

**NASA JOHNSON SPACE CENTER SPACE SHUTTLE PROGRAM
TACIT KNOWLEDGE CAPTURE PROGRAM
ORAL HISTORY TRANSCRIPT**

RODNEY O. WALLACE
INTERVIEWED BY REBECCA WRIGHT
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WRIGHT: Today is May 28th, 2008. We're in Houston, Texas to speak with Rodney Wallace, who is currently Technical Advisor to the Space Shuttle Program Integration Associate Program Manager at United Space Alliance. This interview is being conducted for the Johnson Space Center Tacit Knowledge Capture Project for the Space Shuttle Program. Interviewer is Rebecca Wright, assisted by Jennifer Ross-Nazzal. Thanks again for finding time in your schedule to visit with us today. Tell us how you first came to work with the Space Shuttle Program.

WALLACE: I started my career in 1971 with the Boeing Company in Huntsville, Alabama during the Phase A/Phase B timeframe of the Shuttle Program when the launch vehicle concepts were being developed. In 1972 when the Shuttle Program made the decision to no longer pursue a fly back booster concept Boeing lost their part of the contract. Then I went to work for Northrop Services and supported the aerodynamics group at NASA Marshall Spaceflight Center in Huntsville, Alabama. I continue to work in the area of ascent aerodynamic of the Shuttle Program. In 1977, there was a need for a civil servant position here at JSC in aerodynamics, and that's how I came to JSC to the Engineering Directorate, working ascent aerodynamics. So I worked in the Engineering Directorate from 1977 through STS-1 and up until [Space Shuttle] *Challenger* [STS 51-L accident]. I'd been out of the Shuttle effort for a year when *Challenger* happened.

Then I went to the Shuttle Program Office in the Systems Integration Office to help out after *Challenger*, since the program was staffing up to have a bigger presence in the Program Office. I was a systems engineer working aerodynamics and aerothermodynamics and eventually became an office manager in one of the divisions of the Systems Integration Office. I worked that until after *Columbia* [STS-107 accident]. My office was responsible engineering integration and development of design environments. After *Columbia*, I took a short rotation back to the Engineering Directorate and worked in the Shuttle and [International Space] Station Engineering Office, which looked after the chief engineer functions for JSC Engineering. Then in February 2005 I went back to the Shuttle Program and I was the Systems Engineering and Integration Office Chief Engineer until I retired in 2007. Then I moved to USA [United Space Alliance] and have been in this position ever since. So that's how I got to the program and my life in it so far.

WRIGHT: Your roles with the program have varied some, even though your basis has been a constant. Share with us the details about some of the challenges that you've encountered along the way and some of the lessons that you've learned.

WALLACE: The real challenges for me were the accidents that we had. The challenges were getting to the point of trying to understand what happened and getting past the question of, "Could I have done something different that would have prevented the accidents?" The lessons learned out of trying to reconstruct what happened, is that you never have enough engineering flight data to really know exactly how things went. The Shuttle Program is a balance of spending money in the right places, and putting flight instrumentation on vehicles is a very

expensive part of the program. It has to be managed very carefully. But, in the end, when you need the data you never have enough to really do what you need to do.

Some of the other challenges were—as the Shuttle Program went along and we were going to head into the Space Station era, NASA partnered with Russia. As a result of that partnership the orbit inclination where the Space Station was going to be constructed was changed. The Shuttle Program had to increase our performance capability to be able to support Space Station. The Shuttle Program embarked on a significant activity to increase performance which included a major change to the external tank, changes to flight design, and other significant weight reduction efforts. We had to come up with the ideas and work with the Shuttle Program Manager to manage the selection of the things that would be implemented. The biggest change was changing the external tank—the second time that we changed the external tank. If I remember correctly the external tank weight was reduced by 8000 pounds using aluminum lithium material. We also changed the way we flew the vehicle in several ways.

