

Nagin Cox

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Interviewer

Q: I'm Erik Conway. I'm talking to Nagin Cox at JPL. Today is the 26<sup>th</sup> of July 2022.

So, Nagin, tell me a little bit about yourself. Where were you were born, how were you educated, how did you wind up at JPL?

Cox: That I will do. Thank you for this opportunity to share in this oral history specifically about InSight. So I was actually born in Bangalore, India, and was there just for the first year of my life, when my mother returned to the United States to Kansas City, where my parents had already immigrated. So I grew up primarily in Kansas City, and then also lived in Kuala Lumpur, Malaysia for some years while my father was there researching a book.

I very much did not start out being kind of a math and science gal, right? I came into that appreciation and interest later. But what I did encounter very early on was a difference in the multicultural home that I was brought up in. I did find a difference between the way the boys were treated and the girls were treated in terms of expectations for what they would do in terms of their career and their roles in life, and I do remember being affected by that at a very young age, because it kind of highlighted how we find ways to separate ourselves by gender, race, ethnicity, etc.

So I was also at that time fortunate enough to be growing up in the late Apollo missions and the early Space Shuttle missions, and what I saw in newspapers and in the evening news and

the way people reacted to that was that there was this other thing going on at the same time, called the space program, that tended to bring people together. I mean, even now when I did some public lectures on the anniversary of the Moon landing, not this year but prior years, people don't say, "The Americans landed on the Moon." I happened to be in Mexico City speaking. They didn't say, "Well, the Americans landed on the Moon in 1969," right? They said, "*We* landed on the Moon." And so throughout my life, I've definitely seen reinforced how the space program brings people together, the space programs of the world.

So that translated for me into an interest in working at JPL since I was fourteen, because I was interested in the space program as a way to connect people instead of separating them. And around that same time, so the public knowledge at that point was primarily about astronauts, but there was also a television show called *Cosmos*, the original one with Carl Sagan, and that was some of my first exposure to the amazing images that were coming back and information from these missions of planetary exploration done by robots. So I actually never wanted to be an astronaut, because at the time that I was growing up and, to a certain extent, still, they're kind of stuck in Earth orbit, and if you really wanted to go where no one had gone before, right, that was the robots. And at that time, other than Lockheed Martin, there was primarily one place in the world that was doing this type of work, and that was JPL.

So I determined that I wanted to work for NASA's Jet Propulsion Laboratory. And at the end of *Cosmos*, it would say "Carl Sagan, Cornell University," so knowing how teenagers are, I decided I was going to go to Cornell University. Given the lack of financial resources in the family for education, advanced education for the girls, I was very fortunate in that I found a pathway to getting an Air Force scholarship, without which I would not have been able to afford Cornell.

So I went to Cornell University. It kind of came down to a choice between Cornell University and the Air Force Academy for me, and I attended Cornell on an Air Force scholarship, and I got a degree in both psychology and in engineering, in what was then called operations research and industrial engineering, now would have been kind of more called system engineering, which Cornell didn't have at the time.

Then I went into the Air Force and I really, really enjoyed serving my country, really enjoyed the Air Force, worked in F-16 air crew training systems, and then got my master's degree in Space Operations from the Air Force Institute of Technology. At the time, the Gulf War was happening, so Gulf War one, so anyone with an advanced degree in space operations went to Cheyenne Mountain AFB, which was then part of U.S. Space Command. Again, even though I started out in F-16 air crew training using both my psychology and my engineering, I had kind of a one-track mind, that I was interested in space operations, so went into space operations.

My experience at Cheyenne Mountain, again while in U.S. Space Command, which is now U.S. Space Force, was, again, incredibly rewarding, but in the end, the military space program is about using space assets to look inward, and I came to realize that I was basically facing the wrong direction. When I was in the Air Force, I was looking at the Earth from a space perspective, and I really wanted to turn around and look outward and do the kind of exploration that JPL was doing. So I made the decision to stay in the Air Force reserves and to leave the Air Force and try to get to JPL. I was prepared for it to take many years, but I was actually at IBM Space Systems in the Bay Area for less than a year after I left the Air Force when I got an opportunity to join JPL, and that was over twenty-five years ago, and I've been here since.

Q: So you left, then, probably as a captain in the Air Force?

Cox: I did, and then I served in the reserves for as long as I could, but then it became very difficult to be operational Air Force reserves *and* also be operational on a JPL mission. I was on call 24/7 for the Galileo mission and its extended mission as one of the management engineering team, and it was clear to me that I couldn't do both, so it was a difficult decision to eventually leave the Air Force entirely, but that was because *our* missions take so much weekend and on-call time as well, that I couldn't really do both.

