EARTH SYSTEM SCIENCE AT 20 ORAL HISTORY PROJECT
ORAL HISTORY TRANSCRIPT

MICHAEL R. LUTHER
INTERVIEWED BY REBECCA WRIGHT
WASHINGTON, D.C. – JUNE 22, 2009

WRIGHT: Today is June 22, 2009. This oral history is being conducted at NASA Headquarters in Washington D.C. with Michael Luther, who is currently the Deputy Associate Administrator for Programs in the NASA Science Mission Directorate. This interview is part of the Earth System Science at 20 Oral History Project to gather experience from those who significantly have been involved in various efforts in the launch and evolution of Earth System Science. Interviewer is Rebecca Wright. Thank you so much for finding time in your busy schedule this afternoon to talk with me. I'd like to get started with you sharing some of your background. How did you first get involved in your field of expertise?

LUTHER: It's probably worth saying that basically how I got involved was being a child of the1960s, as I like to say. I went to undergraduate school in the early 60s and mid-60s, and graduated from graduate school in '69, just as we were going to the Moon. With a person with a mathematics and physics degree, what is one expected to do except to go work in the space program?

I had friends who had started working in Huntsville, Alabama at [NASA] Marshall Space Flight Center. Through them, I found a job—at the time, not working as a civil servant, but as a contractor. In the first few years, the big issue at that time was, in fact, Space Shuttle. Even though we hadn't quite landed on the Moon—we did so that summer after I started work—the agency was now turning more towards looking at the downturn in the Moon activity and going towards the next generation of launch vehicles, which was the Space Shuttle.

I spent the first couple of years learning the basic rudiments of being a contractor, of what NASA does, and doing a lot of actual return trajectory design for the Shuttle in those early days, which actually was quite fascinating work, even though I didn't pursue it in the longer run. After a couple of years in Huntsville, due to contract changes and so on, I was looking for another job, and landed a job at [NASA] Langley Research Center [Hampton, Virginia], which is located on Langley Air Field. Although NASA is known mostly for aircraft work there, they did have a vibrant, growing Earth Remote Sensing Program, which I was lucky enough to become a part of. I look back in time now and realize just how lucky I was to have been there at that place and time, because it was really one of the important infancies of Earth Remote Sensing. That was in '72. It was the beginning of that.

I worked in support of a small group of people at Langley, designing Earth Remote Sensing capabilities, testing them—mostly in the computer, as it were, through modeling. We would characterize a sensor of a certain type and then build a model of the sensor and build a model of the Earth in the computer and play them off against each other.

That's how I began to gain a great appreciation for that work, in the sense of remotely measuring the Earth's environment and so on. The activity itself was referred to as the Earth Radiation Budget Experiment. That was the name that was given to the proposed "new start." At that time we called them New Starts in the agency. A New Start was when a program got a major funding effort from Congress to actually go build a satellite, make a set of measurements, and reduce to data.

I worked for several years, as these new starts aren't gained overnight. They have to be worked on for some period of time. You have to demonstrate that you know your business, and know what you are doing, and you have got the scientific and engineering background, so I worked on that for quite a few years.

Just as that project got funded from Congress, right about the time it really kicked off and got going, one of the civil servant employees decided to retire. I had been working closely with him, so the project manager came to me and said, "Would you like to come over to the government side from being a contractor and be closer to what we are doing here and be responsible for one of the instruments effectively?" I didn't have to think about it too long to know that that's what I wanted to do.

So I did, and I was Lead Engineer for the Earth Radiation Budget Experiment instrument that we actually built three copies of. I was lucky enough to see it through development, calibration, delivery to the spacecraft, launch. We launched one of them on the Shuttle in 1984. We launched the other two on some NOAA [National Oceanic and Atmospheric Administration] operational satellites in I believe it was '85 and '86, [on] two separate launches.

That was a very rewarding experience and my first opportunity to actually build hardware. To that point, I had done all computer modeling, analysis, and so on. So I actually got to be associated closely with the actual flight hardware build. In fact, if you saw today's symposium [NASA Earth System Science at 20 Symposium, National Academy of Sciences, Washington, DC], the ERBS [Earth Radiation Budget Satellite] was one of the markers on Chris [Christopher] Scolese's timeline of Earth Science events up there. I'm very proud to have cut my teeth or grown up on ERBS.

About the time ERBS was ramping down, I came here to [NASA] Headquarters [Washington D. C.], originally on sort of an exchange learning program. I came as a deputy program manager for something called Upper Atmosphere Research Satellite [UARS], which was in fact at the time the biggest research satellite that Earth Science had ever built. A large observatory, 10 instruments, to be launched on the Shuttle and all of that. Again, being in the right place, or at the wrong place at the time, I guess, depending on your point of view.

I was only here for a matter of months, and the program manager got a promotion to be a branch head in another part of NASA in Space Science, but in astrophysics. So Earth Science had this opening for program manager for Upper Atmosphere Research Satellite. I look back on that and chuckle, because here I was still wet behind the ears, and I went to my boss, Shelby [G.] Tilford, who was on the panel today, and, as I like to say, I had the audacity to ask him to let me be the program manager. He had the audacity to say yes. Although, he had to think about it a little bit. I suspected he had to actually convince some people besides himself about it, too.

From about ’86 until it launched in ’91, I was the program manager for UARS. Very successful, very interesting, and I’m proud to have been associated with getting through a major program like that at that level—the full observatory and integrating with the Shuttle and a big international program, had a lot of international activities associated with it.

WRIGHT: It was during that time period that the concept of Earth System Science was starting to take hold?

LUTHER: Yes, exactly right. Exactly. When I came up, in fact, right at the time in ’85, I guess right after we launched ERBS, I was coming into Headquarters and got the assignment of UARS.

It was right in that timeframe that I remember very distinctly that while I was an engineer by training, obviously, that we were a smaller science group in those days by relative standards. I remember Francis Bretherton coming quite often, meeting with Shelby. The chart; the famous Earth System Science chart [Bretherton Diagram, 1985]. It went through a number of iterations, as you can imagine, as they kept refining it and trying to get it just exactly right.

Of course, it was in that timeframe that I got to know Dixon [M.] Butler and Stan Wilson and Bill [William] Townsend, as we all worked together in various jobs in the Earth Science area. But, you're right, that's where we were refining the Earth System Science concept. At the same time, selling, if you will, for the next New Start, which was EOS, Earth Observing System. There were, in those days, as we marched along, again spread over several years, lots of workshops and study science teams that delivered reports on instrumentation, and we did announcements of opportunity for instruments and began to build momentum, as we like to say.

So that was going on. By the time, in fact, we got to launching UARS—I remember this very vividly—the concept of Mission to Planet Earth had become a terminology that was beginning to be used. The two missions that we had that were following ERBS, the big missions, were UARS and TOPEX/Poseidon [Ocean Topography Experiment]. TOPEX/Poseidon was about a year behind UARS. We began to refer to those as EOS precursors and missions. That's the way we spoke about them, as sort of the lead-in to the Earth Observing System.

In fact, by the time that we launched, I remember doing a press conference the night we launched, we released the UARS, and it was healthy and working. My introduction was something along the lines of, "Welcome to the beginnings of Mission to Planet Earth." That was truly the first big observatory that we put out there soon to be followed by these other observatories.

