Astronomy Cast Episode 93:
Missions to Mars Part Two

Fraser Cane: Last week was a bit of a dry history lesson. We actually got a couple of e-mails: BORING. We wanted to give people some context and I'm not sure how we could zazz it up.

This week, we're going to finish it off and talk about all the missions that are there on the surface of Mars and in orbit, and really explain all of the science that is happening right now. I think this will be a lot more interesting. Alright, Pamela, so, last we saw our heroes Mars Global Surveyor had died… and then….

Dr. Pamela Gay: But it had a good life.

Fraser: It had a good life, sure. The first mission to arrive at Mars that is still there is the Mars Odyssey.

Pamela: Mars Odyssey. The naming of this is actually a cool story in itself. It didn't start out with the name Mars Odyssey, but it launched in 2001 and one of the things you're going to notice today is today is the pod cast of odd numbered year launches

The launch window for Mars opens up every 780 days and Mars Odyssey's window happened to fall in 2001. So it became instead of 2001 A Space Odyssey, how about 2001 A Mars Odyssey? It's a good enough place to start.

Fraser: I never thought of that. That's why they did that.

Pamela: It's kinda cool.

Fraser: Yeah.

Pamela: So that is our first Sir Arthur C. Clark bit of trivia for the day. When Mars Odyssey got to the red planet it was one of the first to start doing thermal mission imaging. They were looking at how the temperatures fluctuate on the surface.

This is a cool instrument because it allows us to do things like look at the caves that have been recently found, and measure the temperatures inside of the caves and go "yes, we can have frozen things inside of those caves."

It had a gamma ray spectrometer that can be used to detect neutrons which in turn means there's water. It had a Mars radiation environment experiment. This allowed them to measure how much radiation there is in the low orbit of Mars that it's in that is similar to the orbit that the Space Shuttle is in around the earth, and they were able to actually measure that "yeah, the radiation is a lot higher on Mars."

Fraser: I think the measurement was that it was 2 ½ times as much radiation falling on Mars as the astronauts experience onboard the International Space Station. So, any future visitors to Mars are gonna have to deal with a really high radiation load. It's not like it is going give you radiation burns, but cancer will be in your future if you stay out too long.

Pamela: And what's really cool about Mars Odyssey and what's made it so useful today is it has really good communication systems. It can send a bunch of data back to earth in a very effective manner. And today its primary use is actually as a communication satellite. It's the mission that's out there relaying information from the Mars rovers, from Phoenix all the way back to earth.

So those little rovers don't have to expend all of their energy. And right now they don't have a lot because they're pretty covered in dust. They just need to expend enough energy to get a little signal up to this orbiting spacecraft and the orbiting spacecraft does the hard work of sending a powerful signal all the way back to planet earth.

Fraser: Now Mars Odyssey made one of the biggest discoveries on Mars in the last little while, which is water, water everywhere.

Pamela: Yeah. With its gamma ray spectrometer everywhere it looked it was seeing potential underground frozen seas. It was seeing water everywhere. They've been able to actually match underground frozen ice with stream banks, not real stream banks, but fossil stream banks of where we think a stream used to be.

This is a neat way that you can actually tell the difference between a lava channel and an alluvial channel, something carved out by liquid. It's been a spectacular mission and I have to say that as boring as thermal emission imaging sounds, this is one of those things that allows us to see what the climatic changes between winter and summer are.

How do ground temperature and clouds interplay? How does the climate on this other world that hopefully somewhere in the 2030s we'll be exploring on foot, how does this climate vary between the seasons? This also helps us figure out the mineralogy. Different rocks hold onto temperature in different ways.

So, it combines a lot of different things to help, help us understand, "well, where is it that we want to plant human beings once we get there?" It's actually been used a lot to help figure out landing sites as well.

Fraser: Alright. Well, let's move on to the next mission.

Pamela: Well, so that was 2001. So now we go to our 2003 landing system because it is after all the day of odd numbered years. It was the Europeans who got the next orbiting spacecraft there. It was the Mars Express. Mars Express is still out there ticking. It's a great mission that has had amazing, amazing science return.

It's hard to figure out where to even start. Perhaps one of the coolest bits of information to come out of this mission is there's both ammonia and methane in the atmosphere of Mars. That sounds kinda boring. Methane and ammonia aren't exactly the most pleasant gasses to be around, but they don't last in the atmosphere.