The Shuttle Program used a systematic approach to deciding which improvement to implement which considered performance improvement, safety, cost and schedule. Once the improvements were selected our office was involved in getting the analyses completed that were needed to certify the new configuration. A phased implementation approach was selected as way to reduce risk and to see if each improvement achieved to estimated improvement. That's a lesson learned: when you're making major changes it's better to take a phased approach in implementation as opposed to just doing it all at once. STS-1 was a new design. Everything happened all in one flight. Best engineering tools, tests and judgment that we had at the time were used to decide we were ready to go, but we learned that we were not as smart as we thought we were after we flew the first time. When we did the performance enhancements for Space

Station, we took the phased implementation approach which allowed us to understand the piece parts.

WRIGHT: You were mentioning step-by-step sequences. I'm thinking that it takes a great deal of planning. Could you share with us some of the ways that you were able to instill good planning, and some of the recommendations that you could pass on to someone else? What are important steps in making sure that the planning is well done?

WALLACE: In any endeavor of a major configuration change, it's all in the planning. Task planning saves time, saves money. It also reduces technical risk, because if you're not changing everything all at once, then you get to understand the effect of each change. All the flight design changes we made in a package, so we could understand how the flight design was going to change, how much we were really going to get the improvement that we needed. The super lightweight tank was put in at one time. So we stepped up to the full configuration of changes that we were going to make.

We increased the performance capability by about 15 to 17 thousand pounds of payload to orbit more than what we were going to be able to carry to the 51.6 inclination. In the manifesting of all the missions you still had missions that you had to carry out, but you wanted to step up to these things as you could. So you had to plan what you were going to be able to fly to meet the performance capability that you had. With this approach the plan allowed us to have tested the new configuration before we launched the Space Station elements.

WRIGHT: I imagine along with the planning you have budget concerns. Can you share with us some things about how to make a program efficient when you've got so many elements to consider?

WALLACE: Each office in the Shuttle Program has its own budget, and you have to plan for that every year and plan your task accordingly with your contractors to be able to spend the money efficiently. Planning all your tasks and getting your ground rules for the task agreed to beforehand such that you don't have to rework things. Rework costs money. So you set aside reserve budgets to be able to deal with surprises along the way.

It's all in the planning and agreements on ground rules, and making sure that the office management has bought into a task, but that it fits in with overall Shuttle Program's approach to budgeting. We had to be careful, because in the systems integration world you could do something that would make the elements of the program have to go do additional work, too. You could affect your own budget but you could also affect others' budgets, too. That was something you always had to be aware of.

WRIGHT: You used the word, and it's one that we'd like to talk a little bit more about, and that's risk—how every aspect has some underlying risk. Talk to us about risk mitigation and risk management and how you believe that it needs to be instilled in every faction.

WALLACE: Flying spaceships is a risky business, and there's always risk in every part that we do. What we've learned out of the *Challenger* accident and the *Columbia* accident is we did not

know as much about the vehicle as we thought we did. The hazard reports, the fault tree evaluations that occurred after *Columbia* was a significant improvement in risk identification, and gave a tool to the Program Managers to be able to make decisions that could reduce risk. You have to make some kind of change to really reduce risk.

Understanding the risk, or quantifying the probability of the risk, allows you to make better decisions, but it doesn't change the risk. With the external tank and the foam that came off that damaged *Columbia*—since that accident there's been multiple changes in the design of the foam pieces on the external tank. We have learned what the failure mechanisms are of the foam and how to mitigate those.

It all comes down to really understanding the risk and then making wise decisions about design changes that allows you to actually mitigate it. The risk management systems that are in place today—the SIRMA [Shuttle Integrated Risk Management Assessment] and all of the PRA [Probabilistic Risk Assessment] work that's going on—overall system PRA plus the debris PRA—keeps the risk in front of the Program Managers constantly.

WRIGHT: Can you give us an example of a risk mitigation activity or management activity that definitely impacted the Shuttle Program?

