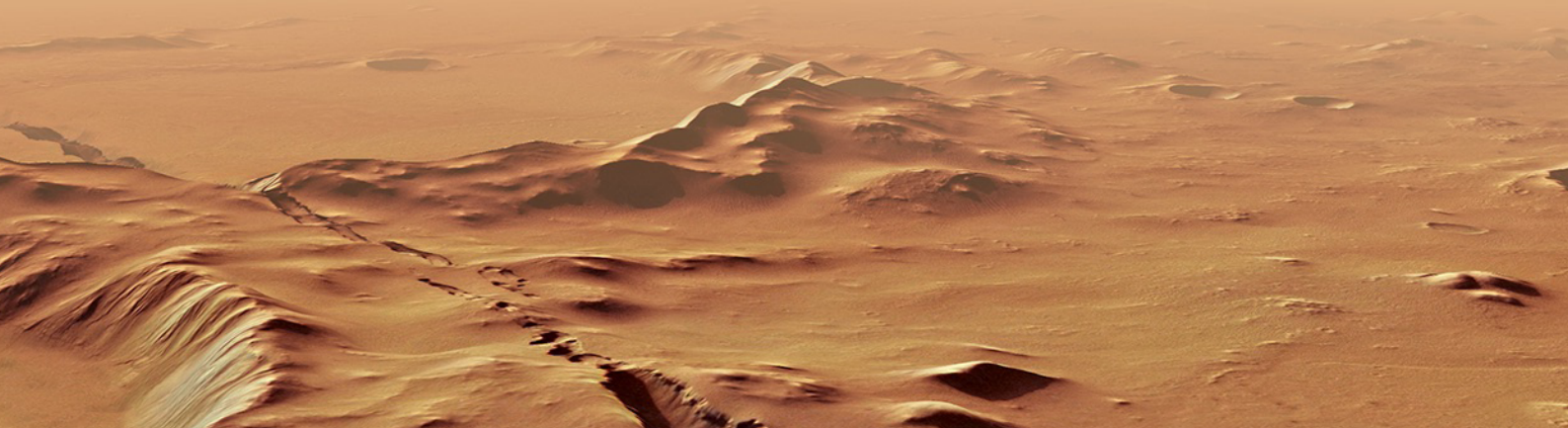
All About Space

LIVING LIKE A MARS ROVER

Interviewed by James Horton



Living like a Mars rover

All About Space caught up with TED Talk speaker Nagin Cox, the Curiosity rover's spacecraft engineer, who lives and works on Martian time

Interviewed by James Horton

Before joining the Jet Propulsion Laboratory (JPL) you served with the US Air Force for six years. Did you always see yourself progressing onto interplanetary space missions?
Actually, I did. I have been interested in working for JPL since I was 14, so I've always had a bit of a one-track mind. I was very fortunate to have served in the military; they funded all of my education from undergraduate to postgraduate degrees, so I couldn't have gotten to where I am today without having served. But then there came a point where, for as much fun as I was having in the military, I wanted to switch back to my original goal. I was working in military space operations at the time and I wanted to resume my quest to join JPL. I felt that it would take longer than it did, but I was fortunate enough to join NASA within a year of leaving the Air Force.

You've had the privilege to work on three of the rovers to have landed on Mars. What stands out to you as the most exciting?
The landings are very hard to beat for sheer excitement and nervousness. But separate from the initial landings and driving the rover from the landing platform and onto the surface – as we did during the Mars Exploration Rover (MER) missions – there have been so many. One that I specifically remember is when the project scientist came into the flight operations room and told us that the water on Mars had once been drinkable. That was quite a moment, and we were told that they wanted to share the information with the flight team before it was announced.

There are many moments like that, where we hear results as they're being developed, and then we can start to think about where we're going to drive to next to investigate the idea further. Overall, as the engineers, our role is to drive the rover and make sure that it's okay, but we also get to participate daily with the scientists as the story develops.

And then of course there are the exciting milestone sols. At first, we thought Spirit and Opportunity were designed for 90 sols – or optimistically maybe we could get an Earth year of use out of them – but 14 years later we continue to be amazed. And although I don't work on Opportunity any longer it's hard to forget your first rover. [Note: since this interview was first published, a dust storm cut communications with the Opportunity rover in June 2018. After many failed attempts to re-establish contact, NASA announced the end of the rover's mission in February 2019.]

