Air and Space this Week

Item of the Week

MARS PATHFINDER

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July 4, 2022 *will be our country's 246th birthday. But there is another anniversary that day that is also worthy of celebration;* ***July 4*** *is also the 25th anniversary of the landing on Mars by the* Mars Pathfinder *spacecraft.*

Pathfinder *was a pioneering flight in several ways. It was the first to use a landing system based on air bags. It had the* Sojourner *rover, the first (semi) autonomous roving vehicle to reach the martian surface. And most important for those of us in the "sharing the benefits of Solar System exploration" crowd, it was the first to use "modern" outreach technology, to huge audiences.*

PREVIOUS MARS EXPLORATION: TELESCOPIC

Mars had been extensively examined by Earth-based telescopes for many years prior to our being able to send spacecraft its way. At opposition, Mars could be seen well enough for some surface features to be mapped, and named. Therein was a problem; English astronomers named what they saw after things English; French astronomers named what they saw after things French, and so on. Nobody could agree, and Mars became a symbolic battlefield, reflecting geopolitical situation of two centuries ago.

But not all Mars observers were American, British, or French. One was an Italian by the name of Giovanni Schiaparelli. He made a good map of Mars, but he was also a scholar of classical Antiquity. He named what he saw, too, but he chose ancient names for features he mapped that (vaguely) resembled their terrestrial counterparts. His map had places like Ausonia (the ancient name for Italy), Syria, Chryse (an ancient name for Burma), etc. There were no modern place names or public/political figures commemorated in his system. It was a great compromise, one to which all could agree. The Mars nomenclature system used by the IAU and all astronomers today grew from Schiaparelli's names.

Schiaparelli was a good observer, but nobody's telescope back then could reveal surface details well enough for accurate identification. The darker areas Schiaparelli mapped as oceans and seas in some cases turned out to be volcanic mountains; thus, we have places on Mars now like Hadriaca Patera (Adriatic Mountain)!

The human eye/brain combination works to give us understanding of the world around us, but does not strictly reproduce reality. For example, we all have a blind spot where the optic nerve leaves the retina – we don't notice it because our brain fills in the gap. Our brain also tends to play "connect the dots" such that we perceive a line where closer inspection would reveal a series of isolated features.

Schiaparelli's telescope could reveal the mottled surface of Mars well enough to trigger the dots-to-lines illusion. He mapped what he saw, and being a good scientist, he called them "channels," a term that means a linear feature but does not imply its origin. Since he spoke Italian, the word he used was "canali," linear features that could be natural in origin, or could be constructed things. Alas, "canali" is very close to the English word, "canals," a linear feature constructed by humans, a topic on the mind of the public because the Suez Canal had been built about that time. Many people mistook Schiaparelli for saying he saw "canals."

So here you have a "learn'd astronomer" talking about "canals" (constructed) on Mars. Mars also had areas that darkened or lightened with the martian seasons. So many non-astronomers thought that Schiaparelli's canals were actually a global network of irrigation structures that would transfer water from the martian polar ice caps (easily visible) and send it to the equatorial zone.

One such person who became a believer in intelligent Martian hydro-engineers was Percival Lowell. A gifted writer, Lowell wrote several popular books a century or so ago in which he expounded on his ideas. They would lead to stories like "War of the Worlds" and a lot of Martians-as-substitute-commies in a lot of bad 1950's movies. As NASA prepared to send a spacecraft to fly-by Mars in the early 1960s, many people expected to see canals, agriculture operations, and perhaps even cities. For more on Lowell and his influence, see the past Item on Clyde Tombaugh, here.

The public might be expecting Barsoom, but astronomers were more circumspect. After WWII, telescope and detector quality had improved to the point that astronomers were beginning to realize that Mars was a cold, dry place, with a very thin atmosphere. They, too, looked forward to seeing the results of spacecraft observation, but not for the same reasons that much of the public was.

PREVIOUS MARS EXPLORATION: SPACECRAFT

Rocket and spacecraft technology had advanced in the early 1960s to make a fly-by mission to Venus and Mars possible. A common spacecraft "bus" for such probes was developed, called "Mariner." Getting to Venus required less energy, so the first Mariner fly-by attempts were targeted there. *Mariner 1* suffered booster problems (caused in part by a missing hyphen in a command sequence!) and had to be destroyed by the Range Safety Officer. But *Mariner 2* fared better. It successfully flew by Venus on December 14, 1962, ***ten years to the day before the last footprint (for now) was made on the Moon!*** What a decade it would be!