Q: Understandable, understandable. So now I need to skip forward to InSight so we can make sure we talk about that. So tell me about, first, when did you start working for the project formulation folks?

Cox: Well, so I actually, when I was working on Kepler, so I worked on the early Mars Rover, Spirit, and Opportunity and then was working on Kepler, and then after Kepler, I was a group supervisor in Section 313, and that was the Surface Systems Engineering Group. As frequently happens, line management is called upon to support proposals in their early stage. So I had actually never worked a proposal until I worked the 2006 GEMS proposal, and it was called GEMS before it was called InSight. Bruce Banerdt was, of course, involved, and Kim Reh was the proposal manager/capture lead, so I, as an additional duty when I was a group supervisor, came on to be his deputy proposal manager. I had literally never worked a proposal at JPL before, but when you get a chance to learn at the feet of the master like Kim Reh, it was a great opportunity.

We weren't selected in that round, and, again, you hear all this history from Bruce of the years of trying, and then when the 2010 opportunity started, I actually was on MSL. I had gone from being the 313 Surface Systems Engineering Group Supervisor to returning to MSL to be involved in a Mars rover again.

I was working on MSL when the call came in to potentially come back and work on InSight, and that was due to Allen Farrington, who was really key in GEMS step one, right? He was the original proposal manager and capture lead, and then he, early in the process, not too early, but he got pulled away because he needed to return to a project that he had worked on that was delivering JPL hardware to the Space Station, and they needed his expertise there. This was actually switching horses in the step-one proposal process pretty late, given how far along the proposal already was, and so when they talked to Bruce about changing his proposal manager and capture lead at that point, and him kind of knowing, I think, in the back of his mind already that this was really one of the last times he was planning on trying to make this happen, that he specifically—you know, a lot of this happened outside of my awareness, but that he specifically said, "Okay, if you're going to change out my proposal manager and capture lead at this stage, then I need you to go get someone who already has background in this, and that would be Nagin."

So he asked for me by name, and my MSL duties at the time did permit me to come over and step into that role, but so much of the basic framework and the early conceptualization of how was this going to be feasible had been done by Allen Farrington, so I just kind of picked up where he left off.

Q: Okay. Well, I know Allen, so I guess now I will go talk to Allen too. I've interviewed him about SPHEREx but not GEMS. I didn't know that bit of the story. So you stepped into it, but you already had a lot of knowledge from GEMS.

Cox: Yes.

Q: And so tell me, I guess, what kind of knowledge was that? What did you need to know to be the proposal manager or participant in the proposal for GEMS and then InSight?

Cox: Well, I learned so much from Kim about what really matters in a proposal, right, and things that I might not have picked up as readily from others, and one was importance of the team, right, of having the folks that understood that we were not only developing a very early mission concept, but that we also needed to sell it, right? There is no step two without a step one, and there hadn't been a winning step-one proposal at JPL for five or some number of years before GEMS step one won, and, again, I attribute that to Allen's foundational work that he did to make the proposal feasible and to the team that was assembled.

So I knew right away that it was important to get a very, very strong documentarian, right? Because, again, the work doesn't matter unless it shows itself in the actual document.

[interruption]

Cox: So let's see. Where were we? We were talking about the things that carried over from 2006 to 2010.

Q: Yes, what did you learn in the process, yeah.

Cox: Perhaps one of the most important things was working with Bruce, right, learning the PI's objectives the InSight study wanted to accomplish, the importance of formulating a team that would stick with you even at the very end, where proposals are notorious for having crazy hours at the end. And also we were able to pivot. The environment was different, right? Back in 2006, we were piggybacking on the proposal concept, which was a Spirit and Opportunity approach, right? By the time it got to 2010, MSL was heavily overrunning, and so what we ran into was there was a lot of costing concern around our costs, which were based off of 2006, and yet there was a general sense of "Look, MSL is overrunning like crazy. Mars can be expensive. What are you doing?" The importance of ensuring that we had learned from that and that we were trying to reflect what had happened on MSL in our costing, and that was part of Allen Farrington's design, was to say, "Okay, we won't be credible." So, trying to be credible with our costing.

But I would say the most important thing was we didn't have to start from scratch in our relationships and we didn't have to start from scratch in understanding the science that Bruce wanted. And then to fill in that gap of the changes, that's the piece that Allen can fill in because he was the proposal manager through quite a bit of the very early formulation in 2010.

Q: So by the time you came in, was the decision to switch to the Lockheed lander made, or is that still in flux?

