Astronomy Cast Episode 200

The Mariner Program

Fraser: Astronomy Cast Episode 200 for Monday September 27, 2010, The Mariner Program. Welcome to Astronomy Cast, our weekly facts-based journey through the cosmos, where we help you understand not only what we know, but how we know what we know. My name is Fraser Cain, I'm the publisher of Universe Today, and with me is Dr. Pamela Gay, a professor at Southern Illinois University Edwardsville. Hi, Pamela, how are you doing?
Pamela: I'm doing well, how are you doing, Fraser?
Fraser: Good. 200 episodes!
Pamela: Yes, it's... wow! How did we get here?
Fraser: How did we get here? Well, it's not really 200 episodes because we did all the question shows... so it's actually... I don't even know how many it is.
Pamela: It's 200 and a lot...
Fraser: 200 and a lot official Astronomy Cast episodes... yeah... We were thinking oh, we should do something really special for episode 200, and our big idea was to update everybody on the science. So, like, what is new from when we started the show until now.
Pamela: Transformatively new... we're not talking about... yeah, Herschel found a many-expletive number of planets... bounce... bounce... it's awesome! Yeah... same technology we talked about before...
Fraser: But I think the problem is that as we've been doing the show, we've been blending in the most recent science results. So we'd have a lot of trouble figuring out anything that's really substantially new since we started recording this. It's kind of weird.
Pamela: It's kind of awesome, too, because one of the things that we've tried to do from the beginning is make this show as timeless as possible so that new listeners newly discovering us can go back and start with show 1 and just power through. We know some of you are doing this and we love you for it.
Fraser: And pity you for it...
Pamela: Yeah, that too. But, yeah, we did what we set out to do which is kinda cool.
Fraser: Yeah. So, Plan B is a regular episode, and that's what we are going to give you today. So, the first interplanetary series of missions was the American Mariner program. These successful spacecraft visited Mercury, Venus, and Mars and laid the groundwork for the U.S. missions to the outer planets. So let's take a look at the program and their incredible accomplishments. I've been writing a whole series of articles on various planets, and for the inner planets, it really... all the groundwork is done by the Mariners. It's quite amazing. And I think they get, maybe... the first ever planetary fly-by was done by a Mariner spacecraft. So let's go back to the beginning and talk a bit about this incredible series of missions.
Pamela: It all goes back to the 1960s. The Pioneer program, which came before it in the 1950s, had started getting the idea that yes, you can get beyond the low-Earth orbit. You can go and visit the moon. You can go out and get beyond even the Earth-Moon system. But it was with the Mariner missions that they finally set to go out and image nearby worlds, visit nearby worlds. And in 1962, Mariner I failed. That's ok. These were

unmanned early attempts... we blew stuff up, and we blew up Mariner I. But Mariner II... it did a Venus fly-by in 1962. This was the first time we sent something out and we flew by another planet. And it was a little heartbreaking because up until that point we still held out hope that maybe there was life on these other worlds, and then we discovered hydrochloric acid in the atmosphere of Venus... no life there.

Fraser: But you've got to think about the timing here. The Space Age had only just begun... just years before. Sputnik, the first satellite to orbit the earth, was launched in 1957. It's only five years after Sputnik was launched... you've got a spacecraft going from Earth and doing a fly-by of a whole other planet. They were working fast!

Pamela: Yeah, it's really phenomenal because we basically went from V-2s during World War II, which didn't hit orbit... they just hit other countries.... to the Mercury Redstone rockets to launching stuff to other planets.

Fraser: And keep in mind, right, 1962... launch of Mariner. 1961... President Kennedy announces that they're going to land humans on the moon.

