Sidedoor S8 Ep. 3 Hubble Trouble Final Transcription

[MUSIC]

Lizzie Peabody: This is Sidedoor, a podcast from the Smithsonian with support from PRX. I'm Lizzie Peabody. On Christmas morning, 2021, Samantha Thompson woke up excited.

[MUSIC]

Samantha Thompson: I woke up very early. I was in California with my family.

Lizzie Peabody: But it wasn't the present under the tree that made her giddy, it was something even bigger than Christmas, something she'd been waiting for, for a long time.

[MUSIC]

Samantha Thompson: It had been years in the making. It had been years of delayed launches.

Lizzie Peabody: The launch of the James Webb Space Telescope. I should mention that Samantha is a curator of science and technology at the Smithsonian's National Air and Space Museum. So, this is kind of her thing.

Speaker 3: Décollage, liftoff from a tropical rainforest to the edge of time itself, James Webb begins a voyage back to the birth of the universe. Punching a hole through the clouds.

[MUSIC]

Lizzie Peabody: Clouds. On December 25th, 2021, the James Webb Space Telescope began its journey to witness the birth of the first stars in galaxies and to explore the outer reaches of space for earth-like planets. But for many of the space nerds, like Samantha, watching from the ground that day, it was nearly impossible not to think back to a different telescope launch, one that happened 30 years before, one that no living astronomer could forget.

[MUSIC]

Speaker 5: T minus 10, go for main engine start.

Lizzie Peabody: In 1990, NASA launched the Hubble Space Telescope, the first large telescope ever put into space.

Speaker 6: And lift off of the space shuttle Discovery with the Hubble Space Telescope, our window on the universe.

[MUSIC]

Lizzie Peabody: With the launch of Hubble, rose the hopes of astronomers all over the world, that we could finally answer some of humankind's biggest questions. At the time of the launch, we still didn't know how old our universe was, dark matter was a mystery, and there were still so many unanswered questions about our own solar system.

Speaker 7: Payloads, waiting on you.

Lizzie Peabody: America had spent nearly $2 billion to build this space telescope. The future of NASA rode on its success.

Speaker 8: Capcom, we have a go for release.

Speaker 9: Discovery. Go for Hubble release.

Lizzie Peabody: Hubble had one job, to be our eyes on the universe. But as soon as it sent its first images back to earth, it became clear something was wrong.

Samantha Thompson: The pictures didn't look, they weren't as good as astronomers had hoped they would be. And the images just weren't quite very crisp.

Lizzie Peabody: Hubble couldn't see clearly. Even worse, nobody knew how to fix it. So this time on Sidedoor, we focus our lens on the OG, the original Space telescope, Hubble, how things went so horribly wrong and what it took to get Hubble out of trouble. That's coming up after the break.

[MUSIC]

Lizzie Peabody: If you've been to the National Mall recently, you might have seen that the Smithsonian's National Air and Space Museum is closed for renovations until this fall. But luckily, I can get you in through the side door. Locked. Okay, nevermind. But at least we can get you in through the figurative side door with the National Air and Space Museum's, Samantha Thompson. She's giving me a virtual sneak peek.

Samantha Thompson: The new museum is going to, I think, make some jaw drops.

Lizzie Peabody: As you step into the new museum, off the mall, you'll see all the things you'd expect, airplanes hanging from the ceiling, various spacecraft. And if you keep walking down the main hall-

Samantha Thompson: You're going to make a left back towards a gallery called Living in the Space Age. And then you won't be able to miss it. It will be the Hubble Space Telescope Test Vehicle.

Lizzie Peabody: This Hubble Test Vehicle was used by NASA engineers to, well, test the instruments that ended up on the actual Hubble. But it might as well be the actual Hubble telescope because it is identical to the one in space.

Samantha Thompson: It looks like a white bus that's been tipped up on its side upon its end.

Lizzie Peabody: Like a white school?

Samantha Thompson: Like a white school bus, yeah.

Lizzie Peabody: Oh, wow.

Samantha Thompson: It's really hard to grasp sometimes when you're not kind of up close and personal, but when you can stand next to it and look straight up, you really get a big sense of that scale.

Lizzie Peabody: Yes, Hubble is big and there is a reason for that. It has to do with the way that telescopes work.

