NASA DISCOVERY AND NEW FRONTIERS ORAL HISTORY PROJECT
EDITED ORAL HISTORY TRANSCRIPT

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INTERVIEWED BY SANDRA JOHNSON
GREENBELT, MARYLAND – JANUARY 30, 2024

JOHNSON: Today is January 30th, 2024. This is the third interview with Rich Burns and is being conducted for the Discovery and New Frontiers Oral History Project. The interviewer is Sandra Johnson. Mr. Burns is at Goddard Space Flight Center in Maryland and talking to me today over Microsoft Teams. Thank you again for talking to me for a third time, I appreciate it, and taking time out of your schedule. When we ended last time, we were talking about OSIRIS-REx [Origins, Spectral Interpretation, Resource Identification, and Security Regolith Explorer] and the sample return canister. We talked about how it had returned successfully in the [Dugway] Proving Ground in Utah. Were you actually there for the landing of the return capsule in Utah?

BURNS: I was, yes, I was in the mission control center for the range, Utah Test and Training Range. That's where the coordination was happening with the recovery team crew and the operation of the range sensors is managed through that. Also I had my deputy delegated as the NASA lead for the recovery effort. He was working with our colleagues at Lockheed Martin and the science team to effect the recovery of the capsule.

JOHNSON: Talk about that. Did you actually go out to the site where it landed or did you wait until the capsule was made safe and brought back?

BURNS: Yes, so we were observing the reentry from the mission control center. I went out after the capsule had landed and during the recovery sequence, I guess. Yes.

JOHNSON: Just walk us through that, once it's brought back there where you were, in a safe room, and then the next day as it was prepared to go to Johnson [Space Center, Houston, Texas, JSC].

BURNS: Right. The recovery team had a number of objectives, safety being foremost amongst them, as well as the reentry. The release of the capsule itself was focused on safety aspects. Most of those had been addressed before we made the decision. However, we were updating things as we went along. Once the capsule had landed the recovery team also had a large safety component to their job. The capsule heats up to extraordinary surface temperatures during the reentry and there is a possibility of some—there's a battery inside. If the battery had been breached during landing, then there would have been some temporary emission of some hazardous gases. On approach the recovery team had to ensure that the capsule was safe to handle and to be in the vicinity of. Once they did that, there was a defined procedure which we had rehearsed many times to process the capsule in the field, which meant bagging it up and preparing it for transport under helicopter to a temporary clean room that we had established in one of the buildings at the Utah Test and Training Range.

That was all successful, went according to our most optimistic estimates. We got the capsule back and into the temporary clean room that we had established. From there the disassembly of the capsule began and we removed the canister containing the sample head at that point from the heat shield and the backshell of the capsule. It was done the same day and then also prepared for transport to Johnson, which we did the following morning. It was quite an eventful day, two days really.

JOHNSON: A lot going on. It was part of I think they called it asteroid autumn, but all these things were going on at the same time. This was coming back, Lucy was reaching Dinkinesh,[1] Psyche[2] was launching. There was a lot of interest by the public and the whole return was live. What were your responsibilities as far as talking to the press while you were there? Did you do any press conferences or anything like that?

BURNS: I had a few opportunities to talk to the press. Most notably probably is the recovery minus 30 day. Since my deputy was on-site, he participated in the primary press events the day of, since my participation was contingent on me traveling. It's a couple hours roughly speaking between Hill Air Force Base where the mission control center is and the Utah Test and Training Range buildings where the press events were, the hangar where the press events were.

JOHNSON: When it was taken to JSC, did you go with it?

BURNS: We did, yes, I did, and a large contingent of the recovery team for processing, we actually ended up with a very large cargo aircraft, so there was lots of room for people, save the taxpayer

[1] Lucy will be the first mission to explore the Jupiter Trojan asteroids. On November 1, 2023, Lucy had its first encounter on the mission with Dinkinesh, a small main belt asteroid. The team soon learned that Dinkinesh had a small satellite and is, itself, a contact binary, made of two smaller objects touching each other.
[2] The Psyche spacecraft is traveling to a unique metal-rich asteroid with the same name, orbiting the Sun between Mars and Jupiter.

some airfare dollars. But yes, so there was a large contingent of us that went with the sample. It was quite an experience.

