Student questions: Farah Alibay colloquium on "Perseverance and Ingenuity Mission Updates"

10/6/21

Question 1: What is the speed of the Perseverance Rover, and what is the average distance it travels per Mars' day?
This is highly dependent on terrain and what our goals are for the day. The top speed is about 125 m/hour and we hope to be able to average somewhere around 200m/ day once we enter our next drive campaign

Question 2: What is the maximum depth of samples that the Perseverance Rover drilling bit/sample cashing system can take?
The samples are limited by the depth of the coring drill and the size of the sample tubes. I don't know the exact measurement but its shy of 6 inches.

Question 1: Has Ingenuity's performance been promising enough that a similar architecture could be used for a standalone mission?
Yes! In fact, there are already studies ongoing to propose future helicopters at Mars.

Question 2: How's the wear-and-tear look on Perseverance's tires compared to the issues Curiosity had?
So far, we have not seen any noticeable wear and tear on Persecerance's tires.

Question 1: When building the Rover, I was wondering if the landing site near a river delta impacted the design. Were you expecting softer sand, steeper/more difficult areas to traverse, etc., and have to adjust accordingly, or is the rover just generally designed to work wherever on Mars?
Answered during the talk.

Question 2: You mentioned that you did a lot of testing with Scarecrow and Optimism (and presumably a clone of Ingenuity) while Perseverance was cruising to Mars. Other than Scarecrow having 1/3rd of the mass of Perseverance in order to accommodate the gravity differences of the two planets, are the Earth-bound rovers identical to Perseverance and, if not, how do they differ?
Scarecrow has a large amount of differences because of what it is used for, it has a different chasis etc and runs flight software differently. OPTIMISM is an exact replica although it does not have a radioactive power source (it has a large umbilical instead). There are a number of other test venues, each of which offer a subset of the capabilities of the full rover.

Question 1: What will be the procedure to get Perseverance's samples back to earth?
https://www.youtube.com/watch?v=0PVjj0PEPMA&list=PLTiv_XWHnOZpzQKYC6nLf6M9AuBbng_O8

Question 2: How will the oxygen that's extracted on Mars be stored for future astronauts?
MOXIE is not storing that oxygen right now, it's just a technology demosntration mission so once it's detected the oxygen it releases it back to the Martian atmosphere. Future missions would have to come up with a design to separate that oxygen from the carbon monoxide bi-product and story it.

Question 1: Why is the rover called Perseverance?
There was a competition: https://mars.nasa.gov/news/8622/virginia-middle-school-student-earns-honor-of-naming-nasas-next-mars-rover/

Question 2: What are your goals, geological speaking for this mission? What are you looking for in terms of geology for this mission?
This is outside of my realm of expertise, but this website provides some high level information: https://mars.nasa.gov/mars2020/mission/science/objectives/. I'm sure that a quick literature search will return quite a few interesting papers too!

Question 1: Did you ever have disputes with your team about how something should be built -- if so, how did you handle them?
Yes, that's the nature of being engineers, it's a good thing to have different options! When that happens, we carefully trade each option against the other and decide as a team which option(s) we should pursue further. This is why communcation skills are so important in engineering.

Question 2: If not Jezero Crater, is there any other place on Mars you would want to land the rover? I don't think I've ever heard an engineer's opinion on the matter. I'm rather partial to the outcroppings around Mawrth Vallis.
I don't think that I personally have a favorite place on Mars, but there certainly are a number of fascinating places to explore! Now of course, I'd love to land a rover on Europa too ;)

Question 1: Were there any particularly scary bugs/issues that were encountered while building or operating the rover?
So far we haven't had anything too concerning in operations. As part of development, yes, bugs are common and some of them can be concerning! That's the whole point of the verification and validation campaign though, to make sure that we test all the key rover functionality and find these bugs early.

Question 2: Were any compromises made on any of the initial science goals due to engineering limitations on what could be feasibly built?
I wasn't part of the team at that stage of the mission, so I can't speak to specifics. However, you'll find that any mission has a healthy tension between a science and enginering team – engineers would built a bullet proof brick if they had their way, and scientists may ask for things that break the laws of physics from time to time… I'm exagerating here, but you get the point: design is all about compromise.

