

NASA AT 50 ORAL HISTORY PROJECT

ORAL HISTORY TRANSCRIPT

SCOTT PACE

INTERVIEWED BY REBECCA WRIGHT
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WRIGHT: Today is March 21st, 2007. We are at NASA Headquarters in Washington, D.C., to speak with Dr. Scott Pace, NASA's Associate Administrator for Program Analysis and Evaluation, for the NASA at 50 Oral History Project. The interviewer is Rebecca Wright with Sandra Johnson. In preparation for the space agency's fiftieth anniversary, the NASA Headquarters History Office commissioned this oral history project to gather thoughts, experiences, and reflections from NASA's top managers. The information recorded today will be transcribed and placed in the History Archives here at NASA Headquarters, where it can be accessed for future projects.

Are there any questions that you might have before we begin today?

PACE: No, not at all. Glad to see you doing it.

WRIGHT: Well, we are, too, and we thank you for giving us this time. Dr. Pace, you're responsible for providing objective studies and analysis in support of policy, program, and budget decisions by the NASA Administrator. Could you begin today by briefly describing your background and tell us how you came into your current position.

PACE: Okay. Let's see. I was originally a physics major as an undergraduate. I'll go back to the beginning. My first job out of high school was working at the [NASA] Jet Propulsion

Laboratory [California Institute of Technology, Pasadena, California (JPL)] in the summer of [19]’76. My first job there was when Viking [1 Lander] landed on Mars. That was really exciting.

I went to finish my degree and I went to graduate school at MIT [Massachusetts Institute of Technology, Cambridge, Massachusetts] in the aeronautical engineering department, but also got a degree in technology and public policy, because I’d become interested in the history of science and history of large government efforts.

So after MIT I went to work for Rockwell International in Downey, California, where they were building Shuttle Orbiters. That was also very cool, because you could walk out on the shop floor and see people machining an airlock door. I was working in both the business development and advanced engineering groups, so I was among the people who pushed paper, not the people who bent metal. But nonetheless it was good to be in a place that was bending metal.

Afterwards, after several years there I realized that a lot of the issues that I cared about in terms of space development and exploration were really more political than they were technical. The problems were more political and somewhat economic, but more policy related. So I went back to school. The RAND Corporation had a graduate school in public policy, so I’ve sort of been sliding downhill for a long time, from physics to engineering to public policy, kind of in this progression.

At RAND I worked on a number of different projects, including reviews of the National Aero-Space Plane Program and some SDI- [Strategic Defense Initiative] related work, as well as doing my dissertation on launch vehicle choices that the nation was then facing. I came back to Washington to work in the Commerce Department. I was a career employee in the Department

of Commerce's Office of Space Commerce. This was in the first [George H. W.] Bush administration. I worked as the Deputy Director there, and I was a career staff employee in the Office of the Deputy Secretary.

There we worked on a number of interesting items; the first regulations for the first private remote sensing satellite systems; became Title 2 of the Land Remote Sensing Policy Act, 1992. We worked on streamlining export controls, which I think today, given the difficulties in export control, people would be thrilled if we could get back to where we were in 1992, because a whole bunch of things subsequently happened in the succeeding administrations.

We did the first agreements with the entry of nonmarket launch vehicle systems, so agreements with the Chinese, the Russians, the Ukrainians, into the international launch market. We did the first real statistics on the growth of the commercial space industry happening at that time. We had the first meetings with the emergence of the direct broadcast audio systems, which today are Sirius and XM Radio. So it was an exciting time for the commercial space area.

This was also the time when there was a National Space Council, and one of the things the National Space Council did were several reports. There were a number of difficulties at the time; the Hubble Space Telescope, of course, was not good on orbit. Norm [Norman R.] Augustine was named to head a commission, the Augustine Commission on the Future of [the U.S.] Space [Program]. I was part of the Department of Commerce team in that discussion. I was also involved in the Space Exploration Initiative [SEI], the first effort to do the Moon-Mars effort again in Bush 1 [President George H. W. Bush Administration].

One of the things that came out of the Augustine Commission Report was that the idea that NASA was going to be doing work that was actually somewhat different than it had done in the past. NASA's work has always traditionally been very project oriented. You build a

satellite, you put it on a rocket, you send it into orbit, you get the data, it comes back. You build another satellite, you put it on a rocket, and send it up, get data, come back. It's not quite building an architecture that's interrelated, that spans decadal long work.

When you're looking at the Space Exploration Initiative, there is sort of a recognition, at least on my part and I think several other people's part on the commission, that what we were trying to have NASA do was something more like the Defense Department, which had a national military strategy; had a force structure that reflected that strategy. You costed out what that force structure would take, resources it would take. It, of course, never fit within the available budget, and so you would go back and redo. So there's an iterative analysis cycle that you go on. You can try to find some sort of longer-term strategy. You have a structure to meet that strategy, made up of a whole bunch of little pieces. You try to integrate all of those with the policy support and resources you had and so forth.

Well, that kind of cyclic analysis and integrative function was something that people felt NASA needed, and, in fact, they refer to it as sort of a PA&E-like function, because the Defense Department had a Program Analysis and Evaluation Office, which arose in the [John F.] Kennedy administration under Bob [Robert S.] McNamara in order to adjudicate all the different competing demands on resources in the Cold War. And, of course, you never had enough resources to do whatever a service wanted to do. You had to pick and choose among them. In fact, that was really the basis of sort of modern military systems analysis, which the RAND Corporation had been involved in and I had been exposed to.