JOHNSON: Was there an official handover from Goddard to JSC as far as the sample?

BURNS: Yes, we didn't have a ceremony or anything if that's what you mean, but we did hand over once we delivered to the clean room. It was then the responsibility of Johnson to manage the sample effectively.

JOHNSON: Based on your experience with OSIRIS-REx, I think we've talked a little bit about this in your other interviews, touched on some things, but if you had to pick a couple of lessons learned from OSIRIS-REx, what would you say were the top two?

BURNS: For sure there's a lesson to be derived, which is probably not very surprising, that when you execute a mission that's to an environment, a destination that no one has ever seen before in great detail, that you should expect to be surprised by that target, and we were in just about every dimension.

Then I guess the one that's a general one about this kind of endeavor in returning a sample is that particularly in a remote area, as is typical for a sample return for obvious reasons, the logistics of that are amongst the most challenging aspects. We had a very large set of people out there. We were dealing with our military partners, who were fantastic. What we found was that investing in them built enthusiasm. They were all wanting to see us succeed. That helped us a lot with the logistics because we were constantly asking them for accommodations that hadn't necessarily been thought through. But they were very very supportive and I think that was in large measure due to the fact that we spent a lot of time with them. They understood what we needed to do. They were invested in our success. That all went very well.

I think that was a very large portion of how we made it manageable. But it was for sure stressing their systems just to support the number of people that we had. We had a very large media event mentioned that was covered live. We made a conscious decision to invest in that. There was a trade where we were deciding, "Do we want a very large public media event at the recovery or is it better to have it at Johnson when things can be a little more controlled." We decided that we would invest in the media event at the recovery site, and I think that was a good decision ultimately but it came with its costs both financially, which we had the resources to pay for, and was a good investment. I think that the Agency got good return just in terms of public awareness and communication value was high in my opinion. But it also strained our human resources. Managing that, the sheer number of people it took to put on that kind of event, was very stressful. In parallel with managing the priority which was the safe recovery of the sample. Always kept that in mind what our priorities were. But yes. It was definitely something that we A, consciously decided upon and B, spent a very significant amount of time and effort to manage.

To address the first lesson learned, I think the surprises at Bennu, being a mission of exploration, not knowing what environment you're going to find. We had partially prepared ourselves for that. We knew that we didn't know the surface properties well, but I think we were adaptive in a way that only very highly skilled teams can do. We were adaptive in a timely way during a global pandemic. I think it's really a testament to our team and how they have an extraordinary balance between engineering skill, knowledge, and teamwork. It had to work across all elements of our team, from the spacecraft operations to the instrument operations to the navigation and the management of all that was challenging in a way that stressed the team and needed. However, I think we had enough experience with one another that we trusted each other. That was well earned trust I'll say, because there was a lot of difficult discussions where there were technical disagreements early on.

There was technical decisions to be made that not everybody—nobody ever is happy with any decision. [President Abraham] Lincoln said something about that. But people learn to appreciate each other's perspective and listen. That put us in a great position when we encountered many of the very unexpected things we saw at Bennu to be able to adapt. I think the balance between skill set and intrateam or interelement trust was really a key factor in us being able to overcome some of the challenges that we saw at the asteroid.

JOHNSON: You were talking about the public interest. With OSIRIS-REx that public interest was back again last week or week before when they finally got the rest of the capsule open where they had to have a couple of special instruments for that. They had to build the tools. I know people wonder why they didn't already have these tools.

BURNS: We had tools. I think the key thing that was a discovery is a couple of the fasteners, many fasteners to get the head disassembled, a few of them required higher torque than we had anticipated. We didn't have tools that could apply that torque without incurring some risk that we'd shear the fastener or otherwise introduce contamination to the sample. We spent seven years to get the sample back to Earth. We don't want to get in a rush over a couple months and then introduce some contaminant into the sample that was unnecessary. The cost of us deferring opening the head and fabricating new tools to do so is very low compared to what would have been the cost of introducing contaminants or something else [to the sample]. This is going to be a sample that's going to be under study for decades. We don't want to introduce something that is going to compromise that study because we want to get it open. That's the balance there.