WALLACE: The performance enhancement program that supported the Station Program was an excellent management program—being able to take an already operating system that would not support the performance requirement of the Space Station. We needed to figure out how to change it. There was a very systematic approach taken of coming up with ideas: assessing the performance gain, how much it would cost, what is the technical risk involved of being able to

really pull it off. All those assessments were done and a series of items were selected to be implemented, which ultimately provided the lift capability that Station needed.

Through that management activity, also, there was a complete recertification of the vehicle. Bringing all the elements of the program, going through their recertification papers and doing the structured reviews, the preliminary design reviews, the critical design reviews—design certification reviews all the way up through the program, even to the Agency level, was a very excellent activity. That would be, I think, one of the finest examples we've had, other than building the Shuttle the first time.

The other thing in a risk standpoint—understanding the failure mechanisms and the vulnerability that caused the *Columbia* accident has got to be the most risk mitigation that's been done. Although there were signs that we had problems all along and should have been noticed and should have been acted upon differently—even by myself and a lot of others. What we've done since the accident, understanding how—if you had a piece of it [foam], it is very light material, and intuition would tell you that it couldn't possibly cause any problems, but it does. Learning the failure mechanisms that makes it come off, figuring out the design changes that would help it stay on better—because it's always going to come off—we're trying to limit the size that comes off.

That was one thing that surprised me, being on the ascent side most all of my career, never really studied the Orbiter that much in terms of the tile and how they actually certified the tile and the RCC [Reinforced Carbon-Carbon] material for impacts. Basically they didn't. The requirement really wasn't there. It was just: “Don't generate debris.” That's easy said, but as we found out—and as we knew for a long time—that was a very difficult, if not impossible, thing to do.

What we've learned is the vulnerability of the tiles and being able to model the vulnerability of the tiles and RCC. And then we look at the debris sources that can come off of all the elements, and then we've stepped up to the analytical analysis of being able to predict the trajectory if something comes off and where it's going to hit and how much energy it's going to have. By doing a lot of impact testing on the elements side, they've been able to determine models of what the damage would be for a certain kind of impact.

Now, with those models and knowledge in place, then we have a better way of characterizing risk. We know that in certain phases of flight we just cannot lose something from a particular place, and that's the place we have to concentrate on to make a design change to reduce the risk. I would say we've beefed up our risk mitigation approaches and management processes significantly because of that accident.

WRIGHT: Speaking of management processes, as you mentioned, you've worked for every Shuttle Program Manager. You've worked for Boeing, USA, and as a civil servant. So you've seen a number of management styles and methods. Give us your thoughts on those that have worked well and those that maybe have not worked as well as they should have.

WALLACE: If a manager comes in with the idea that he knows everything, he's doomed to failure. He has to figure out that the Shuttle Program, or any endeavor as large as the Shuttle Program, is only as good as the weakest person in it. He has to figure out who are the knowledgeable people and listen to them, and not come in to be dictatorial and say, "This is how everything's got to be." The most successful Program Managers were the ones that listened well, asked hard questions, expected answers that were supported by data. One thing that the Program

Manager has to do is provide enough money to allow testing, statistically significant testing, to provide a good answer. One test does not always provide a real answer.

The Program Manager who has grown up either in the engineering side or the ops [operations] side has a better chance of being effective than a person that is just brought in to take the place of somebody who's moved on to another activity. Bob [Robert F.] Thompson, the first Shuttle Program Manager, was very good. He obviously had had lots of experience prior to becoming the Shuttle Program Manager. But since he was the first one he had a lot to contribute from his past.

Now you take [N.] Wayne Hale [Jr.]—Wayne Hale grew up operating the vehicle and learning about it, and I thought Wayne was an excellent Program Manager. He had a more philosophical approach to things. He wanted you to come show him data. Wayne could be hard at times when he didn't like what was being told to him, because ops guys want to make things work. He didn't want to know why you can't do something; he wants to know why you can. During the *Columbia* recovery and Return to Flight activities, when he was the manager we wanted to do things quickly and effectively. But sometimes when things took longer than he thought they needed to take, he still had to back up. At times he would have to back off. When a manager knows when he's reached his limit and knows that he's got to step back and get back in the rational world of listening to folks—that's a good trait for a Program Manager.