So given NASA's proposed new role in things like SEI, there was a thought that you needed a PA&E-like function to do that, and in the final Augustine Report it was referred to as sort of a systems analysis house to do that. With the demise of SEI, NASA didn't really want to

do that kind of systems analysis. There's a whole bunch of reasons for it that would probably take even longer than we have, but my perception of it was because the enterprises or Mission Directorates and so forth didn't want to have independent analysis and trade-offs. They knew what they wanted to do, thank you very much, and without an overarching objective for the agency like SEI, there wasn't really a lot of push to do that integrative function at the agency level and incur all the various pushback that you would get.

Now, the person heading the Office of Exploration at NASA, of course, during that period of time was Michael [D.] Griffin, who I had been aware of in his time when he was with the SDI Program, again when I was at RAND and I would see what the SDI Program was doing and his work; very impressed with some of the things that he was accomplishing. Was very impressed with what he was able to do with limited resources at NASA in the first Bush administration, and really the architecture that he wanted to implement.

But with the end of the Bush administration we all sort of went our separate ways. I went about six months into the [William J.] Clinton administration, again as a career person, but really decided that I had had enough of a government tour at that time. I accomplished a lot, but I really, I think, had run out of new ideas that I wanted to pursue at that time and decided I needed to go replenish my intellectual capital.

So I went back to RAND in the Washington office and actually wound up supporting the Clinton administration through OSTP [Office of Science and Technology Policy]; a number of acquaintances and friends of mine who were doing space and aeronautics work for OSTP, and so I was working for the Critical Technologies Institute, which was a FFRDC [Federally Funded Research and Development Center] for OSTP, and again my area of the portfolio was space policy.

I did a number of things there. Probably the most notable among them was the work that led to the GPS [Global Positioning System] policy statement in 1996, which was the first statement, really, presidential policy statement, on GPS as a dual-use technology. I also did some work for rethinking some of the Mission to Planet Earth and commercial remote sensing, and I also worked on the National Space Policy. So, again, still very involved in policy sorts of issues, but at a bit of a remove supporting my friends in OSTP.

I became involved in the election effort for George W. Bush, on science and technology-related issues, and with the outcome of the election I was part of the transition team, really two people, myself and Courtney [A.] Stadd. Given the compressed schedule as a result of the election dispute in Florida and the Supreme Court case and so forth, there was not really time to stand up some of the larger transition teams that had been done in the past. Past transition teams would be on the order of, for NASA there would be about twenty-five, thirty people and panels and so forth. There was no time. There were two of us.

So we were done by inauguration day, and we split up. Courtney came over here to Headquarters as the Chief of Staff and White House Liaison, and in the space of about a month or two, by April I wound up at OSTP as the space and aeronautics person over there. So again a kind of White House-agency sort of tie. After about a year at OSTP I came back to NASA; went to work for Courtney as the Deputy Chief of Staff for him under Sean O'Keefe. After the accident and loss of [Space Shuttle] *Columbia* [STS-107], Sean reorganized the front office, and actually one of the things that was actually quite timely and advantageous for me was I went back to real work in an area that I had been doing a lot of work in before, which were GPS and spectrum issues.

One of the things I had been involved with at RAND in the nineties, late nineties after the 1996 GPS policy, was a number of large international disputes over spectrum. There were tensions between the commercial communities and the government communities over allocation and access to spectrum, and I became involved in negotiations at the World Radio Conference, which was held every few years. The first major one for me was 1997. I was part of the U.S. delegation there. There were various efforts to reallocate spectrum that was needed by GPS, and so the U.S. opposed that, and it was a large international debate. I became very involved with both the technology and politics of international discussions on spectrum and communications.

So that's what I wound up doing at NASA when I went to work in the Space Communications Office and again working interagency issues between ourselves, NTIA [National Telecommunications and Information Administration], which handles government spectrum; FCC [Federal Communications Commission], which handles commercial issues; involved in a number of World Radio Conferences.

The 2003 World Radio Conference was coming up, and there were a couple of pressing issues there. One of the comments Sean said to me is that he said he wanted me to take that on, that he was obviously busy with lots of other things, with Shuttle and [International Space] Station and so forth. It had registered on him that some of these spectrum discussions and communications issues were important to the agency for science purposes as well as national security, and so his general order to me was, "Pace, don't let anything stupid happen." So with that order of "don't let anything stupid happen," I went and was part of the U.S. delegation again, and we had a good outcome at the conference that protected GPS.

I became more focused on technical work and was then not involved in a lot of the policy work. I was watching some of my colleagues in the policy development for the Vision for Space

Exploration which was sort of bittersweet. On one hand, I was extremely proud of my colleagues, former colleagues, in what they did and pulled off for the President's speech, but on the other hand it was also watching from a distance after having been, you know, directly involved in policy for over a decade on these sorts of issues. But I was very pleased with the outcome.

Then when Michael Griffin was named to become Administrator, he called me up and said that he was forming a PA&E function at NASA in light of the architectural demands that would be involved, the trade-offs and so forth that would be necessary, and he thought that NASA needed a PA&E analytical function.

I said, "Well, that's great. It's been about fifteen years since we made that recommendation, but better late than never. Great idea." Pause.