JOHNSON: It's always interesting reading the press coverage compared to what's really going on because it was almost sensational. NASA can't open the capsule.

BURNS: Yes. They need to attract attention. Headlines get generated that have the purpose of generating, attracting attention.

JOHNSON: Yes. Are you continuing as a project manager for OSIRIS-APEX?[3] Or is that something you're still going to be doing as it moves towards Apophis?

BURNS: Apophis, yes. Yes, I am.

JOHNSON: Between now and 2029 is it just checking what's going on with the spacecraft itself? What are the procedures?

BURNS: There's some significant challenges with Apophis. There's a series of close passages to the Sun. The spacecraft is just now emerging from its first. These are close passages. They're called perihelions, the closest point to the Sun in the spacecraft's orbit around the Sun. It is about

[3] OSIRIS-APEX will study the physical changes to asteroid Apophis after the asteroid's rare close encounter with Earth in 2029.

half the distance between the Earth and the Sun, so one astronomical unit [AU] is the distance between the Earth and the Sun. The spacecraft just passed on the 2nd of January through its first perihelion at about half an AU. That is an environment that the spacecraft wasn't designed to accommodate. In other words it gets really hot. As you get closer to the Sun things get warmer.

The spacecraft team at Lockheed Martin designed an orientation of the spacecraft and a reconfiguration of the solar arrays to shield parts of the spacecraft from sunlight to keep them relatively cool, as cool as they can be, and to protect their longevity.

Our modeling indicates that we shouldn't have any problems. In fact our performance through the first perihelion, while we haven't seen all the telemetry yet because we're not in favorable orientations to communicate at high rate with Earth, but the low-rate data that we've gotten from the spacecraft indicates that our thermal performance was pretty well modeled. Our predictions were pretty good. We don't think we're going to have any problems. There's more of these perihelion passages to come.

We've got to keep the spacecraft safe on its journey to Apophis is one of the chief tasks. There's a few other tasks that we have to undertake. One, there's a set of maneuvers that have to be done to bring us to Apophis, so we'll execute those. Plan and execute those obviously. We need to be careful with how we spend our fuel between now and then.

Then there's the development of new capability for the spacecraft. We have premised the extended mission on the idea that we'll operate more efficiently at Apophis because we had an overall cost constraint that our stakeholders asked us to live within for the duration of the Apophis mission. We need to be able to operate more efficiently with fewer people at Apophis. That is going to involve adding some autonomy to the spacecraft in one form or another that will allow us to have a leaner operations staff. Undertaking that, what exactly does that autonomy do, how does it relieve us of a requirement to staff at higher levels is something we currently are discussing. We have some ideas and they all mostly involve adding capability to the spacecraft that we did on the ground at Bennu. Allowing the spacecraft to estimate on its own its own nadir or where is down.

Because we point the spacecraft relative to its sense of what down towards the asteroid is. To the extent that we can relieve the ground of that responsibility we can adjust our planning so that it isn't reliant on that capability on the ground.

JOHNSON: Why was Apophis chosen? What do you hope to discover there?

BURNS: It's really a rich scientific endeavor. First, Apophis is going to have an extraordinarily close passage with Earth in 2029. APEX will arrive shortly after that encounter. Apophis is going to pass inside the geosynchronous belt within Earth. It's going to be observable with the human eye from certain regions. I think northern Africa if I recall correctly. But it's going to be a major event that people will gain lots of awareness.

That close Earth passage is likely to change several characteristics of Apophis. In particular the way it spins. It's more complicated than Bennu in that it's what's called a non-principal axis rotator. Which means it doesn't have a simple spin pole. It has a more complicated spin pattern. That spin pattern is likely to be disrupted by Earth's gravity. As is the surface of Apophis also likely to see some disruption from Earth's gravity.

One of the ideas is that in addition to mapping the properties we'll be able to inform the assessment of how Apophis's characteristics were changed by Earth. That will inform things like the evolution of the early solar system, how asteroids and planets interacted, and to what extent these types of asteroids are disrupted by passage close to a planet.