Pamela: Right. It was a glorious age where we weren't as limited by... yeah, we cared about safety but not the same way we do today. Budgetary limits were different. When you have an economy driven by the post-war boom, when you are in competition trying to beat the Soviets to everything, when you put all these pieces together and then add just the enthusiasm and the creativity of people who are just like... wow... we're the first to do everything! When you're the first to do something, it gives you a special drive and these men, they just thought entirely outside of the box... heck, they didn't even know there was a box to think within. And they did great things.... 1962 was Venus, 1964 they attempted to fly by Mars... but spacecraft died. They did that back then... that's ok. End of '64... Mariner IV did successfully fly by Mars.

Fraser: Now, they didn't get a lot of science out of these missions compared to the Vikings or the various orbiters that have been sent recently. I mean, these were sort of like... one flight past the planet.

Pamela: Yeah, and they were early spacecraft... we were happy that we could steer them. That was actually one of the really cool things about the Mariner missions... we reprogrammed them on the fly occasionally. This was the first time we'd ever done that. With the earlier missions, everything was... before launch, you test it, you switch the switches, you basically do incantations and hope it works. With the Mariners for the first time they were sending commands to things while they were en route... reprogramming them... adding new science. They did have some pretty cool detectors on them. We were able to figure out Mars may or may not have a magnetic field, which may sound vague and strange, but science does that. Science does things within limits. We were able to rule out a strong magnetic field. Being able to say that Mars does not have a strong magnetic field is actually a pretty interesting result. They had microwave and infrared detectors, they could detect dust, they could detect solar plasma and high energy radiation, and some of them had television cameras on them. So, no... they weren't doing high resolution imaging, they weren't doing gamma ray spectroscopy, they weren't doing x-ray anything.

Fraser: How big were the Mariners? I'm trying to get a sense of scale, because I think of some of the later spacecraft... Hubble is like the size of a bus... Cassini, I know, was like the size of an SUV. They're big. How big were the Mariners?

Pamela: These were much more in tune with if you go to a museum and you see one of the Gemini capsules. These were much more in tune with that size. They had two to four, depending on if they were an early or late mission, solar panels and that was really the bulk of their size... these giant extending out solar panels... and then the radio dishes that they had on them. They weren't that big... they packed a lot of power into what they did. They sent home our first pictures. What's really amazing is... do you ever listen to... I love audible.com... yes, they are one of our sponsors but I've loved them since before they were one of our sponsors. Do you ever go back and listen to the old sci-fi radio shows?
Fraser: I haven't listened to them through audible, but I definitely used to listen to them as a kid.
Pamela: Ok, I've lately been bingeing on old sci-fi short stories, and it's awesome to listen to listen to these old sci-fi short stories because all of them have at least Tumbleweeds on Mars.
Fraser: At least! And swamps on Venus.
Pamela: Right. And these were things that people legitimately couldn't rule out and then Mariner dashed all of our hopes of life on these planets. Then there's this radical change in science fiction that's centered on these simplistic-by-modern-standards missions that did return images of... oh, no... Mars is covered in craters... oh, oh, dear... Mars is covered in craters as bad as the moon. The very first images returned by Mariner of Mars were of one of the oldest sections of Mars.
Fraser: Right, so like one of the most beaten-down chunks of the planet.
Pamela: Right... it just worked out that way. So can you imagine being one of the scientists watching these images come back, and you're thinking plants... I want to see plants... I want to see plants...
Fraser: And life... I want to see zebras...
Pamela: Right...
Fraser: Martian zebras... come on... and what do I see? Trees? Forests stretching... no. Craters. Dusty mountains and craters. Yeah, yeah... think about that.... they didn't even know what they were going to see. All you could see in telescopes was a little orange disk. You could see the polar ice caps... you could see.... could you even see Olympus Mons? You probably couldn't.
Pamela: It all depended on the tracks. That's the thing... these missions... they did a simple fly-by, they had... Mariner III had a digital tape recorder that could take about 20 pictures. So they took these basically straight runs of pictures across the surfaces of these worlds. They didn't capture the entire thing.
Fraser: But they'd never seen it up close...
Pamela: Right.
Fraser: We're so used to it, it's hard to un-imagine this. And I think the only analogy that we're going to get is Pluto.
Pamela: Mercury... that's the thing... we grew up with only half of Mercury.
Fraser: Yeah, but if you think about Pluto, right, we're going to go... right now all we have are Hubble Space Telescope pictures of Pluto which have like ten pixels... and this pixel is a little lighter than that pixel... and that's the best that we can do. Everything you see of Pluto is either these really low resolution images of Pluto or artists' recreations of what Pluto probably looks like. But we have never actually seen the world up close. And