Question 1: What sort of differences in design does Ingenuity need to fly on mars?
I'm not sure what the question is getting at here (differences from what?), but here's some informatino about how Ingenuity was built: https://spectrum.ieee.org/nasa-designed-perseverance-helicopter-rover-fly-autonomously-mars#toggle-gdpr

Question 2: How do Ingenuity and Perseverance cope with the extreme weather?
They were built to survive the harshest temperatures on Mars and have onboard heaters to keep them warm. Perseverance has a nuclear power source so isn't too affected by dust stors. Ingenuity was only built to survive 30 sols, so we have yet to see how it will cope with some of the harsher winter environments, but we have observed that flights help clean its solar panels from dust accumulation.

Question 1: How does ingenuity act as a scout – what are the data inputs it takes and feeds to the rover for decision making, deciding what could be interesting to explore or not?
For each flight, the science team provides the Ingenuity team with an area of interest. Ingenuity takes a number of stereo colour images of that area and the science team analyzes those pictures to decide what areas might be of scientific interest/ where they might want to send the rover next. The images can also help the rover planners decide which route they might want to take (in terms of which might have the least obstacles etc).

Question 2: What is the most fragile/difficult surface operation instrument on the rover?
The instruments at the end of the robotic arm are particularly sensitive, so in addition to the drill I'd say PIXL and SHERLOC.

Question 1: Since the Ingenuity technology demonstration was successful, will future rovers also have helicopters?
Similar question answered earlier, there are ongoing studies but nothing set in those.

Question 2: What is the target amount of samples to be collected by Perseverence?
Perserverance has 43 available sample tube, the goal is to take at least 20.

Question 1: How did the locations of Perseverance's landing and subsequent travel get chosen?
This is all decided by the large science team for the mission, they had a number of workshops to choose the landing site and now decide on a day to day basis where they'd like to go on Mars.

Question 2: Are the locations where samples are taken recorded so that analysis of samples can incorporate that?
Yes

Question 1: How do you name the crafts that go to Mars and other off-world sites?
In this case via a student competition: https://mars.nasa.gov/news/8622/virginia-middle-school-student-earns-honor-of-naming-nasas-next-mars-rover/

Question 2: How does flight on Mars impact geosciences?
This is outside of my field, but I'm sure that the images taken by Ingenuity will lead to all sorts of papers and discoveries.

Question 1: Are there any plans for future flight missions on Mars or another planet, maybe including some sort of atmospheric experiments?
Not yet at JPL although there are ongoing studies. Of course there's also APL's Dragonfly mission: https://dragonfly.jhuapl.edu/

Question 2: Do you move the rover everyday and if not what sort of commands are you coding in the 'night shift'?
It depends on the science goal for the day, sometimes we drive, sometimes we do activities with the arm, sometimes we do remote science with the mast, or we operated MOXIE etc. The key here is that we do some kind of science activity every single day.

Question 1: What are the signs of past life Perseverance is looking for?
This is too broad a question to answer quickly, I'd recommend looking at the information on our website: https://mars.nasa.gov/mars2020/mission/science/objectives/

Question 2: If you could help engineer another rover or spacecraft to go anywhere else in the Solar System, where would that be and why?
Enceladus! It's my favorite moon because it's an excellent astrobiology target (it has an ocean and a core) but it's also an easy place to collect samples from because of the geizers it has at its south pole.

Question 1: Was there ever a point were the team got stuck on a problem that took a long time to figure out and solve?
Yes! There's too many to tell, but this is a common part of engineering, especially when you're literally inventing new technology to achieve science or technical goals.

Question 2: Even though the rover is on Mars safely now and had been for awhile, is there ever moments where you get worried about it's safety?
Not really, the rover was fully tested and knows how to go into a safe mode if something is unexpected. We never send commands that would make us worry for the rover.

Question 1: Are there regoliths on Mars?
Yes?