Mariner 3 and 4 were targeted for Mars. The former was launched on November 5, 1964, but the shroud that protected the spacecraft on its passage through the atmosphere failed to separate properly, dooming the mission. *Mariner 4* worked perfectly, and was pivotal in dooming the canal-building-Martians hypothesis. The images acquired only covered a few percent of Mars' surface, and by chance they only covered heavily-cratered terrain. Scientists saw that Mars was more like the Moon than Barsoom, but they missed the amazing geological features elsewhere on the planet. *Mariner 4*'s contributions were so significant that they were covered as an Item of the Week (here).

Most of the launches in the Mariner program were in pairs, so that each mission launch opportunity had 100% redundancy. *Mariners 1* and *2*, and then *3* and *4*, proved the value of this approach. *Mariner 5*, however, was a "singleton." The spacecraft was the back-up for *Mariner 4* from three years earlier, refurbished and sent to Venus; it flew by Venus successfully on October 19, 1967.

Two probes were sent Mars-ward in 1969, and both were successful. But neither *Mariner 6* or *Mariner 7* returned images that changed the misperception left by *Mariner 4*, they rather re-enforced it. Mars was like the Moon, and the public's capacity of "Moon attention" was already maxed out by the first Moon landings.

The next launch window for Mars opened in early 1971, and NASA responded by sending *Mariner 8* and *Mariner 9*. These were to be orbital missions, not fly-bys, and rapid technology advances allowed for them to carry better cameras and other instruments. Their planned orbits were designed to allow to complement each other's observations. But *Mariner 8*'s launch vehicle failed and it ended up on the bottom of the Atlantic. *Mariner 9*'s orbit plan was altered so it could meet the science objectives of both missions as much as possible.

Mariner 9 was a stupendous success, and forever changed our awareness of the marvelous complexity of the martian surface environment. It, too, was the subject of an Item of the Week on the 50th anniversary of the mission fly-by (here). A number of prominent planetary scientists now looking back on a successful career started out as students working on *Mariner 9* data.

One last Mariner-class mission was flown, a singleton that flew by Mercury three times, after using a fly-by of Venus for a gravitational assist. *Mariner 10* was successful, but only gave us a view of about half of the mercurian surface. That was our best data for a number of years, until the highly-successful *MESSENGER* orbiter went there.

After *Mariner 9*, Mars was visited by the fabulously-successful Viking spacecraft, each comprising an orbiter-lander pair. All four components of *Viking 1* (orbiter, lander) and *Viking 2* (orbiter, lander) worked as planned, and we got a really good look at Mars from orbit and from two landing sites; a major step forward and a topic for another day. Mars science was on a roll, and everyone was looking forward to the Viking follow-on mission, *Mars Observer*, which launched on September 25, 1992.

Mars Observer carried more sophisticated instruments than the Viking orbiters, and scientists were eager to get their results. *MO* was also to serve as a communications relay for the Russian

Mars 1994 mission. The spacecraft launch went well, and *Mars Observer* was cruising along to Mars without significant incident.

Alas, three days before *Mars Observer* was to be inserted into Mars orbit, all contact was abruptly lost. We still don't know for sure what went wrong, but the spacecraft's disappearance occurred just as its retrorocket propulsion system was being activated. Perhaps there was some sort of break/leak in the plumbing system that caused the spacecraft to tumble and lose lock on Earth. We'll never know for sure.

Space exploration dollars were particularly scarce at this time, and *Mars Observer* carried a lot of "eggs in one basket." Its loss was one of the most pessimistic times for planetary exploration ever.

Meanwhile, the USSR had been conducting an aggressive set of Mars exploration missions for several decades, but had extraordinarily bad luck with them. Not one was fully successful, and most were abject failures. Mars is Hard! For a summary, see the spreadsheet in the Archive: Other Stuff section of the Air and Space this Week website (here).

NASA rallied in the months that followed, and planned another, much more sophisticated mission pair, *Mars Global Surveyor* (an orbiter) and the *Mars Pathfinder* (a lander). *MGS* was very successful and improved our understanding of the surface of Mars and the processes that affect it significantly.