WRIGHT: What were your expectations at that time as these ideas were being gathered and developed into a strategy to have an Earth System Science program?

LUTHER: Well, it was an expectation that eventually we actually did fulfill and deliver. But, it was, in fact, an expectation that primarily, first and foremost, that we would have a fleet of spacecraft that could characterize the Earth's system. That Earth System Science that we all talked about, and those disciplines—cryosphere, the atmosphere, oceans, and solid Earth, and so on. That we would have a system in place that for the first time could characterize the entire planet at any given time in a snapshot. That it wasn't just taking the temperature of the planet at a few locations and wondering what it was elsewhere on the planet, but by using spacecraft that you could in fact take a snapshot in time and say, "Here's what the Earth looked like for 30 days." Then, you do have, in fact, Earth System Science, because you can in fact see how those disciplines interact with each other, which is, of course, what Earth System Science was all about.

WRIGHT: If you could, explain why this was such a new concept. Although these disciplines had been around for a while, was this the first time that it actually came together as an interdisciplinary method of looking at the Earth?

LUTHER: Yes. Your words were right on the mark. Those disciplines had all been around for a very long time. They had not been interdisciplinary. Why? Well, there's probably a lot that I don't know about why they weren't. But one way I think about it—and I've said this quite a few times in various discussions—is that up until the timeframe of ERBS, UARS, and TOPEX/Poseidon, and really almost through most of that period, but it began to build at that point—all of Earth Science had to be sustained on what was at any given time usually about one to one-and-a-half satellites' worth of data. And very low-rate data, by the way, in those days, because the communication links were not what they are today. Communication capabilities were not what they are today. So, the community was data starved, was the message. They were just lucky to be able to try to bolster their own understanding with very small amounts of space-based data at that time.

It was Shelby and Francis and that group of people that you heard about today that began to say, "If we could actually get more than one satellite up there at a time with more than one instrument at a time [we could] begin to really see how some of these disciplines do interact with each other." But that thought process had not been introduced to the policy people and—more importantly, probably—to the funding people to try to get to something.

In '89 and '90, when the EOS New Start was put forward, the proposal was that we were going to get the astronomical sum of $20 billion in the next 10 years. We were going to ramp up to $2 billion a year. This was in real-year dollars back then, so in today's dollars, you inflate that—that's a fairly large number.

That was the starting anticipation, and that was the so-called New Start that came actually under the first [President George H.W.] Bush Administration before [President William J. "Bill"] Clinton/ [Vice President Albert A. "Al"] Gore [Jr.] came in. The expectations were large, just to answer your question. They were great in those timeframes. We could see this New Start. We got the President's going support. We've got a large amount of money. We had done all of the leg-work to identify the vast number of instruments it would take to lay a capability like that in place.

We were all quite pleased. In fact, to then follow that on, what happened next was Clinton/Gore came in, and they saw this giant New Start going, how important Earth Science was, and they felt that we should separate Earth Science within NASA to become its own, what we now call, Mission Directorates. At the time, we called them Enterprises, offices of different names.

In 1993, we broke off and created an entire separate entity reporting to the [NASA] Administrator, called Mission to Planet Earth at first, and later the Office of Earth Science. That office then picked up that New Start and was the office that ultimately delivered the realization of that dream with the launch of Aura, finally, as the last major piece of that satellite system. At that time we had 16 different satellites operating, I think.

WRIGHT: Speaking of that, you were Director of the Flight Systems Division, so would you tell us about the responsibilities with that? What did that mean you were doing as part of your job?

LUTHER: It's a fascinating story, less about Mike Luther than about the entire office and the creation of that office, and it's a testament, really, to the people of Earth Science, the entire system. The office was created in '93 under Dan [Daniel S.] Goldin. At the time, what that meant was, we separated the rest of Space Science from Earth Science. Immediately, when they did that—Dan Goldin made the announcement at a press conference or at a meeting, I remember this very well, and announced that oh, by the way—he announced and named the Associate Administrator for the Space Science part of it, but he only named Shelby as the Acting [Associate Administrator] of Earth Science.

Of course, we all knew that Shelby had had some run-ins with Dan Goldin when Dan was in the industry. Sure enough, that meant what it implied—that Goldin did not intend to keep Shelby in that position. He didn't have anybody yet, but that he was going to do that. We were all disappointed, but we pulled together, and Shelby stayed on for several months while they searched for a new director. Bill Townsend was his deputy. I took the position of Director of Flight Systems, which then was just under Bill and Shelby. I was responsible for overseeing all of the activity that was ongoing at that time in terms of formulation and development of all of our missions.

EOS at that point was in formulation. There was a lot of activity, but we weren't yet building a lot of hardware. A lot of planning, a lot of design work, and so on, some hardware, a lot of international partnerships to be worked on. We were finishing up some stuff that we had started and a lot of Shuttle-attached payloads, actually. I did a count, and in that time period of the Earth Science Directorate, we had 15 different Shuttle-attached payloads, which amazed me when I looked back at it. That was an intensive effort.

In fact—I don't want to get too heavy into numbers here, but I looked back, and over the roughly 10 years from March of '93 to August of 2004—which is when we put the organizations back together again—roughly10 year period, we were engaged in some 53 missions: 15 Shuttle payloads, 20 research satellites, 11 reimbursable missions, and I counted 7 international missions. Very intense time period. It was that that led to, really, that capability I talked about of those on-going 16 or so systems that allow us now to, in fact, characterize the planet at any given time in a number of disciplines, and has led us down the path that you heard talked about today.

But what I was going to try to make a point about was that over that 10 year period, the people in Earth Science had 5 different associate administrators. Maybe it's 6, actually? We started with Len [Lennard A.] Fisk the day we broke up. So, if you were in Earth Science, you had Len Fisk on March whatever it was, 1993. The next day, you had Shelby Tilford. Several months later, you had Charlie [Charles F.] Kennel. Two years later, you had Bill Townsend act for two years. Finally, you had Ghassem [R.] Asrar, who was a stability for about a six-year period. Five years, six years.

Since that time, we've had another period of about five years with five associate administrators. So you get the message, which is that the half-life, I like to say, of an associate administrator in this business, tends to be about 18 months. You don't produce what's been produced unless you've got people up and down this floor and at the Centers and at the universities who are dedicated to this work and are carrying the work out, in spite of all of the turmoil around them. It's been a wonderful, exciting ride, as you heard about some of the stories at the symposium today. It was a rather interesting thing.

WRIGHT: While we're in that time period, would you like to share some more about the EOS? This was not a normal New Start, as you mentioned. This was quite a set with each component having more components. Could you describe the process of how you were able to gather information from so many different disciplines and scientists and international and inter-agencies? It's very well-choreographed. It looks easy now, but tell us about those beginning days, and then how it progressed where it survived and now is successful.

LUTHER: It was, as you can imagine; it morphed quite a bit as we moved along. We had an initial concept of the class of instrumentation that we wanted to have as we went forward and began to solidify things and get a feel for what the budget was and what things cost. A few things fell by the wayside, or at least got delayed significantly, and had to come back into the program via maybe other avenues.

What sticks out in my mind was, for example, the embracing of the Space Station as a strategy to help to push along the idea of EOS. Where that came from was Space Station, in one of its earlier concepts, envisioned some co-flying platforms that would carry instrumentation with it. So we latched on to that as a mechanism to get a unified program with other parts of NASA to demonstrate to the country that we were working together internally and so on. We actually brought in some Space Station people. At one time, we were going to use those platforms. As Space Station had its own troubles, then that began to fall away, if you will, into slightly different strategies for gaining the spacecraft and the instruments.