Question 2: Were the rovers built to combat space pollution in mind?
No, this isn't really an issue at Mars for now.

Question 1: How will samples collected by Perseverance be returned to Earth to be analyzed?
Perserverance has 43 available sample tube, the goal is to take at least 20.

Question 2: How did the final version of Perseverance compare to the original plan for the rover?
This is a really open ended question, and I wasn't part of the team at the beginning so it's a hard one for me to answer. I'd say that you could compare the Curiosity and Perseverance design and that would give you a general idea of what changed in this mission: https://magazine.caltech.edu/post/mars-2020-evolution-of-a-rover

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Question 1: Do they put anything in the empty volume of the rocket, since the rover doesn't take up that much space?
No, as I explained we were mass limited, so we only had enough propellant for the mass of the rover. The volume being empty isn't an issue.

Question 2: Do you send the rover longer instructions during the time of conjunction so it can continue to do science?
We built instructions ahead of time that we gave it before conjunction, so it's executing those during conjunction. They are limited though because we don't want to do anything complex or that requires motion without having ground in the loop.

Question 1: How exactly was the navigation program able to alter Perseverance's descent?
I think I explained that pretty well during my talk, but here's more info: https://science.nasa.gov/technology/technology-highlights/terrain-relative-navigation-landing-between-the-hazards

Question 2: What measures were taken to help Perseverance's and Ingenuity's instruments cope with the temperature fluctuations of Mars?
There are heaters onboard that keep them within operational temperatures.

Question 1: How will Perseverance find evidence of ancient life?
This is too broad a question to answer quickly, I'd recommend looking at the information on our website: https://mars.nasa.gov/mars2020/mission/science/objectives/

Question 2: How do you decide what the rover will do and where it will go each day?
This is a process that is guided by the science team based on their strategic objectives. The engineering team then weighs in on what is doable on a given day based on resources and complexity.

Question 1: Why are the wheels on Perseverance better than the ones on previous rovers?
The wheels were completely redesigned to reduce stress and hot spots. Here's some information: https://mars.nasa.gov/mars2020/spacecraft/rover/wheels/

Question 2: How fast can Perseverance move?
This is highly dependent on terrain and what our goals are for the day. The top speed is about 125 m/hour and we hope to be able to average somewhere around 200m/ day once we enter our next drive campaign.

Question 1: How does MOXIE extract Oxygen from the Martian atmosphere?
2*CO2 → O2 + 2*CO, via solid oxyde electrolysis.
https://link.springer.com/article/10.1007%2Fs11214-020-00782-8

Question 2: Beside using a cleanroom to build spacecraft, what else goes into ensuring there is no terrestrial contamination on any pats of a rover being sent to Mars?
This is an entire field, called planetary protection.
https://planetaryprotection.jpl.nasa.gov/missions

Question 1: When is it safe enough to start cheering for a successful landing?
After you hear touchdown confirmed.

Question 2: Were engineering tests of the rover available for the public to watch?
There was a camera in our cleanroom throughout the build that was available to the public, yet.

Question 1: What facilities on Earth are used to communicate with Perseverance?
We have an operations room where we build the commands, and then they are sent via X-Band through the Deep Space Network's antennas.
https://www.nasa.gov/directorates/heo/scan/services/networks/deep_space_network/about

Question 2: Kind of a fun question: Of all the instruments aboard Perseverance, what instrument do you think has the coolest abbreviated name given its functionality?
I like the SHERLOC instrument because it's a neat name and has a companion imager called WATSON. https://mars.nasa.gov/mars2020/spacecraft/instruments/sherloc/

Question 1: What functions of the rimfax antenna helped in preparing for human arrival?
Answered during talk

Question 1: You mentioned you've always wanted to become an astronaut, do you feel like working at NASA is a must before applying for the astronaut program?
Not at all! NASA takes on astronauts from all walks of life.

Question 2: What are the next big plans for building upon the engineering behind ingenuity?
Now that Ingenuity was successful, there's ongoing studies to propose future helicopter missions at Mars. There's no plans yet but I'm sure this isn't the last time we're going to see helicopters on other planets.