These two particular gasses could come either from some sort of active volcanism which is cool. Who doesn't like volcanism? Everyone likes a good volcano explosion I think. But they could also come as the outputs of biological life. There could be some sort of bacteria or something under the surface that's creating these little bursts of methane and ammonia. We still haven't localized where they're coming from, but we know that they're there. And, that's just cool.

Fraser: Right. That slight amount of methane which can only last, what was it like a hundred years I think in the atmosphere and then it's gone because of the radiation from the sun. Some active thing is putting out this methane and you really only have a couple of choices and the more exciting one anyway is life.

The fact that a bacterial life is producing methane gas as a byproduct of its life however it is functioning down there on Mars. Total speculation, no one has found pockets of bacteria. But it's a pretty viable source for where this methane is coming from. So, that is one of the biggest mysteries and I really hope that there is going to be more investigation done.

You know, the methane observer being sent to Mars at some point [Laughter] to really track down the sources.

I think the other thing with Mars Express is the photographs are just amazing. I mean it is an incredibly high resolution camera on that, and it also has the ability to take pictures in 3 dimensions. So, you get these beautiful fly-throughs and 3-D views of features on Mars going to the Vales Marineris, going around Olympus Mons. I really like the pictures that come out of ESA. I would say they're one of my favorites.

Pamela: Yeah. The high resolution stereo camera has two meter resolution which is about half of the maximum resolution that you get if you look in Google maps. And they're doing that from orbit. Most of Google maps is actually done from airplanes.

With the stereo views you can really get a sense for how deep the canyons are, how tall the volcanoes are. This isn't something that we have a lot of 3 dimensional data on like IO or anything like that. It's Mars where we have this unique chance to explore the world as though we were actually there. This allows us to really get a good understanding of the topography.

We're combining 3 dimensional color images with another instrument the MOLA, the Mars orbiting laser altimeter, which can be used to get even more sensitive height information. It helps us get a sense of what is the texture of everything. We're getting basically as good or better geological information on the surface of Mars than we have on the planet earth. [Laughter] That's just kinda cool to think about.

Fraser: Right. There are no pesky trees or buildings in the way…

Pamela: [Laughter], Right, right.

Fraser: No water to obscure things. It's all just there.

Pamela: Yeah. You've gotta love the tropical rain forest, but it's kinda hard to look through them to see what the geology beneath might be. But, in addition to being able to look at the surface and map the surface, Mars Express also carried with it radar that allowed them to basically peel away the surface and look beneath it and see what is the density of the structures underneath. In this way we can look for frozen water.

We can look for hidden craters that are buried in dust. This sort of two dimensional thing we've also done it on the planet earth. It is part of what they do when they're trying to find oil to dig into in the desert and things like that.

Now we're starting to peel away the surface of other planets and see what's beneath their surface. And, yeah, we're not gonna get rich off of finding buried ice, but that's someplace that perhaps someday we can dig a well and get some, for an astronaut much more precious drink of water.

Fraser: Now, we didn't want to make this episode another failure fest, but Mars Express was carrying something else on board.

Pamela: Yeah, the Beagle 2. It died. [Laughter]

Fraser: Beagle 2 was going to be a real exciting search for life. It was a pizza box size spacecraft that folded open and it went missing.

Pamela: Yeah…yeah. It will be found eventually. But you know that was a particular year when there were a couple of other rovers that made a big and very successful splash on the surface of Mars.

The 2003 launch window as well as launching Mars Express also launched Spirit and Opportunity, two Mars exploration rovers. These are the two little robots that won't die. They're barely getting enough electricity. One of them is walking around gimp legged because one of its wheels is locked and its camera is stuck in place, or rather its arm is stuck in place.

But they're still out there. They're still exploring, still doing science and they're still getting data. These little rovers have confirmed there are minerals on the surface of Mars that could only have formed in the presence of water. And so, it's again, water, water everywhere. They're showing that the seasons are harsh, but we know how to build things to survive the worst dust storms that Mars can throw at them.

And it's teaching us how to basically problem-solve on the fly remotely. So you've got to take your hat off to JPL. They have been able to basically problem-solve the most incredible ideas to keep these things going. Poor Spirit is totally covered in dust. It's barely getting any electricity from the sun.

To keep it going until a good gust of wind comes along and clears off its solar panels which we keep hoping for, they've had to brainstorm all sorts of unique ways to shut down this, shut down that. Get it to only call in every couple of days and it's basically in shut down mode waiting for a gust of wind to clear it off.

