32. Maizel, Smith, Smalley & Watzin: Project Management in Outer Space

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0:00:04 Roy Maizel: We are working here at understanding and getting answers to some of the deepest questions that people ask themselves. Are we alone in the universe? How did the universe develop and evolve? What will it look like in the future?

0:00:23 Kendall Lott: That's Roy Maizel, Deputy Associate Administrator for Management in the Science Mission Directorate at the National Aeronautics and Space Administration, better known as NASA. You may recognize his voice from our previous episode in Project Management in Federal Government. His discussion inspired me to delve deeper into the nuances of Project Management in Outer Space.

0:00:43 Voice Over: From the Washington DC Chapter of the Project Management Institute, this is PM Point of View, the podcast that looks at project management from all the angles. Here's your host, Kendall Lott.

0:00:54 KL: At NASA, projects are measured in years, and the programs they serve may last for decades. They can outlive the stakeholders they serve and challenge the attention spans of citizens and politicians. The projects are astronomical and so are the budgets. The probability of success versus failure is virtually unknowable. Add to that the potential dangers associated with failure and, well, frankly, what they've been able to accomplish from a management perspective seems more miraculous than scientific. The number of NASA's successes is a credit to their organizational structure, which includes a strong emphasis on project management and the use of project management principles and their ability to continuously learn and adapt.

0:01:35 KL: My first guest, Dr. Eric Smith, initially came to NASA to work on software development for the Hubble Space Telescope. Now he is the program director and program scientist for the James Webb Space Telescope, the scientific successor to Hubble. It is designed to answer the questions that Hubble raised but wasn't sophisticated enough to answer.

0:01:54 KL: So, how does it feel to be essentially one of the very few people that is responsible for more pixels about the universe than anyone in humankind? Because you're on the two telescopes that matter [laughter] at the universe level.

0:02:08 Dr. Eric Smith: It's been a lot of fun being involved with both of them. Hubble, I came along very late in its development. On Webb, I was involved from the early days, so it has been an honor and a privilege to work with the thousands of talented people, both inside NASA and in industry who are involved in these efforts.

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0:02:32 KL: Give us the fascination story here.

0:02:35 DS: Okay. So let me start with the Hubble Space Telescope, and in particular mid '90s. Hubble has been repaired and it's now about to embark on its great discoveries. And one of the things that the then director of the Space Telescope Science Institute does back then is he decides he's gonna point Hubble at a piece of the sky that pretty much has nothing in it. And the reason he decides to do this is because astronomers have always wondered, "What if you look at something where you don't see anything before, can you find something there?" The traditional proposal process whereby that's how Hubble and Webb get their ideas to the science community says, "I'm gonna point the telescope at this, this is what I expect to see."

0:03:19 DS: So you can't write a proposal and say, "I'm gonna point it at nothing and I hope to see something." But Bob Williams, as the director of the Institute, he has the freedom to do risky things, and he decides to do that, points it at the sky where there is nothing visible and we get back what becomes a very famous picture from Hubble. It's called the Hubble Deep Field and there's thousands of galaxies in there. The reason astronomers were interested in this is that they're looking for the first galaxies. When did the universe begin to form stars after the Big Bang? Hubble takes a deep look. It finds galaxies. What it finds is that none of those galaxies are the first galaxies.

0:04:00 DS: And so, astronomers realize that if they wanna see the first galaxies, they need a bigger telescope than Hubble. And they need to have something that looks in the infrared, because although the first galaxies have stars that emit in the visible and ultraviolet, by the time that light reaches us, it's been shifted to infrared. And that's the genesis for the James Webb Space Telescope. The telescope we need is bigger than any rocket fairing that the world has. We have to think of a way to fold the telescope up, to fit it inside the rocket. We have competitions. We end up picking TRW, they become Northrop Grumman. And we pick science teams.

0:04:46 DS: And so since that, early 2000, that's when the work has really been going on. Right now, we're in the last stages of manufacturing. Just a few bits needed to be made and we're primarily in the integration and test phase of the program. And so this is really exciting because all those PowerPoint drawings and sketches that you saw from the late '90s are now realized in hardware and you get to see it, particularly the mirror is just something that's gorgeous. It's covered in a very thin layer of gold, about a thousand Angstroms of gold, because gold is the best metal to use for reflectivity in the infrared.

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0:05:32 KL: The genesis was to find the earliest galaxies.

0:05:35 DS: That's right.

0:05:36 KL: What are we anticipating seeing now? Has the science mission got more refined or more expanded?

0:05:42 DS: Webb will be a broad-purpose telescope and what it actually does will be determined by what people write in, what they propose, and what gets selected by peer review. When we were designing it, though, we knew we couldn't just design it to do these first galaxies. So we picked four broad themes to try to design the telescope around. One was this first light, or early galaxies

mission. If you can see the very first galaxies that formed, and you can also use it to study nearby galaxies, then you can watch the universe build up structure over cosmic time. And so, another theme that you may see on the website or hear people talking about is called 'galaxy assembly', and that's just shorthand for watching how the universe builds up structure in cosmic time. Because it's infrared optimized, that means we can see through dust clouds to look at forming stars within our own galaxy. So, that's another big area of emphasis, and that's gonna be the study of the birth of stars and planetary systems. The last topic we picked for the early designs, we called it 'solar system science'. We now know there are thousands of exoplanets that we might also look at.

0:07:02 KL: And tell us what an exoplanet is.

0:07:03 DS: An exoplanet is a planet that orbits around another star. We've now discovered, and particularly recently, that there are thousands of planets we can see orbiting around other stars. People will most certainly use Webb to study these planets. We will certainly be looking for possible planets that could be hosting life as we know it.