WRIGHT: Listening, asking hard questions, and looking for answers that have data that supports it. I think those are three really good aspects for that. Following that line of thinking, if you were tasked to train the next group of leaders coming in, what are some of the elements or attributes that you would be looking for in those people? What would be some of the lessons

that you would like for them to learn from you or from others that you've gathered so that they can be the leaders that the Agency needs next?

WALLACE: It's not just classroom training that needs to take place—whether degrees or through the management training that happens during the leadership development. I think it's experience that is the key. So for the next group of the leaders—for, say, Constellation—I would suggest that they get testing experience and hardware experience. If you're going to manage a program that's going to be all made up of hardware and analytical activities and they all need to be validated—and testing is how you validate the data that's going to be brought to you—I think they need to have a broad experience in technical area management. Whether that's a single discipline or whether they move around and do multiple discipline management activities, particularly if they get into the systems engineering integration world, where they would have the bigger picture which all Program Managers have to have; he has to have the complete picture. I would recommend getting experience in multiple parts of the program where you can get a better perspective of the overall activity that you will ultimately lead, is very important.

A Program Manager is going to have to know how to deal with requirements. Some have done well with requirements. Others didn't quite know why requirements had to be there. But the requirements are how you structure the program. It tells everybody that's building something or analyzing something what they have to meet. I think that is very key. So you have to be able to manage requirements.

Somebody wants to change a requirement, you have to make sure they're changing in an appropriate way. Mr. Hale did not like waiving requirements, which is saying, “Well, for whatever rationale we can come up with, we really don't need to meet that requirement for right

now.” I agreed with him, I don't think waivers are the right thing to do. If we have a problem we ought to make a change either in the requirement or change the hardware in some way. I think that's something the Program Manager has to deal with.

In the Constellation side, the program management are going to go through the design certification process. They're in the throes of that—the requirements reviews, the preliminary design reviews, the critical design reviews and design certification reviews. The program management needs to be trained in that—how to pull that kind of review off and what the purposes are. That's how you ensure that the vehicle is ready to go fly. I think that is a good training activity for a new leader.

The leaders have got to start from the first day they get the job—on their path to the leadership—they have to figure out who are the smart folks, observe what they do—not just what they do right, observe what they do wrong. The best experience I ever got was watching folks that really knew how to make this business work. I don't necessarily think we've always picked leaders based on their on-the-job training. In on-the-job training, I think you learn so much more than just what you learn out of a book. I think to me that's key. I would try to structure a training activity or an experience activity for whoever the Agency picks for leadership roles.

WRIGHT: Being on the contractor side currently, can you share with us some of the differences in decision-making and/or requirements and recommendations, now that you've seen both sides—a couple times you've seen both sides.

WALLACE: I've seen both sides; I've seen multiple roles on the contractor side. USA—my role is basically to apply my experience and give recommendations to my management. But on the

contractors as a whole, they're tasked to do specific work to get the vehicle ready to go fly and execute the flight. Their decision process is a little different. We get paid based on our performance, so you have to keep in mind what the customer needs and wants, and you try your best to make recommendations to the customer that would be beneficial for the whole program that are sometimes taken or not taken. The leadership is on the NASA side and the execution is on our side. It is different, but you're after the same objective.

There's also the support contractor role. I worked for Northrop in Huntsville supporting the Marshall Spaceflight Center. Support contractor is a different role. You really are following the lead of your NASA counterparts and helping them get the work done that they need to get done. That's the same as at JSC with Jacobs Engineering. They're following the leadership of the NASA folks and helping them do the tasks that need to get done, and then identifying tasks if something is not getting done. That's part of the job. Hopefully you get funded to do those tasks that you feel like need to get done. But the contractor world—it's a lot to do with funding and whether you get to do that.