Question 1: What would have to happen for the timeline for a mission like the Mars 2020 mission to move faster?
That's a question that we keep working on, there's a lot of options but one of the big changes that is coming is something called onboard planner which will allow the rover to make more autonomous decisions.
https://www.cpp.edu/~gkuri/classes/ece4310/scheduler_mars2020_jpl.pdf

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Question 1: How does the team test the diagnostics of the instruments on the rover to make sure they are working correctly and not sending incorrect signals?
We start with simple low risk activities and then build on them as we build confidence on the instrument's health.

Question 2: What is the planned timeline for Perseverance and is there a possibility for the mission extending beyond this point?
The timeline is 1 martian year (2 Earth years). It'll be up to headquarters if they want to extend the mission or not, but if the mission is doing well then yes, there's a good chance it will receive an extension.

Question 1: You mentioned the rover would have the ability of determining if a landing spot is safe; what factors would the rover have to investigate to determine if the landing spot is safe? Is it able to determine factors like slope, stability, etc?
I didn't work on that system so I don't have all the details, but it was able to feature match and had an oboard map that told it which areas were preferred (so the ground ranked different areas ahead of time and made a goodness map.). It was also abel to detect obstacles (rocks, boulders etc) which are the main concern/ which cannot be seen from orbital imagery.

Question 2: Are there means of recollecting the helicopter on Mars if it were to be separated from the rover or does it not differ too greatly from a normal drone that would return to it's launch site once the battery is low?
Are you asking if there's a way to connect the rover and the helicopter again? No, there isn't. The helicopter is a fully idependent mission and has solar panels to charge its batteries.

Question 1: Can Ingenuity store its own data, or can it only transmit data to Perseverance?
It can store it's own data, but the only way to get it to Earth is via Perseverance.

Question 1: Why does Perseverance have six wheels?
This is a heritage design that we've used for all our rovers:
https://www.jpl.nasa.gov/videos/building-curiosity-rover-rocks-rocker-bogie

Question 2: Did you pick Jezero crater as a landing site because the crater exposes the stratigraphy of the river delta?
I'm not part of the science team, so this is outside of my field of expertise. Here's some information: https://mars.nasa.gov/mars2020/mission/science/landing-site/

Question 1: What is the speed of Perseverance on Mars?
This is highly dependent on terrain and what our goals are for the day. The top speed is about 125 m/hour and we hope to be able to average somewhere around 200m/ day once we enter our next drive campaign

Question 2: Can Ingenuity be used to update the internal maps within Perseverance to allow for better automation? Is that something that could be considered for a future mission?
No, Perseverance makes its own maps at it drives and is already able to drive in an automated way, so this is a feature that exists regardless of Ingenuity.

Question 1: What were the biggest obstacles to overcome when building Perseverance?
The sample caching system as I explained was a highly complex and new piece of engineering that required extensive development and testing. I explained in my talk why it was complex.

Question 2: Does Ingenuity have the capability of exploring areas of Mars outside of the landing site? (How far?)
Answered in talk.

Question 1: As you mentioned in the lecture, the rover will pick up 2 or more samples from the surface of Mars. I was wondering how to get the device that holds the samples to return to Earth?
Perserverance has 43 available sample tube, the goal is to take at least 20 samples.

Question 2: How long did it take for the rover to take action after it was given orders on Earth?
We send all the commands during a single uplink pass. The rover then picks up the days' plan every morning (so it's not direct commanding, the rover knows every day at a certain time to look for a new plan in its file system and execute it).

Question 1: How did you decide when to transition back from Mars time onto Earth time?
Once the main commissioning activities were over and we had a slightly more efficient operations timeline. That turned out to be about 68 sols into the mission.

Question 2: How has your role at JPL changed in this new mission compared to the last one?
Answered some of this in my talk, I gave details of all the missions I've worked on and what role I had. Long story short: I've worked in many different roles since joining JPL: https://mars.nasa.gov/people/profile/index.cfm?id=23065