JOHNSON: That's interesting. Let's talk about Lucy, since that was happening. It launched in 2021. At what point did you become the project manager for that? Was that after launch? Or did you come on before launch? You were talking about with OSIRIS-REx that you came on before launch, and that was a good model going forward to have that crossover with the team. Let's talk about that for a minute.

BURNS: Sure. In both cases my organization became involved before launch but wasn't responsible. The development project remained responsible through commissioning in both cases. Spacecraft commissioning and instrument commissioning. Then after that is complete is generally the beginning of what NASA calls Phase E. That is when I begin project management responsibility. The prelaunch involvement involved getting people who are going to work from my organization involved on a day-to-day basis, participating in reviews and planning, but in an advisory role as this is the perspective of how this decision is going to affect our operations ultimately. That's probably important to point out. But yes, after commissioning is effectively when I become the project manager.

JOHNSON: It was shortly after launch when they found out about the solar array problem with Lucy. That team actually stayed on longer because they were trying to work on those solar arrays. Of course everything's happening during COVID again. This launch again went off without a hitch and launched on time and when it supposed to, even though they were finishing up when COVID hit. Talk about that time period. Once the solar array problem was found and they had to figure out how to do that, were you actively involved? It was actually happening at a time where once that commissioning happened, you would have taken over. How did that work?

BURNS: First I want to acknowledge the extraordinary efforts that the development team made to get to the launch window. As you said during the pandemic. They were executing the assembly and test of the spacecraft during the most severe phases of the pandemic and it was really extraordinary that they were able to get the vehicle to launch on time. That's important to note.

The anomaly that occurred with one of the solar arrays was discovered on the day of launch and began to be worked immediately thereafter. It was being worked in concert with the other commissioning activities that were happening on board the spacecraft. More or less the commissioning occurred. The diagnosis and troubleshooting and recovery attempts were being planned in parallel with all that in coordination with Lockheed Martin, the spacecraft vendor, and the solar array vendor Northrop Grumman, who went to extraordinary lengths and demonstrated in great detail that we understood the cause of the problem and that we had ways to mitigate its impact. Effectively the circular solar array was being deployed and it didn't get all the way deployed. It's supposed to latch at the end of its deployment and wasn't latched. That solar array is very large, about 7 meters in diameter. It's a very flexible material. Latching is a tensioning event for that solar array, so it makes it a stiffer structure. What we're dealing with is a structure that has more flexibility than was intended.

There's two aspects of the anomaly. A, can we fix it? B, can we live with it if we can't? Fix it means latching the solar array. Post commissioning there was still the transition of project management. Much of the engineering team remained in place in the development heroically. Went above and beyond. They had other jobs they were supposed to be transitioning to. There was a lot of accommodation in that area as well. But as I said it was a very large effort to understand what happened. We were successful in understanding it, to a very large extent, and showing in the laboratory environment that we could reproduce very similar events.

We had a series of redeployment attempts where we know that we advanced the deployment of the solar array and stiffened the structure, which is a good thing. We don't want the solar array to be moving in an unplanned fashion when we have so-called energetic events which we're about to have one tomorrow which is our first main engine firing. These are the most energetic events on the vehicle because we're obviously intentionally imparting a large force to the spacecraft as we fire the main engine. Which we need to do to change our trajectory to get to the targets that we're attempting to get to.

Tomorrow and Saturday are our first two main engine thrust events. Those will be telling. we have models. We have a very good sense now of how far the solar array is deployed. We didn't get it all the way to latch because the mechanism that is responsible for deploying it just didn't have the muscle, the authority to get it where it needed to be.