0:07:32 KL: So, at least it's not a highly risky project, right?

[chuckle]

0:07:36 DS: Well, I think that's part of the appeal. If you were to tell somebody, "Well, I'm gonna see something 5% better than I ever saw before," mm, not so interesting. If you're gonna see something never seen before, or do something a hundred times better, that's when you can really convince other folks of the importance of it, and it's also what's needed to help people grasp the expanse of these things.

0:08:00 KL: And I'm gonna roll a dice here and try and go one step further talking to a scientist here, and what's exciting is the project management aspects around this because...

[laughter]

0:08:09 KL: No, I'm gonna make the case. Here we go. You're gonna help me here. It's because if you don't have support from the people that funded, we don't get to do the science. So, there was a time when this project was in some sort of budget and schedule problem, perhaps, compared to its risk, and we just heard about the re-baselining that happened, I believe, in 2010. So, tell me a little bit of the situation that walked us into the re-baselining, and what does that baseline look like now?

0:08:33 DS: Yeah, and let me go back again to the earliest definition of Webb. Astronomers wanted it bigger than Hubble and infrared optimized. So, astronomers said, "We would like a four-meter diameter mirror and optimized for the near infrared." Now, a four-meter mirror would fit in a rocket faring. So, that was the first thing that NASA began to study. At that same time, we had... The NASA Administrator was Dan Goldin, and he was very visionary. So, he said to the astronomical community, "Why not an eight-meter mirror?" And tell an astronomer, "You need a bigger telescope," and the answer is, "Why, of course, you're right." So, we eventually write RFPs, Requests For Proposals. So, this is now 2000 when we first bring industry on board. The mission at that time was part of the Astrophysics Division here at headquarters and it was a project led at the Goddard Space Flight Center.

0:09:34 DS: Because it's a large project and it has a large budget and a large amount of reserves that go with it, at the time, if you're the Astrophysics Division Director, you have a portfolio of missions, big and small and research, and if you have a near-term mission... Let's say, you have a mission that's gonna be launching next year, and it has a budget problem, and you look and you say, "How can I help?" You say, "Well, oh, here's this big telescope, and they have a lot of reserves, 'cause they're big, but I'm gonna take a little bit of that this year because I need it right now to fix my problem today." So, that would happen. It happens all the time. But now the big project was running into concerns with being able to complete its work because it was finding problems, discovering new engineering difficulties. So, if now you're the project manager and someone just said, "Well, I'm gonna take some of your reserves," so now you can't fix a problem because you don't have the reserves, so you say, "Well, okay, we'll do that next year. We'll work on that problem later when we have the money."

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0:10:47 DS: So, in 2005, at the time I was the Program Scientist here at headquarters, one of the things I did to try to contain any cost growth was say, "Let's look at the scope of our mission. Are we asking this telescope to do too much? Can we make it cheaper by making the science goals, the science requirements easier?" So, we did some science requirement relaxation in about 2005, but we were still very much in the mode of discovering how hard it was to build this thing in the first place. And also, I think this was something that none of us appreciated early on, the amount of money we would need to spend on infrastructure for testing. Not only were we building a telescope that had never been built in space, but to test it on the ground, we needed to build... We call it 'ground support equipment', GSE, that didn't exist, so we could test it.

0:11:47 DS: And so there was an area of cost growth that while you might have predicted, "Oh, I'm sure that telescope's gonna be harder than you think, here's some reserves," no one would have said, "Oh, that vacuum chamber to test it is gonna be harder than you ever thought so you need more reserves for that too." So, come 2010, I asked for a group to look at our integration and test program to say, "Jeez, is there anything we can cut out of that? Can we make it shorter? Can we double up shifts?" Right about the time Senator Mikulski, a big supporter, asked for her own review of the program. So, that panel gets convened, it was called the Independent Comprehensive Review Panel. And they issued a report saying, "Well, here are some things that you need to do to get this program kind of back in a box." And through the big changes they make that I think have contributed to success, was the removal of the Webb program from the Astrophysics Division. So they took it out and made it its own separate entity.

0:12:53 KL: Little harder for it to leak its funds somewhere else.

0:12:55 DS: Right. And it also elevates it to Congressional eyes, so they can directly watch it. So, it becomes much more visible but it's separate from other pieces of NASA so you don't have this raiding of resources.

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0:13:15 DS: The other thing we did then was, we said, "Okay, let's look at what do we really need to do to budget for this program?" And, so, the project, which is at Goddard Space Flight Center, they went off and developed their required budget profile to launch. At headquarters, we looked at

that and said, "Okay, we know how this game works, everyone goes onto this with the best intentions and nobody ever leaves these projects... "

[laughter]

0:13:45 DS: "At the rate they think," it just doesn't happen. And so, we laid in a lot of UFE reserves at headquarters, UFE stands for Unallocated Future Expenses. Because we thought, "You're just not gonna roll off like you think you are". And sure enough, they haven't been able to roll off. But rather than the project saying, "Oh, we've now run out of resources this year, we're gonna push some work", we've had headquarters UFE to say, "No, get that extra shift in there, we'll give you additional resources, here's the money to keep the work going, to keep the launch date the same."

0:14:24 KL: So, when does it launch?

0:14:25 DS: The launch readiness date is October, 2018. We want the program to launch essentially with the full suite of observations ready to go. So, astronomers will be proposing about a year before launch, so the observations begin right away and the data starts flowing back.