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Had the idea to amend your working hours to Mars time (by coming into work 40 minutes later every day) been introduced when you joined the rover missions? Why was that decision made?
I was on MER from day one, and whether or not to operate on Mars time for each rover, or a lander like Phoenix, is an ongoing discussion. The basic idea is that you can be more efficient with the rover if you work as if you're actually on Mars [by elongating the Earth day by 40 minutes to accommodate Mars' slower rotation], rather than operating strictly according to the Earth day. However, there is always a question about the toll it takes on the people on Earth, and the complications that surround it. So we're constantly


Cox at Mission Control back in August 2012

INTERVIEW BIO

Nagin Cox

Nagin Cox is a spacecraft engineer at NASA's Jet Propulsion Laboratory (JPL) and part of the team responsible for operating the Curiosity Mars rover. She has a master's degree in Space Operations Systems Engineering and joined JPL in 1993 after six years with US Air Force. She has worked on NASA/JPL's Galileo mission to Jupiter, the Kepler telescope that's hunting for Earth-like exoplanets and three of the Mars rovers.

thinking about whether it's necessary to do that; we ask whether we've learned enough about operating on the Red Planet to either shorten or lengthen the amount of time spent working on Mars time to make it more sustainable. We only have a few data points about this, so it's a constant conversation about whether we need to operate on Mars time, and for how long. It's a fascinating conversation that goes on and on; I'm also a member of the Mars 2020 rover team, and Mars time is still an ongoing discussion.

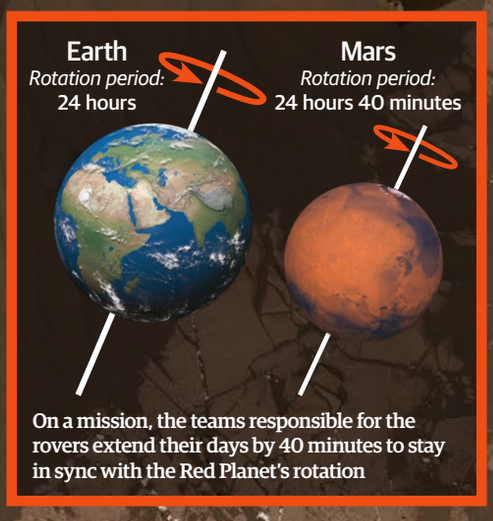
What were the main obstacles you and your team faced when trying to operate by Martian time instead of Earth days?

Those of us who live in Pasadena [California] and work on the missions have the advantage of remaining at home, but when you're switching your own body clock to Mars time it's important to consider the impact it has on your family. For the scientists and engineers coming from other parts of the country and the rest of the world, they have a different set of challenges. They'll be living in either townhouses or rented apartments with roommates who are also likely on Mars time, so there's not such a sense of inconveniencing those around you. However, those scientists and engineers are gone for three months or more from their families.