Cox: That had not yet happened. When I came in, we started the actual proposal, and a huge part of what we had to do was the costing, and it was challenging to get the costing into the box that we needed to, and we tried—you know, there's a lot of avenues at JPL for helping with costing, and that's Team X and also to have the divisions do a ground-up costing. So that was our answer to trying to be convincing about why we thought we could do this within the Discovery cost cap, given what was happening on MSL.

So the divisions did their very best to give credible assessment, to give credible costing based on what they were experiencing on MSL, and that is eventually why we needed to go out of **house with a contractor**, is because there was this disconnect between what the divisions could sign up to and the cost that Lockheed Martin was able to provide, given that we were going to piggyback off of the Phoenix heritage. The Phoenix heritage had an advantage in that it was much more current, right? That was a 2007 mission, 2008, as opposed to our Spirit and Opportunity, which was back in 2004.

So the divisions, understandably, said, "You're hearkening back to an earlier design. In a lot of cases, are the parts available? Is the expertise still there?" So they did their best to cost. And when it became clear that that wasn't going to fit in the Discovery box, we said, "Okay, 2007 is closer. Lockheed Martin, the in-house knowledge is still there."

So we pivoted at a time when we didn't think we were going to continue. This was kind of a last-minute adjustment, was as opposed to the proposal folding, because at the time, there were like fourteen proposals in step one from JPL, and certainly the Formulation Office could have said, "Well, we're looking for ways to down-select the amount of proposals we have, and this seems like an obvious case." Instead, we got the opportunity to pursue this pivot to

Lockheed Martin. However, at this point, it was again so late that a lot of their folks were already committed to other proposal teams.

So we were very lucky that they found Richard Warwick [phonetic], a very experienced engineer, and were able to put together a proposal team that would support us as late in the game as the change happened. I think that's kind of one of our lessons learned, is that our proposal process at JPL can handle kind of a Hail Mary or a last-minute pivot, right, that it's not over till it's over if you have that mindset of "Let's keep going," right? And that's what we did with Bruce's support.

Q: So it happens late in the process, then you have to—you must have been a lot of hours to re-integrate, once you completely switched the lander hardware.

Cox: Absolutely. And so I think when I look back at things that I thought we did well as a team, when you have a very limited amount of time, right, there are ways to—if everybody's kind of happy with the job they have, it shows itself in the product, right? I made sure I had a very strong flight system engineer, and that's Calina Seybold, and a very strong payload engineer, Ken Hurst. Then none of us wanted the other person's job, right? I was the proposal manager and the capture lead, and that had a huge amount of work, as you might expect, with the pivot, as did the flight system engineer, who suddenly had a completely different spacecraft, right? And the payload engineer, who had different instruments that were all out-of-house and international, that were being pursued.

So we were very busy, but we all empowered each other. There was no, “Oh, wait. I want to be involved in that decision on the flight system because I’m the project manager,” or the proposal manager, right? I let the team do their jobs. We had to, to complete it that quickly.

We shared people with other proposals, and the Formulation Office was great about us having spaces like this one, having our own proposal room, and I shared people with the proposal that was right next door. So I tried to have better food in my room [laughs] so that they would hang out in my room, right? A small thing, but as with any human endeavor, food matters, right?

We still didn’t work around the clock at the very end. That was a goal of mine, because I’m not a procrastinator, and so I did my best to try to stay a little bit ahead of the team. And again, there were a lot of folks that were surprised that we didn’t choose to simply fold up that stake.

Then the divisions suddenly had to kind of redo their costs for this new situation, and, again, everyone was supportive in the end, but I also recognized that the team was going to be thinking about the technical work, right, of the sudden switch in design, but again, none of that matters if you don’t get it onto the paper in a credible way. So I worked very closely with our fabulous documentarian, Susan Foster, to reflect that in the proposal. And she was not a documentarian; she was a documentarian *and* an author *and* a creative, and knew darn well that we had to sell this, right? So we had multiple things going in parallel of trying to work the design.

Bruce’s area didn’t change that much in terms of the science objectives were still the same, but then he was working all the international partnerships. And then again, the importance—and I think it helped to a certain extent that I have outreach experience right? So

when we were thinking about the proposal writing and we were trying to figure out how to convey this very quickly, that was not a foreign concept to me, and the idea of making trades, where this may cause hardships in phase two and this may cause hardships in the project, but there isn't going to be a project unless there's a step two. So, trying to find this middle ground between being credible in what we presented and having it be doable. Like they said, the moment when you win step two and you become a real project, then people go, "Oh, my gosh. We have to actually do this?" It's to make sure that at that moment, it was a doable project. It was hard, it was heavily cost-capped, and it was not an easy mission to launch, to get to launch because of all the things that we had to do to get it sold, so to speak. But finding and doing that constant trading was my job, right?