Our modeling of the structure predicts that it's good enough. That A, we won't damage the solar array during these energetic events, and B, that we can control the vehicle well enough that these flexible modes that weren't planned to be there can be accommodated in how the vehicle is pointed as we pass one of the targets. That's why we added the Dinkinesh encounter. Dinkinesh encounter executed in November was not a planned event. We added it once we realized hey, we're living with these flexible modes, we want a demonstration that the spacecraft's pointing control and our ability to track the target can accommodate these additional modes which introduce additional complication to the control and our ability to monitor, our ability to track the target is integral to Lucy's success. And Dinkinesh was a wild success not only in the unexpected scientific bounty, but the discovery that it was a binary object and that the satellite object was in itself a contact binary was just a lot of icing on that particular cake. The cake of that encounter was that the controllers that had been updated to accommodate these additional flexible modes because of the unlatched solar array worked perfectly. That builds a lot of confidence that when we get to our ultimate targets, we will be successful even though the solar array is not latched as it was intended to be.

JOHNSON: That was exciting, that find. You were talking about OSIRIS-REx previously, that it is discovery, that's the whole point of these missions. It [Lucy] got a lot of publicity too in the public.

BURNS: Yes. One of the great rewards of jobs like this is being in the room when those first images are seen by first ever eyes on this. The set of people in the room waiting for the first, and they come by. The first images were not clear what that object was. Maybe it's a binary but it looked. We saw them out of order in terms of the sequence they were taken in because the closer images were higher priority. At any rate it was a sequence of surprise and astonishment that was really invigorating to be a part of.

JOHNSON: It is exciting to see those, like you said to be some of the first humans to actually see something like that is pretty amazing. Talk about that team a little bit because I know you'd worked with Arlin Bartels, or was working with him, because of OSIRIS-REx. But the rest of the team members, had you worked with any of them before? You talked about with OSIRIS-REx how important those team bonding moments were and how important it was to have that.

BURNS: Another extraordinary team first of all. They made a lot of things happen that were not planned. Our whole effort to get the solar array as deployed as possible was an added complexity to things that were supposed to have been relatively quiet. I worked with Arlin. Arlin had been my deputy for OSIRIS-REx before he took on his Lucy responsibilities and so it was just a pleasure to work with Arlin of course. Donya [Douglas-Bradshaw] was just a pleasure to have hand over. She really managed things, and we already said the ability to get to launch was really—she had a large lever arm in that.

Then the science team led by Hal Levison is just extraordinary to deal with. We had an engineering team that had come over from development, and the Lockheed Martin team and the Northrop Grumman team all just pulled together to really understand what was happening with respect to the solar array and how it would impact us. It was an extraordinary thing to be a part of. It's really invigorating when you have the intersection of these really hard engineering problems with a team that's just overflowing with talent and mission investment, wanting to get it solved. People went to extraordinary lengths to understand and model the situation, to explore every aspect of it in a way that was necessary, but was comprehensive, rigorous, and pragmatic. The combination of all three of those things is rare. What I mean is that the ability for a team to focus on the intersection of those three attributes, you know a team is firing on all cylinders when they can do that.

JOHNSON: I've talked to several of them that were on the team, and everybody talks about how it's one of the best missions they've worked on as far as the team members and the way everything worked. It's exciting and the public has been somewhat involved. They had a lot of outreach for the public as far as the posters that were created and all the different things that were created. How much involvement have you had? Or did they have the same kind of public events? I know with OSIRIS-REx that was obviously you were getting something back, but as far as these encounters are those kind of events being planned to bring people in and to bring the press in?

BURNS: We haven't really had a large discussion about that because these encounters, the Trojan encounters begin in 2027. Our next target is in 2025. That's the Donaldjohanson main belt asteroid. I think we will be building towards larger media presence I guess as we build towards the Trojan encounters which are the primary science of the mission.

JOHNSON: As project manager, after commissioning, and you come on, compare the two missions. Are there other things about being a project manager that you would tell someone that had to come in and do the same type of thing on another mission? What do you think makes a good project manager for the Phase E time period? I know I'm asking you to talk about yourself a little bit.

BURNS: I'm wondering if I consider myself a good project manager. I think attributes that are necessary are not very unique to project management. I think you need to have a holistic view of what you're trying to achieve and what the priorities need to be at any given time.

That's true for systems engineering and partially true for subsystems engineering. I think the unique aspect of project management in addition to having some decisional authority is the integration of the programmatic side, schedule, cost are two you want to deliver for the resources we promised we could deliver under. Which is a very large responsibility. Balancing that with what is technically necessary, technically optimal. I'll speak to some engineering. In any optimization problem what you're trying to optimize is often the most difficult part of formulating such a problem. The so-called cost function. You're trying to balance technical performance, ability to deliver within a budget and on time, with team dynamics.