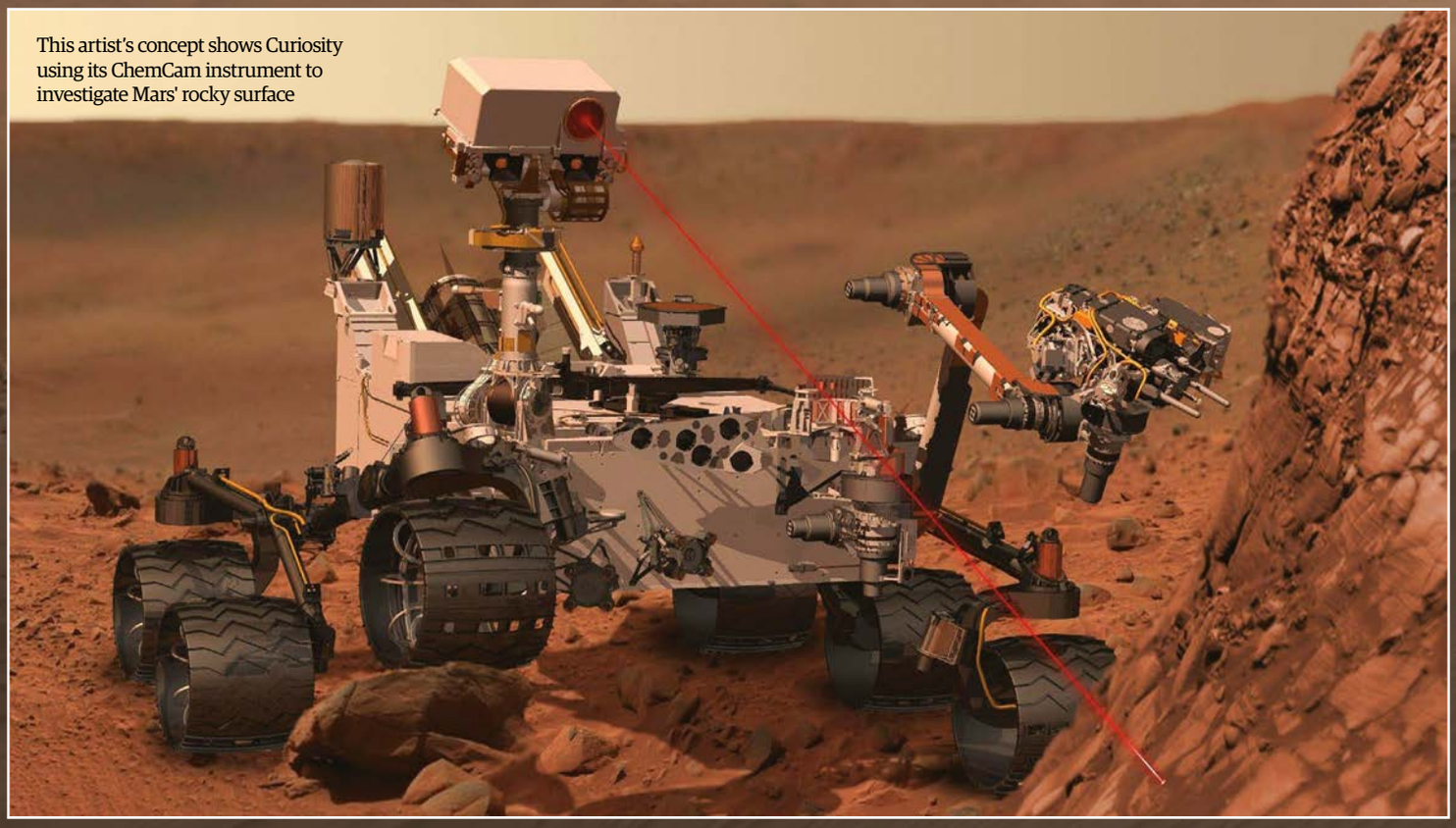
But whether living at home with families or away from them, all of us had to face the challenge that the Sun rises above the Earth at a certain time, and you can't block out everything. The errands and daily activities that you have to do are still there so you have to learn where the 24 hour fueling stations, diners and grocery stores are; but there's still a lot you can't do. It's a challenge to conduct the rest of your Earth life while your work life is on Mars time.

Were these changes why you and the other members of your team came to think of yourselves as full-blown 'Martians'?

The thing with calling ourselves Martians and feeling disassociated with others was because we were out of sync. A good parallel is to think about going camping, say when you're away from



On a mission, the teams responsible for the rovers extend their days by 40 minutes to stay in sync with the Red Planet's rotation



This artist's concept shows Curiosity using its ChemCam instrument to investigate Mars' rocky surface

Nagin outlines the Mars Science Laboratory mission in a presentation at Dryden, Ontario, describing it as the most difficult planetary mission ever attempted

The Mars Science Laboratory operations team members have to meticulously plan Curiosity's route through the ridges of Mount Sharp

"It felt like exploration in the days of old. We would drive the rover over a hill and wonder what we were going to see"

civilisation for a week. You immediately become very attuned to nature but grow disconnected with the news and other things. In the same way, when we were coming into work 40 minutes later every day our attention was on work, on Mars. So although we weren't removed from information about the Earth we were there to do a job, and that job was on Mars. And once our working hours had rotated into the Earth night we grew very disconnected. For those three months, we had to put our Earth lives on hold until the end of Mars time, and so the dissociation eventually just happened.

To help your team adapt to Mars time you were given watches that run slightly slower to match the Red Planet's rotation. Is there anywhere we can get our hands on a Martian-time watch?
At the time they were specially made. The first were made for Mars Pathfinder, which was in 1997, and then when I got mine in 2003 for Spirit and Opportunity, they were being made by two local jewellers. At the time they were quite inexpensive; I had two – one for Spirit and one for Opportunity – and they were only $70 (£55) apiece. But now they're such a speciality item that a mechanical Mars watch is over $400 (£310), however, there are apps for Android and digital watches that can perform the same function.

How instrumental do you feel the findings of the Mars Exploration Rovers have been in our efforts to understand the Red Planet?
I think they have been very instrumental in our understanding of Mars as a whole, but they do fit into a larger overall program. Because the rovers are on the surface and we can drive them around, we can bring a different data set than the orbiters. But the orbiters are also key. When we started out, we didn't have the HiRISE camera on MRO [Mars Reconnaissance Orbiter] with its incredible resolution, and at that point it felt like exploration in the days of old. We would drive the rover over a hill and wonder what we were going to see because the pictures from orbit weren't at the level of today's incredible cameras. Now we can get a better sense from orbit of where we're going and what's the right path to take, which makes us very efficient. And secondly the orbiters also make discoveries on their own based on their global data set.