All along the way, continually working with our international partners, because getting that New Start, of course, draws attention internationally. They could see that something real was happening, when you would go talk to an international partner, and they would say, "I could give you a microwave imager to fly on your platform to satisfy one of your needs." We had published our scientific needs and documentation. Well, hey, that's an instrument we didn't have to fund. We could partner with them, bring it on board, and then that was part of the puzzle. The Japanese offered AMSR-E [Advanced Microwave Scanning Radiometer for EOS]. Another part of Japan, METI [Ministry of Economy, Trade and Industry], offered ASTER [Advanced Spaceborne Thermal Emission and Reflection Radiometer]. The Canadians offered

MOPITT [Measurements of Pollution in the Troposphere]. I'll forget somebody, but we had a very international program.

Earth Science has always been a leader in NASA of partnering internationally. The reason for that was that we understand that first off, it's a global problem; you've got to have global solutions. So you can't do it all yourself. No single agency could afford to do it. Second off, if you're going to understand the planet, and if you need to make national policy from that understanding, then you've got to have everybody looking at the same set of data and believing that same set of data.

Country A isn't going to want to make policy on a set of data that they're not engaged in, that they don't feel that their scientists have owned and looked at and are comfortable with. So that strategy and thought process is what drove a lot of our open data policy issues, as well as our partnering. We would drive the partnering, first and foremost, over the measurement and the hardware. In a lot of cases, there was some difficulties, but then we had to hammer out open data policy, so that everybody shared all of the data all of the time.

That was a little bit of a new thing, because we were in our infancy. In the early days when there was so limited an amount of space-based data, the scientists wanted some exclusive period, because that was their career. They wanted to publish that data and so on. We began to move away from the scientists having any, or if they did, very small and short, periods of exclusivity, and into the era of broad open data policies and competitive activity.

So the system morphed. We went from trying to get to $2 billion a year, and $20 billion total in 10 years, to ultimately, we ended up with something less than $8 billion. It got cut. We went through all kinds of reviews. Everybody had an opinion about how to implement it differently. We kept changing it and looking at it in different ways. Ultimately, we did end up moving away from a few very large platforms to many smaller platforms, although the three big [satellite] buses, Terra, Aqua, and Aura, survived and of course, are sort of the flagship missions.

We had many more, both our own small buses and many more partnerships with other countries. We flew an ozone monitoring instrument with the Russians. We did lots of different things to fill those data gaps that we couldn't maybe quite reach with our program.

WRIGHT: Does any one of those three have more of an indention in your memory of your work? I know those were some of the missions that you worked on specifically.

LUTHER: It's hard to say.

WRIGHT: Are they like children?

LUTHER: They're like children. Right. That's a good analogy. They are like children. Each is a little different. They had their own character. The Terra spacecraft was in fact a holdover from the Space Station. It was built by General Electric, at the time it was called. It had a slightly different kind of design. It was, in fact, the largest of the three. It carried very large, complex instruments. Of course, Chris Scolese, who spoke today, was the project manager and then program manager for that later on.

Aura was, probably, maybe if I had to pick a favorite, in some ways a favorite, only because it was perceived to be the follow-on to UARS. It was the atmospheric chemistry-based observatory. It had a lot of similar international cooperation. I knew some of the Co-Is [Co-Investigators] and PIs [Principal Investigators] on the instruments, so that was kind of a favorite.

But Aqua was also fascinating to work with. I enjoyed each one of them in their own right. Of course, they each had their own project managers and project teams as they evolved, so you get to know the people. Of course, in the end, while we're all about the science and so on, it's also all about the people. You make good friends and work with a lot of good people as you work your way through those missions.

WRIGHT: You end up managing, also, the personalities of the scientists, as well?

LUTHER: Yes, the personalities of the scientists, and the engineers for that matter. Engineers can be temperamental, also. Project managers can be temperamental. So yes, you definitely do. Where we sit here at Headquarters, after you acquire the money, which is of course the first thing you have to do, then you have to deal with the allocation of the money and the people's reactions to directions and disappointments, for that matter, sometimes. When money has to be moved from one place to another, it may negatively affect one project.

With the PIs, it's getting them to deliver their instruments on time and be happy with the data and so on. It is a very challenging thing to do, but, it's a lot of fun. As I was talking to Bill Townsend today, it's not so much fun at the time, but after it's over, you go, "Well, it was okay."

WRIGHT: You like looking at that data, and I was just thinking, as a trained mathematician, you have gathered now quite a bit of science information just by dealing with all these different projects.

LUTHER: Yes, one of the really fun parts of the job now is that I'm more of an administrator and part-time psychologist, I think, than engineer or scientist. But, I do have the opportunity to sit in meetings and get briefed on either results from existing missions or plans for upcoming missions. It's absolutely fascinating.

As our Chief Scientist, just next door to me, Paul Hertz, says, "Don't ever forget the wow factor." You get to do this everyday. That's what I keep telling myself. They actually pay me to come and get exposed to all of this wonderful scientific information. In the meantime, there's just a little bit of aggravation, but that's well worth the effort.

But yes. It's been a very fascinating ride through Earth Sciences, as you heard a lot about today. I've been lucky enough to be pretty close to a lot of it. The more I think about it, the more I think how lucky I am to have been to be able to do that.

WRIGHT: Speaking of rides, your projects—your children—have taken different ways to get to where they need to go. I know that when you were working on that level, you put some on the Shuttle, some launched at Vandenberg [Air Force Base, California]. Are there things that you have to do to prepare them differently, and what was that process in working with the different Centers?

LUTHER: Actually, it's been an amazing experience base. Let me just say a couple of things. One is that most of what we do gets launched on U.S.-based launch vehicles, i.e., either Shuttle or a commercial launch provider from the United States. Nowadays, there's really only two—ULA [United Launch Alliance] and Orbital [Sciences Corporation]—that we use. Those two are in and of themselves extremely different. Because Shuttle involves humans on the launch, it's extremely complex. The complexity of that launch vehicle is just amazing every time you go through it. We were using it extensively in the late 80s.

Then, when the [Space Shuttle] *Challenger* [STS 51-L accident] first came along, we migrated away from it and have used it very, very little. The primary exception being Hubble [Space Telescope]. Of course, we just got through with the Hubble Servicing Mission IV, so I got a chance to go back and be engaged in that for the first time in quite a few years; it's probably been 10 years or more, at least, since I had been engaged in a Shuttle integration and launch and mission.

On the one hand, it hasn't changed a lot. On the other hand, it has changed. It hasn't changed in the complexity and the detail and the attention to detail, and the way they basically core operate. It has changed in the additional requirements they carry as a result of *Challenger* and [Space Shuttle] *Columbia* [STS-107], the additional care and risk management that they do in those areas. It just makes it even more complex. Yet, we pulled off a beautiful Hubble repair mission that was 100 percent successful, so my hat is off to the Shuttle folks. I know they're struggling emotionally with the policy direction to get away from Shuttle.

On the expendable side, we work with a couple of suppliers, as I mentioned, but all that, our single point of contact in NASA is through [NASA] Kennedy [Space Center, Florida]. We have a launch service provider program that does that interface for us. I enjoy working with them, but the systems are significantly different.