0:14:48 KL: When you've mentioned that one of the changes allowed Congress to have more oversight, you actually... That's a positive thing, and it tied to something I saw when I was looking on your website. I was struck because I just haven't seen this, that if you go on the NASA website and the science part of the website, you can see all of your program milestones and drill down into the project. You are exposing directly where you are to date, and where the next ones are coming up. And it is a full life cycle of, kind of, to date. You seem to almost take pleasure in sharing these management details. It's a cultural thing, it seems to me.

0:15:25 DS: Yeah, coming from the science side of things that was always natural to me. You have to show people your data, so that they can reproduce your results or judge whether you're on the right track.

0:15:37 KL: Show and tell's not new? [chuckle]

0:15:38 DS: Yeah, yeah. The second thing that I've now seen is really the value added, is that it brings other people along on the journey. This is not just NASA's telescope or the astronomers' telescope, right? We do this for the greater benefit of the American taxpayer and, indeed, world citizens, because we have international partners. It's a tremendously exciting thing to build a telescope and study the universe. And so, I would just think people would be interested in following along and getting them invested in the process, too. So that, when we talk to Congress or whatnot, they're interested in a greater level of detail because you've brought them along for the journey and you're just not some person telling them, "Well, I need more money".

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0:16:33 KL: How many projects are inside your program already? You're the Program Director, so if you had to name them as projects, the parts that start and stop?

0:16:40 DS: There is the Observatory Project, and that is the piece of it that's centered at Northrop Grumman, and that consists of the spacecraft bus, the structure that holds the infrastructural pieces

of the mission, like fuel tanks and batteries and electronics. And then it has also the sun shield. Unlike most telescopes that have a tube that protects the mirror for stray light, we just have more or less a parasol. Now, it's a parasol the size of a tennis court, but it protects us from infrared radiation, from the sun and Earth. So the sun shield and the spacecraft you can think of as the Observatory Project. The Science Instrument Module, the cameras and spectrographs that come from the US and foreign partners, that was another project. The telescope itself was another project you can think of.

0:17:32 KL: The unfolding mirrors.

0:17:33 DS: Right, the unfolding mirrors. Now that the telescope is finished, and the instrument project is finished, we're going to bring those two elements together. So that's another project, the integration and testing of the science payload. Once that's done, then we really no longer have separate projects, we'll just be the one project.

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0:18:00 KL: Where have been the key decisions that you've needed to make?

0:18:04 DS: I think the first instance probably was when I initially came to headquarters, and I came as the program scientist and ran the process that selected the science team for Webb. And so, that was actually critical for getting the team that would ultimately drive the science. It's this core science team that really is... It's sort of the conscience of the mission, and so, picking that science working group, and orchestrating that process was, I think, the first critical management function I had.

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0:18:42 DS: The second one probably was this 2005 period, where, as a scientist, I typically don't have any control over the funding, that's the program and project manager. But I could see they were running into problems, and it wasn't easy for them to solve, because they were given a, "Build this widget," and they couldn't find a way to build it, so I had to say, "How about if I give you an easier widget to build? Will that help you any?" And that helped some there, probably in the schedule, and a lot of cost avoidance there. And then the last time was in the development of the new program office, when we decided to lay in these extra reserves.

0:19:28 KL: From a general breakdown, if you can share, what is the basic breakdown of the reserves, versus the stuff planned? We often hear in project management, "10% management reserve", and this is a higher risk project, what would be that balance in your mind?

0:19:40 DS: Right now, the traditional NASA figure of merit is to hold about 30%.

0:19:44 KL: 30%?

0:19:45 DS: Yeah.

0:19:45 KL: Okay.

0:19:45 DS: And we're actually... We're doing a little better than that in the out years. And so, some

people are now beginning to say, "Oh, well, what's your plan for releasing that?" And I'm saying, "No, we're getting to the riskiest part. INT is always worse than people expect, so I think we have what we need, but I'm not giving anything up yet."

0:20:05 KL: That's really...

0:20:06 DS: Got burned once on that. [chuckle]

0:20:07 KL: No, that's really important. I've done an earlier podcast on the nature of risk inside a project, in terms of its execution. And one of the things is, as you move through the project, just, almost definitionally, right? Events are now known.

0:20:18 DS: Yes.

0:20:19 KL: So risks begin to fall at the activity level, because now you know you either do the activity, who did, and you have an outcome, or you don't, right?

0:20:26 DS: Yeah.

0:20:27 KL: And what you're observing is, "Right, but some of the product we do, the milestones we do, the ones at the end are riskier." So just because we're more clear we're getting to that point, integration, it doesn't mean integration is any less risky.

0:20:40 DS: Not only that, if you have a problem then, it's gonna cost way more to fix if you have to de-integrate, or something. So your problems, while fewer in number, are more costly.

0:20:49 KL: And higher impact.

0:20:50 DS: Yeah, as you get to the end.

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0:20:57 KL: What is the role of project management going forward, as a scientist?

0:21:01 DS: I think it's bringing the viewpoint of the scientist into the whole systems engineering process, and then, using that as the management structure. That's sort of your foundation that you're gonna build on. So, the end for NASA is not actually the fire and smoke and the rocket leaving. That's very cool, but ultimately, that's not the point. It's the result of that rocket launch, that's what we wanna get. And so, you wanna optimize across that whole product, and not just the fire and smoke. If it doesn't translate into something that people are interested in, we've just wasted a lot of money.

0:21:36 KL: In our community, we call that 'benefits realization'.

0:21:39 DS: Okay.

0:21:39 KL: In the end, if it doesn't deliver the things that matter to the institution, it doesn't matter, even if the project's well done.

