Air and Space this Week

Item of the Week

Mars Odyssey

Originally appeared October 18, 2021

KEY WORDS: *Mars Odyssey* TES GRS MARIE Thermal Infra-red

Sunday, October 24, marks the 20th anniversary of the Mars orbit insertion of the Mars Odyssey *spacecraft. It is still going strong after two decades in orbit, making it the longest continually-active spacecraft orbiting another planet. Its mission is to map the chemical and geological composition of the martian surface and to assess potential solar radiation hazards to future Mars astronauts. The mission team also focuses on using the public interest in Mars to engage life-long learning about STEM topics.*

Mars is Hard

The 1990s were a mixed bag for Mars exploration. The heartbreaking failure of the *Mars Observer* spacecraft as it neared Mars in 1993 was followed by the rousing success of the *Mars Global Surveyor* and *Mars Pathfinder* in 1996, which was followed by the embarrassing failures of the *Mars Climate Orbiter* and *Mars Polar Lander*. The next launch window was in April, 2001, and it was time for another success story. We got it with the Mars Odyssey mission!

Mars exploration has always been difficult, since going to Mars requires the latest technology – no going down to the local used spacecraft store and buying off the rack! Rocket problems and other infrastructure failures doomed many early Mars missions, but with the 1971 Mariner 9 and the 1976 Viking missions, the United States was on a roll. The Russians, not so much. They had a run of successes at Venus, but their Mars exploration program floundered. They had lost two advanced missions to Mars from the 1988 launch window, their next attempt in 1996 failed, as did an attempt to return material from Phobos back to Earth in 2011.

Mars is Hard, indeed! For a run-down of all missions to Mars to date, and their degree of success or failure, see the Item of the Week from 9/3/20: http://www.airandspacethisweek.com/assets/pdfs/20200803%20Mars%20is%20Hard.pdf and its spreadsheet in the "Other Stuff" Archive: http://www.airandspacethisweek.com/otherstuff.

NASA's Mars Science Objectives

NASA's Mars Exploration Program had four overarching scientific goals for the Mars Odyssey mission:

1. Determine Whether Life Ever Arose on Mars
2. Characterize the Climate of Mars
3. Characterize the Geology of Mars

4. Prepare for Human Exploration

The Mars Odyssey mission was planned with the four objectives in mind. The *MO* spacecraft would carry instruments that would measure the elemental composition and shape of the martian surface (satisfying goal #3), determine the abundance of hydrogen (hence, water) just beneath the martian surface (toward goals #2 and #3), and characterize the radiation environment of the martian surface (important for goal #4).

In addition to the instrumentation needed to address the science objectives, the *Mars Odyssey* spacecraft has a high-quality radio relay capability. It, and similarly-equipped orbiters that have come later, make a relay network that can communicate data to Earth 24/7, except on those rare occasions where Mars is behind the Sun as seen from Earth.

Another aspect of the ongoing success of the Mars Odyssey mission is the degree to which lifelong learning was incorporated as part of the mission activities.

Mars Odyssey

The *Mars Odyssey* spacecraft carries three instruments that allow it to address its science objectives:

- The THermal EMission Imaging System (THEMIS)
- The Gamma Ray Spectrometer (GRS)
- The MArs Radiation Environment Experiment (MARIE)
- *Mars Odyssey* also carries a sophisticate radio relay system, still in service. Along with several other Mars orbiters, it uses its stronger transmitter to relay information from itself and other spacecraft at Mars, especially the rovers.

The THEMIS instrument operates in both the visible (five wavelength ranges) and the far (thermal) Infra-red part of the spectrum (ten wavelength ranges). The visible light data have been useful in characterizing the shape of the martian surface, and the thermal IR data help scientists determine the nature of the surface layer.

Rocks and finer surface cover heat up during the martian daytime, but the rate at which they cool off at night depends on the composition of the surface, and whether or not bare rock or particles of rock are present. By comparing a daytime thermal IR image of an area with a nighttime thermal IR image of the same area, additional information about the Mars surface materials can be derived.

An earlier orbiter, *Mars Global Surveyor*, also carried a thermal IR instrument, the Thermal Emission Spectrometer (TES), which returned much useful data. THEMIS was a significant improvement over TES, and thermal infra-red instruments have flown on some subsequent missions. Another derivative of the MGS thermal IR instrument is the “Mini TES” that roved the martian surface on *Spirit* and *Opportunity*.

Data from the TES was used to help evaluate and select landing sites for the *Mars Science Laboratory*, aka *Curiosity*.

The atmosphere of Mars does not protect the surface from gamma rays. When gamma rays strike the surface, they are changed when the reflect, the details of which can reveal the composition of the material doing the reflecting. The Gamma Ray Spectrometer (GRS) on Mars Odyssey looks for changed reflected gamma rays, but also can detect neutrons being released from the martian surface, which can reveal the presence of water beneath, even if it is frozen.