The thing here at USA—which is complex, makes me think twice—is the way NASA has structured Constellation. You have Shuttle money and you have Constellation money. And if Constellation would like to have some particular Shuttle experience they're having very hard times getting the mechanisms that allow that to happen, and I find that troubling, because the new program needs all the experience that they can get.

WRIGHT: Could you expand on that a little bit? Because we're looking for recommendations and suggestions for new management processes or new methodology.

WALLACE: That is a key one. There needs to be a process developed that will allow Shuttle experience on the civil servant and the contractor side to be utilized to assist Constellation during this phase. NASA has taken an approach of doing systems engineering and integration work in house at multiple Centers. That work was contracted out for Shuttle. That's fine, you're covering highly skilled civil servants. But a lot of them don't have the experience in the hardware that's needed. Dealing with the multiple programs appears to be an issue—you got three programs—I do not think big a problem for Station and Shuttle. But for Constellation right now it appears to be a significant problem to get enough experienced personnel.

WRIGHT: You were just talking about programs, but you mentioned you worked at Marshall and you've worked here at JSC. Are there quite a number of differences on how management and planning, the basic aspects we've been talking about, between how one Center does compared to the other?

WALLACE: Yes. Marshall and JSC operate in, I would say, significantly different approaches. Over the years it's always been a battle between the two Centers to see who was going to be the lead Center. JSC, in one management system, was the lead Center for Shuttle. So Marshall had to answer our Center Director. But Marshall is more process-oriented. They structure things in a particular way, and once they set up their structure that's how they function. JSC is more program-oriented. Programs lead the way and everybody else tries to get in line and get their piece of that pie. Marshall appeared to be more structured about how they included their technical expertise. They would have project offices and then also have a chief engineer's office, which was not part of the project. It was in support of the project from their engineering

organization. They just functioned a little differently. But they build a lot of hardware and manage a lot of hardware. That's a capability that the Agency needs.

WRIGHT: What would you consider to be the hardest or maybe the best lesson that you've learned through your years of experience?

WALLACE: The best lesson I've learned is that systems engineering and integration, is key to the success of any program. The project elements of a program have their hardware to go build, and they can get that built and delivered, and then it might not necessarily function with the rest of the elements like everybody thought it would. Systems engineers look across elements and make sure that things are going to work together. They can bring up problems that can be solved before they're problems. I think that is key.

The first Shuttle Program, Bob Thompson, realized that right up front. He had Owen [G.] Morris, who was the systems integration manager, and he had Max [Dr. Maxime A.] Faget, and he had those two guys beat against each other till they came up with good solutions. Other Program Managers didn't feel the need to have Systems Integration to be as strong as it had been over the years, and I think that led to some misjudgments.

WRIGHT: What advice would you share with someone getting ready to enter the space program or even a similar program?

WALLACE: Be well educated. Apply your expertise and look for other opportunities. I think to advance you have to have the big picture perspective and you need to have multiple experiences.

You can't just stay in the one spot. I know lots of guys at JSC that have been in one division, one branch their whole careers. While they're outstanding at what they do, it doesn't always lead to opportunities, and it doesn't always lead to providing the biggest impact for the overall program.

I think there has been several smart people that stayed in one place that if they had broadened their horizons would have made better leaders than the leaders that were chosen. But they didn't choose to have that experience. So I would suggest that a new person coming into a program get the broadest range of experiences that they can get. I think you'll be happier over your career by not doing the same thing all the time. If you're good and it's recognized and you advance, then it's even more satisfying.

WRIGHT: I'm going to let that lead into my last question, which is: what would you recommend to improve management performance?

