Speaker 1 (00:14):

Welcome everyone to the final AE 590 talk of 2021. Today we have with us, Josh Adamson. He's from Northrop Grumman. He has been a Spacecraft Thermal Design Engineer for Northrop Grumman in Redondo Beach since 2008, working on the James Webb Telescope since that time. He received a Master's degree in Engineering and Space Systems Engineering at the University of Michigan. His advisor, Thomas Zurbuchen, is now the Associate Administrator of NASA's Science Mission Directorate. And he is now part of the Mission Systems Engineering Team for Webb Flight Operations. And he's been a former student of mine from way back in Fargo, North Dakota, many, many years ago. So I really appreciate the time he's taking today to speak to us all on the James Webb Telescope, as we get ready for the launch, hopefully at the end of the month.

Josh Adamson (01:10):

All right, I guess that's my cue. We'll just get right into it, because 20 minutes is not very long for this really fun program. So I put this together before I knew I was going to have a bio beforehand, but here is my little path around the world or at least the country, and also changing the amount of people around me. So back in Fargo for high school and college, a hundred thousand people around me. Went to University of Michigan, 120,000 Ann Arbor. Then I go to LA, 10 million people. There's a few more people there. And then down in the lower corner there's my wife and I, and my two boys in front of our little, well, in front of JWST or the Webb Telescope. And I put number... I started out here with numbers because the standard presentation that gets sent around for things like this, talks like this. It's what's called By the Numbers, JWST By the Numbers.

So we start out with 13 and a half billion. And normally when you have a talk, you get feedback from the audience, but we'll just go forward with the number. And that basically is how many light years distant and back in time we get to go see. And this is a nice little graphic that compares how far Hubble, and it's Hubble deep field views, have gone back. So where you've got present day on the lower right, and then all the way up to the beginning of the universe way back when. And the main reason for JWST, for Webb, is to kind of search out these really, really, really early times in the galaxy, or not galaxy, but in the universe formation. When you get these first galaxies and these first stars, Hubble with its optics and the kind of light that it can see, can really only go so far.

And we just have a different color of light, we're infrared light, that goes just a bit further and you can see that 0.1 billion is actually really important, because there's a lot of stuff that happens, I guess, right around that time and distance.

Now we get to one and a half million. And the answer to that question is how far away we are. So we're a million and a half kilometers away from Earth, which is four times further than the moon. And unfortunately this I don't think this is quite to scale as far... Well, definitely not to scale, but in a different graphic that I've seen, the orbit of Hubble there is 570 kilometers or so, is really tight to Earth relative to us. So, Hubble got repaired now four times by astronauts because it's really, really close to the earth. Whereas we're going to be a million miles away, so we have to get it right the first time.

So 40 and 178. We have 40 different deployable motions. We're a giant transformer basically. And unfortunately I forgot to put in a picture of how big this is, but we'll get to that eventually. But yeah, we're this giant transformer, we will not fit inside the rocket. So you can see on the lower left, how tight it is inside the rocket, faring at the top of the rocket. Then we come off and we start this two week long deployment procedure where we're opening everything up very slowly and carefully and 178 represents how... actually picture. Yeah, all right. 40 deployable structures. There we are. And then 178 different release devices. So these are the things that are clamped together by bolts or whatever, however, pins, whatever there will be, to keep us together during the vibration during launch. And then we get a bunch... You got to release all that stuff. And so just a whole bunch of things there.

And I guess I haven't practiced this very much, but I forgot to go back through. But where, now we got a nice picture. You got a nice telescope here at the lower left that will always be in the sun or maybe... Ah, nevermind. Okay.

So -388 and 185. This is actually, these are my two favorite numbers because they are the temperatures of JWST. You got the hot side, that's always facing the sun. That's the bottom. That's not the telescope side. And also the cold side. As I mentioned before, we're an infrared telescope. And when most people think about infrared, you think about heat. And so when you have an infrared telescope, your sensors and your mirrors all have to be cold, cold, cold in order for them to actually work.

The joke I like to say is that if JWST is too hot and not cold enough, it's like going outside in the middle of the night with this flashlight in your eyes and trying to see the sun. And the joke part about it is, we're down in LA, it's like trying to go outside in the middle of the night in LA and trying to see the stars. It just doesn't work because there's too much light around. So just the thermal noise you could call it, of the heat of the telescope would be too great if it was not cold. And so that's the reason for the sun shield. And now the sun shield as you see here, it's five different layers of one or two thousands of an inch thick plastic material with special coatings, special thermal coating to get rid of the heat that's coming from the sun and not to pass it on to the telescope itself.