It's waiting for the sun to get a little higher in the sky. But they've kept it going. It's still doing things like measuring the atmospheric opacity and it's still taking pictures. But mostly it's just sitting there trying to stay alive.

Meanwhile, Opportunity is off and roving. It just keeps going. What's incredible about Opportunity is it's had problems with one of its arm/shoulders since day one pretty much. It has a thermal relay that doesn't know when to work, so it pretty much stays on until it overheats and then shuts off. And this is a huge energy drain.

So, they had to figure out how to reprogram it so that they could put Opportunity into a super sleep mode to conserve power when it was covered in dust and getting not enough electricity in the Martian winter.

Also, as a result of just getting way too hot at some points, the thermo coupling slowly did damage to the shoulder such that the arm it didn't want to move anymore. And this is kinda scary because they don't want to drive around with the arm extended out in front of them.

So they normally tuck the arm down underneath. But if the shoulder gets stuck with the arm down underneath that means that they can't use the arm anymore. The arm has cameras on it. It has a little thing called the rat that goes out and burrows away a little bit of the surface of rocks so that they can see what's beneath the surface. The arm is just really useful. You want to keep it going.

And any of you who have ever had a shoulder injury know that you still can do a lot with an elbow, wrist and a bunch of fingers. So the decision was made to figure out how to un-jam the shoulder, get the arm into a good position, and then drive with the arm up which wasn't something they'd ever planned to do.

But to get the shoulder unstuck they had to do this crazy combination of waiting for the temperatures to be just right and then throw in all the electricity they could through the circuit to get the thing to move.

It was an amazing bit of problem solving of if we do this it sorta works. If we do this, this is when it works best, so let's combine all these different things to finally get the shoulder to move. These are arthritic little robots but they're still returning science.

Fraser: Yeah. They were supposed to last 90 what are called sols. Those are Martian days. And they're in, what, 800's now?

Pamela: [Laughter] They're in the 1500s.

Fraser: Oh, the 1500s. Sorry.

Pamela: But to go from 90 to 1500 [Laughter]

Fraser: Yeah. So, that's pretty amazing. Although I suspect the engineers were kind of under-promising, and over-delivering, which is good. But, still I don't think they expected them to last this long…

Pamela: Well the thing we're most worried about is once these things turn off we're not getting them back. They have to keep themselves warm or their electronics freeze.

I don't know if any of you have ever had the misfortune of leaving your laptop outside say in an observatory or something in Michigan. We had a computer at Michigan State that one night we couldn't observe because the hard drive was frozen in place and there was nothing we were going to be able to do to get that hard drive to spin itself up. Now, if you just leave the computer on, the heat the computer itself generates will keep the computer alive.

Well, on Mars that's not enough. On Mars they have to run heaters. If you have ever used batteries while hiking in the cold, you know if the batteries get too cold they stop working. So they have to use heaters. Well, if the rover is completely shut off, their heaters go out everything freezes and they never come back to life.

And the concern was that during their first Martian winter they would get covered in dust, wouldn't be able to get enough electricity to keep their heaters going, and they'd turn off. It turns out that gusts of wind just kept saving their little robotic butts and allowing them to consistently get enough electricity, just enough to keep warm and call home periodically.

Fraser: Now this has been a bit of a super tangent, but we should just spend a second I think and explain the scientific objective for the rovers. They were to search for past evidence of water that acted on the surface of Mars millions, billions of years ago. Both rovers did find that. I think we've talked about this quite a bit in, in previous shows, so we won't go into details.

But the goal was, was there water on the surface of Mars? In finding minerals that can only be created by through the action of water or through the chemical processes of minerals working with water, both rovers have found evidence separately that confirms that yes, liquid water was on the surface of Mars for long periods of time billions of years ago. Probably, you know, not since almost the beginning of the planet. [Laughter] Still the water was there. So, why don't we move on then to the, the next spaceship?

Pamela: Okay. So this gets us to the new favorite child of anyone who loves pretty pictures of Mars. And that's Mars Reconnaissance Orbiter. They have a camera called high-rise that just takes the most spectacular images. The, these images have .3 meter resolution. This means that if I decided to sprawl out on the surface of Mars, I'd be more than one pixel, I'd be several pixels in length and that's kind a cool.