we won't, and in 2015, when New Horizons gets there, we're suddenly going to see photographs of Pluto. So you've got to understand that the way you feel right now about Pluto is the way the whole world felt about Mercury, Venus, and Mars, which are now so familiar.
Pamela: At least I'm not hoping for life on Pluto... I'm kind of...
Fraser: Or tumbleweeds! Until now every sci-fi writer included tumbleweeds on Pluto...
Pamela: Yeah... these were missions that changed everything. And what's so amazing to me is this is a program that left a very lasting legacy. Now NASA has this habit of changing the names of missions. So like the Hubble Space Telescope... we all call it Hubble... but for years it was simply the Large Space Telescope. Fermi... it was known as the Gamma-ray Large Aperture Space Telescope, GLAST, for a decade or so. Some of the Mariner missions... we also don't recognize them as Mariner missions because they had a different name. So, Mariner X is the last mission that really got the Mariner name. It did Venus and Mercury fly-bys. Well, like we talked about in our last show, Mariner XI and XII were actually Voyager I and II, so we see this lasting legacy. Then there was this new program, the Mariner Mark II program, which is a modern-day program. This included Galileo and Cassini. So Mariner... the technology is living on... the legacy of this mission is still living on and still getting rebuilt into these new modern-day programs that are still returning science.
Fraser: Now, you've jumped forward a little bit so I'd like to click rewind for a second here because when last we saw our heroes, we had... with Mariner IV... we'd done our first successful fly-by of Mars and taken a collection of pictures.
Pamela: Right. So here we finally know... oh, no, Mars... old... Mars... cratered... Mars... lifeless and dead. Dear sci-fi writers... please stop writing tumbleweed on the surface of Mars... we're sorry. It was a sad day, but that's ok. Science sometimes breaks your heart. Then Mariner V... a few years later... now we have a gap in our planetary explorations up until 1967... and here Mariner V goes to Venus and it did radio wave experiments, it scanned the clouds looking in ultra-violet light, it took samples of solar particles, not a whole lot of exciting, pretty pictures came out of this mission, but more indications of the lifelessness, deadliness, overly-hot nature of Venus. Cool science.
Fraser: I mean the problem with Venus still is that there was no spacecraft able to peer beneath the clouds yet. So they could study the clouds but they still didn't have really any sense of what was underneath all that.
Pamela: It really takes radar or laser altimetry...
Fraser: That was the Magellan... which was another Mariner spacecraft, Mark II...
Pamela: Exactly.
Fraser: Yeah.
Pamela: But ?????? radar... that takes a huge amount of energy and we just weren't there yet with our technology. But we kept going... and Mariner VI and VII... these were identical spacecraft. They went to Mars and did fly-bys of Mars... took a couple more strips of the surface for us... allowed us to see in 1969 a little bit more of the surface of the planet. Here they flew over the equator, they flew over the southern hemisphere, so slowly, one strip at a time, we were mapping out Mars.
Fraser: What a waste... I mean obviously not a waste, but you go to all this effort, you build this spacecraft, you send it to Mars, and all you get is a couple of hours of a fly-by and then the spacecraft is trapped in orbit around the sun, not in a path for anything else.