0:21:46 DS: Yes. I think, as we can begin to look at all these science missions as, really, from inception to data in the hands of the community, and science results in the hands of the public. Ultimately, that's what we gotta get it back to. Something in the textbook. Something on the news, that's the real product, not the very cool mirror, as beautiful as it is.

0:22:09 KL: For more information on the James Webb space telescope, go to www.jwst.nasa.gov. There you will find the latest videos, photos and scientific talks about the telescope, and also be able to track the project milestones. Or go to webbtelescope.org. That's Webb, with two Bs.

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0:22:37 KL: My next guest, Sandra Smalley, has a strong foundation in project management. In fact, she was very involved in the development of PMI's Organization Project Management Practice Guide. Sandra came to NASA in 1992, and is currently the Director of the Joint Agency Satellite Division in the Science Mission Directorate, which supports other organizations in delivering satellite-related projects. Their primary customer at the moment is NOAA. I spoke to her about project management in the science/engineering environment, and about the challenges and workarounds for partnering with other organizations.

0:23:11 KL: You have a background, literally, with Project Management Institute, and with project management. I noticed, in your bio, that you've come from what appears to be an engineering and even IT background. Some of your earliest success was around the IT systems at the Navy.

0:23:24 Sandra Smalley: Yes.

0:23:25 KL: So I have someone at NASA here who's actually IT and engineering.

0:23:28 SS: Absolutely. I am not a scientist. However, yes, I would say I've applied project management processes throughout my career, starting with an IT implementation for the US Navy. But then, in various forms, even as a science manager on one of our other science projects many years ago, it was one of the first attempts to really start to structure their activities in a more organized manner, so when we started forcing the scientific community to utilize schedules, utilize estimates, actually lay out the products that they were going to deliver and manage against it.

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0:24:13 SS: So I would say everything that we do for NOAA as a joint agency satellite division applies project management expertise. And that's part of why other organizations come to NASA, is because we're known for our expertise and being able to deliver projects on schedule that are very technically challenging.

0:24:32 KL: This division kind of is an odd man out, as it were, an orange in a pile of apples. Why is this one different?

0:24:39 SS: Yeah, so it was imposed in an effort to streamline and apply better project management principles to our operational weather satellite systems. Our two large projects that we support now with are the JPSS, Joint Polar Satellite System, and the GOES program, which is a geostationary

satellite program. Both of them support weather forecasting for NOAA.

0:25:05 KL: So the implication underneath that, then, it sounds like with different organizations working together to make sure projects are delivered, is that it's in some part a stakeholder issue. You have a very broad stakeholder base that you're working with?

0:25:16 SS: Certainly we have a very broad stakeholder base. In fact out of... Now, I have to say all of NASA missions are incredibly interesting, they're amazing. What we do, though, I think is very, very tangible on a day-to-day basis to the average person walking around on our planet. Because who doesn't wanna know what's going on with the weather?

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0:25:40 KL: What did you see as the hardest part to wrestle as someone coming from a systems development or project management background when working with scientists?

0:25:50 SS: Certainly, there's a cultural difference. Now, I've been fortunate enough to work with the science side as well as the engineering side for many, many years. I think the key is that everyone has the same objective. I think the challenge, typically from an engineering perspective, you're looking at actually delivering on your requirements, and from a project management perspective you're making sure you do that within schedule and cost. On the scientific side, you actually wanna stretch your requirements to the point that you can achieve the most science within the cost and schedule. So that's where the healthy tension comes in.

0:26:23 KL: Right.

0:26:23 SS: Did they talk to you earlier about the role of the PI, Principal Investigator?

0:26:27 KL: Yes. Tell us a little more from your perspective how that works from a project management point of view.

0:26:32 SS: Exactly. NASA does a lot of in-house development. But within the science mission directorate they also compete for missions to achieve the most exciting science that is being proposed within any specific solicitation. So in that process there's an individual that is selected, who's called a Principal Investigator. He or she is typically the lead of that proposal and they will end up performing the project management responsibilities, both making the scientific decisions, as well as the project management decisions for that project. So it is taking a scientist and not only expecting them to make the science trades and all, but also to apply project management practices. So they are responsible for delivering the project within cost and schedule.

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0:27:29 KL: What struck me as even more interesting on behalf of NASA's role with that was the Master Forum.

0:27:37 SS: The project managers' Masters Forum?

0:27:38 KL: The project management aspects. And the fact that that education, that socialization

happens, I thought was really interesting.

0:27:46 SS: The Masters Forums are basically a forum whereby the project manager can interact with experts in the field, people who have gone on before them and been successful and share lessons learned. That ties into the whole knowledge management practice. So there's a piece there. And then also we have our governance processes, which are incredibly important for success. Also making sure that you have the policies and procedures that reinforce the lessons learned and best practices that have been achieved over the years. So I think all of those things collectively are important for enabling a project manager to be successful. Can someone do it on their own? Yes. But having that institutional, compiled support is, I think, very important to an overall success for an organization.

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0:28:43 KL: So you're in a joint division. You're working with other agencies?

0:28:46 SS: Yes.

0:28:46 KL: Is the project management practice that you have different, because you're working with other agencies external to NASA?

0:28:53 SS: One of the reasons why we were created as an organization was to bring to bear NASA's processes because of our demonstrated success. So we actually apply the NASA processes we are supporting other organizations and delivering their missions. So NASA does implement its own practices; however, there are differences when you're working with other organizations, and you just have to make sure that you clearly define how you're gonna operate and where those interfaces are. Part of the challenge there is governmentally, the way projects are funded, the politics behind, all of that's very different when you're working with internationals. So I think you have to keep that in mind too.

