Air and Space this Week

Item of the Week

Three Mars Missions – July, 2020

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The Mars Opposition of 2020 will be outstanding for backyard astronomers, and for robotic exploration. Three missions are presently* en route *to the Red Planet, the UAE's* Hope*, China's* Tianwen-1*, and the USA's* Mars 2020*. But "Mars is Hard" when it comes to exploration…

The cold equations of orbital mechanics limit the opportunities to launch Mars missions efficiently to every 26 months or so. At present, there are five active spacecraft in Mars orbit (*Mars Odyssey, MRO, MAVEN, Mangalyaan,* and the *Trace Gas Orbiter*) and two are active on the surface (*Curiosity* and *InSight*). We have been learning much about the surprisingly-complex Red Planet over the past few decades via exploration by increasingly-sophisticated robotic surrogates. And three more are headed Mars' way!

Mars exploration is fraught with peril. By definition, the technology needed to explore the planets forces rapid advances in a variety of fields, from computing to metallurgy. One cannot purchase Mars-faring spacecraft "off the rack" down at the local Spaceships are Us store! But the lure of Mars has spurred exploration as soon as it was technologically possible.

The difficulty of conducting a successful Mars mission is very high. That is why, of the 44 rockets launched to Mars prior to this month, only 17 could be considered "fully successful." Another 9 failed to achieve their pre-mission objectives, but did return at least some useful information, and 18 were abject failures. Most of the missions were launched by NASA and the USSR/Russians, but ESA, Japan, and India have launched missions, too. That's a nice Club to be in!

Most, but not all, of the unsuccessful mission occurred in the first few decades of planetary exploration. Rocketry was in its infancy, and many early missions were lost before even reaching low Earth orbit. As rocket reliability improved, missions began living long enough for other weaknesses to become a problem (*e.g.* electronic, software, and other cutting-edge components). And now, even with "modern" capabilities, missions can still be lost, sometimes for weird reasons (e.g. *Mars Polar Lander* and *Mars Climate Orbiter*).

We are presently in the middle of a launch window, and three missions to Mars are either on their way, or almost ready to launch (as of 7/26). The two already *en route* are Mars mission newcomers, the United Arab Emirates and China. NASA is scheduled to launch *Mars 2020* on July 30.

HOPE: The Emirates have been moving rapidly to expand the technology prowess in many areas, and openly view their mission, *Hope*, as a demonstration that they belong to the Mars Mission Club (some have even called it "The Arab World's Moon Shot."); see also here and here. Their orbiter will acquire data on the dynamics of the martian atmosphere and its interaction with the Solar Wind. Some of the data will complement observations being made by the *MAVE*N orbiter. The spacecraft was built by the Laboratory for Atmospheric and Space Physics, at UC Boulder (also the home of MAVEN mission PI, Bruce Jakosky), and it was launched from Japan, but mission and science management is being handled in large part by a young cadre of UAE scientists and engineers. The spacecraft carries three imagers, an infrared spectrometer, a visible light imager, and an ultraviolet spectrometer. The mission is off to a good start, launched successfully on July 21. If all goes well, *Hope* with enter orbit around Mars next February.

Tianwin-1: China successfully launched *Tainwin-1* ("Heavenly Questions"), an ambitious Mars mission, comprising an orbiter, lander, and rover, on July 23. They had tried to get to Mars once before, providing a key mission element to the Russian *Fobos Grunt* spacecraft, but the spacecraft failed to even leave Earth orbit, dooming the *Yinghuo-1* orbiter. Only the USA and the USSR/Russia have landed successful on Mars so far, but the Chinese have acquired a lot of practice in conducting remote exploration with successful missions to the Moon, and now it's time for them to also join the MMC, Rover Division.

The orbiter mission element carries two cameras, a magnetometer, a spectrometer tuned to identify surface materials, a sub-surface radar, and other instruments. The lander is merely the transportation mechanism to get the rover to the surface. The rover is relatively-small, similar to the *Sojourner* rover carried by *Mars Pathfinder*, but carries quite an instrument suite, with several cameras, a multi-spectrometer, a meteorological instrument package, a magnetic field detector, and a ground-penetrating radar. I hope they are as imaginative at naming surface rocks and features they encounter as we are!

If all goes well, they will land on Utopia Planitia in mid-February of next year.

***Mars 2020*:** NASA is returning to Mars with the *Mars 2020* spacecraft, with a rover, named "*Perseverance*," similar to *Curiosity,* and a drone helicopter named "*Ingenuity*." The lander will be delivered to the surface using the "Sky Crane" technique pioneered by *Curiosity*, using first a heat shield and then a parachute to slow the landing module, which then hovers above the surface while it winches the lander to the ground. The hovering part then cuts the cables and flies of to crash out of the way, its mission completed.

Perseverance is built on the basic successful design of *Curiosity*, but its suite of instruments, and its mission, are different. It will land at a place called Jezero Crater, a really interesting site that was almost selected as the goal of *Curiosity*. What makes it so special is that the crater was clearly once filled with water, brought into the crater through what is obviously a water channel. As the water entered the crater, much of the sediment it carried was deposited in a "delta" exactly like we see on Earth. Since then, the lake dried up and the upper layer of the delta was eroded by the wind, but most of the delta remains intact. One of NASA's key themes

in Mars exploration is “Follow the Water,” this site is tailor-made for researching the characteristics and history of the water-laid deposits there.

Perseverance is a very capable roving explorer, tasked with “searching for signs of past habitable conditions on Mars in the ancient past and for signs of past microbial life itself.” IT carries a sophisticated camera atop a mast, allowing for panoramic and stereoscopic imaging with zoom capability, a camera capable of making chemical measurements from a distance, and instruments to make detailed chemical analyses of surficial materials, and to look for to search for organic compounds (remember, “organic” does not equal “biologic!”), a ground-penetrating radar, and “MOXIE,” a demonstration project that will investigate how oxygen can be generated by breaking down the CO2 in the martian atmosphere; see also: . https://mars.nasa.gov/mars2020/spacecraft/instruments/moxie/for-scientists.

For more lander info, see:
https://mars.nasa.gov/system/downloadable_items/44738_Mars2020_Fact_Sheet.pdf

Ingenuity, like MOXIE, is also a demonstration project. Its mission is not to make scientific observations of the martian environment, but more to prove drone flight is possible in the rarified martian atmosphere in the first place, that the necessary miniaturization of drone components still allows for flight, that a drone could operate sufficiently “on its own” to be able to function successfully several light-minutes away from instructions from home, and that its solar power and nighttime heating system allow it to function for several days.

The Mars 2020 mission is scheduled for launch from Cape Canaveral at 7:50 AM EDT on Friday, July 30.

In addition to the links embedded in the Item above, see also a good summary of the three missions in the July issue of *Sky and Telescope* magazine, page 22, or here at: https://skyandtelescope.org/astronomy-news/three-missions-head-for-mars. Check it out!

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