If you imagine trying to understand Liverpool by just having a car that's able to drive around, but without a larger picture of the city and Great Britain to go with it, it would be difficult. So the rovers, the orbiters and even the landers – which don't move around, but give us a picture of what's going on under the planet's surface – all go together. For example, every so often you'll hear people say: "how many times is NASA going to

"They may be growing lettuce on the ISS, but we don't have a lot of experience in hydroponics anywhere else"

announce water on Mars?" and you can see how, to the general public, it seems like they've heard it all before. However, as part of the scientific method, it is reassuring that we continue to find evidence that there was once liquid water on the surface of Mars in the past and that we are able to evolve that story.

How has the Curiosity rover mission been progressing on the Martian surface?
Well, we've made our way through Bagnold Dunes as part of our ascent of Mount Sharp, and for me as someone who has been working on the rover from before we even landed, it's exceptionally gratifying to see the parts of the mission that take a long time to happen. When we picked the landing site of Gale Crater and saw that there was this remarkable dune field surrounding the base of Mount Sharp, we had to ask ourselves how we were going to get through those dunes. We had to pick a decent crossing location and be aware that it was going to take a considerable portion of the mission to traverse down to a point where we could navigate between the dunes safely to continue our ascent. So it's been gratifying to have us arrive at a point that we've been heading towards for a while now and seeing it as a milestone in our exploration story, which has been a long time coming.

What new information will Mars 2020 bring?
Each rover builds on the previous so this time we'll be caching samples taken from the surface of Mars, but we'll be leaving them there for the next mission to bring back. We'll also be taking equipment that can help us take the next step in detecting life, which will provide us with the ability to detect different kinds of biosignatures.

We have to be patient, given that we're trying to get samples that are going to come back to the Earth. These are the samples that generations of scientists will be using, the same way that we still use the Moon rocks. Our scientists will want every last bit of information they can get from Mars before selecting a sample, and you can understand that. This is going to be their legacy to future scientists and students all around the world. For me it is very interesting to work on a mission where we in operations have an equal standing in designing the rover for this historic step in gathering samples, which the next rover mission will then come back and get – and that will be the hard mission!

You've spoken before about the rovers acting as pathfinders for human astronauts to follow. Do you feel that this goal is achievable in the coming decades, given what we now know about Mars?
I do think that it's achievable. It has been achievable to send people to Mars for some time now, but it's a matter of how many resources the world wants to devote to it. One can invest the time and the resources to send people to Mars, but often the goal is not yet one of colonisation but more likely something similar to the permanent presence we've had in Antarctica for 100 years, where we have very small scientific research bases.

Now you could brute force your way to Mars using rockets, sending all the needed supplies, assembling in orbit and those sorts of things. But there's a lot of engineering work that needs to be done in parallel to getting humans ready to send to Mars. For example, on 2020 we have an instrument on the rover called MOXIE (Mars Oxygen In-Situ Resource Utilization Experiment), which is going to be a prototype that can take in Martian atmosphere and pull apart the carbon dioxide to make carbon monoxide and oxygen, and that will be the very first step on that path.

I actually worked on that instrument for a while, and the idea is that you could scale up from the Mars 2020 prototype and then eventually you'd be able to send a mission to Mars that can land an oxygen production plant on the surface. That could then sit there and make oxygen for a couple of years until the astronauts arrive.

So to make Mars sustainable – even in the way that we call our bases in Antarctica sustainable – there is a lot of engineering work that has to be done first. They may be growing lettuce on the International Space Station, but we don't have a lot of experience in hydroponics anywhere else. Also there's the idea of going back to the Moon or an asteroid or cis-lunar space as a proving ground before going to Mars. Getting there will also be down to international cooperation, because to go alone just doesn't seem to make any sense.

Finally, your namesake asteroid, 14061 Nagincox, is shooting through the cosmos. How does it feel to have a celestial object named in your honour?
I'm still so amazed by it, and it transpired in such a surprising way. I was in Florence, Italy, with the State Department and I was giving a presentation, and in one of those crazy coincidences the discoverers (Ulisse Munari and Maura Tombelli from the Cima Ekar observatory) happened to be at this talk in a library, and afterward they rushed the podium and said: "we're going to name an asteroid after you!" It was such a tremendous honour that I'm still beyond amazed. And I'm also really glad it's not an Earth-impacting asteroid!

Described by Cox as one of the most exciting parts of the mission, the Curiosity rover's landing is facilitated by a sky-crane manoeuvre