It no longer has fuel. The newer spacecraft... Mars Express or Venus Express or even Messenger that's going to Mercury... these are orbiters, so they're designed to make their way and make a fly-by of the planet, decelerate into orbit, and then just stay there for years and years, going around and around the planet, taking hundreds of thousands of images and observing the planet from incredible detail.
Pamela: But getting yourself in orbit is hard!
Fraser: No, I know, I know... so this is once again this is what they had to do because this was all they could do.
Pamela: Yeah. But we did figure it out eventually. And what's interesting is Mariner VI and VII... they flew by, took their pictures, kept going. These were small, versatile, non-steerable spacecraft and they only weighed about a thousand pounds. Now Mariner VIII and IX, well Mariner VIII died, but Mariner IX made it and it orbited and it's still there orbiting Mars. We think it's going to be there until about 2020-ish.... 2024-ish... probably 2022 because you average... it will fall out of orbit. But right now it's still shut off and happily orbiting. To build the spacecraft that was finally able to put itself into orbit around Mars and systematically map out this planet, we had to double the weight of Mariner. It went to over 2000 pounds to be able to add in everything that was needed to make this simple change in trajectory.
Fraser: Right. So Mariner IX became the first artificial moon of Mars.
Pamela: And it really helped us finally be able to see the entirety of the planet. And that's kinda cool. And it was Mariner X, in 1973, right before I was born... I just love it... all this stuff happened before I was born...
Fraser: I was 2!
Pamela: You were 2! You're an old man.
Fraser: I remember... no, I don't remember.
Pamela: So Mariner X... it actually made it all the way into Mercury. Getting to Mercury is about as hard as it gets for a spacecraft because you're getting a little close to the sun so you're dealing with a lot of gravity and you're dealing with a lot of heat and you're dealing with solar wind... you're getting impacted by tons of radiation. But, they figured it out, and they were able to get in and send back images of Mercury that up until Messenger remained some of the best pictures that we had. They're still getting used on a regular basis... just got re-reduced and made into gorgeous images about three years ago by an amateur astronomer.
Fraser: So, Mariner X went past Mercury and Venus as part of its mission which, I think, was a first. In it's fly-by of Mercury it was only able to capture half of the planet. So... I guess this is what you were getting at before... before I so rudely interrupted you... until about three years ago all our images of Mercury were half was beautiful cratered gorgeous images, looking like the surface of the moon... incredible detail... and then half—I don't know... completely unknown.
Pamela: And what's been awesome is there's been some imagers who've tried really hard to get ground-based images of Mercury using high-speed video and then stacking their images. The folks at the Dexter Southfield School in Massachusetts who also do imaging for NASA and for Space X and several other projects... they have images that hint at the existence of craters, hint at all of these features but they're really noisy images, and we're going to be able to confirm whether they were right or not because it's hard to publish fuzzy images, as one might guess. So we had guesses at what the rest of the