I think having some appreciation for how those things are in tension with each other and being able to both relieve and apply tension are important. You need to have a good insight into when those different approaches are necessary. That means knowing people as well as engineering and financial. Things like contracts and fees and stuff like that are all part of managing that team to try, managing that whole mission, where the team is a very large component.

But we have corporations. We have agencies. We have partnerships. All need to be healthy, communicative. Effectively communicative. There's a lot to balance. There's just a lot of aspects of those. It's challenging, which is what makes it fun partially. Sometimes the challenges are not so much fun to deal with. But the technical challenges, if you can't get excited by working with a skilled team to try to solve a hard problem then this isn't the right job for you.

If you're not willing to do some things like manage a budget or manage a contract and understand how those things relate to solving the technical problem then project management is not right for you. Those are the things that it takes. Not all those things are enjoyable, but keeping sight on the end objective to make sure that the things that have to be done that are maybe not the most enjoyable thing to do get done, so that we can achieve what we're trying to achieve.

JOHNSON: Discovery and New Frontiers are both programs that are PI-[principal investigator] led. The model to get things selected and get them out there and keeping the cost down is similar with the two. Of course different cost and different way of picking some of those missions. But the PIs themselves, what would you say, since you've worked on these and Dante [Lauretta] and Hal

[Levison] both I'm sure have their own way of leading these missions, but talk about what you think makes a good PI for these types of missions.

BURNS: First I really enjoy working with principal investigators. I think in both these cases for sure they're people who have invested very large chunks of their career in achieving what the mission is. I'm mindful of the fact that I'm a small part of their overall objective. There's some element to gain trust through open communication and thoughtfulness in terms of technical demonstrating that there's some rigor here and also that there's a human element to this. You need to build relationships and in both cases it's relatively easy to do. These are people, as I said, nothing bonds people like a common problem to solve. I think what makes a good PI is that investment and willingness to lead a team, to trust the elements of the team to do their jobs, to demand performance, but do it in a way that is consistent with maintaining a healthy team dynamic. I think we've been successful in both instances.

Communication of the science objective is another key part I think. Absorbing and being active participant in the programmatic side, these are not natural things for scientists to do, is to go learn about how our financial systems work. But lots of times a major factor in key decisions is the financial factor. Understanding that—and it's arcane stuff, it's very arcane stuff with how the federal government operates and how NASA operates as an Agency and then within it SMD [Science Mission Directorate]—are things that don't come naturally to anybody, let alone people who are invested in solving really important scientific questions are by nature disincentivized to absorb such things. But I think investing in that capability is something that sets PIs apart, and I think in both cases we have really strong PIs that are willing to solve problems technically, programmatically, and keep teams healthy and talking to one another and open channels of communication are really what I think are high priorities for a PI.

JOHNSON: Talking about these two missions, and you can talk about each one separately, but what would you say you're most proud of?

BURNS: I'm proud to be part of these teams and the accomplishments. The fact that we delivered a sample on OSIRIS-REx that exceeded our requirements significantly in the presence of such monumental challenges at Bennu, I couldn't be prouder of that. Really it boils down to being part of the team that did that. Really, I honestly don't think OSIRIS-REx would have launched if people knew what Bennu looked like.

Then also Lucy. We've already overcome so much. I already mentioned we have some challenges ahead of us this weekend. But being part of a team that coalesces around a hard problem and treats each other with respect is something that I think is not that common in the world. Particularly when you're solving these problems that are really unique. Just being in a position to participate in that is really something that I will always hold as something that I value deeply. A life experience that I could have never imagined that I could be a part of at the outset.

JOHNSON: Is there anything we haven't talked about that you'd like to mention?

BURNS: No, I don't think so.

JOHNSON: Okay. I'm going to stop for today but I appreciate you talking to me again and talking to me all three times and helping with the project.

BURNS: Certainly, happy to do it.

[End of interview]