WALLACE: I have, probably, a little different idea about management than some people. A manager is only as good as the people that you have working for you. My first rule of management is to take care of the people that work for me. Know that the person that works for you is not the same every day. It's not just his expertise or his technical know-how; it's everything else that's going on in his life. That can have just as big effect on the overall team as anything. So you have to encourage them to take care of their family and themselves first and then the work will not be a problem. Because you can't have people working for you that are divided. When they're at work, they need to be at work. If they feel that you're supportive, then they're going to provide their best efforts all the time.

Other part of management is making sure that planning is done first. You can't spend your money wisely on a plan that you're willing to say is not *the* plan. You save schedule in the long run by doing advance planning and allowing the work to be done one time and not having to do multiple reruns of the same activity because somebody didn't think of the right things. If you have a broad-based experienced team that reviews the plan before it starts to execute, I think you save time and money in the long run.

WRIGHT: Sounds good. I know you have made some notes. I'm going to give you an opportunity to look through those and make sure that we didn't miss anything.

WALLACE: As you grow in your experience and knowledge and have data at hand, don't be afraid to tell your leader that he's not correct. If your leader is dissatisfied with that, if you have data to support it, don't be shy about going above your leader. You have to have data; don't just do it because you don't like what the leader said or did. You have to have data and rationale for why it was wrong or why something else needs to be done. It's all based on data and sometimes that's hard to get. A gut feeling, intuition is never as good as data. Fight for data, even though you have a gut feeling there's something wrong. Management can put you down for your gut feeling, but they can't put you down for requesting data. So I think that's key.

I did talk about the fault tree and the hazard work. I thought it was the biggest improvement in the risk management activities. I think we did fairly well with the performance enhancements for Space Station. But developing a process that allows you to assess the—I call it the “bang for the buck.” You're getting the most for the money that you're going to spend. If

there was a formal process where all decisions were run through—that required money—I think that would be an improvement.

WRIGHT: Are there some elements to that process that you feel would be important?

WALLACE: It's assessing the cost of what it is, it's the improvement that's going to be realized, it's the technical risk of actually realizing the improvement, and then if it's a risk reduction activity—how much risk does it really buy you. If right now my risk is 1 in 100 and I can make a design change that costs little and I can get to 1 in 1 million—that kind of assessment is what you want to be able to do. As far as someone that's coming into the program, you have to get to know your leaders at all levels. They need to get to know you. Once they know you, that's how they get to trust you. I think having your leader trust you to do your jobs correctly and provide good advice is key.

WRIGHT: Is there a way that you have seen that works when people start to instill trust in others and vice versa?

WALLACE: The people that I worked with—if I trusted them, I think they trusted me more. If they weren't quite as reliable and I didn't feel like I could trust them, then I felt that they didn't trust what I was telling them quite as much. I think trust is key.

WRIGHT: Is that something that can be taught to others? I know it can be tested.

WALLACE: I don't know if that can be taught. I think it's more of a goal. You need to start as a goal to gain trust from either somebody working for you or who you're working for. Getting to know the leaders—shaking hands, whatever it is, whether you see them outside of work or whether you get exposure to them through your technical work—so they'll know who you are.

WRIGHT: Any other thoughts you'd like to add as a closing?

WALLACE: You had one question [about] who else you might want to interview. I've jotted down some names. Bert [James B.] Jackson [Jr.] works here. He was the guy that put the configuration management process in place originally for Shuttle. There are some retired people I know that are still around. I think Dick [Richard H.] Kohrs and Owen Morris are still around. I think Dick Kohrs has got an office over in Building 1 somewhere helping Constellation. I thought he was one of the best Program Managers we ever had. Owen Morris was the initial systems integration manager and I think he's still working with Dick. Others come to mind are Lambert [D.] Austin [Jr.], Don [Donald E.] Prevett, Tom [C. Thomas] Modlin [Jr.] and Jene [A.] Richart—one of the guys that used to work for me, he's been there a long time. Probably good folks to interview.

WRIGHT: All right, sir. Well, thanks so much.

WALLACE: You're quite welcome.

[End of interview]