planet looked like, guesses at features, and only with Messenger can we pattern match and put all the pieces together. We've lived in a land of fuzzy and known and Mariner X gave us great results, but now Messenger's taking everything a little bit further.
Fraser: And most of the images you see of Venus, and well not the ones of the surface of Venus... those were done by Magellan... but if you see sort of an orange-ish color photograph of Venus, or almost all the pictures of Mercury that you're going to see, and even many of the pictures of Mars... although those were all the ones taken by the Mariners, you don't realize that it's been 30 years since those pictures were taken, but they're still the ones that people use... no, 50 years... 40 years... yeah...
Pamela: Yeah... 40 years is kinda scary... Something most people don't think about is with these fly-by missions, they're taking pictures as they're approaching their planets, and they're taking pictures as they're receding away from the planets in a lot of cases. Whereas today's orbiting missions, they settle into orbit, get themselves situated and then start mapping away. The US Geological Society and other groups have done some really good work piecing together these mosaiced high resolution images to create full-globe maps. But the grab a picture of the entire planet all at once, that was a specialty of the Mariner missions.
Fraser: And you don't get that very much... that's right.
Pamela: Now the other neat thing about Mariner X was it was the first mission to do a gravity assist. So it brought itself up to Venus, used the gravity of Venus to swing itself into the right course that it needed to reach Mercury. And this was something that needed to be practiced before we sent missions out to Jupiter, Saturn, and beyond. So Mariner X in the inner solar system opened the door for us to go out and explore the outer solar system.
Fraser: The planning was done for two more Mariner missions, Mariner XI and XII, but as we said in the last show... I guess we did this backwards... those were the Voyagers.
Pamela: The Voyagers used the same technology... did modify things... you do modify things when you're going to the outer solar system... modified things but used the same basic spacecraft model... same basic instrumentation suite. They went out and went to Jupiter and Saturn in one case and then plunged out to the outer solar system, and in another case went to Jupiter, Saturn, Uranus, and Neptune and is now headed out in a different direction to interstellar space. Now these were all huge massively-expensive missions. We had money back then. In modern years as we've been looking into the 1990s and forward as we've been looking to get back into the space exploration business there's this huge gap in sending missions out to explore space that occurred in the late '70s and '80s where you basically see nothing. In the '90s we decided to go back to space exploration, to go back to doing science with NASA, and that was an awesome change.
Fraser: It was like Magellan in the '80s... '89...
Pamela: But that's good and all but you don't see this every couple of years space probe going off that you see today and that you saw in the '60s and '70s.... early '70s. So there was this gap late '70s through most of the '80s... not all of the '80s. In the '90 we made this concerted effort to go back to regularly doing science with NASA. This is where you start seeing the every launch window to Mars... pretty much... not always but pretty much every launch window to Mars we've launched something to Mars. We've gone off to Venus, we've gone back to Mercury. These new probes... we wanted to build on old technology because that's cheaper. Why throw out something that still functions? This is

where the Mariner Mark II program came in. These are programs that are hoped to be cheaper... and for the most part they have been... and they build on the Galileos... they build on the Voyagers. Now we're looking to continue this legacy. So with our new funding round, we're looking at within this spacecraft sequence a comet sample return mission. We're looking at potentially more Pluto fly-bys. It's all building on NASA's desire to keep doing science. Now the thing that might happen is that it could be that the Mariner Mark II program gets completely replaced with the Discovery programs. But this hasn't happened yet. We still do have the Mark II program going... we're just going to have to see how long it lasts.

Fraser: Galileo, Cassini, Magellan... these are all examples of the Mariner Mark II program. The Discovery program... these are the smaller, inexpensive, probes like Dawn, which is going to asteroids, New Horizons, which is going to Pluto, so that's sort of a different class... very... sort of a different structure the way they set up the missions, the way they fund them, how long it takes to build them and launch them, and how they operate...

Pamela: Right. So the Voyager missions and such... these are basically billion dollar programs. With the Mariner Mark II... by reusing things and by basically reining in the number of instruments that go on each mission, they're trying to keep them down to about $400,000,000. Sometimes sending a whole bunch of smaller things out to look at a whole bunch of different places is a great way to figure out where to invest big spacecraft in the future. This is a good way to go. It's going to be interesting to see what happens into the future.

Fraser: And I guess part of this is going to come from the decadal survey that we talked about a couple of weeks ago. When the planetary scientists let NASA know what big unanswered questions in planetary science need to be answered, that will help determine the next round of spacecraft.

Pamela: Exactly. So we live in an age of this growing legacy of the Mariner missions from giving us our first pictures of a dead... dead... we're sorry, dead Mars... through to giving us continuing imagery of Saturn with the Cassini mission. This series of spacecraft has brought us all eight planets in our solar system. It's a really amazing legacy.

Fraser: Alright, thanks, Pamela. And congrats on 200 episodes... nice work!

Pamela: Thank you, Fraser. It's been a wild ride. One more thing... we're going to be at the Science and Engineering Festival in late October in Washington DC, and we're going to be doing a live show up on the main stage out in the Washington Mall. So if you have a chance, come out and help us celebrate our 200 episodes in person.

Fraser: Alright, well thanks, Pamela.

Pamela: Thank you. Bye-bye.