The smaller system of the ones we use is called a Pegasus [rocket]. It launches from under an L-1011. It carries smaller payloads and is just a total different launch day experience than a standard pad-based rocket, a Delta-II or an Atlas. We've heavily used Delta-IIs. They're going out of business. We hate to see that happen, but time moves on in the marketplace.

We're going to Atlas-Vs now as the larger unit and that is going to be a new experience. We've done some Atlas-Vs already, but it's going to be a different world because more people are going to them and the manifest is getting crowded. It's very, very difficult to find a slot on the manifest.

The other interesting thing, getting back to the Earth Science part of this, is that from a launch vehicle standpoint, the majority of Earth Science payloads tend to want to go into a polar orbit. If you're going to get into a polar orbit on a U.S.-launched vehicle, you need to be launched from the west coast, from Vandenberg. Can't get there from Kennedy, simply because of the safety issues of flying over land. From Kennedy, you've got to go east somehow, even just a little bit; whereas, in central California, you can go due south and you miss Los Angeles in that direction.

So it's a different world, a smaller team, no less intense, no less dedicated, but slightly smaller team to launch a Delta-II or an Atlas out on the west coast. Then, I guess the other thing I would contrast is that on occasion, we do partner and use foreign launch vehicles. We have used a couple. We've launched an instrument on a Russian spacecraft on a Russian rocket. Of course, that's not too new today, because we use Russian rockets to go to Space Station, but back when we did it in the 80s, it was a little rarer.

We also have used a Russian rocket that was purchased by our German partner in a mission and launched GRACE [Gravity Recovery and Climate Experiment] using that vehicle from over in Russia. While I did not physically go there, my employees went, and came back with wonderfully interesting stories about how the Russians work versus how we work on launch vehicles and so on.

We've had launch missions and joint activities with the Japanese and their H-II rocket, not unlike one of our Delta-IIs, I would say. I have been lucky enough to go to a couple of those launches out in Tanegashima.

The short answer is the complexities of preparing payloads in those environments that are so different from our environments are pretty labor intensive. Very labor intensive. But we do it. Our people are dedicated. They go to the launch sites in advance, work out the logistics, make sure that things are clean. If we've got any outdoor issues that we need to protect sensitive hardware, we take care. I think we had to have somebody babysit our SAGE [Stratosphere Aerosol and Gas Experiment] instrument 24 hours a day when it was in Russia before they launched it, because people were afraid they would get some of our electronics or something out of it.

The launch business is a fascinating business that until I came into this position and had been through so many launches—I have to honestly say that I started out in remote sensing and instruments, and I did not have an appreciation for the complexities of launch vehicles. I thought they were just big, dumb explosions that just happened. When you realize what goes into one, you realize it's a real challenge. I have a lot of respect for the launch vehicle people. They do a wonderful job.

We've been lucky. We just lost one OCO (Orbiting Carbon Observatory) mission due to a failure of the launch vehicle. In total, I've been associated with 50 or 60 launches, an upper number like that. That's the only launch failure—I take that back; there was one other one. Two launch failures in some very large number of launches that I've been associated with, so it's more than luck. There is some luck, but it's hard work by everybody's job to do.

WRIGHT: If we can, I'd like to pick up with asking you about working with other agencies within the nation. I know that you work with USGS [United States Geological Survey], of course NOAA. If you could explain how these partnerships work well, and what are maybe some of the challenges of working with these groups?

LUTHER: Yes, we do work with quite a few other agencies. Dominant in my mind at this point, of course, NOAA is probably the biggest partner. But, significantly with USGS on the Landsat [Land Remote Sensing Satellite] program. We've worked and of course currently we're working very closely with the DoD [Department of Defense] and Air Force on the NPOESS-NPP [National Polar-Orbiting Operational Environmental Satellite System-NPOESS Preparatory Project] program. In the past, we've had a wonderful mission called Shuttle Radar Topography Mission, in 2000, in which we worked with, at the time; it was referred to as the Defense Mapping Agency, where we had a partnership.

We've really had a breadth of experience with domestic, as we refer to them, partners. What's interesting is that you realize that each partner has its own mission, and consequently it has its own objectives for any given partnership, and that those can come in conflict on some level with NASA's mission, which is predominantly research. It's always a rather interesting situation.

We've gone through various waves, especially with NOAA, because it's been such a long partnership. We've been with them for some 40 years or more, developing and launching for them the weather systems GOES [Geostationary Operational Environmental Satellite System] and POES [Polar Operational Environmental Satellite System], and then turning them over to them, more recently on NPOESS, and also with transitioning certain capabilities to them.

The interesting characteristics are that everybody likes space. I guess I'll say it that way. Everybody wants to be a space agency, but the country really only has one civilian space agency, and it is NASA. Therein lies the source of some conflict sometimes.

If you take our partners, for example, NOAA and USGS, they have similar difficulties in the following characteristic. They're both sub-elements of a much larger cabinet-level organizations. NASA, as you know, is a stand-alone, called an independent agency. Our [NASA] Administrator is a Presidential appointee and reports to the President. We don't have to go through another cabinet officer or whatever. Although he's not a cabinet member, our Administrator, he doesn't have to report through that either.

Whereas, at NOAA, they have to report through the Department of Commerce. At USGS, they have to report through the Department of Interior. The Departments have lots of other varied interests that aren't necessarily in space, especially when they realize how expensive space is to do right and to perform in. This gives their people—their budget people, their administrative people, people who aren't familiar with space—some pause. It's more difficult to communicate with them about the cost of things, why things need to be done in a certain way on a certain timescales.

It's never a personal conflict with these organizations. We get along famously with the people, but organizationally, their mission makes them think slightly differently about their priorities within their budgetary realms, and so on. Consequently, that creates friction in trying to be a partner with them quite often.

DoD and Air Force, on the other hand, have a large space experience base, but they do business dramatically differently than we do. They rely very, very heavily on aerospace as a contractor to perform oversight for them, whereas we have 17,000 people that we employ constantly that do space. There are differences that I won't dwell on with the way DoD and the Air Force acquires their systems, but with them pretty much the origin of the conflict is the methodology, the way they relate to the contractors; and their tolerance for risk, also, is somewhat different than ours.

That said, we have launched a very large number of polar orbiting weather satellites for NOAA, as well as geostationary satellites. We partnered with the Defense Mapping Agency in 2000 and had a Shuttle mission that mapped the entire planet between plus and minus 60 degrees latitude. In one 11-day mission, we mapped the entire planet's topography to something like nine meters, I think, of resolution up and down. This is something that they had a plan to do that was going to extend for 30 or 40 years, to do it with ground-based observations and have them be all resolved with each other for accuracy. We just did it in 11 days from the Shuttle.

On NPOESS now, we're struggling, the NPOESS system. The responsibility there lies with the Air Force, and so our role is sort of a junior partner on that. Still, we're there to help to bring technology and try to make the system be as good as it can possibly be.

We've done a lot for the country, and we look forward to doing a lot in the future, especially with NOAA, as we transition a lot of our research missions over to have them do them on a repeat basis, and help produce long-term climate records. That's the goal of that activity.

WRIGHT: Since you mention the records, what do you think is the significance of having consistent data for now 10, 15, sometimes 20 years, that scientists and scholars can view and analyze?

