Rappahannock Astronomy Club

Minutes, October 20, 2021, Online Meeting

In attendance:

Scott Busby
Bart & Linda Billard
Don Clark
Glenn Faini
Tree Greenwood
Tom Hinke
Glenn Holliday
John Maynard & son
Mark McDonagh
Michael Ottenberg
Megan Reese
John Roberts
Matt Scott
Senthil Nagappan
Ashley Stroupe
Myron Wasiuta

The meeting began at about 7:05 p.m., with introductions. Twelve members and six visitors were present, including our guest speaker.

Program

Ashley Stroupe started at Jet Propulsion Laboratory in 2003 and began working on rover operations in 2004. She gave a presentation on Mars rovers, in which she focused on Curiosity. She said that trying to cover 6 years of Spirit, 14 years of Opportunity, and 9 years of Curiosity was getting too much for one presentation. A side-by-side image showed a shiny Curiosity at Sol 84 (84 Martian days after landing) and a dusty Curiosity at Sol 3070. Ashley said earlier rovers focused on geology and searching for evidence of water while Curiosity's primary scientific goal is "to explore and quantitatively asses a local region on Mars' surface as a potential habitat for life, past or present." It is equipped to study geochemistry, with about a dozen instruments in its science payload. One is for multispectral imaging, and another is for identifying organic molecules.

Curiosity's landing site was in Gale Crater. Ashley mentioned the rover's size led to a new, and at the time, frightening way of landing payloads on Mars. After a parachute slowed the descent, Curiosity was suspended from the descent stage that maneuvered it to the landing site, lowered it down gently on a cable, and cut the cable to fly away to crash at a safe distance. This landing technique has now worked successfully for two rovers and a lander. Ashley said her story picked up once Curiosity landed. Gale Crater was selected because it appeared to have been the site of a river delta, with the mountain at the center built up by sedimentation. Orbiters had found evidence of clay formations that are interesting because clay could be a result of life on Mars and because it indicates samples of what was present when the formations built up could be preserved.

Ashley explained why real-time communication is impossible in working with Mars rovers. A signal between Earth and Mars takes 4–23 minutes each way. Waiting even 4 minutes to see an obstacle ahead and then 4 more minutes for the rover to receive a command to put on the brakes is no way to operate. Communications resources are in high demand, allowing different missions limited slices of time to send instructions and receive data back from their probe or rover. Currently, Mars is near conjunction, and interference from the Sun prevents communications for 2–3 weeks. Curiosity is therefor designed to operate autonomously. On a typical day, the team on Earth spends about 8 hours planning the day's mission, sends the instructions, waits about 8 hours for reports and data back from the rover, and then uses the rest of the time to analyze the results. The planning includes choosing waypoints where the rover to decide how to get from one to the next.

The central mountain, Mount Sharp, is a sedimentary formation. Ashley showed a picture looking toward the mountain that revealed the layered structure showing different chemistries with the passage of time. She identified three of the layers going upward as a hematite-bearing unit that only forms in the presence of water, a clay-bearing unit that signals good preservation, and a sulfate-bearing unit that is more inert. Curiosity has essentially moved forward in time as it crosses this terrain. A view from above with Curiosity's path and position in September 2021 marked showed it has crossed the hematite unit and explored the clay unit, arriving at a valley near the transition between three different units.

Ashley showed a mosaic of Curiosity images of the 33 drill-holes it has completed so far. The last 4 were done during the pandemic, with the team members working from their homes. The drill is a key instrument

that allows Curiosity to collect powdered samples of the rocks to analyze the minerology and look for organics. The images showed a wide variety of colors and textures.

Ashley introduced the topic of autonomy that the rover needs on board because of the communication constraints she had described, mentioning that this autonomy was her area of specialization. The rover has to “look out for herself,” especially when driving. Her team studies a 3-D model of the terrain based on orbiter and ground data. They choose a set of waypoints they want the rover to pass through on her way to the goal and allow her to choose her path between them. They also choose, based on the uncertainty of their information and how much navigation difficulty it indicates, how much “paranoia” they want the rover to have about navigating each segment.