Fraser: We're kinda going in reverse detail here but, with the landing of the Phoenix Lander, there were pictures captured from the Mars Reconnaissance Orbiter of the space craft landing. You can see the spacecraft itself, the parachute up above, and it's over the top of this crater and it is one of the most spectacular images. I would say it's up there in my top 10 images that I've ever seen of Space exploration.

It's just, when you think about what you're seeing and then they showed, you know, the back shell, and where the parachute landed, and there's the lander, and there's all the parts of the space craft. It's just amazing. There are images of the Mars rover seen from orbit. It's just such an amazing spacecraft. And the cameras.

Pamela: And these are huge images. They, they can get as big as 4000 by 40,000 pixels. The only thing limiting how big the images can get is the size of the memory on the poor innocent computer on board. They've developed the camera in such a way as it flies over the surface of Mars it's scanning the pixels out of the camera at the same rate the orbiter is moving forward.

So as the view changes, it is sorta like if you can imagine moving the film in front of the lens so as the film moves where an image shows up on the film is moving at the same rate.

Fraser: It's not really taking pictures. It's just like trolling the surface of Mars and just dumping out the data from the camera.

Pamela: And they get these long, long strips of images. With the particular image you mentioned where it's a crater and you can see superimposed in front of the crater the landing Phoenix with the parachute and everything else. That's an image, that, like I could put up on my walls such that Phoenix is an inch or more in size on the wall and the crater would pretty much fill the wall of the small room. We don't have images of the earth at that resolution.

Fraser: It's a military satellite. It is watching us work right now through a ceiling. Yeah.

Pamela: But the high rise camera is actually a half meter reflecting telescope. I'd take one of those. And, and it takes multicolor images and it's just spectacular. This is the camera that found the avalanche on Mars.

In addition to that they also have spectrometers that allow them to again look at what are the minerals found on the surface of Mars. They have a context camera that high-rises off taking these amazing images. It takes a picture of the entire region around the high-rise strips so you can see where this fits within the greater landscape of Mars.

It again has another radar that allows us to start looking beneath the surface and finding out where's the ice, where are the different densities of rock. Again, an absolutely fabulous image that's doing a great job and it also does double duties as a telecommunication satellite when it needs to.

One of the cool things about the way we are designing missions today is we're taking the time to figure out how we can make things work together. Mars Express is a European mission, but it can act as a back up communication satellite for Opportunity, Spirit and Phoenix. Mars Express is doing a great job. Mars Reconnaissance Orbiter can relay communications as well.

All these missions are working together in complimentary ways to allow us to get the most science with a suite of instruments that are all peering down at the nearest world that we might eventually walk on.

Fraser: Sure wish the other planets were covered this well. It'd be great.

Pamela: Well, this is one of the controversies with NASA right now. It's been realized "wow, we've sent a lot of resources to Mars, and we sort of ignored the outer Solar System."
We know very little about Uranus and Neptune, and Pluto and Charon. There are all the really cool moons out there as well with Saturn and Jupiter. So NASA is going to be doing some budgetary restructuring and the money from Mars isn't going to stay stupidly large, high as it currently is.

This makes a lot of people sad because this is spectacular science coming out and these are people whose careers have been dedicated to the red planet. And now they're going to have to be looking at other worlds as we go off and try and throw some more amounts of resources at discovering new things in other places in the Solar System.

Fraser: Well, let's move on to the last current mission at Mars.

Pamela: Oh, this would be Phoenix, and it's throwing out science so fast that even though we are recording on Saturday by Monday what we could say could be obsolete.

Fraser: Take all this with a grain of salt. [Laughter]

Pamela: And go check out Emily Lakdawalla's blog on the Planetary Society Web site. She has all the latest up to date information on Phoenix.

Fraser: We also have great coverage on Universe Today.

Pamela: That's true. You also have great coverage on Universe Today.

Fraser: Yeah, but Emily's is pretty great. I gotta say Emily does a great job of covering planetary missions, so…my hat to her.

Pamela: So this is a mission that is there to, to figure out, well we know that there is ice on the poles, let's dig in it. Let's go see what's in the soil, let's go see what is in this completely differently part of Mars.

Previously we've always landed things near the equator because they have a better hope of survival. There's more sunlight, more heat. It's easier to keep things alive.

We don't think that Phoenix will have the triply, quadrupaly, just keeps going on forever and ever Energizer Bunny mission that Spirit and Opportunity had. It won't survive winter.