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0:29:41 KL: NOAA's an example. You can even need to work a project with them. How does that interaction actually happen and get structured?

0:29:47 SS: So from a contractual standpoint our contracts will actually say that we'll apply the NASA practices. I think that the real challenge for our organization and working with our partners, is looking really at the governance process and making sure that we have balance there, because they're the primary stakeholders. They're the ones...

0:30:06 KL: They're your customer almost.

0:30:07 SS: They're our customers, they're the ones that are providing the funding, they're the ones that are having to deliver a requirement to their stakeholders, so they provide a key role. One of the things that we really try to focus on is joint governance processes, and often that partner will sit on a senior level management council but they also might be engaged in lower levels. So, in the case of my partner with NOAA, they come to both our monthly reporting processes at the centers as well as we sit jointly on the management councils. Now, they ultimate carry the final decision authority, but

NASA also makes a decision before they have a final decision that's made at their level.

0:30:51 KL: So, they're literally integrated into your governance process as customers?

0:30:55 SS: Yes. We integrate them.

0:30:56 KL: That's a fascinating evolution. Do they have their own governance process that you also then report to?

0:31:02 SS: Yes. And like I said, it's a joint process, so that is something that is discussed up front in terms of, "How are you gonna govern the project?" So, we apply our principles, so having those various tiers of review is very important. Their program director and program leadership will come over and attend the monthly reporting statuses at the center level; similarly we will go over to Department of Commerce and NOAA NESDIS and support the monthly reporting at their senior leadership level. So it's an interchange, it's a mutual support, it's a mutual governance process.

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0:31:47 KL: You are managing the commercial site for this manufacturing satellites, as well as then preparing them and integrating them with the work that NOAA needs. But you're actually at the point where they're being made.

0:32:00 SS: Yes. So they come to us to build their satellites and build their ground systems. So, our program management's out at Goddard, as well as project management for best space flying ground systems, and they will do a combination of in-house activities but also often have prime contractors for the spacecraft, as well as instrument developers. And so they manage and integrate all of that, or oversee the integration, depending on the project.

0:32:23 KL: How many project managers do you have in your space?

0:32:26 SS: I would say half a dozen.

0:32:28 KL: Only six? What do you see as the role of the project manager, then? Very specifically, what's in their scope and what's not in their scope from where you're sitting as an executive?

0:32:39 SS: So, from a project manager is actually where the metal, or where the rubber meets the road, so to speak.

0:32:45 KL: I heard the metal gets bent, they said earlier.

0:32:46 SS: Yeah, exactly. They're the ones that actually are responsible for building a spacecraft within assigned cost and schedule. So they have a content schedule scope that they're responsible for delivering.

0:33:01 KL: The project manager very clearly then does projects that have clearly defined starts and clearly defined endings.

0:33:07 SS: Yes.

0:33:08 KL: When they cut the satellite or the ground system over to NOAA, in this case, they're done. It goes operational and that project manager comes off from that project? It closes.

0:33:15 SS: Yes. The operation will be transitioned, yes.

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0:33:24 KL: What do you see as the risk profile as you're looking at the different projects in your portfolio, inside your division? Do you manage an overall risk dashboard and how do you manage things?

0:33:37 SS: So, that's multi-layered. Risk management is critical to the successful project management, successful delivery of a mission. So, at the project level, the project manager is responsible for managing their cost schedule and technical risk. But they're looking at it from a very structured scope perspective. So, the program manager also looks at risk and they're overseeing what the project manager has identified as a risk and monitoring it, but the program manager may have a slightly broader scope, may be looking at some additional risks that wouldn't necessarily be the responsibility of a project manager, but again looking down the road, looking at potential budget challenges, things like that. Similarly, at my division level we also maintain a risk matrix. Now, I make an effort not to repeat what the project and program has. But, is there something that our mission directorate should be looking at? Are there cross-cutting challenges that might apply to other divisions? In which case, we should share that. Are there things down the road that maybe aren't impacting my specific program but maybe it could impact multiple programs within my area of responsibility. So, I look more broadly than the program or project does. And all of that gets rolled up to the NOAA level. They also have a detailed risk management process.

0:34:54 KL: Can you share either an example or characterize a type of risk that you actually look at?

0:35:01 SS: Occasionally, you know when you say, "It's not rocket science," but sometimes it really is. And sometimes our rockets don't perform the way they're expected.

0:35:09 KL: Yeah, they're mechanical. [chuckle]

0:35:11 SS: If you have a rocket anomaly, that could certainly impact future missions that we're planning to utilize that launch vehicle to support, they're on orbit delivery, and so if there's an anomaly, even though it's to different mission, it could impact your mission. So, we periodically track things like that.

0:35:32 KL: Oh, a classic external dependencies type of thing, then.

0:35:34 SS: Yes. Another one might even just be budgetary challenges. As you know, we're a government organization, so we propose a budget, but it goes through Congress and it goes to the President and decisions are made, so there's risks associated with that too, that you might track and might try to plan for and address.

[music]

0:36:00 KL: How do you monitor and manage quality, what does it mean from where you're sitting to have quality in your division?

0:36:06 SS: NASA has very strong principles around what we call technical authority and there's three technical authorities within the Agency that all fall within their institutional organizational stove pipe, but they're matrixed in to make sure that these key principles are reinforced through all the projects. One of them is engineering technical authority, so it's making sure that from an engineering perspective the decisions that are made are sound decisions.