[MUSIC]

Lizzie Peabody: Telescopes have been around for centuries. The first telescopes were long magnifying lenses used for navigation, the kind you might see in the hand of a cartoon pirate. Land ho. You get it. But it was Galileo in the 1600s who gets credit for first pointing a telescope at the sky. This drove a push for telescopes that could see things thousands upon thousands of miles away, farther than any magnifying lens could see. And this led to the creation of reflecting telescopes. Instead of magnifying lenses, they used curved mirrors, like a spoon. But when I look into a spoon, I'm upside down and distorted. So, how do you get a clear image out of a concave shape?

Sandra Faber: The image looks that way because you are viewing it from a point beyond the focus.

Lizzie Peabody: This is Sandra Faber. She's an astronomer with the University of California, and she says, if you're the exact right distance away from a curved mirror, you can get a crystal clear image of something light years away. Think of it this way. When you see an image, you're actually seeing the light that has hit that object and then bounced off of it. Curved mirrors, like your eyes, are like nets that gather up all the scattered light bouncing around and bring it into focus so your brain can recognize what you're seeing.

Sandra Faber: The good thing about mirrors is you can make them big, much bigger than your eye.

Lizzie Peabody: The larger the mirror, the more light it can collect from distant objects. Looking into a big, curved mirror is like giving yourself a bigger eyeball. This is why bigger is better when it comes to telescopes. Imagine what you could see with satellite dish sized eyeballs. You could actually read the engraving on a penny three miles away. But even the biggest telescopes on earth still have a problem seeing things clearly in space. And that has to do with this pesky thing called the air we breathe.

Samantha Thompson: So, when we think about looking at the stars, we think about twinkling stars, which is fantastic because they're pretty. But that twinkling is not caused by the stars themselves, it's caused by the movement of water in our atmosphere. Yeah, so we want to be able to get above the atmosphere so that things aren't twinkling anymore.

Lizzie Peabody: Trying to see distant galaxies from Earth is like lying at the bottom of a swimming pool, looking at your friend standing on the diving board above you. They're going to be all wavy and distorted. Moisture and particles in the earth's atmosphere distort our view of anything in space. But in the 1940s, an American astronomer named Lyman Spitzer offered a solution. Why not put a large telescope outside of Earth's atmosphere? Astronomers were like, "Okay, that is a great idea. But it is the 1940s. We have no way to get a telescope into space. And even if we did, how are we going to transmit these images back to earth, by telegram?" Spitzer may have been before his time, but in 1957, time caught up.

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Speaker 11: Until two days ago, that sound had never been heard on this earth. It's a report from man's farthest frontier, the radio signal transmitted by the Soviet Sputnik, the first manmade satellite as it passed over New York, earlier today.

[MUSIC]

Lizzie Peabody: In the 1950s, the Cold War tit for tat between the US and the Soviet Union fueled a space race that led to satellites and a type of space telescope. But if you asked astronomers at the time, these telescopes were pointing the wrong direction, down at earth. They were built for spying or reconnaissance, as the military would say.

Robert Smith: Having developed the capability, the technologies, the ideas, the skilled people for the reconnaissance satellites, those could now be applied to developing space telescopes.

Lizzie Peabody: This is Robert Smith, former historian for the Smithsonian's National Air and Space Museum. He says that a small group of astronomers in the late 1960s saw an opportunity. They said, "Hey, we've got the tech to get a telescope outside Earth's atmosphere. Now we just need to convince the US government to fund one of these telescopes to look into space, not just spy on the Soviets. And we've got the perfect name picked out."
Samantha Thompson: It was just called the Large Space Telescope. We called it the LST. Astronomers can get very, very basic with our acronyms.

Lizzie Peabody: I like that.

Samantha Thompson: There's a telescope in Chile called the Extremely Large Telescope. We don't try too hard. But eventually, in the 1980s, they did decide to name it after Edwin Hubble.

Lizzie Peabody: Many astronomers credit Edwin Hubble for discovering in the 1920s that the universe is expanding. And this new telescope, in theory, could help measure just how fast it's expanding, to finally determine the age of the universe. And in the 1970s, astronomers headed to Washington to convince lawmakers to care about and pay for the Hubble Space Telescope.