Q: The proposal manager's job.

Cox: And the capture lead. I was both the proposal manager and the capture lead, and that combination gave me a lot of flexibility. Is that distinction something I should explain?

Q: Yes, just to make clear. I suspect it's different for different people, too, but let's try to be clear about it. What's the distinction?

Cox: So the proposal manager is basically the manager of the part of producing the book, right, producing the book, and not just "the book," but the story told in the proposal. The capture lead is more like the chief engineer, right, in terms of the trades, the technical trades, the architect of the actual mission, right? Often, almost always, those are two separate people, so that you have

someone working the “Well, if we change this orbit,” if it’s going to be an orbit, or the orbital trajectory and the flybys and the actual mission planning. Capture leads are often mission planners, because that is what they’re doing, is they’re making the actual technical trades and the decisions about how to architect this mission in a way that it is doable from a technical engineering perspective. Then you have the proposal manager, who is converting all of that into the story, into the book. The proposal manager’s also responsible for the budget of the proposal. Where the two work together is the capture lead tends to be a very technical role, but there’s also the budget for the actual mission that the proposal manager and the capture lead work together. So they are often separate people because they are quite often separate skill sets.

Q: Okay. That’s interesting. I sort of assumed from the name “capture lead,” that person’s job would be more talking to the NASA folks and selling it, as opposed to technical, but that’s interesting. Thank you. It’s very different.

Let’s see. Who were the other key players? You’ve mentioned some, Susan Foster, Allen Farrington, but who else?

Cox: Calina Seybold was my flight system engineer, and payload engineer—[Ken] Hurst

Cox: Are you talking to folks who did step two?

Q: I don’t know who those people are yet.

Cox: Troy Hudson. So, Ken Hurst and Troy Hudson were two people who actually went from step one all the way through and worked the entire mission, so they have a unique perspective in that they were with us the whole time. Troy Hudson stayed focused on the mole, the HP mole, and Ken Hurst was my payload manager, payload system engineer during the proposal.

The other thing about proposals is you end up with people who are very part-time, very part-time, right? Scheduling, you know, Bryan Kobie was our cost engineer. I don't know if he's still with the Lab.

One of the things that I would do is have a yearly—a GEMS reunion, so I would get the step-one team together to celebrate and to reconstitute our group until we got selected into step two.

And then I also remember telling that there was at the time—this is another anecdote, that as we got near the end of step one, there was a European mission called GEMS, and I said, “Bruce, we're not the only one with the name GEMS.”

And he said, “That would be a wonderful problem to have if we get selected and we have the same name as another mission, so let's worry about that should that problem come to pass.”

Then we honestly thought that after we submitted the proposal, we honestly—we just, completely separate from the proposal's chances as a standalone proposal, we were very sure that our mission would not get selected because there was already a separate line of funding for Mars missions, right? And there were so many other well-deserving missions that did not have kind of already a program funding line, and so the idea that Discovery would select a Mars mission instead of Venus or Titan or wherever, you know, these other missions that didn't have anywhere else to go to get their funding, was the reason that we were so stunned.

And I think we started to realize that we might have a chance when we got our major weaknesses back, like you get the response back, and we're kind of going, "Huh," right? Our requests for clarification, our major weaknesses, were not very significant.

And then folks who had more experience in the proposal world—because, again, this was my first full proposal—they talked about how in the end what's important is that the proposal be selectable, that there's two real pieces here. One, is the proposal selectable? Does it have credible costing, a reasonable design? Does it look doable? And then of that subset of selectable proposals, then the science makes the decision. So when they give the ratings on the proposal, right, like were you a 4, a 5, a 3, how was your proposal actually rated, then that was the key. If you were a 4 or a 5, a 5 ideally, then you were selectable, and now the powers that be in the Selection Committee, selection area, were free to choose based on the science. Then, of course, Bruce's science was obviously very compelling. So that is certainly one of the lessons that I took away from that, is, you know, as much as there are political things at play for what will get selected, your job is to give them a proposal that, if they choose to, from a science perspective they can select, because everything else is doable.

Q: So your goal is a proposal that's selectable and fits in a cost box, in essence.

