen into the atmosphere of Mars after synthesizing it from locally harvested CO_2. This is the first attempt to consciously affect the environment of a planet. While MOXIE is just a technology demonstrator and will not have any actual impact on the atmosphere of Mars, it is a first test of how we could utilize local resources to support future human missions and habitation. Resource utilization on Mars is the next challenge and, in addition to Perseverance, there are already some ongoing projects, in particular concerning water reservoirs. In this issue we present an effort to map the likelihood of water ice availability in the shallow subsurface of Mars and just last month the US, Italian, Japanese and Canadian space agencies announced a partnership for an International Mars Ice Mapper orbiter that could fly as early as 2026.

The 2020 launch window saw exciting new perspectives open up for Mars exploration, and this trend will continue in the already busy next launch windows. Martian exploration has always been fertile terrain for international scientific collaboration: we hope that these novelties will not change that and the way forward will be inclusive and concordant. ❐

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