Robert Smith: You've got individual astronomers writing letters to their Congress people. You have visits to Congress people talking to staffers, writing articles that go into magazines and so on. And even Superman at one point is lobbying.

Lizzie Peabody: Superman? Yes, Superman. Astronomers even enlisted America's favorite superhero at the time to help their cause. And all these efforts paid off. Congress gave Hubble the green light. And after nearly a decade of construction and nearly $2 billion spent, the first ever Large Space Telescope was cleared for takeoff in 1990, ready to make good on its promise to change astronomy forever.

Robert Smith: The stakes were very high because it was, here's a big prestige project. And there had been quite a bit of hype on Hubble, the most perfect telescope ever built.

Lizzie Peabody: The most perfect telescope ever built sounds a little bit like the unsinkable ship.

Robert Smith: That's right. And that was the belief

Speaker 13: Discovery, now at 14,000 feet, making the final approach lining up over runway 22.

Lizzie Peabody: In April of 1990, the discovery shuttle crew carried Hubble 400 miles above Earth, released it into orbit and returned home to celebrate.

Speaker 14: Houston to Discovery. Welcome back.

Speaker 15: Roger that Discovery. Welcome back. Congratulations on a super mission. And the world is looking forward to reaping the benefits of your good work over the next 15 years.

Lizzie Peabody: Hubble, the most perfect telescope ever built, floated above earth, poised for action. But a few weeks later, when Hubble beamed its very first images back to earth, astronomers huddled around the computer screen, anxious to see what no human had ever seen before. But the excitement didn't last.

Samantha Thompson: Astronomers were just realizing there's something not quite right here. So, then it became, what's not quite right?

Lizzie Peabody: Hubble's images were not crystal clear. They weren't clear at all. They were blurry. NASA rushed to figure out what was wrong. It tested all of Hubble's instruments, tweaked things, shifted focuses. Still, images kept coming back blurry. And in June of 1990, NASA faced a harsh truth. It gathered reporters for a somber press conference.

Speaker 16: There's a significant spherical aberration appears to be present in the optics, in the optical telescope system optics. Now, some people asked me earlier today, what is spherical aberration? The simplest way of understanding it-

Lizzie Peabody: Spherical aberration. Nobody knew for sure how it happened. But the curved primary mirror, the all-seeing eyeball, the thing that brings images into focus, the heart of Hubble, was shaped incorrectly.

Samantha Thompson: This is one of the worst-case scenarios. They had done a lot with Hubble to make sure that it could be maintained and parts could be replaced in space. They did not design it so that the mirror could be replaced.

Lizzie Peabody: Imagine you're driving your car. There are some things that can break and some things that definitely cannot break. Let's say your radio goes out.

Robert Smith: It's not a big deal.

Lizzie Peabody: Your tire goes flat.

Robert Smith: That's right. You can get out, you can go fix it.

Lizzie Peabody: The windshield cracks,

Robert Smith: But you bust your engine, you're not going anywhere.

Lizzie Peabody: Hubble was busted. And to give you a sense of just how busted, it was supposed to see things in space 20 times sharper than some of the most powerful ground-based telescopes. But its actual ability, three times worse. And you can be sure after NASA's press conference, Hubble made headlines.

Samantha Thompson: The next day, you end up with a Newsweek article that says, NASA's $1.5 Billion Blunder. So, it became a big news story, really quickly.

Lizzie Peabody: When we come back, the fallout and the fix. That's coming up, after the break.

[MUSIC]

Lizzie Peabody: In the summer of 1990, the Hubble Space Telescope was the sizeable butt of countless jokes, Hubble Trouble, Hubble Sees Double, cartoons of flying lemons, late night comedians, like David Letterman and Johnny Carson, had a field day.

Johnny Carson: Have you heard about the problems with a Hubble Space Telescope?

Speaker 18: Yes.

Johnny Carson: Well, we paid for that, you know. Billion and a half dollars. We put up a telescope and it's out focus. NASA's in a bit of trouble. They called the NASA official repair man to fix it. And he said he'll be up there sometime in the 21st century between noon and five.

Samantha Thompson: There was a lot of, I will say, ridicule around it.

Lizzie Peabody: This is the Smithsonian's Samantha Thompson again.