"I want you to head it."

"Oh, okay. Great. I think I know what to do."

So in 2005 I left doing technical work and came back to doing policy-technical work, so in April of '05, and I've been in this position ever since. We stood up the new organization, and it was part of the change of the agency's governing structure; having the Centers report to Headquarters, to the Administrator, versus having to go through the Mission Directorates; that you have a balance between the programmatic side of the house and the institutional side of the house. You want those tensions not resolved at lower levels, but you want them resolved at a Headquarters level, and you want PA&E to be not the adjudicator, but really the independent voice that says, "Well, there's A and there's B, and here's the pro and con of each side."

So our organization is made up of several parts. We do studies and analysis, any PA&E Office does, for the Administrator and for those top-priority questions that the Administrator

thinks are worth looking at. We have a Cost Analysis Division that provides independent cost estimates, again, crucial in terms of resource allocation.

We have a Strategic Investments Division, which does the budget, essentially. As part of the reorganization we pulled the strategic investments work out of the Office of the CFO [Chief Financial Officer] and made it a separate organization. When you look at the PA&E systems and the budget systems, for example, at DoD [Department of Defense], it's what's known as Planning, Programming, Budgeting, and Execution, PPBE. The planning and programming side is one major set of steps, and the budgeting and execution side is the other, so there's those who authorize the checks and those who cut the checks. You keep those functions separate.

Now, NASA traditionally had put those functions together in the CFO and, oddly enough, put them under the Comptroller. So we've had very, very powerful and competent comptrollers in NASA for many years, and they were the ones who were responsible for putting the budget together. But it's also sort of odd, because in any normal corporate world the Comptroller is the person who determines that the numbers are good for the CFO, who in turn advises the CEO [Chief Executive Officer], who does strategy using the CFO. Well, the Comptroller function we had in NASA was extremely powerful and focused, out of any proportion to what you would see in sort of a normal governance environment.

That was because work needed to get done. I don't think there was any malice aforethought of anybody. Work had to get done, the budget had to get done, and it was the easiest way to do it.

But as we thought what the governance of the agency ought to be, one of the things you wanted to do was to separate the authorizing of checks from the cutting of the checks so there

isn't this sort of self-dealing problem that you would sometimes—people would see a lack of transparency I think would be the polite way to call it.

So what PA&E does in the strategic investment side is prepare the strategic planning guidance, which is approved by the leadership; pulls all the input from the Mission Directorates and Centers and so forth; identifies where there are issues; crisps up those issues for decision that are then decided on by the leadership chain, Mike or Shana [L. Dale] or Rex [D. Geveden], the Administrator's Deputy Administrator or Associate Administrator.

So we're staff, a corporate staff function. We are not a chain of command function. We don't tell anybody what to do, push this button or close that building. But we are corporate staff. So again a very, very important role that PA&E plays, I believe, is the PPBE part of the process. Now, after the budget is done and it's approved and its monies appropriated, the CFO is in charge of executing that money fund distribution and all the accounting side of things. So there's really two different cultures. There is a CFO culture, and there is the PA&E, a budget and policy and programming culture.

We have an Independent Program Assessment Office, which reviews programs and projects at major milestones. It's governed by Project and Program Guidance 7120.5, now "D" version. It's gone through several versions; and there's 7120.4, Program and Project Management. Again, we've made a number of changes there where projects come forward at particular milestones. They're independently reviewed. There are differences that you then try to reconcile. Where the differences cannot be reconciled, you bring those forward to Program Management Council for people to hear both sides.

But you work very collaboratively. It is not an audit function the way reviews might be thought of. Again, what we try to do is it's like having a graduate student preparing for his

exams. You want to work them really hard, because you want them to pass, not because you want to fail them. But you want to work them really hard so that they pass.

So Studies and Analysis, Cost Analysis Division, Independent Program Assessment, and budget, and then I have a Mission Support Office, which covers travel, procurement, and admin [administration], all that kind of stuff, and it's to try to provide a common basis for all these rather disparate functions.

So anyway, that's where we are today, which is we have a PA&E function, which I have long thought was necessary, not just as a good idea in and of itself, but one which comes out of the kind of work NASA has been asked to do by presidential policy and legislation. You could certainly do without having a PA&E function if you simply wanted to be a collection of projects. The National Science Foundation, for example, doesn't really need a PA&E kind of activity, but places like the Department of Energy or DoD or so forth, where we have overarching architectural issues and trades between disparate organizations, I think it's a useful function.

So, sorry; long answer.

WRIGHT: Good answer. And as I've been listening, I believe that you've already answered partially this next question I'm about to ask you, but what lessons have you learned through these years that you were able to apply as you created the formation of your organization, and ones that you'll be applying to reach your mission?

PACE: Lessons, hmm. Well, a lot—this is sort of very idiosyncratic; if you asked me at a different time or a different place, you might get a different answer; so it's idiosyncratic, so whatever's on my mind, I guess, at the moment.

I think a lot of the lessons learned, to my mind, have been incorporated into the governance model. The idea of checks and balances; the idea of documenting decisions; the idea that how you operate and manage a bureaucracy, as prosaic as that might seem, is absolutely critical to achieving more transcendent or visionary goals and objectives. One of the things I guess I learned in my first government tour in Bush 1 was that I came in with maybe some of the usual prejudices about government service and government bureaucrats in Washington and all that, and I, I think fairly quickly, came to the conclusion that the people were much better than I might have expected. I also concluded that the system was much worse than I might have suspected.