LUTHER: Perhaps reaching beyond the boundary of my scientific knowledge, but I think the best way to talk about it in terms of layman's terms is that the weather predictions are very near-term, relatively speaking. We've recently increased our capability in three, five, and seven-day type forecasts, working towards 10-day forecasts, perhaps, in the weather systems. Those forecast are particularly dynamic, so the accuracy coarseness, if you will, needed to make those measurements isn't nearly as demanding as when you're looking at a climate record.

If you're going to predict climate, first you're talking about the difference between climate at weather's timescale, right? Another way to think about it is you're looking for very small changes in a very low signal. In order to see that very small change in a very low signal or small signal, you have to look at that signal for a very, very long time, very, very accurately, and you've got to keep watching it and try to see what its trends are and how that it moves. If you interrupt that chain for some reason, and then come back to look at it again, there's always a question in your mind of whether or not you're using the same quality instrument, whether they're calibrated the same as the instruments you used before.

In climate, we like to have our measurements when we go from one satellite to another measuring the Earth's irradiative heat, just to take a simple example. We like to have those instruments overlap by about six months, so that we can see that the new instrument that's about to take over for the next five or six years, how it relates to the old instrument and its five or six or whatever year record it had, so that we don't lose that continuity. We can calibrate them against each other.

The challenge of climate is it requires long-term, continuous, overlapping, well-calibrated, highly sensitive measurements. Whereas, weather, if I have a gap in my weather prediction, then I just can't predict the weather Wednesday. But, if I then replace the instrument, I can pick it up on Thursday, Friday, and Saturday, and no harm, no foul, because that's all I'm trying to do, just look at that chunk of data.

But, if I've got 10 years' worth of climate data and I drop the measurement, then I got to sort of start over. It's not impossible, but it's very difficult to get back and link up your data sets. That's the challenge of climate. That's why we're struggling so hard to make sure that we do have overlap in some of these measurements and make sure we understand which are the highest priority measurements to have that overlap in.

WRIGHT: I know that you're now responsible for the program and project management oversight functions for the Science Mission Directorate, as well as NASA's Deep Space and Low-Earth Orbit Communication Networks. You mention that the Directorate currently has more than 80 missions in formulation, development, or operations. There's a lot to juggle and to keep going. How do you manage to do this, and what is the difficulty in balancing those research missions and operations missions, those ones that need to happen now, and the ones that need to be in place for the future?

LUTHER: Yes, well, one minor correction is that we've recently moved the communications portion of that to another directorate, so I don't have to deal with that.

WRIGHT: Well, it's good to have one less thing.

LUTHER: One less thing, right. But we still have 80-some-odd missions in some stage of development, formulation, or operations. We structure ourselves into divisions that are responsible for the different disciplines. Then, those divisions have both—we call them program executives and program scientists, sort of the engineer and science team, along with a budget person to track each of their major missions. Then they leverage the information that flows up from our implementing centers to monitor out into the field. They actually go into the field, visit the sites, attend reviews, and so on. Then they bring that information, through various written and oral communication devices, back to Headquarters.

I personally run a review, lasts two full days each month, at which I go over each one of our missions in some fashion. The ones that are operating and are doing well, we don't spend much time on. The ones that are in formulation, we just track and make sure that they're moving in the right direction. The ones that are in implementation, that is to say, we have committed to Congress the schedule and technical content and dollar amount from the time until it launches and gets on orbit and begins to operate, because that's the peak spending time. That's where you spend most of your time worrying about them, because that's where the money is going. Follow the money, as they say.

We spend most of our time at our monthly reviews going through those missions and those stages and trying to identify problems, taking corrective actions, making sure we understand where we are, basically, just managing the programs. We communicate directly with the Centers that are responsible for them, either through the divisions, or in some cases, if appropriate, from myself or from Ed [Edward J. Weiler, current Associate Administrator for Science Mission Directorate], to make corrective actions and redirect or reprioritize, in cases, what needs to be done.

It's fascinating work. I enjoy it, but I depend on a cadre of scientists and engineers here on the floor as well as at the field Centers to execute and report and take action as need be. If I feel that we're not getting where we need to be fast enough, then we get together with the implementing Center and map out a strategy for corrective action.

WRIGHT: You just mentioned funding. When you're working with international partners and you're working with domestic partners, you each have your own funding venues. What happens when somebody stops somewhere in between, and how does that affect what you have to do to get things rolling again?

LUTHER: Yes. It does happen. As you point out, we execute our partnerships for the major part on what we call a "no exchange of funds basis," so we decide how the program looks. We divide up the parts of the program. Then we say, "You build that and deliver it. I'll build this and deliver it. We'll decide who pays for the integration and launch and so on." We all have our own pot of money to do the things we committed to do.

The failure comes or the difficulty comes when somebody can't meet their commitment. That can come in a couple of flavors. One is, the money doesn't flow fast enough, and you get behind schedule. Then, of course, in very rare cases, once we've actually struck the partnership, sometimes some people do back out, but that's pretty rare. These are international missions of high prestige, high-profile. In fact, we sign what is effectively a treaty on international missions. On domestic missions we sign what we call MOUs [Memorandum of Understanding] between agency heads, and so on. By the time you get to that point, everybody is committed to do the job.

Now, what we do say is we like to communicate, communicate, communicate. If you're having difficulty, whether it be funding or technical, that is causing you to be late, you want to let your partner know as quickly as possible. You want to do everything you can to avoid it, if possible. In some cases, it's just unavoidable. We all have to then say, "Look, that's the price of the partnership." An example of that that is particularly disquieting right now is that we have a satellite that's ready to launch. Our piece of it is ready to go and has been for quite some time. The DoD is trying to deliver two instruments to it, and they're late. They're very late. By years. We're holding up the launch, because those instruments are extremely important to us scientifically, so we're just paying the freight.

We've gotten inventive. We've ramped down and got people off the job and try to manage it and we keep the bill as low as possible, but it's still a drain on our program. They're not reimbursing us for it. That's just the price of the partnership. We expect that if the tables were reversed and we had that unfortunate situation, we would expect them to do the same. It's sort of a gentlemen's agreement approach.

But it's fairly rare. Every once in a while, it's not unusual on an international partnership, one partner maybe gets a month or so out of sync. But, that's not the end of the world. You can usually deal with a few weeks and adjust things. It's if it gets much longer than that then it really gets expensive and difficult.

WRIGHT: You've been in your field for quite a while. You might be able to say that technology has been your best friend, at the same time, been your worst enemy. Can you give me an example of where technology has changed? Where it has benefited Earth System Science greatly, but at the same time, with the current or the constant evolution of it, has it ever caused a problem where you've had to go back and maybe do something different?

LUTHER: Yes. I guess I can think of one or two of what are pretty classic examples. One is just sort of a broad picture, which is that because our science has matured now over these 20 years. One of the things that we tend to talk about is that we're moving from two-dimensional characterization to three-dimensional characterization of the Earth. In the early days, the Landsats and the ERBS and so on were mostly looking down, taking various pictures in various wavelengths and looking at a flat space and characterizing it in two dimensions.

As we begin to get into atmospheric work, we were able to do a few things, occultations, where you could get vertical profiles. But because of the way that we had to do it, they were very limited geographically. You always had this trade of, I can do a big geographic area, but I can't go up and down, or I can go up and down, but I can only do it over a narrow column, and it takes me a long time to get all of that data.