Gamma rays are dangerous enough, but cosmic rays are even worse. They aren't part of the electro-magnetic spectrum, rather they are (primarily but not exclusively) protons moving at near light-speed. They will hit both the spacecraft and the astronauts within when we send people to Mars. Cosmic rays are tough on electronics, and on humans, too; they can trigger cancers and cause nervous system difficulties. The MArs RadIation Environment Experiment (MARIE) was designed to monitor the cosmic ray environment. It returned useful data from part of its path to Mars and for two years in orbit, which showed that astronauts at Mars will receive 2-3 times the amount of damaging radiation than if they were in Earth orbit.

MARIE took a beating. One of its computer chips was fried, presumably by a solar wind particle, when *Mars Odyssey* was *en route* to Mars. The instrument was turned back on six months later, and it worked. Alas, a major solar event sent a lot of high-energy particles Mars' way on October 28, 2003, finishing off poor MARIE.

TES is still operating, as is the *Mars Odyssey*'s radio relay system. MARIE is dead, and while I couldn't find a definitive status for the GRS, its webpage is not available, so I'm guessing it, too, is no longer operational.

And yes, the name of the mission, Mars Odyssey, is a direct nod to the famous 1968 movie by Kubrick and Clarke, 2001: A Space Odyssey (IMHO the GOAT of films)

Mars Odyssey's Education and Outreach Efforts

Most of NASA's missions now have a very significant education/outreach component built in as part of the mission's mission. The Mars Odyssey team, especially the TES group at Arizona State University, helped pioneer the way on making the mission more accessible to the public and useful for education.

The ASU Mars Education Program is built around their Mars Student Imaging Project (MSIP), which uses an award-winning, inquiry-based, student-centered, educational approach. Teacher-led teams of students work with a coordinator at ASU on realistic exercise where students develop a Mars research question as part of a practical experience with the process of scientific inquiry.

The ASU Mars Education team has also prepared a number of standard-aligned STEM lessons based on Mars data, and teacher professional development and assistance in curriculum development is also available.

Another fun learning experience from the ASU folks is their "Rock Around the World" program, where teachers and students can send in a rock from their home area and the TES instrument at ASU will be used to analyze it and tell the sender what type of rock it is and what kind of minerals it contains. To date they have received almost 13,000 rocks from all over the world. Alas, COVID

has slowed their analysis capability, so they is a hold on further rocks coming in at this time (10/2021).

And if all of the education/outreach described enough, there's one more thing the TES team did.

In the Olden Days, the public did not see much of the (image) data returned from planetary exploration. The advent of digital imaging and the Internet changed that dramatically, but the public still doesn't see much of the data, and there is usually an embargo on data release prior to the first scientific papers being submitted for publication. But Phil Christensen, the TES Principal Investigator, is a strong proponent of outreach, and made TES available for public display at the Smithsonian National Air and Space Museum much sooner than usual; THEMIS images were displayed in the former "Exploring the Planets" gallery within ~2 weeks of their being transmitted to Earth. Museum visitors weren't the first to see them (as with *The Al Hibbs Show* – *be sure to check out my retirement video*!) but they were seeing them before the imaging team had analyzed them. Most engaging!

REFERENCES

Mars Is Hard

Item of the Week for "Mars is Hard": http://www.airandspacethisweek.com/assets/pdfs/20200803%20Mars%20is%20Hard.pdf

Spreadsheet of Mars Successes and Failures: http://www.airandspacethisweek.com/otherstuff.

A Wonderful Resource for Planetary Exploration: https://www.nasa.gov/sites/default/files/atoms/files/beyond-earth-tagged.pdf

Mars Odyssey

Mars Odyssey: https://nssdc.gsfc.nasa.gov/nmc/spacecraft/display.action?id=2001-013A

Mars Odyssey: http://themis.asu.edu/about

Mars Odyssey: https://mars.nasa.gov/odyssey

NASA: https://mars.nasa.gov/odyssey and https://mars.nasa.gov/odyssey/mission/overview

THEMIS: https://mars.nasa.gov/odyssey/mission/instruments/themis

TES: http://tes.asu.edu/about/instrument/whobuilt

GRS: https://mars.nasa.gov/odyssey/mission/instruments/grs

GRS: https://mars.nasa.gov//images/odyssey/technology/h2o_map-br.jpg

MARIE: https://mars.nasa.gov/odyssey/mission/instruments/marie

Cosmic rays: https://imagine.gsfc.nasa.gov/science/toolbox/cosmic_rays1.html

Mission Accomplished:
https://mars.nasa.gov/odyssey/news/whatsnew/index.cfm?FuseAction=ShowNews&NewsID=387

Solar Wind damage:
https://www.sciencedirect.com/science/article/abs/pii/S0168900207014374

Mars Odyssey an Education/Outreach

Mars-related lesson plans, information, and other resources: http://marsed.asu.edu

Mars Student Imaging Project: http://marsed.asu.edu/msip

Rock Around the World: http://ratw.asu.edu

Last Edited on 17 October 2021