0:36:34 SS: Safety and mission assurance. And then, for the human space flight programs, there is a health and medical. And the idea behind these technical authorities is when you have a budget and schedule and you might have other external pressures, or maybe even internal pressures to deliver, it's to ensure that we are looking robustly across the trade space, that we're not making a decision just to meet a schedule or to deliver within a cost, that we're gonna make sure that we actually deliver the technical requirements and that we do so safe and robustly. The tech authority process actually is one of the really great things that NASA does.

0:37:15 KL: It sounds a little unique, almost. Do they come in at the end of the project cycle or throughout?

0:37:20 SS: Oh, no, no.

0:37:20 KL: How does the interaction happen?

0:37:21 SS: No, no, no, no, no.

0:37:22 KL: This would be a great lesson for others, they're sitting outside of it.

0:37:25 SS: They're institutional organizations. You have the project organization, the project team stood up, but you have engineering organizations that matrix engineers into the project, you have safety mission assurance that matrix those folks into the project, and on the human space flight, like I said, you have health and medical, so you deal with doctors in the process. So, they are actually matrixed in and for our large programs, large projects there's actually an assigned technical authority for each of those roles, so you know who that person is. They know their job is to not only contribute to the design and the development and all that, and make sure it's successful, but their role is also if a decision's being made that's trading, say, something more that's on the programmatic side for something that could risk the actual success of the mission from an engineering perspective, they have the option to escalate it up through their organizational channel. It can go all the way up to the administrator.

0:38:21 SS: So, in most cases, project managers are the final authority, not counting the whole governance and the decision making process, but as you're making trades within your scope. But what this tech authority process does, in addition to ensuring that the designs and all are robust as they're being developed, if there is a decision that's being made that's a concern, you can wave a flag and say, "I want to take it up a level because I'm concerned that we might be making a trade here that could end up being catastrophic."

[music]

0:39:00 KL: How is that technical authority? How does it actually interface with the project manager? Whenever scope changes or a certain type of schedule change? Or, is it a weekly meeting?

0:39:10 SS: They're embedded as part of the project. So, again it's truly matrixed, the engineering tech authority on a project is actually part of the project team. They report organizationally to their institutional manager, which that's what provides the independence.

[music]

0:39:32 SS: This actually was a result of the Columbia accident investigation.

0:39:38 KL: Specifically why?

0:39:39 SS: Some of the engineering workforce had expressed concerns and because of other drivers we went ahead and launched. I'm actually thinking Challenger, actually, rather than Columbia, but Colombia was the one that resulted too. But the bottom line is NASA is very adverse to catastrophic failures like that, particularly in killing human life, but we also don't wanna blow up a billion dollar spacecraft. This sets a check and balance in place to ensure that their voices can be heard if they need to be heard so that a senior-level decision can be made. And there have been topics that have been escalated all the way to the administrator.

[music]

0:40:21 KL: So, this is really interesting, the project manager is in charge but is not the technical expert, necessarily, about the product they're building.

0:40:28 SS: That's correct.

0:40:29 KL: And we often take pride in that, "I can come and deliver for you in any field." But NASA has really integrated that and embedded it at the project level and simultaneously made sure there is an independent voice as well. And that's a tremendous adaptation here, I think. Did you observe that anywhere else? Are you aware of anywhere else that's using that in terms of their organization?

0:40:49 SS: Yeah, my understanding is that it was originally modelled off of DOD, they implemented it in a very different way, but I think the intent is the same, and again, it's about checks and balances. Ultimately, it's don't kill people but, again, don't destroy very high-priced resources.

[music]

0:41:16 KL: How have you seen in a project management this kind of change, or how has it changed in the time you've been at NASA?

0:41:22 SS: We do continuous improvement, measure how you're doing and make adjustments as you go.

0:41:26 KL: How do you do the continuous improvement? Do you have an organization set up to watch for that or is there a process that all of you engage in at your different levels?

0:41:33 SS: The organization, the Office of the Chief Engineer, that's responsible for the agency-wide policy is the one that's responsible for maintaining that policy. They use multiple methods to assess in the continuous improvement process, so the policy typically gets updated on a five-year profile. Every project's responsible for collecting lessons learned and they do it at every major life cycle milestone. We are always looking for our lessons learned, what worked, what didn't work, how can we tweak our process.

[music]

0:42:12 KL: Telescopes, satellites. Cool technology all, but imagine managing a project that could change how we understand ourselves. Roy Maizel, who told us how project management works at NASA, left me with a teaser.

0:42:25 RM: Are there signs that there was once life on Mars which would truly be, I think, a fundamental change in human thinking. Because if we were to determine that Mars supported life in the past, that would mean that there was once life in the first place we looked.

0:42:48 KL: Yeah, Mars. We've got the PM. Trained as an engineer, Jim Watson has spent more than three decades at NASA. He started out in guidance and control, worked his way into systems engineering, and from there moved into project and then program management. He is currently the director of the Mars Exploration Program in the Planetary Science Division and is responsible for all the missions that NASA has been sending to Mars, as well as the orbiters that circle it. If we ever discover signs of life on Mars, Jim Watson will be the program manager that gets the call. He'll be one of the first to know.

0:43:21 KL: What are the names of some of these things sitting on Mars that are fixed and some of the ones that are roving?

0:43:24 Jim Watson: We have the Curiosity Rover, it's probably what people are most familiar with, the large rover that has been going around doing some remote sensing of the geology in the area, but more importantly has been drilling into the surface of Mars and then processing the dust from the drillings in a mass spectrometer that they're carrying, where they can try to break it down into the molecular constituents. And this all in the search for signs of ancient life that may have existed on Mars. Now we're not talking about animals or plants, but we're talking about microbial life.

