Air and Space this Week

Item of the Week

Mars Science Laboratory, aka *Curiosity*: A Decade on Mars

Originally appeared August 1, 2022

KEY WORDS*:* ***Mars Science Laboratory*** ***Curiosity*** **Gale Crater** **Mt. Sharp** **Sky Crane** **Mohawk Guy** ***On the Red Planet***

The incredibly-successful Mars rover, Curiosity*, has spent the last ten years exploring the interior of Gale Crater and is now climbing a layered lake-bottom deposit in contains. It used a novel landing process that involved a parachute and a "sky crane," and touched down ten years ago in the wee hours of* ***August 6, 2012****. Its design and its success inspired a more-capable rover,* Perseverance*, now roving the Jezero Crater river delta.* Curiosity *was designed for 23 months on the martian surface; this Saturday, it will start its 11th year. As only NASA can!*

A NASA HQ BRIEFING

Most of you know that I spent a two-year detail assignment at NASA HQ, starting September 1, 2011. I helped support the outreach efforts for the launch of the *GRAIL* spacecraft in the second week of my assignment, and was awed with the way NASA approaches explaining what it does to the public (see more about that in the About A+StW: A+StW History page of my website). Shortly thereafter, a Directorate-wide notice went out announcing a briefing for the staff about the next planned mission to Mars, the *Mars Science Laboratory*, aka "Curiosity." I was excited to attend; it was another chance to see NASA in action.

As I filed into the large meeting room, actually more of a theater, I didn't know what to expect. I watched closely to see who was there, who sat with whom, how they were behaving in this particular environment, and other aspects of the room's "atmosphere." I was well familiar with previous missions to Mars, and was curious to see what would be coming next. Of course, the engineering and mission folks had already been planning for some time, but this would be the first time the mission specifics would be discussed with the staff.

NASA had already landed on Mars successfully using a combination of parachute and retro-rockets (*Viking*) and parachute and air bags (*Mars Pathfinder* and the Mars Exploration Rovers, *Spirit* and *Opportunity*). But the next lander/rover was going to be much more capable, and much heavier.

The presenters started off with a bang, and briefly outlined the mission profile. Initial reentry would utilize a parachute (no surprise there). Mars' atmosphere is very thin, about 1% that of Earth, but a parachute could kill a lot of, but not all, of the speed of an incoming spacecraft.

What was to happen next was, indeed, a surprise. The presenters stated that after the parachute had done its job, the spacecraft would descend slowly on rockets, *a la* Viking, and *then lower the lander to the surface on cables slung from the rocket platform*. When the lander touched down, the cables would detach, and the rocket platform would then fly off to crash away from the landing site.

I was shocked at the audacity of the plan, to the point that I thought this was some sort of a weird practical joke, or an attention-getting presentation gambit, and that the presenters would get a laugh and then tell us the actual plan. And I wasn't alone; I heard a few mutters and stifled chuckles from the audience. I thought for a moment that we were experiencing an April Fool's joke on par with the great story of Siddartha Finch, published years before by George Plimpton and *Sports Illustrated*. [See this week's Didja Know? section, too.]

But it wasn't April, and the presenters were dead serious. They walked us through the engineering constraints step-by-step, and by the end of their presentation, they had almost everyone convinced that not only was their "sky crane" method possible, it was the best, perhaps only, solution to the problem.

Here, in a simplified form, is their logic. Viking and MER landing technology worked fine, but only because the landers were relatively small. *Curiosity* had a mass of one metric ton or more, and that's just the lander, not its landing system. A large rover atop a landing pad with rockets beneath would be too top-heavy to be stable without a ruinous amount of lateral rocketry and stability control systems. The solution of slinging a rover *beneath* the rocket platform would lower the center of gravity, making the lander/rockets craft to be much more stable (think of a tightrope walker and their long pole the curls down below the wire), but the platform above the rover would crush it after touchdown. Lowering the rover while the landing rockets were hovering above it was the best way to deliver a *Curiosity*-sized rover to surface!