To some extent this was just the nature of human organizations. Another extent it was actually intentional by the founding fathers in terms of setting up divided government. The federal government in particular was not set up for efficiency, and that's intentional.

So one of the things I learned was the importance of collaboration. Sometimes I refer to it as an open conspiracy between career staff and political staff. Politicals can get things done that careers cannot do. They can make very fundamental sorts of changes. On the other hand, if you want those changes to be long-lasting and enduring, you really have to involve the career staff, and you have to convince them that this is actually for the long-term good of the agency where those career staff will be spending their lives, many of them. You still have long tenures in the federal government in ways that you do not have in the private sector much anymore.

So as a result there is sort of a miniature democratic conversation that goes on, to my mind, must go on sort of successfully as a negotiation between the careers and politicals on getting things done. One of the things that I say is that career staff should learn how to, where there's opportunities for reform and improvement, they need to learn how to use politicals, and

the political in turn need to understand how they need to use and involve career staff to elicit more permanent change. So that kind of continuing democratic negotiation is something that has certainly informed my background.

Another thing I would say is the differences in sort of cultural views that people bring together, particularly in the space area. Space has been interesting to me in part because of the conflict between the use of dual-use technologies. Satellite navigation systems, communications, launch vehicles, all these things have both civil and military applications. They also have public and private uses. Actually, I wrote a paper on this topic called “Merchants and Guardians,” which refers to different cultural views.

There are the guardians, sort of Plato’s guardians of *The Republic*, who have very long-term views, make change fairly slowly, slow to trust, fairly conservative, interested in long-term principles and values. Then there are the merchants, who are entrepreneurial, risk-taking, energetic, will make a deal with anyone; relationships are fairly short; everything kind of stands on its own individual merits. Those are two very different ways of interacting and working, and there can be merchants in the government—rarely, but some—and there can be guardians in industry, but again rarely.

So as the public and private sectors try to talk and come to—they talk about policy issues and programs and priorities—you find them often having mental models of themselves that are culturally very different from each other, and space, which has lots of other aspects to it, political and emotional and visionary aspects to it, comes in for more than its fair share, as well as being technically challenging. So that’s a sort of a second lesson or whatever, but certainly it’s a reality that I’ve seen.

Then finally I would say NASA, which tends to be very dominated, of course, by scientists, engineers, astronauts, the technical community, we tend not to pay attention to more prosaic things, what I've sometimes called the soft underbelly of the agency, which is things like procurement, legal, financial, all the things that are necessary to make an organization run. I would submit that you can have a mission failure just as assuredly because funds distribution doesn't work, or because the HR [Human Resources] Office doesn't get you the right people, than as if you blow up on the pad.

So in some ways this to me is reminiscent back to the James [E.] Webb sort of experience, where James Webb was very much interested in management. He came out of the Bureau of the Budget; understood that major endeavors are often unstable conglomerations of forces and interests that you're trying to keep in metastable balance and moving in the same direction. But that interest of his during the Apollo period, you can definitely, I think, see the merit of it, because if all you focus on is the science and engineering aspect, you will find yourself in deep trouble in other areas, costs, monies, resources.

In management there are really four things to keep track of. There's people, there's money, there's what physical assets you have, and then what programs you're being asked to do. Pretty much things evolve down to problems in those areas. Either you've got the wrong program, you've got the wrong people, you've got the wrong assets or too many of them, or you've got the wrong amount of money at the wrong time. So attention to management of a large bureaucracy is also crucially important.

Now, this may be biased by my having spent more time in Washington than in a field Center. I did a master's thesis on the Shuttle, and I dug through a lot of the archives at JSC [Johnson Space Center, Houston, Texas], and I dug through a lot of the archives back here at

Headquarters, and—well, during the time period '69 to '72 there were all these decisions being made. Although everybody ostensibly was working on the same problem, the records at Headquarters were just a dramatically different cultural environment than the records at JSC.

JSC, you worry about wing planforms and whether or not Max [Maxime A.] Faget's straight wing would win out over the Delta wing, and why the Air Force wanted the Delta wing, and arguments over mission models and design reference missions and so forth. At Headquarters, there are letters back and forth between Jim [James C.] Fletcher and George [P.] Schultz and "Cap" [Caspar W.] Weinberger and Don Rice and OMB [Office of Management and Budget] examiners and all kinds of stuff that occasionally intersected with technology in debates over the size of the payload bays and so forth, but in a very, very different world.

So my bias has been more toward the policy and the Washington world, so someone with a different NASA experience, maybe more in a field Center program, will come up with a different view. Again, from my experience the managerial side, the relationship between political leadership and career staff, and the importance of dealing with different cultures of the merchants and guardians, I think are sort of, in my mind, the enduring touchstones that I've seen over and over again.

WRIGHT: How have you watched NASA change over the years since you first became involved to where you are now generally? And then, of course, you've already explained how it's affected your area, but just in general.

PACE: Well, some things are the same and some things are different. Right now we're in a period where we're trying to develop a new generation of manned access to space to replace the

Shuttle after 2010. As a result of that, we've had to take some steps such as moderating the growth in the science budget, which had been projected to grow. We, of course, have slowed that growth in order to pay for Shuttle and Station operations as the highest priority things now and as we're trying to develop, within a fairly capped top line, a bunch of new systems.