And one of the fun things about it, if you... Every once in a while, they'll in articles about JWST, you'll find a statement, something like the sun shield has an SPF rating of 1 million. Meaning, you know, it's a really good sunscreen. And yeah, it's just a huge knockdown in the amount of power that comes through the side. And you can kind of tell in the picture that it's got through the different layers, there's the separation of them. And so you get the vast, vast majority of the heat coming out the sides that you don't... Yeah. And so very little of it comes up into the telescope itself. And the telescope again is almost 400 degrees below zero. And this view here gives you the overview, but inside behind the telescope are the instruments. And there are four instruments in there.

Three of which are near infrared. And so they are passively cooled down to about -388, but there's one more instrument called the mid infrared instrument that goes a little bit further in the infrared than the other ones. And so it needs to be actually very, very cold. And so that one's down in the -450, -440 range with absolute zero being about -460. So it uses a special refrigerator called the Crowd Cooler to do that, to cool that thing down.

But in general, the telescope itself is passively cooled by space and just by being in the shade all the time. Which is different than other infrared instruments or infrared telescopes, space telescopes in the past, because they would bring up a big, heavy tank of refrigerant of some sort that would eventually just peter out and they'd last a year or two, but we're going for 10 years. That's the mission goal. So yeah, we're there. And just to let space cool us off.

Let's see. Okay. Now we have some really fun pictures here to give you where we're at because we are going to launch sometime in October. I think it's the nominal date is at the end of October, but that's our launch readiness date. So we are really in the end game of where JWST is going to be right now. So it's just sitting on the high bay going through kind of final closeouts and all this stuff. So we've got a lot of really great pictures of things. And this picture here represents the telescope flight satellite as deployed as it could be at the moment.

So for those of you that may have been following JWST for a while, back in 2016, it was all those mirrors and whatnot. The telescope part of it was, it was out at NASA Goddard in Maryland. I went back there a few times to help with the thermal installations and checkouts and whatnot, but there they were able to fold the mirror segments completely open. And whereas here, I guess our support structure and maybe just the general layout of how the telescope is on top of the vehicle is not able to support that deployment. So this basically represents the fullest deployment that we could do on the ground as of the whole observatory.

So pretty cool stuff. And so, my background picture is, I think a picture of that. And then that picture that I had on my second slide with my family is when we got a family photo shoot basically with that.

But you can see if you've noticed by now the little red box at the end of the JLG lift there, that's a person. I don't think he's right over the sun shield, but he is nearby it. So it gives you an idea of how big this thing is. It's six and a half meters in diameter. So 22, 25 feet. And Hubble was, I think about seven. I already forgotten one... Little bit over... No, it was two and a half, I think. So we got seven times the collecting area and just a lot bigger. So it's just really kind of fun.

Here's a picture of when the telescope by itself went down to Houston, Texas to Johnson to undergo its Cryo vacuum test, Cryo vacuum thermal test to make sure that everything works at the extreme cold temperatures that it will operate in. And fun fact is that this test went on during Hurricane Harvey. And thankfully I wasn't there for that, but other people were, and they had to hunker down for quite a while. And so, but it was a browsing success. Actually the facility never lost power and they didn't have any real issues outside of extreme tiredness. But yeah, again, I've got a little red box showing how small people are relative to this thing. So it's nice and big. And if Chamber A at this Houston facility, if you've ever seen Armageddon, is where Bruce Willis and his friends, there's a scene where they pop out of it. But it's one of the famous places and where they also had tested out many Apollo parts. I think the command module. I think that was tested in there.

Next up is in the stowed configuration. So more or less, this is what we are like now. I think I might have another one later, but here's a couple pictures again, showing how tall the stack is and how small people are as well as giving an idea of, for those really high heights, how people do their work inside the clean room. You know, you got that lift that's in the upper left of the picture, but you also have these diving boards where people are harnessed in and they more or less lay down or sit up like this to do the work that they need to do from really, really high heights. And there are definitely people that don't want to go up on there. And you can see in this case, I think this one's almost fully deployed. On the left side, it's really, really high up there.

We have a solar ray that deploys, it's got five panels. And I got a video of that. Hopefully I've got enough time to show that. It's a short little thing to show how that deployment works. It's kind of fun. So we'll hopefully get to see that here shortly. This is the secondary mirror. So you got the big primary mirror that collects the first amount of light and that bounces it off to the secondary mirror in a somewhat focused way. And then that secondary mirror passes the light into the instrument cavity behind the primary mirror. And you can kind of tell here that we're on our side when they're doing this deployment. And the reason for that is this is so you can offload the hinges and the structure that's holding on by holding it from the top. So because the motors are sized for operating in Zero-G where there's no gravity. So if you slip yourself on your side to be parallel with the hinge line, that allows you to do that. So, and that is why in that previous picture where the whole thing was open. This secondary mirror support structure was folded back. Because again, we're not... The structure itself can't support its own weight fully in gravity.