0:43:57 KL: What are our other assets on the planet?

0:44:00 JW: If you recall, eights years ago we sent a pair of smaller rovers to Mars. One of them is still operating. The two were Spirit and Opportunity. Opportunity is still functional and will continue to explore, and in fact, it has roamed greater than the distance of a marathon. So, pretty phenomenal for something that was designed to have a very short-lived life. It was really just a tech demonstration to see what we could do, it has continued to thrive and do meaningful science.

[music]

0:44:29 KL: What do we have going around Mars right now?

0:44:31 JW: So, we have, our workhorse orbiter is called the Mars Reconnaissance Orbiter and it does several things. It has some remote sensing instruments on it. The primary one we rely heavily on is an optical imager called HiRise, and we use that to do surveys of Mars. We use the precise things to explore areas of interest, areas that may we go to in the future for landing, areas where the rovers are now for the tactical planning of what shall we do next week, which direction should we go so we don't end up in a blind canyon that we can't get out of, those kind of things.

0:45:06 JW: So, there we use the very precise imagery. But because of the data restrictions, moving data from Mars back to Earth, and the limitations that go with that, we've only been able to do the precise imagery of maybe 3% of the planet. So, you'd think, we've been there for 10 years, we would have had it all covered by now, but we don't. And the other thing it has on it, it has some other instruments that sense in other wavelengths and it gives us insight into the mineralogy of the surface. So, that's used for geological exploration in context.

[music]

0:45:44 KL: You've been used to working with guidance, from engineering and from systems engineering, it's a lot of build, a lot of design and build. So, when you got into the project management, how did you experience that as different?

0:45:55 JW: I saw it as a natural progression. It was fairly straightforward to make the evolution from system engineering into project management, and then from there into program management. I think it's very difficult to manage successfully the kind of programs that we do at NASA, they're one of a kind, first of a kind, unique developments, completely by process. Process has its roots in history, good practices, good approach, thoroughness, the introduction of risk management, controls, all those kinds of things that are in there and it has its place, it's very necessary. But to manage without having a finger in the technical arena and having a gut sense for what the lion's share of your team is wrestling with as they go forward to implement, I would find to be extraordinarily difficult in managing, and managing successfully.

0:46:53 JW: And I've seen folks thrust into the project management role that didn't have a reasonably cohesive technical background that would relate them to the subject matter of that project properly, and trying to follow the recipes and formulas and policies associated with project management, and then struggled because they couldn't get into the complexities and the nuances and the issues that they had to manage. And if you're managing budget and you're managing schedule, and you're trying to proportion out a game plan, you have to have some sense for the adequacy, otherwise it's a blind trust relationship, or, you simply ask everybody what they need, they tell you, you put it on a list, and then you just stand off and the check the box when it's done. That's not management, that's accounting.

[music]

0:47:53 KL: The role of the technical authorities, I thought was impressive.

0:47:57 JW: There's layers of technical authority throughout the structure at NASA. At the headquarters level, there's technical authority, but it's tied closer to the policy landscape associated with what we do. At the field centers you'll find the deeper technical disciplines that's relative to the technical authority that you go with. But it provides this independent, somewhat independent chain of command, where if the team is struggling with some particular issues, you can go to as a manager and you can bring in other eyes of that disciplinary to take another look at what you're doing, or to validate what you're doing.

[music]

0:48:46 KL: How many projects are in your program, your portfolio? What's the size of this?

0:48:51 JW: The Mars program annual budget, it goes up and down depending on where we are in the development life cycle. But let's pick an average number of maybe $500 million a year. There's probably a half dozen operational missions that we predominantly are responsible for and another couple that we're partnered with in terms of other agencies, so we have a contribution or a role in that. And then we have development projects which consume the lion's share of the budget, if you will, and that's developing the next missions that are gonna go to Mars. Right now, we have two development projects under way, a very, very large one, the next rover that'll be going to Mars. And then, within the program we have a technology development activity where we're trying to address risk, buy down the risk if you will, prepare the readiness of the long pole items associated with the future missions that we wanna do. We are driven by recommendation from the National Academy of Science to obtain and return to Earth a sample from Mars. And so everything we do is about advancing the ball towards that goal of getting a sample back on Earth from Mars.

0:50:09 JW: There's several things that have not been done that we really need to cut the risk down on before we can commit to a mission, and so we have development activities going on on to or three different major areas associated with those missions. For example, the more obvious one is if you're gonna bring something home from Mars, you have to have the capability to launch a rocket off of the surface of Mars. So we have a technology program that's addressing the fundamental design of the rocket. Now the rocket isn't huge, by any standards, but nonetheless it has to operate in a completely different environment and it has to be relatively autonomous.

[music]

0:50:52 JW: We have to be able to land very precisely on Mars, because if I'm gonna go retrieve a sample and load it into the rocket, I can't be wandering all over Mars to go find it. So the next rover will drill for samples, put them in tubes to be returned and leave them on the surface in a pile for the next mission to come and retrieve. So we wanna land very close to where that pile is.

0:51:17 KL: Yes, 'cause it's just sitting there.

0:51:19 JW: That's right, that's right. So, we have that work going on and then, since we don't know for sure whether or not life, microbial life exists on Mars, we have to take all the precautions as if it did, all the precautions that assume that it might be harmful to you and I. And so there's a requirement to safely and assuredly contain that sample until we get it back into a secured facility here on Earth.