If you look at the Apollo Program, there is this large spike in the budget between fiscal years '62 and '64 which enabled the parallel development of multiple activities. The assets at [NASA] Kennedy Space Center [Florida], developments of multiple Saturn vehicles. Now, that peak died off afterward, but that pulse of money at the beginning was very important to doing simultaneous development programs.

Well, we don't have that kind of pulse of money. We have a capped top line. So as a result, if we're going to start something new, other things have to end. Shuttle Program has to end not only because the CAIB [*Columbia* Accident Investigation Board] Report on *Columbia* pretty much made it clear that we needed to transition off of that, and I think people's experiences with Shuttle as an aging vehicle, but I think there is pretty much a consensus that it's time to wrap this program up, that that has to end in a way to make room for a follow-on. We can't do major simultaneous development within a capped program.

As a result we have to make painful choices about what has to end and how we start transition over to something new. So that's, on one hand, different between today versus, say, back in the sixties.

On the other hand, I remember during the seventies, late seventies, after the last Apollo-Soyuz [Test Program] mission in '75 and before Shuttle in flew in '81 when I was at JPL. I was a lab technician making \$2.85 an hour analyzing data, and I had my overtime hours cut to zero because NASA was paying for Shuttle. This was during the summers of '77 and '78, when

Shuttle main engines were blowing up down at [NASA] Stennis [Space Center, Mississippi] and we were having lots of difficulties with the program.

So I tell that story because, I say, “You know, when you’re making \$2.85 an hour, overtime is really important, and I had my hours cut to zero to pay for Shuttle. Not that I’m bitter about it or anything”. You tell people, “Hey, guess what? We’re in a generational change today which is also forcing constraints,” because the option of walking away from manned space flight is really not something a great nation should do.

There are some differences between now, and the first effort at the Space Exploration Initiative. One of the things that is striking is that the degree of denial that was present in NASA in the early nineties but is not here today. I thought that NASA’s reaction in the SEI Program—NASA has come under a number of unfair criticisms for that program—but it seemed to me that NASA was offered a very compelling and attractive vision, something it had long argued for a long time, in the SEI Program.

But faced with a choice between making reforms necessary to achieve that vision, within a capped budget environment and turning some things off in order to do new things, making those kind of reforms and choices to go after its vision, or preserving its culture. NASA chose to preserve its culture. It chose to stay within its comfort zone of what it knew and its routine rather than move out. Now, maybe that was because it felt that they should be given more money to do these things. But, that wasn’t going to be forthcoming. So in a choice between its vision and its culture, NASA chose its culture.

Are those painful culture choices here today? Yes, they are, but, I think the experience of the nineties and all the turbulence that NASA went through, such as the pain of the *Columbia* accident and so forth, I don’t see that sort of denial anymore. I see more a sense of yes, we need

to make tough choices. What we want to know are the choices logical? Can we understand what the priorities are and what the logic of it is? Yes, we always like more money. But given that there's not more money and we have to make painful choices, do we think that there is some sort of logical process that's being followed that therefore can make our lives a little bit more predictable in what we're asked to do?

Again, this is probably where I'm biased, is I think we do have that logic. I think that the Administrator has been very good at articulating that logic in a way that NASA folks sort of understand, and that the way that the Vision for Space Exploration was done this time is somewhat different than the SEI effort. One of the ways it was different is that the resource constraints and the need for tough priorities were really spelled out right from the beginning. The President made his speech saying, "This is a journey, not a race."

The FY '05 budget had some increases in there. We would love to get back to where we were in FY '05, by the way, versus dealing with some of the CR [continuing resolution] issues and so forth we are today. I would love to be back at the NASA budget in real dollars terms where we were in 1992. It would solve a lot of current problems. Again, it doesn't need to be an Apollo-like effort of money. It just needs to be a little bit better than it currently is. But again, those constraints have led to more willingness to make some hard choices and the Administrator's ability to articulate the logic behind those choices, both on the [Capitol] Hill and with career staff, I think has been very helpful.

Nonetheless there are enduring differences. You will always have folks in the science community who will say, "Well, the money should go to my projects, because I think they're wonderful." They have a point, and they should articulate that point, but it's up to other people to make those trades. Similarly you have technologist who say, "Hey, more money ought to go

into new technology because that's the way of the future." On the other hand, you don't have a future if you don't have manned access to space.

In my view, personal view, we wasted about a decade if not two decades on Shuttle replacement with all sorts of excursions, beginning with, say, the National Aero-Space Plane experience that I reviewed when I was at RAND; also the Space Launch Initiatives and other efforts. In part we did those things because we thought we had the luxury of time and that the Shuttle could go on. When I first came here there were people talking about Shuttle operations in 2020 and what would be necessary for that, which I think were completely not viable.

Nonetheless people thought that that culture and that vehicle could and should go on for a long period of time, and that therefore one could afford to take higher chances with exotic technologies. If you look at decisions like the X-33 Program, there was an intentional choice made to go not with a vehicle that probably could be built—say, a two-stage orbit vehicle—but intentionally went for the most exotic technologies possible. So over-optimism on technology, a sense that the downside risks were covered by an existing vehicle, meant that when you did have an accident and you said, "You know, we really do need to do something different," you had to go with what you knew, and that's why a high degree of Shuttle heritage parts and use of the existing industrial base and so forth is so important to our plans today.