Samantha Thompson: But a lot of folks at NASA said, how we're going to be judged moving forward is not that it happened, but it's how we work our way out of this. Can we resolve this? Can we remedy the situation?

Lizzie Peabody: NASA took stock of its options. It could let the broken telescope float around like a constant reminder of one of its greatest failures, that was not likely to happen, or it could send a shuttle crew to retrieve Hubble, bring it back to Earth and repair the mirror there. But that option had its own problems. This is then NASA administrator, Daniel Goldin, explaining why that wouldn't work.

Speaker: The problem is the Hubble Space Telescope has some very, very fine optics. And if we were to put the Hubble Space Telescope in the shuttle bay and bring it down to the ground, there's a very, very high probability that we may permanently contaminate those optics. So, we have only one choice, fix it in orbit or let it die.

Lizzie Peabody: NASA needed to fix Hubble in space. But how?

Sandra Faber: That was by far the most intense period of my entire life.

Lizzie Peabody: Sandra Faber was one of the astronomers working on the problem. In 1990, she teamed up with a handful of researchers from around the country to try to figure out how to repair Hubble in space.

Sandra Faber: I couldn't go to sleep at night. I woke up early in the morning. I just lived and breathed this problem.

Lizzie Peabody: So how did you approach the problem?

Sandra Faber: Which problem? Now, at this point, there are lots of problems. That's the problem.

[MUSIC]

Lizzie Peabody: Hubble had five different instruments that each played a different role in sending images back to earth, and they all got their information from the incorrectly shaped mirror. Since the mirror itself couldn't be replaced, each instrument would have to be swapped out or retooled. Faber and her team sent a report to NASA explaining just this.

Sandra Faber: Jokingly, we called it 50 Bad Ways to Fix Space Telescope. They were bad because there wasn't any single fix. So, the actual fix that was devised was a piecemeal fix, which applied to each one of the instruments.

Lizzie Peabody: Remember, there were five instruments. The first was the main camera. Luckily, NASA had a backup. All it had to do was tweak the mirrors inside the backup camera to correct for the blurry images and then swap out cameras. Easy peasy. But the other four instruments couldn't be swapped out as easily or peasily. Since the primary mirror wasn't shaped correctly, the light beams bouncing off the mirror were zigzagging all around the inside of Hubble and hitting these instruments in the wrong spot. And so, the question was, how can you redirect these zigzagging light beams to hit the instruments in the exact right spot? For a while, scientists were stumped, but then a NASA engineer named Jim Crocker had an idea. And it came to him in the place where all the best ideas come. Crocker was meeting with the European Space Agency in Germany to work on a fix for Hubble. After coming up short on ideas, he went back to his hotel for the day and while he was freshening up, he noticed that the shower head in Germany could move up and down to adjust for your height, but also left and right in case you wanted water to hit you on a specific side. And that gave Crocker an idea. He jumped out of the shower to call his teammates over at NASA. He told NASA that astronauts could insert a refrigerator sized box inside of Hubble between the mirror and the instruments. It would be full of tiny quarter sized mirrors that could move around just like his shower head. The light from the primary mirror would have to detour through this field of little mirrors and that would give engineers the ability to redirect the light beams exactly where they needed to go. This would be the equivalent of putting a pair of eyeglasses on Hubble or as one newspaper put it, the most significant contact lens in the history of America.

Sandra Faber: It was risky. But nevertheless, that was the combined approach that was adopted.

Lizzie Peabody: The solutions for Hubble's hobbled eyesight couldn't have been more welcome news for NASA because at the same time it green lit the repair mission, it was trying to secure money from Congress for the International Space Station.

Robert Smith: It was always kind of teetering on the edge of being canceled.

Lizzie Peabody: This is Robert Smith again. He says, because the International Space Station would be assembled in space and require multiple repair missions, some members of Congress

saw Hubble as a proxy for this new-fangled space station idea. Like, all right, you think you can fix stuff in space, prove it.

Robert Smith: And so surely, if they can't fix Hubble, they're going to have really big problems with the space station. So, there's a lot riding on the Hubble repair mission that comes in 1993.

Lizzie Peabody: With the whole world watching and the future of the International Space Station hanging in the balance, NASA knew it had to send its very best repairmen into space for their appointment sometime between noon and 5:00 PM.