Fraser: Right. Come Martian winter the rover will be encased in a couple of meters of frozen carbon dioxide - dry ice. And temperatures are gonna get down negative 120 degrees Celsius. So it's gonna not be doing so well.

Pamela: And it does have a Lazarus mode. When the winter ends it has been programmed to attempt to resurrect itself and send a little sad message back to Earth saying I'm here. It might work. No one is particularly hopeful. But while its there it's going to dig into the dirt for all its worth.

It doesn't just have an arm that goes out and touches the dirt like Opportunity and Spirit. It has a Tonka truck style claw that goes out and just digs like a 2 year old. It's about that size in scale if you can think of a big child's Tonka toy truck. And it's going out and digging holes, it's seeing white stuff in the dirt that could be ice, could be silicates or could be something else. We don't know.

What's cool is that it has a whole series of ovens on it that they can dump little tiny, tiny particles on. They have a screen on it, they dump a bunch of dirt on top of the screen shake the thing and little particulate falls through into the oven. Then they heat it up and see what vapors come out. They measure the composition.

They measure what are the ices, what are the other things that when heated go to vapor that they can then study the elemental composition of. What are the atoms that are trapped inside these bits of dirt that they are going to heat up? They're opening up these ovens one at a time. They have dirt in the fourth oven currently and they are going to see what they can see.

The other thing they also have that's really cool is a microscope. They're picking up dust particles and studying them under the microscope. They're looking at what is the dust in the atmosphere. They are looking at what is the dust in the soil. This is a way to look at things like they're finding there is still volcanic dust settled out on the surface of the ice.

And we're pretty sure that this is ice that is covered in a little bit of dirt because this mission didn't land like Opportunity and Spirit. It didn't bounce around on air bags.

It actually came in really Buck Rodgersey where it fired rockets and leveled itself down onto the soil extending its arms to gracefully just sort of land and sit there.

They needed to make sure that its legs were all well planted and none of them were sort of on the edge of a rock where it was waiting to fall over at the first shaking of something. When they were looking at the legs, they found that underneath one of the thrusters it had cleared away the soil to reveal what looks like a large patch of exposed ice.

So it looks like this rover is basically on dirt covered ice. That's exactly what we were hoping for. And hopefully we'll be able to find out just what is all the stuff in the ice in that particular little patch of Mars pole.

Fraser: Now in talking to the folks from NASA, they're pretty cagey. They're not gonna say they're looking for life.

Pamela: They're not allowed to say that actually…

Fraser: Right.

Pamela: Congress mandates that NASA cannot look for life.

Fraser: You're not allowed to look for life. But what they're looking for is evidence of organic molecules and just sort of get a sense of what the composition of the ice is because by knowing the composition of the ice you can kind of know what conditions were on Mars as the ice was laid down.

But the series of ovens and the scientific equipment that they have on the spacecraft is pretty sensitive. If there is some vigorous life there, when you give it some warmth, it might be that they can sense some of the reactions coming off of it.

Pamela: The ovens are actually designed to very specifically look for things like proteins, amino acids, and other acids and bases. Just the same way a CSI agent might look for things like that in crime scene carnage. So, if its there to be found they're going to find it.

It's just like looking for ice up in the high mountain peaks and down in the valleys of Antarctica. It's just a lot colder there, but there's a chance.

Fraser: So, and unfortunately this last part of the podcast is probably going to be completely out of date in a couple of weeks. We try not to report news but this is pretty exciting stuff so...

Pamela: So here's to 700 good days of life that's kinda what they're hoping for. We don't know if they'll get there, but that's what its power source, has the operating life span for, so we'll see.

Fraser: We're kinda running out of time. We wanted to talk about future missions to Mars but I think maybe we'll cover that at some time in the future. The future missions are so up in the air that it's really hard to know what they'll eventually turn into.

The one we definitely know about is the next launch window is going to be the Mars Science Laboratory which is going to be a SUV sized rover, which will be equipped with the tools to search for life. This will be the launching in another year.

Pamela: And in the 2030s they're looking to launch us. Well, not us, but humans.

Fraser: Right. And that's what our next episode is going to be about, the colonization and maybe even terraformization of the red planet. So although there might be a question show in between so…

Alright Pamela well thanks a lot for sticking to it this week and we'll talk to you next week.

Pamela: Sounds great. We'll talk to you later Fraser.

This transcript is not an exact match to the audio file. It has been edited for clarity.
Transcription and editing by Cindy Leonard.