Technologists don't like and rightly are critical, saying that there are more promising things that we could have done, or could be done better, it could be this, it could be that. Well, yes, but that was maybe fifteen years ago. We're out of time; pencils down.

The tensions we're balancing today are between, again, the lofty goals we have, the resources we have, the realities of where we are, and the consequences of decisions that were made earlier and commitments that were made earlier. I think part of the challenge for us or the

opportunity for us is how we deal with those constraints, the processes, the governance, the explanations, the rationales, the logic, about how we deal with those constraints is important to the sustainability and the viability of the vision as it goes forward. It's precisely how we deal with these problems that ensures that we can rebuild our credibility, both with our stakeholders externally and also with the NASA folks internally.

WRIGHT: I'm going to stop you for just a minute, because our break time is here.

[pause]

If you would, share with us what your thoughts are and what you believe NASA's impact on society is as well as its role for the future.

PACE: There's several different levels to that answer. At one level NASA is a discretionary tool of Presidents. It's sort of an ultimate discretionary activity. Not only is science a discretionary activity, but exploration is a discretionary sort of activity, and therefore if public resources are going to be used on it, it has to be in some ways responsive to what the Presidents want and what the [U.S.] Congress will support.

Kennedy used it as a means for Cold War competition with the Soviet Union, in terms of hearts and minds of the third world and making a demonstration of American capability. And therefore we did things, with going to the Moon, that arguably were ahead of their time. They were not things that normally emerged or evolved in terms of the course of normal science or exploration, but were driven at a heated pace by the political requirements of the Cold War.

You can also say that President [Ronald W.] Reagan used the space program as part of his broader themes for "Morning in America," American renewal, as a counterpoint to the

policies of the [Jimmy] Carter administration, who explicitly disavowed large major-scale engineering projects. There was a debate in the seventies about things like solar power satellites and responding to the energy crisis and so forth, and the Carter administration explicitly said that in their policy there was no need for high-challenge engineering projects, which while not naming solar power satellites and those kinds of things explicitly, were definitely caught by it.

Ironically, the support for and interest in some of those things came from Congress, in the form of people like Don Fuqua of the House Science and Technology Committee at the time. The Reagan counterpoint used the Shuttle and its symbolism, plus the Space Station, to be a unifying force among the alliance, again in counterpoint to the Cold War as an overarching political theme.

But with the Clinton administration you saw the Space Station nearly died in Congress a couple of times, and at one point only surviving by a single vote. With the Clinton administration, the involvement of the Russians in the Space Station Program provided a new alignment of political support for Station. You lost some conservative votes who didn't like to see the Russians involved; they saw it as more of a U.S.-centric project. But you also picked up a larger number of votes from people who liked the idea in Congress of involving the Russians in the Space Station, now symbolizing the end of the Cold War.

So the large programs, particularly the human space exploration programs, are responsive to the needs of the Presidents at the time. Now, there are transcendent reasons and experiences with space exploration and science that go beyond any particular President. You simply look at some of the public reaction to Hubble Space Telescopes, the reaction to the Rovers and so forth on Mars, the support and interest in human space flight that's still enduring there, although certainly not what it was in the sixties, and to an extent, the exploration in science and space

symbolizes Americans' definitions of who they are. This is part of what great nations do. This is part of what Americans define themselves as doing.

You could, of course, stop all this tomorrow, and we would still have all the practical benefits of space, satellite communications and navigations and remote sensing and all that sort of thing. But if you weren't doing exploration, and I think the Administrator put it well in one of his speeches, that there would be sort of a sense that something lost, that something was missing by America not being involved in this. I certainly recall a feeling of relief or of satisfaction at the launch of *Columbia* in 1981 with the return of humans to space, who had not been there for the previous six years, and even longer if you count back even to the Skylab missions. So the idea that Americans are not in space, not exploring, I think is something we would find disturbing.

But also ironically, and again the CAIB Commission put their fingers on this, was the idea that we are only going around in low-Earth orbit was also somewhat disturbing. People were getting the sense of, "Well, where are we going with this?" prior to the President's speech. So having a sense of direction, even if we are constrained by realities of money and resources and technology to maybe schedules that take longer than we would like or progress is slower than we would like, the idea of making progress, of engaging in exploration as opposed to not doing those things is very important to Americans' sense of themselves.

So there are the immediate necessities of day-to-day budgetary decisions that the Congress deals with. There are the slightly longer term issues that Presidents deal with in terms of what are the demands of the country at the time and what is the overall tone and tenor of the environment that we're in. There are even longer term enduring issues of Americans' senses of themselves as to what they're engaged in.

So the importance of space is, of course, not just the practical benefits but also the inspirational benefits, and inspiration means different things to different stakeholders, the American people, Presidents, and Congress. As we wind up going forward with hopefully the next set of explorations, I think that the general direction that the President laid out of journeying on to the Moon and on to Mars will be sort of a cornerstone of what NASA will try to do.

What's different today, with this effort versus maybe things done in the past, is the role of the international community, the role of the commercial community; and that there are these possibilities of space tourism. There are possibilities of independent space capabilities from China and India and other new players. Now, they're facing a number of difficult challenges. I don't think that they are going to supplant NASA or the United States anytime soon unless we ourselves relinquish our efforts and give up, but it is a much more crowded and dynamic field.