Mars Pathfinder landed on Mars on **July 4, 1997, twenty-five years ago this week**. It, and its successes, are the topics of this Item.

MARS PATHFINDER

NASA managed to continue an aggressive Solar System exploration schedule in the 1990s by creating lower-cost missions with a tighter scientific focus that the "flagship" big missions like *Mars Observer*. A whole new class of missions was created, the Discovery class, covered as an Item of the Week in February (here). *Mars Pathfinder* was second one of them launched, but the first to reach its destination (the *Near-Earth Asteroid Rendezvous* mission was the first launched, on 2/17/1996), and a worthy topic for a future Item). The program continues to this day, with a number of important Discovery class mission successes under NASA's belt.

Mars Pathfinder was a "three-fer" when it came to mission importance. It was an exploration tool that would help scientists understand the composition of Mars surface materials, but it was also a technology demonstrator. And, most importantly for those of us who share the joy and importance of Solar System exploration with the public, *Mars Pathfinder* was a major breakthrough!

One of the things that frustrated planetary scientists about the Viking landers is that they revealed features tantalizingly-worthy of a closer look, but without the ability to get it. *Pathfinder* would carry a small, semi-independent roving vehicle named *Sojourner.* It had limited mobility, but carried several rock-analysis instruments; ground crew could send it to

interesting rocks and other materials in the immediate vicinity of the landing site. Data were acquired and relayed by the lander to Earth.

Pathfinder used a novel way of landing a payload on Mars. Like the Vikings and other landing attempts prior, it would use a parachute to slow its speed in the martian atmosphere, but instead of using small rockets to land on the surface after the parachute had done its thing, mission engineers planned for it to deploy a system of air bags that would cushion its post-parachute descent. After the spacecraft finished bouncing around, the bags would deflate and the lander would open up like a flower, letting *Sojourner* drive off it and away. Rube Goldberg would have approved, and it worked perfectly. True to its name, *Pathfinder* showed that the air-bag system worked, and it would later be used to land the Mars Exploration Rovers, *Spirit* and *Opportunity*. [But both the *Curiosity* and *Perseverance* landers were too large and heavy to use the air-bag technique; they had to use an even more amazing sky crane system to land. Another topic for another time.]

Mars Global Surveyor was a highly-successful mission, accomplishing all of its pre-mission science objectives and demonstrating the utility of a novel landing system that would be used again later. *Mars Pathfinder* similarly met both its scientific and its technology demonstration objectives. But I believe that *Mars Pathfinder*'s extreme success in outreach to the public was of even higher value in the grand scheme of things!

A BENEFICIAL CONFLUENCE OF FACTORS

The 1990s were a pivotal time in how Americans interacted with one another via technology. MTV, the Internet, and the cell phone were in their infancy. Cable TV existed, but with a much more limited slate of offerings. GPS didn't exist. I lived through it all, but it still seems difficult to imagine life without devices we now take for granted.

Toys were relatively unsophisticated, too. "Tickle Me Elmo" was a hot December toy the year *Pathfinder* landed. But one toy took advantage of improving radio-control technology and built "slot cars without slots" – radio-controlled cars, and enjoyed strong sales. It seemed every kid wanted one (and had I been their age, I'd have wanted one, too!). Those cars were about the same size as *Mars Pathfinder*'s *Sojourner* rover….

Cartoons had been a staple in the movie theater, and were still a staple on morning TV, so a wide age-range of folks then interested in Mars exploration had fond memories of cartoons. There were fewer cartoon producers then, so everyone was familiar of with the characters of Chuck Jones, Walt Disney, and Walter Lanz. Even the most mature acting had a fond memory or two of Yogi, Boo-Boo, Mickey and his Friends, Chilly Willy, etc.

The (pre)teen demographic also was disproportionally the first adopters of new communications technology then coming on line – the Internet. This was the same age group as the radio-control fans, and the same age group as many of the Mars exploration fans.

A few scientists and other pre-influencer "influencers," had tried to share scientific information via the Internet, with mixed results. The technology was frustratingly-limited (dial-up bulletin boards, etc.), but the potential of the Internet to share data quickly was clearly significant.

One event foreshadowed what would come. Fragments of Comet Shoemaker-Levy 9 had been seen to be on a collision course with Jupiter in July, 1994, and the early Internet was used to facilitate a worldwide campaign of observations of the fragments' impact. Real-time distribution of images severely taxed NASA's servers, and traffic across the Web was slowed severely during the time fragments of the comet were hitting Jupiter.