Curiosity has different modes of navigation that planners can choose for travel between waypoints: Blind Driving (driving without imagery), Visual Odometry (position tracking), and Autonav (hazard detection and avoidance). Ashley’s slide showed examples of each. Blind Driving terrain is flat and clear. It allows quicker progress because the radiation-tolerant computers on the rover are not as fast as someone’s phone and would require the rover to slow down to allow time for negotiating hazards or slipping on slopes. Visual Odometry is best for slopes or sand, and Autonav allows the rover to be especially careful on unknown terrain. Visual Odometry and Autonav can be combined.

Ashley paused for questions, and Tom Hinke asked what the rover used for positioning since there is no GPS on Mars. She said they used a local coordinate frame based on positions relative to nearby landmarks. They use gyros and motion integration to track position and reset every so often to zero out the errors. She said they were less worried about exact latitude and longitude, but someone checks rover images and satellite data once a day to provide approximate geographic location. In response to questions in the chat window from John Roberts, she said that JPL had indeed “given up on English units” quite a while ago, especially because they use international contributions. She said impact history helps with aging of rock but that, in addition, Curiosity can analyze age with radioisotope measurements.

Autonav hazard avoidance can also use “keep-out” zones (effectively artificial hazards), “keep-in” zones (drive boundaries), and adjustable “bravery” among other options. Ashley described a case where Perseverance, which also has Autonav, was told to go straight across some terrain that appeared clear and flat. Afterward, the image she included in the slide showed where its track paused and made a sharp turn to go around a pile of rocks that its hazard avoidance had detected.

Curiosity can also autonomously select and observe science targets (AEGIS, or Automated Exploration for Gathering Increased Science), using image analysis of a photo from the Navcam to select targets. For example, in an area with a lot of light-colored sandstone, they might tell her dark things are interesting. She might then select the darkest rock for analysis. Curiosity can use the ChemCam to take high resolution color images and do spectroscopy on emissions from blasting material off the surface with its laser. Before and after images show exactly where the laser sampled based on the lack of dust on the spot.

In another pause for questions, Myron Wasiuta asked about whether the colors in the images were actual ones we would see if we were there or whether they were artificial in some way. Ashley’s short answer was “all of the above.” She said some multispectral images were artificially stretched to show more detail, but the ones where the sky was orange were usually true color and ones where it is blue have been stretched. There was an exception for sunset images. Unlike on Earth, the color of the dust in the atmosphere gives the sky the orange color during the day, but at sunset, the sunlight goes through enough dust to leave a blue color. Blue sky at sunset could be true color.

Ashley next covered science results from the mission. Curiosity provided more evidence of bedrock that had water flowing through it for a long period. The example image she showed had many bright veins visible in the rock, indicating mineral deposited from water that flowed through, while the rock above the layer with veins was dark and had none because it was formed later. She also showed evidence of sandstone buildup indicating surface water flowed on Mars in the past. The search for organic molecules has successfully found a large variety, many of which have a sulfur component that makes them more resistant to degradation. Curiosity found an environment with the key ingredients required by life: water; chemistry involving carbon, hydrogen, nitrogen, oxygen, phosphorus, and sulfur; and chemical energy sources usable for microbial metabolism. The early Mars environment was similar to Earth in habitability, and now Perseverance can look for evidence of whether any life formed to take advantage of it.

Curiosity is currently exploring the transition from clay-bearing to sulfate-bearing strata that likely records the transition from a wetter to drier climate. Ashley turned to discussion of Martian weather with a video showing “dust devils” that form on Mars, one showing beautiful cloud formations lit from underneath by the setting Sun, and three images of a rock that changed from slightly reddish tan to orange to red at the height of the dust storm that ended the Opportunity mission on the other side of Mars. The winds on Mars do not exert enough pressure to affect the rovers, but they can pick up fine dust particles. Ashley said they were still not sure whether the clouds were water or carbon dioxide or a mixture.