I left the meeting room shaking my head in wonder. It was amazing! As only NASA can.

MARS SCIENCE LABORATORY

NASA had great success prior to the last two decades in its efforts to explore Mars, both from orbit and the martian surface. *Mars Reconnaissance Orbiter* and its fabulous HiRise camera continues to photograph Mars' surface at high resolution, and *Mars Pathfinder* and the *Mars Exploration Rovers* more than met their scientific objectives. The next logical step was to land a much larger and more capable rover in a place of scientific interest.

Spirit and *Opportunity* performed extremely well, but they were solar powered and relatively small. Spacecraft and instrumentation technology had made significant advances in the decade previous, so it was time to take the next step forward – the *Mars Science Laboratory*. The question posed: Did Mars ever have a surface environment more conducive to life than it is today, even microbial life?

The upgrades in *Mars Science Laboratory* included a more robust wheel/suspension system, a great camera system, and a battery of sophisticated sensors. The **CheMin** is an X-ray

diffraction/fluorescence instrument designed to identify the minerals in rocks and soils. Those data are supplemented by the **Alpha Particle X-ray Spectrometer**. The **Mars Hand Lens Imager** (MAHLI) allows extreme close-up images of various materials to be acquired. The **Rover Environmental Monitoring Station** measures air pressure, temperature, humidity, winds, and UV radiation levels. There was even a Russian contribution aboard, the **Dynamic Albedo of Neutrons** instrument, that could probe the martian subsurface to a depth of one meter or so, and measure the presence and quantity of hydrogen present there. Detection of hydrogen would be strong evidence of the presence of water bound to minerals.

My favorite, though, was the "laser eye" on *Curiosity*. The **ChemCam** device would vaporize materials from the surface, using a powerful laser beam, and then use its on-board spectrometer to determine the chemical composition of the material vaporized from the spot the laser blasted.

Mission engineers faced a tough task figuring out how to power up so many instruments and to move the massive rover around over tough terrain. Solar panels could power a rover the size of *Spirit*, but they'd have to be impossibly-large to power *Curiosity*, and there would still be the problem of nighttime and wintertime operations having enough sunlight. A different power source was needed. Engineers selected the Radioisotope Thermal Generator, which produced electricity directly from the heat generated by the decay or radioactive material.

How Did the *MSL* Become *Curiosity*?

NASA held an essay competition for school kids, like they did for *Spirit* and *Opportunity*, and the entry from a 12-year-old girl named Clara Ma, from Lenexa, Kansas, was selected. The name she chose was "Curiosity," and she wrote eloquently about it in her essay. See more about Ms. Ma and her essay here: https://academictips.org/blogs/who-named-the-curiosity-mars-rover.

Why Gale Crater was Chosen as the Landing Site

The presence of water is likely required for life to arise, so there has been a consistent them of "follow the water" in Mars exploration since the days of the Viking program. We see lots of evidence of water on Mars' surface in the distant past, but was it there long enough for life to arise? We even saw some evidence that Mars has a lot of ice buried underground, with the possibility of at least a partial water cycle in operation even at present.

Spirit and *Opportunity* had been targeted on areas satellite data indicated might have had water in the distant past. Geological evidence was used to decide *Spirit*'s site; geochemical evidence was used to decide *Opportunity*'s site. Both missions were successful and returned good data FAR beyond their lifetimes [see the Didja Know? bit in the Calendar: This Week section of the website]. The geochemical folks were right…

Engineering and mission safety considerations negated some potential *Curiosity* landing sites, but there were still a number of good candidates to choose from. NASA had a lot of data at its disposal, and two candidates rose to the top of most everyone's list. One was Jezero Crater, the site eventually chosen for *Curiosity*'s immediate successor, *Perseverance*. The other was Gale Crater, after a prominent amateur astronomer from Australia named Walter Frederick

Gale. Follow the Water: Gale Crater has a river channel flowing into it, a river channel flowing out of it, and a large pile of layered sediment inside it, looking for all the world to be a lake-bottom deposit. What better place to look for possible biological activity in the past?