Space is literally larger than NASA and larger than the United States, and so the question is now not whether anybody is there in space or not, but who is there, how are they there, how are they operating, and how are they working with each other. So are we engaging with the commercial community in productive ways? Are we engaging with the international community in productive ways? How we do those things will reflect what values we are taking out onto the frontier, to use that metaphor, and it is those values that are probably the most important for defining what NASA and what space exploration more broadly are. It's not just our DNA and our robots that go out there. It's the values we carry.

I got involved in a number of debates back in the eighties with people who wanted to go to Mars with the Soviets as part of détente, increasing cooperation, and so forth. I opposed those kinds of efforts, spoke against them as a private citizen or involved in various space activist groups like the National Space Society and the L5 Society and so forth, and would debate

people. Their comment was often, “Well, I thought you were a space supporter, so why wouldn’t you support going to Mars with the Soviets?”

I said, “Well, because it is not just our robots and our DNA that’s out there.” To maybe make an inflammatory point, I’d say things like, “Well, I don’t want to see gulags on Mars.” It is overly narrow to say that there are not values associated with who we decide to cooperate with. The Space Station, for example, is a cooperation of democratic countries, some more than others, but nonetheless democracies who engage in mixed-market economies and some sense of a standard of respect for human rights. Again, one can debate that in the case of individual countries, but nonetheless that is a common aspect of the advanced countries.

So when we look at cooperation going out there, and we look at what values we have, are we going to promote values of a market economy? Are we going to promote values of a liberal, tolerant, democratic culture? Are we going to just go with people who have technical capabilities, never mind what values they represent, or are we going to try to behave and act in ways on the space frontier that are not only consistent with our science and exploration objectives but consistent with our social ideals as well, however imperfectly expressed? That will be the challenge going forward.

JOHNSON: You mentioned human and robotic space flight, and that’s part of what NASA does. Another aspect is the importance of aeronautics. What are your thoughts on the importance of aeronautics and that part of it staying with NASA?

PACE: Well, aeronautics, interestingly, is also reflective of what I said earlier about responding to what are the priorities of the country. NACA [National Advisory Committee for Aeronautics],

NASA's predecessor, was founded in 1915 in part as a result of concern—an earlier version of Sputnik [Russian satellite], if you will—that Europe was advancing beyond the United States in aeronautical capabilities. Even though the first flight had occurred in the United States with the Wrights [Orville and Wilbur Wright] in 1903, by the period before World War I European countries had advanced quite beyond us, and there was a concern that we were losing our advantage there, and NACA was one of the responses; so later when Sputnik had its political impact, and NASA was a response to that, absorbing NACA.

Aeronautics is a relatively smaller part certainly of the agency's budget today, and, should it be more? Yes, there are certainly some things that they could do more in, but it's not the same environment. The technical challenges are not the same as space. The issues that aeronautical research have to face are not quite the same as they were in the environment, say, again, World War I and II and so forth, where people see as some of the golden age of aeronautical research and advance.

On the other hand, there are very important foundational questions that aeronautics can and should answer. The experience I think of is in STS-114, where we had the gap filler protruding out from underneath the vehicle, and some of the nation's best hypersonic aerodynamicists could not tell you whether or not that would disturb the flow field and change the flow on reentry from laminar to turbulent with the consequent heat pulse change at Mach 23 or Mach 16 or Mach 8, and there was lots of debates about it. The fact that what seemed to be a very simple question did not have an answer from the best minds, and therefore in order to minimize risks we put someone out on EVA [extravehicular activity] on the end of an arm to pull the gap filler out, a somewhat sporty maneuver, but this was seen as the lowest risk thing to do in light of our ignorance about hypersonic reentry.

When we look at trying to land larger payloads on Mars, okay, we've landed a couple of Rovers on Mars with air bags. We landed Viking on Mars, which is a hefty-sized vehicle but did an all-propulsive landing. When you start scaling up and think about landing humans on Mars, thirty-, forty-metric-ton vehicles, it's fairly clear that we don't know how to do that. An all-propulsive landing would be very, very expensive in fuel. It's hard to see how that would be practical. On the other hand, the Martian atmosphere is so thin that parachute systems would be the size of a football stadium if we were going in that way. So Mars is large enough to have a gravity field that makes a propulsive landing difficult. It's small enough that its atmosphere is so thin that the kind of aerodynamic entries that one might do on Earth are not really practical as you go up in weight.

So here is an area where in order for us to carry out space exploration on planets with atmospheres, and there are several bodies in the solar system, such as Titan, which do have atmospheres, that we need to have advances in aerodynamics. These advances are in difficult, esoteric areas such as hypersonics, which don't have immediate commercial issues, but are really fundamental research. So I think aeronautics still has a strong role in NASA, but it's in more in the foundational work.

NASA is an organization that responds to the needs of the country, and there are clearly problems in air traffic control systems. The FAA [Federal Aviation Administration] doesn't have the necessary R&D [research and development] capability. They are very, very involved in operational issues. People are looking to NASA to do this, to help with it. But we have not been really given the resources necessary to fully do that. I think what people are seeing with aerodynamics is that there are foundational issues that we should be working on. There are other

issues people would like us to work on but are not able to provide the resources. So you're seeing a debate over what priority aeronautics should have.