0:51:48 KL: You don't wanna kill it on the way back.

0:51:49 JW: And we don't want it to get out into the Earth environment. Correct.

[music]

0:51:58 KL: Who do you perceive as your customer?

0:52:01 JW: Ultimately the customer is the administration, we work through the appropriations process in terms of what we're supposed to do. But that's a little bit of a cop out for the answer so it takes a lot of...

0:52:14 KL: By administration, you meant the White House, the political administration.

0:52:16 JW: Correct, the political administration.

0:52:17 KL: And the control of Congress around the budget.

0:52:19 JW: Right.

0:52:20 KL: Okay.

0:52:20 JW: But in reality, many, many years have been spent trying to set the framework for the Mars program, and it struggled for a while. It started as most programs, it was a project here and a project there. Some successes, some failures, and so we spent a fair amount of time with the community at the various universities and institutes across the country and actually throughout the world, to some extent, trying to frame a set of questions and objectives and prioritize them against some themes.

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0:52:57 JW: The community then ultimately reflects itself in the Academy of Science's opinions, and NASA started a process that tried to bring order to that chaos, if you will, all asking to have decadal surveys or decadal plans made. The Academy conducts that at the request of NASA and that decadal plan has stressed and is anticipated to reiterate when it's revisited in a couple of years, that the highest priority is Mars sample return. I have that very top objective, and the program actually then becomes the customer and the headquarters program then works to define how we're going to achieve that, what the road map of that is. We obviously have to socialize that with the stakeholders, the appropriators and others so they understand there's comprehensiveness to it, it's traceable back to the fundamental requirements which were reinforced and emphasized by the community. So that's how we sort of bring order and then the program itself is the manifestation of the customer to the implementers.

0:54:06 KL: It's not the politics as the voice as much as the sense of the science community why this is valuable to be expecting money for.

0:54:14 JW: Correct.

0:54:14 KL: And then you have to, of course you deal with your stakeholders...

0:54:17 JW: Right.

[music]

0:54:22 KL: We get to Mars and that's really the platform for then being able to do more science beyond that.

0:54:27 JW: There's a lot of attraction to Mars, because it is the most challenging place in the solar system that we think we actually could, if we put our mind to it, go and spend some time and explore it and learn it and actually start to live there.

0:54:42 KL: It's attainable.

0:54:44 JW: In many respects, it's obtainable. I think we have struggled because we haven't really figured out what's the most effective way to do that. You can't start a project and run it very effectively if you don't have the fundamental idea, and the mandate to go produce. And then you bring those together and you create a realistic plan, and then you guide the team on implementing that plan. So you can see from our discussion on the bigger topics here, exploration, if you don't have a solid mandate and you're not really sure which idea is best, why it can be such a struggle to implement effectively.

0:55:30 JW: So there's the big debate over how do you go to Mars? Do you first go and just check it out as quickly and as affordably as you can? Or do you say, "Hey, I'm not gonna do that because I may fall prey to the same things that are talked about as undermining the Apollo program after we landed, so I'm gonna plan from the beginning to have a sustained presence." The problem is that that makes it extraordinarily expensive and it puts it off for two or three decades.

0:56:02 KL: Your risk rises dramatically.

0:56:03 JW: Right. So stakeholders are as difficult to sustain interest in something like that. And then meanwhile, do I know everything that I need to know about the planet to safely deal with the human element? The robotic program is kinda unique, 'cause we're exploring at a, albeit nobody likes to see us fail, and we are investing a sizeable amount of money to do the robotic exploration. But you can tolerate more risk than you can when you send a crew. I think undoubtedly my prediction is that we will be demonstrating some of the core technologies for the human element at Mars before they show up.

0:56:43 KL: Before they need it?

0:56:44 JW: Yeah, we'll be robotically landing supplies, the infrastructure, a power plant, for example, or something like that to, we'll be demonstrating the ability to do precision landing which, as I said, was important for sample return. So those kind of things to help enable it, but we've struggled, because it's such a big leap, because I don't think we have consensus, the best strategy across the board of stakeholders that have to pay for this and implementers that have to implement it. I don't think that we have been able as an agency, a community and a country to really put our finger on the risk element and have a good discussion over what's the appropriate risk to take.

0:57:30 KL: And how about the benefits?

0:57:32 JW: The benefits to some extent are not quantifiable. Project management at the highest level takes an idea and it marries it with a mandate, and creates a solution or it delivers a solution.

0:57:47 KL: So, NASA which undertakes some of the most complex and most challenging projects on Earth, or Mars, really brings home the importance of project management and the invaluable role that project managers play. While some knowledge of the science or engineering is essential for effective PMs at NASA, it's their project management expertise that enables them to connect the vision of the benefits, the possibilities of the science and the limits of the budget to help NASA implement and complete these awe-inspiring projects.

0:58:19 KL: And now for an update. A few months after my visit to NASA, astronomers in Europe discovered a new potentially habitable exoplanet, Proxima B, the closest known planet outside our solar system. While not likely to impact the current Mars program, this discovery may add an observational target to the James Webb space telescope when it launches in 2018, giving us our first glimpse of Proxima B's atmosphere. For more information about all of NASA's projects and programs, go to nasa.gov. Special thanks to today's guests, Roy Maizel, Dr. Eric Smith, Sandra Smalley and Jim Watson.

0:58:58 VO: Our theme music was composed by Molly Flannery, used with permission. Additional original music by Gary Fieldman, Rich Greenblatt and Lionel Lyles. Post-production performed at Empowered Strategies and technical and web support provided by Atomic Management Resources.

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