[The layered mountain inside Gale Crater's official name is Aeolis Mons (Wind Mountain). But almost nobody uses that name. Instead, it's usually called Mt. Sharp, after the late, great geologist and teacher Robert P. Sharp. Personally, I think it's a bit odd to examine lake bottom deposits on a mountain named for the wind, so put me firmly in the "Mt. Sharp" group.]

Summary of Key Science Results

Mars was warmer and had a much thicker atmosphere in the distant past.

Curiosity found evidence of persistent liquid water on the surface in the past!

The surface chemistry of Mars in the past was conducive to support living microbes.

Organic carbon was found in some Mars rocks. [Important, but remember "organic" does not necessarily mean "biological."]

Methane cycles through the martian atmosphere, a possible metabolism by-product.

Mars' atmosphere does not stop all hazardous Solar radiation from hitting the martian surface.

All of the discoveries listed above have a profound effect on the possibility of life arising and persisting on Mars.

NOT YOUR GRANDPA'S NASA

Curiosity's journey from Earth to Mars was relatively uneventful, and everyone at NASA HQ was very excited about the mission prospects. I was mid-way through my NASA detail, and having a blast. As related here, the database I had been using for the Calendar part of Air and Space this Week had attracted by NASA boss' attention, and I had been working with an app development team to beef up the NASA-related stuff in it for use in the about-to-be-released NASA365 app. It was scheduled to be rolled out at NASA's Marshall Space Flight Center in Huntsville just a few days before *Curiosity*'s landing. I was honored to make a presentation at the rollout, and to support the outreach efforts around the landing there, too. In between, NASA asked me to make a presentation on both the app and the *Curiosity* mission at the public facility that would soon become the Infinity Science Center, just outside the Stennis Space Center. It was a bit of a drive to go from Huntsville to Stennis and then back to Huntsville, but it was worth it. The presentations went well, and I appreciated being able to look around the MSFC's Space & Rocket Center and Space Camp facilities prior to the landing.

If you haven't been to the Space & Rocket Center, you might want to plan a trip; it's really fantastic. They have a tremendous collection of rocket and Space exploration memorabilia! Their Davidson Center for Space Exploration contains one of the three remaining Saturn V rockets, slung overhead in a giant room. A presentation theater was adject to the Saturn V hangar, and it was there that the landing outreach programming would take place. It had been

a full three days for me, and I had driven up from Stennis earlier that day. The landing wasn't scheduled until the wee hours of the following day. The outreach program shut down around midnight, and everybody moved into the theater for the televised landing.

Except me.

There was a giant TV screen on the wall beneath the Apollo command module on the Saturn V, and it was playing the same video feed that was in the theater. So I strolled beneath this mammoth rocket, enjoying the exhibits beneath, as the tension built for the landing. I was absolutely alone in this giant open space, contemplating on the 40+ years that separated Apollo and *Curiosity*. And I celebrated with a silent smile when the landing proved successful, as the theater-goers cheered wildly.

There were no outreach events scheduled for the next day. It had been cheaper and less effort to rent a car and drive from DC to Huntsville and back, especially since I had to get to Stennis and back, too. I didn't want to sleep at Marshall, so I loaded up my outreach stuff and drove home that night, way too amped up by the events on Mars to be bothered with sleepiness.

One thing had been apparent in the landing telecast. This was not your (grand)father's NASA. The landing team was much more diverse than their predecessors, and it showed. The morning after the landing, and for a week afterward, I received a number of phone calls and emails that basically said the same two things: "Wow, NASA sure has changed" and "Who was the guy with the Mohawk?"