Cox: Selectable *means* that it fits in a cost—selectable fits in a cost box, is credible, doable engineering-wise. And then step two is obviously intended where they've said, "You know, the science is compelling enough that we're now going to expand upon the rest of the proposal," because in step two—and again, I didn't experience step two because I was on MSL—was, of course, the science objectives become more detailed and evolve as you learn more about the

instruments and the instruments' capabilities, but fundamentally, step one said "This is science we want to pursue *and* you made it look doable and credible. Now, is it *really*?" And step two says "Flesh out all the other stuff. Actually do Phase A, and then we'll choose at that point."

And I did join InSight some years later. I think I joined InSight as the assistant payload manager in 2014, I believe it was, very briefly, and then I was like, "I'm an ops person. I want to stay on MSL," and I decided not to go full-time on InSight, because I thought, "You know, I've already done my part, right? Step one." We have this mission. We had the opportunity to compete for step two.

I think that's the message that I hope conveys, is there are a lot of people who work in formulation on proposal after proposal after proposal, right? And we tend to focus as a lab on once they're in development and launched and landing, right, in the big milestone events, but especially in our competitive environment, right, there aren't missions unless formulation or early mission planners work on them.

I was stunningly lucky that my only proposal was one that won, right? And yet what stays in my mind is the thirteen other proposal managers and the thirteen other proposal teams that moved their mission concepts forward and worked just as hard and, for whatever reasons, were not the ones that ended up on the docket to move forward. So I think in terms of space program history, I would like to take this moment, even though my foray into formulation has been very brief, to give a shout-out to all of those who spend a large time in their careers devoted to this part of the life cycle.

Q: So who was your competition then? I mean, what were the other thirteen proposals or twelve proposals that were floating around JPL for that 2010 round?

Cox: Well, now, let's see. I don't know how easily I would find that. I guess, I mean, to a large extent, we weren't supposed to know, right?

Q: I know.

Cox: We were all very firewalled, but there were Venus proposals, there were outer planets. I think at the time it was more Titan-focused, then Enceladus, because Cassini hadn't gotten as far. There were Mercury ones. Because I technically wasn't supposed to pay attention, wasn't supposed to know, that's something that, like, Kim Reh would know. I could also potentially dig it up, but not in a way—I guess the real answer to that is it didn't matter to my team, other than two things. Fourteen proposals meant that everyone had trouble staffing their teams, and you had people spread out. You had people on multiple proposal teams trying to stay firewalled, and you had JPL divisions trying to respond to the costing and questions from fourteen different proposals. So it was demanding on the divisions to staff and support those proposals. What they were, to a certain extent, didn't matter from my narrow focus, especially coming in part-way through as I did.

Q: Okay. So after the InSight proposal, you don't follow the mission. You go back to ops and stay there?

Cox: To MSL. I went back to MSL operations preparation, and then worked on MSL. You know our ten-year landing anniversary's coming up next week. But I worked on MOXIE, right? I

*really* like operations, and there are very few things that would pull me away, and one of them was InSight, right, to work on the mission that I had some history with, and then discovered that, you know, that I was happy to participate in InSight operations, right, but as far as development, that I wanted to stay on MSL. Then there was such an *unusual*, just *unheard-of* opportunity where JPL got the opportunity to build MOXIE, right, and the oxygen-making prototype that 2020 carries.

And ISRU, right, In Situ Resource Utilization, was very much *not* part of JPL's scope at the time, so there had been these other centers that had been working for *years* to try to get something like this flown. Then for it to come to JPL was kind of a hard pill for some of those other organizations to swallow, but, understandably, it was like "Build this and built it quickly as flight hardware." Like Kepler operations when it went to Ames, I didn't follow it to Ames. And I remember the day MOXIE was announced, and I very distinctly remember kind of my head coming up, going, "What? What? We're doing an ISRU instrument here at JPL?" And that got my attention, very much so, because I have an interest in the human exploration preparation part of these missions as well as the science. So then I called up Division 38 and said, "Hey, I'd be interested in working on MOXIE part-time," right, again continuing MSL operations.

So it has been very interesting, and as InSight starts to come to the end of its mission, right—in fact, I just moved forward a reminder that I had to myself that after the end of mission, right, that I would once again maybe reconstitute the GEMS step-one team for a lunch or something, and also I had some quotes that when I was remembering my history for this meeting, I remembered that I had kept a list of quotes of funny things that we said during the proposal, and I thought, "Oh, that'd be fun for people to see at the end of the mission," right? So I hadn't thought about that aspect either, that as the mission ends, that in some way step one comes back,

right, that my job as the step-one proposal manager in some ways returns, because Bruce and Troy and Ken were there the whole time, right? But that I also should play some role in reminding people of the beginning as the end happens as well.

[End of interview]