Now, with the presidential policy on aeronautics—for the first time one has come out—perhaps that will help in this priority setting. But in an era of constrained resources, which is almost always the case, we will have to do triage and set priorities, and people will not like those results. This is the democratic conversation I referred to earlier. There are useful things for us to do. There are not adequate resources for us to do withal of them. Therefore decisions need to be made. By what logic will we make those resources allocations?

I think what we've tried to do so far is to focus on those things which are really unique to NASA, such as the foundational research, rather than those things which could be done by others, such as some of the air traffic control system changes. Now, we might get the assignment. We might get told to do that, and if we get the resources, we will. Again, NASA responds to the discretionary will of the President and Congress. But it's not clear that that will really happen, so right now we're trying to find those areas where there is consensus for us to be working and not operate in those areas where there is not yet a democratic consensus.

WRIGHT: You mentioned, of course, working for NASA when you were very young at \$2.85 an hour. What would you say to someone today that wanted to build a career and begin working with NASA?

PACE: I guess one of the things I would say is do they want a career in the space business, or do they want a career in NASA, because there is all kinds of ways to participate in the space business rather than working for NASA. I worked at JPL, which is, you know, an FFRDC and

part of Caltech [California Institute of Technology], although associated obviously with NASA. It wasn't until 2001 that I came and actually joined NASA. So I had been in the space business for twenty-five years but was not really part of NASA. I worked on NASA contracts. I worked in FFRDCs for NASA. I worked on policy issues that affected NASA, but I was not formally part of NASA.

I think that the question people should ask is what is it about space that's interesting, aside from thinking it's cool. Sometimes you go to space because that's the only way to answer other questions that you're interested in. If you're a biologist or interested in advanced materials or you're interested in astrodynamics or something, you wind up in space as a means to an end, not as an end in and of itself.

I was interested and continue to be interested a lot in commercial space policy issues, because they are at this intersection between public and private interests that I find very interesting, and they have particularly interesting expression in policy debates between these public and private interests over space issues. I think that greater growing commercial space activities is good for the nation, not only economically but also as part of U.S. leadership in the world. It has an additional benefit that by encouraging growth of the commercial sector you could ironically put pressure on NASA to rethink what things it should be in versus what it should not be in.

I recall debates in the eighties, quite bitter, between NASA and the Commerce Department where NASA deeply resented the intrusion of other agencies into what it saw as its realm. It was willing to tolerate the military world, off in its own separate realm, and that goes back to the beginning of the space program really with the [Dwight D.] Eisenhower

administration. But the intrusion of these upstart agencies such as Transportation and Commerce was not welcomed.

Those debates are largely gone now. They're completely water under the bridge and as a result NASA makes, I think, a bit more intelligent decisions about how to involve the private sector. We still have lots to do, as with the COTS Program, Commercial Orbital Transport System, in buying commercial services. We're still not at the point of buying, say, microgravity aircraft services the way we probably ought to be. We still don't utilize as much of the commercial sector as we could.

But nonetheless we can have those debates, whereas if you go back in the eighties, the idea of commercial space being anything other than a NASA contract was almost an oxymoron outside of the satellite communications world.

So having a richer ecosystem, if you will, in the space business, I think, allows for NASA to have some healthy competition. It allows it to really think what are its fundamental core capabilities that it wants to work on, which are in my view, exploration and science, not operating things. So we've gotten out of the aeronautics business in many areas, large assets like wind tunnels. Four of our ten field Centers are aeronautics based. But 40 percent of our budget is not aeronautics based.

For those field Centers, if they are to be viable and healthy, have to do those things that the President and the Congress are paying NASA to do, which in large part is exploration and science. So they have to get into the exploration and science business, not just the aeronautics and R&D business. Other Centers that have been operational and R&D Centers, say, like Johnson, their task in this new world is to become more involved in doing spacecraft development work. That's work that they have not done in almost a generation.

There are major, major cultural changes that have to happen, even at the manned space flight Centers, which on the surface look like they're well funded and healthy and large, but on the other hand are facing fairly wrenching cultural changes that they're, I think, just now realizing.

So, where we're going with the future is that there are many different possibilities for young people to be involved, not just as civil servants in a system, and I think they have to ask questions about what business they want to be in—I was interested in space business and then chose, because I thought it was important for the nation and part of national interest and power and so forth, and I chose to focus on commercial issues as a counterpoint, intentionally not NASA, in order to stimulate changes that I thought would be healthier for the nation as a whole.

Now with the Vision for Space Exploration, I came back into NASA to work on those parts which I think the agency needs, which are better management systems, better analytical systems—bringing analysis to making decisions in a constrained environment so that you can preserve and advance the vision, but in ways that are sustainable and logical and that will have a buy-in for a long, long period of time. It is not enough simply to have an inspirational speech and for people to be inspired, because that can go when they walk out the door. You have to build the mechanisms and the processes and the relationships in to sustain those sorts of visions for a long period of time, because emotion just is not enough.

So that's a very roundabout answer. The obvious things for young people are to have some literacy in math and science, but you don't have to be a scientist or engineer to be involved and to contribute to space systems. But it is important to have some degree of self-knowledge as to why you're involved in this, and sometimes that takes a while to answer for many people.

WRIGHT: Well, thanks for your time.

PACE: Okay. Well, thank you.

[End of interview]