His name is Bobak Ferdowsi, and his haircut, complete with stars, created quite a stir! He epitomized the notion that NASA had, indeed, been changing with the times, and NASA had the good sense to send him on a variety of outreach activities (I even had the pleasure of working with him on a planetarium show in Virginia). He turned out to be a great asset to "The Cause!" When President Obama called to congratulate the team on a successful landing, he made reference to the "Mohawk Guy," saying, "It does seem NASA has come a long way from the white shirts, dark-rimmed glasses, and pocket protectors. You guys are a little cooler than you used to be."

Indeed. They are NASA and they know it.

STILL GOING STRONG AT GALE CRATER

Curiosity landed in the middle of the crater, away from Mt. Sharp, because it was safer to do so. The "sky crane" landing system worked perfectly, and after activating its systems, it began exploring toward the mountain. The mission scientists and controllers have been doing a great job navigating *Curiosity* safely through the foothills.

Curiosity has been lots of data back to Earth as it climbs Mt. Sharp's lower slopes. Its picture showed a wind-sculpted layered structure consistent with being a lake deposit. But just recently, mission scientists noted that there was a change in the overall appearance of the rocks *Curiosity* was passing. They had the internal structure more indicative of a windy surface environment, not a lake. The interpretation would be that *Curiosity* had been in lake-bottom

sediments on the lower slopes, and was now encountering material laid down in a sandy area adjacent to the lake.

One of the items *Curiosity* encountered and analyzed back in 2016 was baffling. After extended study, it was recently determined to be a chunk of tridymite, a type of quartz that on Earth is formed by silica-rich volcanic eruptions, which tend to be explosive. Its likely source was the eruption of a high-silica volcano in/near Gale Crater while there was still a lake present. Most Mars volcanoes are low in silica and produce lava flows, not big explosions, like the basalts of Hawaii and Iceland, but Mars does have some volcanoes that were higher in silica and more explosive.

NASA released a spectacular 360° panorama video on July 22 that acquired by *Curiosity*'s main camera, see: https://youtu.be/-WHBpBO1W0g. There are a lot of places on Earth that look very much like this… Check it out!

NASA's requirement for *Curiosity* was that it would be productive for a total of 23 months. It's starting its 11th year this week.

CODA

The Fairfax County Public School system, one of the largest in the country, received a generous grant that allowed the Education team at the National Air and Space Museum to work with them to prepare a set of four educational videos. The result was "Flight School," with all aspects of aviation and flight covered. I was proud to play an instrumental role in securing the grant and getting the program off the ground. The FCPS had a wonderful studio facility and several talented video programming folks, and each one of the four videos won awards for their quality. By the time that happened, I was well into the first year of my NASA HQ detail.

The award-winning Flight School quartet was so popular that other funding became available to make a fifth video, called "On the Red Planet." It was about Mars exploration in advance of *Curiosity*, and it featured a number of NASA and NASM people. I was still in close contact with the NASM Education team, and I was able to assist them in the production by arranging for a VIP pass for the FCPS film crew at the *Curiosity* launch. They had an extremely favorable location to record the launch, and I was able to secure a number of interviews with Mars-related NASA personnel, many of which were in the final video. The FCPS team was outstanding, and the video production was excellent. It won a regional Emmy!

On the Red Planet, the fifth in the "Flight School" series of educational videos produced by the Fairfax (VA) County Public School system, is still available on-line at: https://www.fcps.edu/node/31440. Check it out with your friends and family!

REFERENCES

NASA's Mars Science Laboratory webpage: https://mars.nasa.gov/mars-exploration/missions/mars-science-laboratory

NASA's Mars Exploration Program MSL webpage: https://mars.nasa.gov/msl/home

Mission Website: https://mars.nasa.gov/mars-exploration/missions/mars-science-laboratory

MSL Launch Press Kit: https://mars.nasa.gov/internal_resources/822

MSL Landing Press Kit: https://mars.nasa.gov/internal_resources/823

NASA Curiosity Results: https://mars.nasa.gov/msl/mission/science/results

For the Younger Curiosity fan: https://spaceplace.nasa.gov/mars-curiosity/en

Last Edited on 31 July 2022