The managers of the Mars Pathfinder mission decided to use the Internet to share mission results more quickly that ever possible before. Their management approved, but perhaps, like so many more-senior managers of the time, they (grossly) underestimated the potential response to an Internet-supported mission.

What a Perfect Storm! Interest in Mars exploration, using a radio-controlled car like everyone wanted, being operated in the coolest location imaginable, with the data being made available via a medium in which the above groups have special interest and expertise – all of these things contributed to a response that has been termed, "The Day the Internet Stood Still."

Quoting from https://www.nasa.gov/specials/pathfinder20:

> "Shoemaker-Levy made it clear to JPL they would have to prepare for something even bigger with Mars Pathfinder.
>
> Webmaster David Dubov told the New York Times shortly after the landing that he estimated the site would be receiving 25 million hits a day. (A "hit" is a request for information from one computer to another. On the web, a hit can represent the transfer of a picture, text or other page element. In the case of Pathfinder's deliberately stripped-down site, each web page comprised a few hits.)
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> "Dubov and JPL engineer Kirk Goodall would later revise that estimate to 60-80 million hits a day, traffic that would crash JPL's networks if the servers were hosted there. Goodall set out to **build a network of mirror sites** [emphasis added] that could take the traffic off JPL's networks. Working with other U.S. science agencies, and ultimately corporations and Internet "backbone" providers, he did just that. (In other words, JPL crowd-sourced their solution a couple of decades before anyone knew crowdsourcing was a thing.)
>
> "And the solution worked. The site took 30 million hits on landing day, July 4. On July 7, the first weekday after the landing, the site got 80 million hits. In comparison, the year before, the chess match between Gary Kasparov and IBM's Deep Blue computer peaked at 21 million hits, and the Atlanta Olympics website had topped out at 18 million hits on one day."

The new technology made on-line viewers feel like they were part of the exploration process themselves, which drove interest further. Then the mission folks did one more thing.

Previous landers showed areas only in the immediate vicinity of the landing site. Scientists analyzing the pictures needed a convenient way to refer to the rocks and other features in their limited field-of-view. In a few instances, they came up with nicknames for the rocks they saw; "Big Joe" is an example from the *Viking 1* landing site.

The *Sojourner* rover was active among the rocks scattered around the *Mars Pathfinder* landing site, so there were a lot more features of interest. The rover operators got a bit whimsical, and began naming most of they could see. Some of the names were descriptive, some were cryptic, but a lot of them were popular cartoon characters. The avid on-line viewers of *Pathfinder* images were regaled with commentary about the geological aspects of Scooby Do, Dilbert's Boss, Ren, and Stimpy.

They could not have come up with a better engager for public outreach if they had started with that as their primary mission!

[And months later, with the mission scientific results were being reported at professional conferences, it was a hoot to hear distinguished senior mission team members speaking earnestly about the detailed composition of Bullwinkle and the evolutionary history of Space Ghost!]

NASA has always done a great job sharing the thrill of exploration with the public. They want their outreach efforts to be just as "cutting edge" as their exploration capabilities. Already successful, they took the outreach lessons from *Pathfinder* to heart, expanding its real-time reporting and image distribution capability, and coming up with engaging events like having school children compete to come up with appropriate names for spacecraft. When you add that to the educational and education-support websites, apps, e-books, and other modern information exchanges, NASA's important role in the Smithsonian-esque "acquisition and dissemination of knowledge" becomes readily apparent!

So, as you are celebrating our nation's birthday on the Fourth (and every day), pause a moment, this one time, to commemorate a successful spacecraft, *Mars Global Surveyor*, and the team that made it possible!

REFERENCES

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Rock Names on Mars: https://en.wikipedia.org/wiki/List_of_rocks_on_Mars

"Mars Attacks the Web": https://mars.nasa.gov/MPF/press/webweek/19970818-mars.html

"Pathfinder Gets Hit Hard on the Internet":
http://passporttoknowledge.com/lfm/discuss/9707/article-60.html

Matt Golombek of JPL was the Principal Investigator for the Mars Pathfinder mission. You can find out more about him at: https://mars.nasa.gov/MPF/bios/golombek.html. See also: https://www.planetary.org/profiles/matt-golombek.

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