We're now moving to more aggressive use of active sensors, radars and LIDARs [Light Detection and Ranging]. The radars we have been using for sea surface winds and altimetry going back quite some years. The capabilities in those areas have expanded, and so we're now looking at using more powerful radars to do more extensive and complex science.

What really seems to be new recently is we're much more confident in being able to use our laser systems, our LIDAR systems. We demonstrated that on ICESat [Ice, Cloud, and land Elevation Satellite]. We refer to ICESat as the first civilian laser system for Earth Remote Sensing research. It was a very challenging mission. The lasers themselves had some lifetime challenges that ended up where we had to modify our operations in order to save the life of the lasers. However, we've gotten quite a few years, now, of data from them just by calibrating that system and learning to use it and the cleanliness requirements. That whole laser technology area is a fertile ground for Earth Remote Sensing in particular.

I think the Decadal Survey calls for the use of more radars and lasers, not surprisingly, as we move into this era. It's been a wonderful challenge, but we can do it better. We have a laser system on CALIPSO [Cloud-Aerosol LIDAR and Infrared Pathfinder Satellite Observation], also, built about the same time as the ICESat system. A slightly different system, but it is performing at a much higher level of confidence. We're very pleased with those and those systems are very good.

I mentioned the Shuttle Radar Topography Mission. When that was getting ready to fly, I swore I was ready to wring the neck of the person who committed us to it, because of the challenges of having a synthetic aperture radar on the Shuttle, and having to have a 180-foot boom come out of the Shuttle Payload Bay with a radar system on the end of it, and have the knowledge of where it was relative to the Shuttle itself so well understood in order to interpret the data. We all were, I think, questioning whether or not we would be fully successful in that mission. It turned out to work wonderfully. Sometimes, the ones you worry about the most are the ones that work the best.

I love a quote from John [W.] Young, when he was sitting on top of one of the launchers, I think. They radioed up and said, "John, what are you worried about?" He said, "I'm not worried about anything we've thought about." I thought that a great quote. If you thought about it, we usually work it to death.

So, technology is a wonderful challenge, but sometimes you think, "Are we really going to do this?" JWST, James Webb Space Telescope, is in development right now. Every time I hear about it every month, I go, "Oh my goodness." The details of what we have to do to make that entire system work and bringing all of that technology together in space is just an amazing challenge. It's something else.

WRIGHT: You've met so many challenges over these last 20 years. Let's talk, if you would, for a few minutes, about the key elements, or the decisions, events, that you believe provided the current direction of Earth System Science.

LUTHER: That's an excellent question. I really think that there are two or three key events or turning points, areas, that I can point to. One is just the infancy of Earth Science with the selling and the development of ERBS, UARS, and TOPEX. That was sort of the beginning in my mind. Not just because I was there, I don't think, but because that's when people started really paying attention, saying, "There's some stuff we really need to do here, and we're going to put some investment into this, we're going to really put some big systems up there and go make some measurements."

That was sort of the kick off. As you mentioned, at that same time, then Shelby and Francis Bretherton and everybody, the collective intellect of that time, was saying, "Okay, so we got people thinking about it now. How do we really get to the next step?" So, Earth System Science, that terminology, that report by Bretherton and the whole infusion of that thought process into the community, not only the science community but the political community, was obviously huge. Then that was followed, or as a result came EOS. Clearly, those were the big sociopolitical, scientific events that shaped Earth science at the beginning.

Then we went through this period of struggle where EOS, I think what happened is people looked at it and said, "Well, gee, they got it—$20 billion over the next 10 years. They're going to fill the dark in the sky with satellites and go forward and do all of this." So, it was a struggle for the community to deal with—there was a perception, and to some extent it was true, that, "Well, they got all of this money, and they know what they're going to build, and they've picked the instrument people, so we have now the Earth scientists that are either the haves, they're either part of EOS, or they're the have-nots, they're not part of it, and there's no way to be part of it for ten years. Because that's all that Earth Science is going to do for the next few years."

It was almost in the arena of be careful what you ask for because you may get it, and then you don't realize the unintended consequences. An unintended consequence was that we got the big start, and then there were people who said, "Oh my goodness, they got that, and I'm not part of it."

We had to go through a maturation of the community, and of the program, in fact, to open it up again so that we could get new people into it. That's when we did some new things. We created some new programs called Earth System Science Pathfinders—where if you weren't part of Terra, Aqua, and so on, you had an opportunity. When we chopped up some of the other missions, and we got inventive, and as Shelby said, put our thinking hats on, we found ways to then begin to embrace the community. We got that realization over with and that hump, and so I think we were doing pretty well there.

Then, I would say that perhaps the most recent shift has been the result of NPOESS. When NPOESS came along, it was a Presidential decision directive that said, "You're going to merge the two weather systems, the defense weather system and the civilian weather system." It didn't say anything about climate, didn't say one word about climate. At that time, which was about '94, if I remember right, climate was mostly in NASA's mind, but through sheer, as I like to say, force of will of basically from a lot of dedicated NASA people, climate came on the scene. That's what we've been talking about here. It got talked about.

Then by sheer force of will, it got built into the NPOESS system. We started adding Earth radiation budget sensors and solar sensors. There was talk of altimetry missions, how that would be encompassed into NPOESS. We modified the MOUs and the management structure so that people could get climate information. We struck agreements on modifying next generation weather instruments to make them of better quality, so that they could do climate job.

Working closely with NOAA, we began to transfer those requirements into NPOESS. That, in and of itself, was a huge piece of strategic thinking. Some argued then and argue now that it was bad strategy. But, it was a strategy. I'm not going to try to pass judgment on it, because I don't know what we would have done differently, quite frankly.

So we did that. Then our worst nightmare was what happened, which was that a set of laws kicked in, called Nunn-McCurdy [Amendment introduced by Senator Sam Nunn and Congressman Dave McCurdy] on the [Capitol] Hill that affect the Air Force. The Air Force had to go, and the first thing they did was toss all of the climate stuff overboard. Since there was no hard written agreement anywhere at the Presidential level that said they had to do that, there wasn't any way to stop it. It [the integration of climate capability into the NPOESS system] had happened because everybody knew it was the right thing to do, and we all just worked at it real hard.

That leads us to where we are today, which is we still will get some significant climate measurements from NPOESS through the VIIRS [Visible Infrared Imager Radiometer Suite] instrument and the CrIS [Cross-track Infrared and Advanced Technology Microwave Sounders] instrument and the ATMS [Advanced Technology Microwave Sounder] instrument. Assume they will perform right. They will give us next-generation weather and some long-term climate measurements. That's important. But they put at risk, then, other climate measurements that all of the sudden we don't have plans for and we have to try to scramble. That's what we're in the throes of right now.

I guess the good news, one can say, is that in the 20-some-odd years, we've gone from really onesie-twosie spacecraft, discipline focused, is it atmospheric chemistry or is it an altimetry mission or is it an Earth Radiation Budget mission, to interdisciplinary missions, to 16 spacecraft across lots of disciplines, to worrying now more about the measurements than we are about the instruments or the disciplines themselves. But what are the climate measurements you're making? So that's a pretty good set of progress. It's not bad for 20 years.