Ashley’s final topic was astronomy, which she began with a true-color image of a sunset on Mars. The sky definitely looked blue, especially around the Sun. Next were three movies on the same slide showing eclipses that can be seen on Mars. Phobos and Deimos can eclipse the Sun (though only partially), and Phobos can eclipse (occult) Deimos. She said they were actually able to refine the orbits of Phobos and Deimos with movies like these and she was told that one of their orbits is actually decaying and the other moving out. She pointed out the features visible on Phobos in the movie with Deimos disappearing behind it. Another image of the night sky was obtained when the microscope was used to look for photoluminescence of Martian sand at night and it captured Phobos and some stars. She also had in image of Vega and a sequence following the comet Siding Springs.

After the presentation, John Maynard’s son asked why they would not bring Curiosity back to Earth. Ashley explained it took a really big rocket to get it to Mars and would take another big rocket to get it back. She said they were planning to bring samples back some time in the next 10 years, but they would be very small samples and not require such a big rocket. Scott Busby asked about Curiosity’s health and whether there was any deviation in capabilities. Ashley said its health was good, and the only deviation was a work-around for using the drill, which had a failure of the motor used to extend the bit into rocks. Now they use the arm the drill is on to push the bit into the rocks the way we use a hand drill.

Old Business

- Treasurer’s Report—Matt Scott reported three new members joined in September. One also joined the Astronomical League, making the total incoming dues $67.50. There were no expenditures.
- Vice President’s Report—Glenn Faini mentioned that there was a star party scheduled for October 2 that he could not attend, and he was not sure if anyone else was there. He said the extra October star party on the 30th had to be cancelled because of a conflicting Caledon event. He expressed his concern about decreasing attendance at star parties and asked whether we should continue holding public star parties. Myron advocated asking members to sponsor star parties that could then be advertised. Rather than discontinuing them, we could just not advertise star parties with no sponsor.
- Secretary’s Report—Bart Billard said he had posted September’s minutes, thanking Glenn F. and Matt Scott for their comments on the draft he sent out first. He mentioned that when we have presentations, summaries are included in the minutes. They are posted on the club website and a link can be found under “About RAC.”
- *StarGazer* Report—Linda Billard she had not really started work on the newsletter but had lined up some people for contributions. She said she needed contributions by the middle of the week after this meeting.
- MSRO Report—Myron said they were still busy observing Nova Cas. In the latest observation, Alex Filothodoros got a nice spectrum the morning of the club meeting. Another nova they were observing has faded, but they were now seeing an outburst of RS Oph. He said Eric Goforth was nearly qualified to use MSRO, and they were getting images to make a 25-tile mosaic of M31. Three stations (1,2, and 3) were working, and Myron said club members needn’t be worried about trying MSRO (nothing would break). StationFOUR had some PMC-Eight failures but should soon be in operation. It is equipped so that flats and darks are possible to take without opening the roof. Every observation can have fresh calibration frames. Myron invited interested members to contact him and try the MSRO telescopes.
- Communications—Myron and Don Clark had nothing to report on the Facebook page or the website. Glenn F. only mentioned the Groups.io list was running smoothly.
- Equipment Inventory—Scott had nothing new to report. Myron noted the passing of Don Yeier, the founder of Vernonscope. He said a Vernonscope was now part of RAC’s telescope library.

New Business

- Officer Nominations —Glenn F. asked for nominations or volunteers to run for club officer positions. Myron said he would run for Vice President. Bart said he was willing to continue as Secretary, and Matt said he was willing to continue as Treasurer. Glenn asked a few members present if they might consider a position but received no more nominations. He said he would open nominations from the floor at the election meeting next month.
- Other Items—Glenn F. mentioned that we reached 60 members for the year with Megan Gleeson joining this month. (She gets credit for renewing for next year because she joined in the fourth quarter.) He said our next star party was scheduled for November 13 and would be a first quarter star party (not a new Moon star party). The business meeting would be November 17, when we would hold our officer elections. Don asked about when the first virtual star party Myron was planning would be and whether it could be broadcasted to his retirement community. Myron did not have a date planned yet but thought he could announce one soon. Glenn F. said we are limited to 100 people with our Zoom account. He thought that might be enough for Don's broadcast idea. Myron said he also planned to record them and make the video available.

Next Meeting

The next meeting is on Wednesday, November 17, 2021. It is planned as an online meeting. Officer elections are on the agenda.