So let me jump over to the videos here quick. This gives you, hopefully this comes through, but it's a little time lapse of various things that are coming through and all the people that are part of it. I think you can find this online. I don't know. NASA has a great set of pictures and videos that you can find on the Flickr page, on YouTube, all over the place. So there's good stuff all over the place here. You can see it unfolding, and then they did the deployment of the different layers. And then you ended up with this rather glorious looking very large telescope that's going to space. That's cool little flying shot here as you come around it.

But yeah, as a thermal design engineer, I get to go in that high bay and just do checkouts when they do insulation... Oh, here's my other one. Here's that solar. Right? So you got five panels that were all snapped together. Then they go through these hinges and you got this really interesting truss structure at the top. That's kind of like a mobile that allows free movement of all those hinges. And yeah, I think I just hit 20 minutes. So I think I'm doing pretty good. Anyways, I think it's Q&A time.

Speaker 1 (15:34):

Thank you so much, Josh Adamson. If anyone has questions, you should be able to unmute yourself now.

Heidi (15:40):

Josh, this is Heidi. I have a question. Would you mind sharing how you started actually, or how you got the job to work at the James Webb? Just so that students know how you ended up where you are?

Josh Adamson (15:53):

Yeah. So when I went to the University of Michigan, I was in Space Systems Engineering and in a relatively small department there. And like, again, from that the U of M had a really good relationship with Northrop and of course with other companies and going from... They had a career day and dropped the resume off. But I think being in the program that I was in, helped me get an internship there in one summer and on JWST as a systems engineer. And then after that, or during that, they liked me enough to give me an offer at the end of my internship. And then I went back to school for one more semester and then started in January of '08. So yeah, that's... You know, career day and a good program.

Danielle (16:43):

Hi, my name is Danielle I'm from NIU. I was just wondering, what is one of the hardest projects that you've encountered?

Josh Adamson (16:55):

So one of the... So on this program specifically... So JWST is really, I mean, like that one picture said... let's see if I can find it again. The temperatures, again, are all thermal. You got more or less really hot on one side and really cold on the other. And on the cold end, you're trying to keep everything cold and away from the hot. So you got design features in there, but because of limitations in the electronics processing, I guess you could call it, of the instruments, we had to put a refrigerator sized box that wants to be roughly around zero Celsius, 32 degrees Fahrenheit, next to something that wants to be 400 degrees below zero.

And so in a thermal sense, that was difficult to ensure the mechanical design could accommodate the thermal shielding that we needed. Because oftentimes the solution of the problem is straightforward, just block it off and keep the heat from coming this way and go that way. But when it comes to practical matters, you've got to work with the mechanical engineer. You've got to work with the group that's making that refrigerator box. That's essentially full of electronics, hot electronics. So that took several years. And that was one of the main reasons that, for my tasks when I would go back to Goddard in 2016, to just make sure that all those parts were put together. So that program, or this program was a tough one too. Let's see. So yeah, I'll keep with that one.

Danielle (16:55):

Thank you.

Speaker 1 (18:41):

We do have a question in the chat. It's from Diane Jeffers. She was a little late in joining the talk, so she didn't know if you'd already mentioned the estimated launch date for the telescope.

Josh Adamson (18:51):

Yeah, it should be in October. I think, like I mentioned, I think October 31st is the date that's out there. But October of this year, so we're not that far away. So we've got some, that's why we get some great pictures about the satellite. Because oftentimes when you talk about spacecraft, you often get just pictures like this and maybe some animations, but we've got the real deal, which is fun.

Speaker 1 (19:19):

Thank you.

Speaker 6 (19:20):

Hi. I had a quick question. So obviously you're dealing with some really extreme temperatures. I'm a chemistry student, so material science really spikes my interest, but did you guys pretty much know what materials you were looking for when you started the design draft process or was it really kind of a discovery trying to find materials that would hold up for the project?

Josh Adamson (19:50):

So for the most part, yes. I think we knew or the program knew. So that was about 10 years... So JWST has been more or less going on since 2003. So it's a long haul program and I've been on it for 13 years now. And there's people that have been on it for the whole time. Or even part of the proposal stage back in late '90s. But back then, they still had the idea of, you use composite... Much of the structure there is composite. And it's just laid up in a specific fashion such that you don't change shape very much in temperature.