Jeff Hoffman: It's hard to remember for people who didn't actually live through it at the time what a disaster it was for NASA.

Lizzie Peabody: Jeff Hoffman was one of the four repair men and women recruited for the Hubble Repair mission. And if anyone understood how messed up Hubble's optics were, he did because in addition to being an astronaut, he was also an astronomer.

Jeff Hoffman: My doctorate is in astrophysics. So, I had a lot of astronomer friends and I can't tell you how many phone calls I got during our training because they had seen all the things we were planning to do and how complex the mission was. And they would say, "Jeff, can you guys actually do this?"

Lizzie Peabody: Jeff and the team trained in a pool to mimic zero gravity conditions, refining the different procedures they'd perform in space. They'd have five days to swap out the parts on Hubble. There wouldn't be room for any mistakes, no time to waste. By December of 1993, they were ready.

Jeff Hoffman: We had hacksaws and hammers. We were ready to go up and do whatever we had to do.

Speaker 21: Three, two, one.

Speaker 22: And we have lift off. Lift off of this space shuttle endeavor on an ambitious mission to service the Hubble Space Telescope.

[MUSIC]

Lizzie Peabody: 400 miles above Earth, Hubble hurdled through orbit. Jeff could see it slowly appear in the shuttle window.

Jeff Hoffman: The first thing, you just see this little speck of light out there and then as you get closer, it starts to take a form. Remember, we're both moving at 18,000 miles an hour.

Lizzie Peabody: Oh my gosh. At 18,000 miles an hour, 400 miles above Earth, Endeavour pulled up alongside Hubble and gently grabbed onto it with its robotic arm, careful not to bump into the telescope and send it tumbling into outer space.

Jeff Hoffman: I'll always remember when Dick Covey, the commander, called down to Houston to announce that the Endeavour space shuttle had a successful handshake with Mr. Hubble's telescope.

Lizzie Peabody: Is that what he said?

Jeff Hoffman: Yeah. Yeah, that's what he said. Successful handshake.

Dick Covey: Houston, Endeavour has a firm handshake with Mr. Hubble's telescope.

Speaker 23: We copy that. There are smiles galore down here.

Dick Covey: It's quite a sight.

Lizzie Peabody: After the rendez-vous with Hubble, Hoffman suited up and got to work. But the repair mission trouble started on the very first day. After working all day long, Jeff couldn't get the access door on the outside of the telescope to close.

Jeff Hoffman: I had done this countless times underwater and there were never any problems. But when I went to do it up in space, the upper latch would not close. If we can't get the doors closed, we lose the telescope.

Lizzie Peabody: Jeff and his partner, Story Musgrave, figured out a way to close the door with a ratcheting tie down strap, the kind you'd use to strap a mattress to the roof of your car, actually. But ground control was worried they'd damage Hubble. With time running out intentions rising flight director, Milt Heflin jumped in and said-

Jeff Hoffman: "All right people, look, we're running out of time. Jeff and Story obviously have a better sense of what's going on and they're not going to hurt Hubble, so let's just let them do what they want to do." And we did it and it worked. But that was the very first day.

Lizzie Peabody: Wow. What a start.

Lizzie Peabody: It was a rough start, but the crew didn't get discouraged. They were astronauts, gosh darn it. They rolled up their sleeves and got to work.

[MUSIC]

Lizzie Peabody: Over the next four days, they went down the checklist of repairs, replace the solar panels, check. Swap out the camera, check. Insert corrective lens check. Slowly and meticulously, they pulled off one of the greatest space repair missions ever.

Jeff Hoffman: I always remember at the end of that fifth and final space walk coming into the airlock and then back into the cabin when we realized that it had all worked, we had done it all.

Lizzie Peabody: But it wasn't time to celebrate just yet. It would still be a few weeks before NASA could turn on the new equipment.

Jeff Hoffman: And I'll never forget, it was New Year's Eve, 1993 to 1994. It was about one o'clock in the morning. The phone rang and it was an old astronomer friend and we wished each other Happy New Year. He said, "Jeff, do you have any champagne around? Yeah." We had

some left in the refrigerator. He said, "Well, pour yourself a glass. I'm really not supposed to tell anybody because there's going to be a public announcement next week. But we figured somebody on the crew ought to know that we got the first images back from Hubble and it worked."