WRIGHT: I was going to ask you what you thought was some of the greatest accomplishments? Would you list that as one? Being able to move toward that thought process?

LUTHER: Absolutely. I think the state of the dialogue has to be listed. The pure state of the dialogue has to be listed as a success story. Who would have thought that in the days of the mid-to-late eighties that we would be talking about data gaps in climate records and somewhat? Some people dreamed it, but we are having that dialogue, and the country is concerned.

The sheer shift of the dialogue in the last five years to the recognition of climate has been amazing, because until then, there were enough detractors from that dialogue that it didn't have as much traction. But in the last four to five years, that dialogue has moved to the public forum. Not because the administration wanted it to, necessarily, or we wanted it to, or any particular group wanted it to, simply because the quality and quantity of the science brought it there. It was undeniable.

I think that goes back to the fact that we did deliver on EOS. We did put those 16, ended up being 16 or so satellites up to monitor in all of those disciplines in the Earth System Science. We did have a free and open data policy. We delivered on all of that. Now, we're seeing the fruits of it in that those results are getting into the community. In fact, not only into the science community, and in the world community, but into the lay community for this dialogue to take place.

If you've been as close to it as people like I have for 25 years or so—actually longer than that if you go all the way back—you know that it has been a huge success to move from that early, not only capability, but that early dialogue to the current capability and the current dialogue. Therein lies the grand measure, I think, of the success. Being able to effectively understand and predict El Niños. Who'd have thought it? Three-dimensional rainfall measurements, looking through clouds with lasers and radars, and looking at aerosols at the level that we look at them now.

Just the fact that we now understand the importance of aerosols. When we first started talking about EOS, I don't remember aerosols being a very big discussion point. It was out there. It wasn't being ignored. But, subsequently, we've been able to quantify the uncertainties associated with our measurements and with climate over aerosols, so we're trying to increase our knowledge of aerosols. We're constantly rebalancing the priorities of the measurements.

WRIGHT: We've talked about some of the accomplishments, but do you believe through those last 20-25 years, there have been some missed opportunities that you wish maybe you could have taken another pass to get something accomplished along the way?

LUTHER: It's been so busy, I can hardly think about it. Probably. Clearly, from a previous reference, I guess I'd have to say that NPOESS and the convergence clearly could have been handled better. I haven't thought a lot about what we could have done differently. I think it was clearly the right direction to go to try to leverage that system to be a climate system. What we should have done, in retrospect—but maybe the timing maybe just wasn't right—was try to get the political system to acknowledge the need for climate back then, and not just think of it as a weather system. That had to evolve over time. Maybe there wasn't anything we could do about it. I don't know. We'll have to think about that.

The one thing that we didn't do, and I say "we" collectively as a nation, and we still don't have standing here or sitting here today, is a well-articulated strategy for developing and maintaining a climate monitoring system. We are still, as a nation, it's being done basically by sheer force of will, mostly of NASA. Nobody has written a Presidential decision directive that says, "We shall have a climate monitoring system, and it shall be conducted in the following fashion." We haven't been able to bring ourselves to deal with that as a nation.

That's a missed opportunity. It's a missed opportunity not to have been able to bring NOAA, somehow politically, into a world where they could actually take on the technologies that we develop and make them operational more easily. We're ready to hand them off. I'm not blaming it on NOAA. The political system, the way the agencies operate, simply makes it very, very difficult for them to do that. It looks like they're going to do that on altimetry. After we've flown three of them, they're going to maybe fly the fourth. We'll see if their budget holds up.

Most of the missed opportunities, I think, at the national level, at those kinds of levels, I think we've done well partnering. We've never walked away from a partnership. We've had a few people walk away from us. Rarely, but sometimes. So I don't think we've missed many opportunities to do things right. We took some risks with some things that actually, I thought, paid off quite well. I think the missed opportunities lay in the strategy area and the big national policy area.

WRIGHT: What do you believe needs to happen in the next years to set the foundation for the next 20 years for Earth Science? As you mention, one of them was to have a climate monitoring system in place. Do you feel that is something that's essential to fully utilize what the Earth System Science has already put in place? If so, what else is on your mind about those?

LUTHER: Yes, you've got my tip-off. I do think that consistent with the missed opportunities, what needs to happen in the near term, and this needs to be said correctly, is that we need to have a national strategy for developing and maintaining a climate monitoring system. The reason I'm saying that that way is that that strategy can involve several agencies. So, I don't know that you necessarily want to say that one agency is in charge of that. I don't know. I don't know the answer. I'm not pre-judging the answer.

I know that given the current structure and budgetary limitations, NASA is a research agency and under today's conditions, we're not prepared to be an operational agency, that is to say to make the same measurements over and over and over. We could do that, but we'd have to change our structure. We'd have to change our mission. We'd have to change our budget and resource guidelines. It would be a full change of mission for us if we were going to do that. We could, but it would take that kind of national commitment.

In the absence of that commitment, we're always going to struggle with that situation where we know what it takes to have a climate monitoring system, but we don't have the resources and the wherewithal to put it in place. We're going to be constantly struggling with that tension of what we can contribute to it, how we can help to move it forward, but it will almost always be lacking in some fashion because of that.

Whereas, if we could evolve a national-level agreement for resources with the administration and Congress marshalling the capabilities of, perhaps, NASA, NOAA, USGS, maybe the Air Force, DoD, I don't know, maybe the National Science Foundation could play a role in that. Maybe DoE [Department of Energy]. There are other agencies that could contribute in some fashion. So the government is like a large corporation with different divisions, and the President, the CEO [Chief Executive Officer], needs to set that strategy for the different divisions and help them understand what role he or she thinks they ought to play in this grand strategy.

That's the biggest thing. I think, from a pure NASA-centric standpoint, it's sort of the mirror image of that. We will want to continue to advance Earth Science. We'll want to continue to try to contribute to data records as best we can, while striking the balance of doing new research and taking our results and feeding them back into new instruments and either get the next generation of measurements and models, or better measurements and models, or more resolution. Wherever the science drives us.

That's the nature of our business. We're a science investigative research organization. We're a feedback organization. We don't want to ever lose that. That's why we're so concerned about, we know that need for monitoring and what we tend to call operations is, but we can't be drawn into that, not totally, because it would consume us wholly. Then we wouldn't be doing the investigative part of it, the research and the technology and the wherewithal. We'll have to continue to fight that struggle until told to do otherwise.

WRIGHT: Do you have a vision for what you would like possibly the next EOS-type New Start to be? Is there something out in the talks with your colleagues?

LUTHER: That's a really good question. We just got—just, by our standards—within the last two years, the first Decadal Survey for Earth Science. Some of the other Space Science disciplines have been doing decadal surveys from the National Academies for some time, but Earth Science had not done that until fairly recently, a couple years ago.

Now we have this on the table, which is the collective wisdom of a large group of very smart people as to what the next generation of measurements ought to be. In some sense, it is the next EOS. They spaced it out over ten years, and they told us, sort of coarsely, which one should come first. Not specifically, not one by one, but in three groups. This group first, this group second, this group third.

That is what we would plan to do. It's clear the minute that the ink dried on it that we don't have the resources to do it, not even in 10 years. If the budget and the resources are increased to EOS-class, $2 billion a year was the number that we talked about before, which is in the decadal survey, then there's hope that we could exercise that roughly in a 10 year or so period. Perhaps longer, but still not too far off from that.