And I think, I'm sure there were trades on materials. I think the mirrors themselves, the primary mirrors, that was one of the early trades of what material to go with. And, but yeah, for me, well before my time, but yeah, I think most of the materials are normal space materials. And when it comes to a mission like this, you can only go so exotic because this is a large scale Class A program and where you have very low, what's it called, appetite for risk. So you want to use something that's tried and true, or if it's not quite tried and true, you test it really, really well before you incorporate it into the design.

Speaker 6 (21:19):

Thanks.

Josh Adamson (21:22):

Let's see. I'm trying to think of some random fun facts. The mirrors themselves are... Each one of them you can see in the picture and actually let me go to a real or even... You know that one here, you can see the lines in between them. There's 18 different segments each. So they're each individual mirrors, but they are aligned via little mechanisms on the back so that they all act as one mirror as one. And the flatness requirements on these are really, really tight. Now, I guess, not as tight as Hubble because of the different wavelength that they use, but to give you an example or an idea, each one of these mirror segments are about three feet, three and a half feet from flat to flat side, because they're hexagons and a few stretch that flat to flat out to the side of the United States, the tallest hill or the deepest valley was on the order of two inches, taking from three and a half feet to like 3000 miles, right. Just two inches or so it's that flat, microns is what we're talking or nanometers. Very small.

Speaker 1 (22:35):

Okay. We do have another question in the chat who made the mirrors.

Josh Adamson (22:40):

Let's see. So there's a really interesting graphic on NASA's website if you can find it. That has a picture of the United States with a bunch of arrows all over the place. The mirrors are made of beryllium and that beryllium came out of the ground in Utah. Then it went through various processes. So Northrop Grumman is the prime contractor for the observatory, the whole thing. We subcontracted the mirrors and the optical system out to Ball Aerospace in Colorado. So in their supply chain and in all subcontracts that's where they came from.

So, but yeah, it's really neat. They bounced around the country I want to say three or four, no, probably like eight times. Utah and... getting put together, getting polished, being light weighted, being integrated, and then shipped over here, shipped down to Johnson and shipped down to... Oh, we are launching out of South America, if we didn't know that. We're riding on a European Space Agency rocket known as The Ariane 5 out of French Guiana, which is on the northeast side of South America at about five plus or minus five. No it's plus, plus five degrees latitude. So very near the Equator. Being near the Equator is helpful for us to get out a million miles with using a little less fuel [inaudible 00:24:07] want to go...

Heidi (24:08):

Okay, Diane asked "Didn't Ball do the Hubble mirrors?"

Josh Adamson (24:14):

I don't know who did those actually. Lockheed was in charge of the Hubble as a whole. So yeah, I don't know. But of course this being a NASA program with the space telescope that's extremely expensive. They learned a lot from what Hubble did and didn't do right, as far as figuring out whether their mirrors are proper. One of the things like I mentioned, each one of these mirrors has actuators in the back that they can refocus and in case something it gets out of balance. And actually it will happen during this course of the mission. So they have kind of regular scheduled realignments, I guess you could call it.

Heidi (24:58):

We have one more. "Are micro meteoroids or other space debris, a concern for the JWST or if so, what kind of measures have been taken to protect it?"

Josh Adamson (25:09):

All spacecraft have to worry about micro meteoroids, electrons, protons, all those kind of space environment things. And so the way it was told to me, as far as the mirrors go... So two major things, when it comes to micro meteorites, most of the time, what you do is you just make your walls thicker in your panels, your electronics panels. But for something exposed like a mirror and also the sun shield, I guess the way as far as the mirror is concerned, the way it was explained to me is that to get the mission, the science objectives completed, they needed a certain total effective area of the mirror. And so what they did, I think, is they took that minimum area requirement and then expanded it by X percent to account for any loss that comes from being banged around by micro meteoroids.

On the sun shield side again, the sun shield is there to stop any sunlight from going all the way into the telescope. And again, knowing information about, or having models of the location in space that we're going to be at, the thickness of the membranes again, was chosen and analyses have been done such to say that in the statistical realm, some things are going to punch through one layer. And there's a couple, a smaller percent, that's going to be able to punch through one and two layers if it's coming from the bottom or from the top. But it is statistically very unlikely for something to punch through even three layers because by the time it gets to the second one, it's just lost so much energy or it's been scattered enough.

So, and also the fact that sun shield is what's called a high aspect ratio, very large area, but very small thickness, you know, quote unquote thickness. It's not going to, nothing's going to really come in from the side to cut that out too. So I thought those were interesting. But every once in a while I get a question [inaudible 00:27:25] when I do tours.