[MUSIC]

Jeff Hoffman: And of course, the rest is history.

[MUSIC]

Lizzie Peabody: Hubble could finally see clearly. And soon after, it sent an image back to Earth called Pillars of Creation, whose beauty captivated the world.

Robert Smith: Stars, information, gas clouds. That is an absolutely spectacular image.

Lizzie Peabody: This is Rob Smith again.

Robert Smith: And it gets onto the front pages of newspapers, news magazines. It opens evening news bulletins. And it's really, I think, a decisive moment because here is the very, very, very clearest demonstration that Hubble has been fixed.

Lizzie Peabody: With that single image, Hubble went from national embarrassment to national hero. Amazing images kept coming. Data from the outer depths of space poured in. And in 1999, Hubble finally gave astronomers the answer to the question, how old is our universe? 13.7 billion years old, give or take a couple million years.

Jeff Hoffman: Hubble has made so many groundbreaking discoveries, it's rewritten astronomy textbooks many times over.

Samantha Thompson: It has to be one of the greatest achievements of space astronomy that has been accomplished. And everything that's come after it has really followed in its footsteps and owes a lot to that project as well.

Lizzie Peabody: Following closely in Hubble's footsteps is the James Webb Space Telescope. Remember that one? The largest and most advanced space telescope to date. It's a giant leap for space discovery and it wouldn't be possible without Hubble's successes and its failures. Many experts think Hubble's mirror problem was caused by underfunding. Not having enough money led to less oversight and fewer tests. And that's why the problem with the primary mirror went undetected. The James Webb's Space Telescope couldn't afford to make the same mistakes though because it's beyond the reach of the shuttle or any repair mission, farther than any large telescope has gone before. So, in those first few days that James Webb was in space, the entire astronomical community held its collective breath.

Samantha Thompson: So, when they first started to let light hit those mirrors and make sure that everything was focused correctly and that light was focused perfectly, you could just hear the deep sigh, just this general relaxation across the astronomy community because things look like they were working well. And I can't wait to see what the images look like from that telescope.
Lizzie Peabody: And we don't have to wait any longer. NASA released the first images from James Webb on July 12th. And oh man, they are... You know what? I'm not going to spoil it for you. Go see for yourself. No, really go. What are you still doing here? Go. Get out of here.

[MUSIC]

Lizzie Peabody: You've been listening to Sidedoor, a podcast from the Smithsonian with support from PRX.

[MUSIC]

Lizzie Peabody: You can see many of Hubble's actual parts, including some of the things we talked about in this episode, at the Smithsonian's National Air and Space Museum. The newly transformed museum is scheduled to reopen later this year. In the meantime, we'll share all sorts of cool Hubble stuff in our newsletter. You can subscribe at si.edu/Sidedoor. And if you want to share any of your Hubble memories, you can find us on social media, @SidedoorPod on Twitter and Instagram. You can email us at sidedoor@si.edu. We'd love to hear from you.

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Lizzie Peabody: For help with this episode, we want to thank Samantha Thompson, Jennifer Levasseur, Robert Smith, Sandra Faber, and Jeff Hoffman.

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Lizzie Peabody: Our podcast team is James Morrison, Nathalie Boyd, Ann Conanan, Caitlin Shaffer, Tami O'Neill, Jess Sadeq, Lara Koch and Sharon Bryant. Episode Artwork is by Dave Leonard. Extra support comes from Jason and Genevieve at PRX. Our show is mixed by Tarek Fouda. Our theme song and episode music are by Breakmaster Cylinder.

[MUSIC]

Lizzie Peabody: If you want to sponsor our show, please email sponsorship@prx.org. I'm your host, Lizzie Peabody. Thanks for listening.

[MUSIC]

Jeff Hoffman: Then of course, we come home and what's the first thing that my wife says to me, "Well, Mr. Hubble repairman, while you were up there fixing Hubble, the washing machine broke. So go and get your toolkit. And oh, and by the way, the kitchen door isn't closing properly and you're an expert at closing doors. And also, the grass in the backyard didn't know that you were up in space. It kept growing."