But what it assumed was that the NPOESS system was going to do the things that had been agreed to and worked out. We've got the decadal survey that isn't fully funded. In addition, we've got some breakage from the NPOESS system that we have to figure out how to fix; that's what we're struggling with now.

We think that this administration [President Barack Obama] has clearly demonstrated through its words that they want to dedicate some more resources and focus to Earth Science.

So, we're hopeful that we'll get some support. We'll have to go through a couple of budget cycles to see where exactly we are to get there, but I think the decadal survey provides that road map for us.

If you look at it, it makes sense as the next logical step from EOS, really. A combination of better accuracies, better coverage, more three-dimensional measurements, as we talked about, and adds some knowledge into aerosols and things like that that we've since learned about. Something like that will be the road map that we're going to follow.

WRIGHT: It sounds like good timing for it to come out when it did.

LUTHER: Yes.

WRIGHT: You've talked this afternoon about your experiences and also about Earth System Science experiences. When I was putting some notes together, I was thinking about how Earth System Science has been reshaped and refocused, reprioritized, rebalanced. I guess, if nothing else, it's been resilient. I think you've used the term force of will. How would you characterize it? What propels it? What keeps the momentum of this overall effort moving toward more than just survival, and how has it not been defeated over these last 20 years, with all of the—I think one of the words you used was turmoil. It's gone through its scrapes, and how has it come out to be so successful?

LUTHER: That's an excellent question. I alluded to it, I think, when I first started talking. First and foremost, it's the sheer dedication of the literally thousands of individual people that are engaged in this enterprise. The fact that they believe in it. After all, it's pretty easy, I like to say, to believe that protecting the Earth is a good thing to do. Oh, by the way, you can almost explain it to your mother-in-law. Most of it; so that part is very nice.

But I think a couple of things. One is that the people believe so strongly in it. It has, in fact grown from really an infant, in some sense, to certainly a young adult, if you put it in human terms, in a 20-year period. That's a career. We've got people like myself who were lucky enough to be born at the right time and get engaged, certainly not at the very, very beginning, but when it really got interesting. When people woke up and said, "Hey, Earth Science really is something that's important."

We've had just enough excitement all along the way to keep us from getting too discouraged at the low points. As I kept saying during the refocus, rephasing, and the budget kept going down, the number kept getting smaller, but all along the way, my mantra was constantly, "Well, look, we ought to be able to do something good for," fill-in-the-blank: $10 billion dollars, $9 billion, $8 billion. You just keep reminding yourself, "Yeah, they took another," pick a number, "billion dollars away from us in the last exercise. We still got a lot of money. We're building hardware. We're delivering. We're getting stuff on orbit." It's just the human spirit. You don't want to give up.

I will say that it was rather interesting to see the fact that the New Start for EOS was in '89, the '90 budget. The first really big year, I guess, was '99. It was almost 10 years to go from a New Start to the first big satellite. That was a long time, and it was a struggle. It was because we went through all of those re-plans, re-budgeting, chopping things up. It was just incredible.

In between, as I mentioned, we spun off as a separate entity in terms of within NASA, as a Mission Directorate. We went through a couple of three AAs [Associate Administrators].

Finally, Ghassem Asrar was selected in '98. At the time, he asked me to be his deputy. More or less the same position that I'm in right now. Boy, the next seven years until 2004, when we put the organizations back together and launched Aura, that was when we launched most of those 16 missions.

It wasn't that Ghassem did it, or I did it. It was all the people that spent the 10 years getting there. But there was this huge pent-up capacity that we had built. We were getting it there. It just so happens that it all came spewing out, spread over about six or seven years. All of those spacecraft, instruments, and missions all got delivered and integrated. We put them on rockets, and we got them launched.

It was a very, very intense period right there when we had that capability and had all that frustration. I guess what I'm trying to get across is 10 years, 9 years, whatever it was, of work, and you're not seeing anything go into space to speak of. We were doing a lot of small stuff and Shuttle missions and some things, but you're not really seeing that big EOS thing going up there. But that's what this business is. You have to do that. You struggle, and you get it, and you get it in place, and then finally, when it's right, you launch it. It just so happens that stuff just sort of got pent up.

Boy, when we released it, we were having four, five, six launches a year for the next six years, it seemed like. International partners and all kinds of stuff. It was an amazing pay-off that you could see in your career. That while there was thing long period of frustration and re-planning, and so on, if you hung in there long enough, you got to see the result come out of the end.

Then, as I said, the change in the dialogue, the delivery of the science, change in the public discourse. The timescales we work on are climatological in nature, I guess.

WRIGHT: Well, I believe, on my end, I've covered pretty much of what I wanted to ask you and ask you to share with us. But, I wanted to ask you, too, I know you made some notes, and I'll give you a second to review to see if there is something you'd like to add before we close out today.

LUTHER: Well, you gave me enough time and rope, so to speak, to cover everything, I think. I just want to make a comment. I got to thinking about how many really fascinating and unique experiences I had on almost each and every one of these missions. The partnerships would drive issues out, and you'd have run-ins, and you'd have to work hard, and sleepless nights. But in the end, I made lots of fast friends, both domestically and internationally. I had some funny experiences dealing with the Russians. I laugh about we used to meet with the Russians periodically. Man, those people drink vodka like nobody's business.

WRIGHT: Just something you can't explain unless you've been there, huh?

LUTHER: Right. Just the great people who have come and gone through my career and contributed so much, each and every one of them. That is, in the end, what it's all about.

WRIGHT: Would you like to mention one or two that especially have made an impact on you being able to do what you've accomplished?

LUTHER: Clearly, I owe a huge vote of thanks to Shelby Tilford for picking me to do UARS first, as program manager, when I was just up from the Center and just learning what it was like in D.C. Having that trust in me and letting me run that program. Then, he followed that by picking me to be Flight Program Director when we spun the Earth Science off. That was another huge vote of confidence on his part in my abilities. Getting picked for those kinds of roles is a humbling experience sometimes.

I have to say, Ghassem Asrar, for asking me to be his deputy when he came in. I know, in his case—I don’t know, because I wasn’t actually part of the conversations, but I had enough sense to guess strongly that he had to do battle with Dan Goldin to let him name me in that position, because I think I was perceived to be somebody Goldin wasn’t particularly fond of because I was associated with Shelby. But in the end, I think it was sort of like what Bill said today. I was about the best they could do, so they didn’t have any choice.

So certainly, from a personal standpoint, those people, and quite frankly to Ed Weiler for having the confidence to bring me back to this position. I was in another position under the leadership before Ed. Ed could have not selected me, nobody would have blinked twice, to come back and do this. But he did, and I appreciate that very much, and I’m enjoying it more than I’ve ever enjoyed anything, I think, working with him in this position. Those are the people that I personally owe a vote of thanks to.

Along the way, I could only say that I owe a vote of thanks to every project manager and systems engineer out there who is overseeing the projects that I’ve been charged with worrying about. They’re the ones where the rubber meets the road. They’re the ones that produced it. I've gotten to know a lot of them at different levels. I think we’ve all gotten along pretty darn well, considering things. We've put together, at the highest level, a pretty nice system. We got more to come.

WRIGHT: That's good to hear. Well, thank you so much for all of the great information you shared this afternoon.

LUTHER: Thank you.

[End of Interview]