NASA JOHNSON SPACE CENTER ORAL HISTORY PROJECT
COMMERCIAL CREW & CARGO PROGRAM OFFICE
ORAL HISTORY TRANSCRIPT

ANTONIO L. ELIAS
INTERVIEWED BY REBECCA HACKLER
DULLES, VIRGINIA – 3 JUNE 2013

HACKLER: Today is June 3, 2013. This oral history interview is being conducted with Dr. Antonio Elias at the Headquarters of the Orbital Sciences Corporation in Dulles, Virginia, for the Commercial Crew & Cargo Program Office History Project. The interviewer is Rebecca Hackler, assisted by Rebecca Wright. Dr. Elias serves as Orbital's Executive Vice President, and also as the Chief Technical Officer.

Thank you very much for taking the time to talk to us this morning as we compile a history of the Commercial Orbital Transportation Services [COTS] program. To start off, we'd like to ask you to give us a brief overview of your background and how you came to join Orbital in the 1980s.

ELIAS: I have a terrible memory for dates, however September 2nd, 1986, is a date that will live in infamy, because that's the day that I walked through the doors of Orbital. It was also the day that Orbital went from their first program and headquarters building [in Vienna, Virginia] to their second program and headquarters building [in Fairfax, Virginia]. So everybody was moving in, all 19 of them. I was the 20th through the door.

Let me start at the very beginning. I've always been, even as a young kid, enamored of aircraft and flying, probably more with aircraft and flying than space itself. I've always wanted to be an aeronautical engineer. My father was in the Spanish Foreign Service, so he always

thought I should study in Spain first, which I tried. I did start aeronautical engineering in Spain, and it didn't go too well for me. Kind of a cultural mismatch.

After three or four years of trying hard, I decided to transfer. I applied to this little technical school in the northeast of the United States called MIT [Massachusetts Institute of Technology, Cambridge], and then a miracle occurred and I was accepted. I'm saying this seriously, this is not a joke. Obviously they didn't understand the translation of my grades from the Spanish system to the U.S., otherwise they would have never accepted me. But they did accept me, and I was both very happy and very lucky at MIT. As a matter of fact, I was initially accepted as a sophomore because they were a little bit unsure about my background. After one term I had accumulated enough credits to be reclassified as a junior. After another term I piled up enough numbers to be reclassified as a senior. After a third semester, I graduated.

I was an undergrad at MIT for the grand total of three semesters, although cheating. That is, having started from my background in Spain where I wasn't getting anywhere. I was extraordinarily happy at MIT as an undergrad, so I tried to milk being a student as long as I could. Got into grad [graduate] school, and luck struck again. I got a research assistantship at a place called [Charles Stark] Draper Laboratory.

I actually worked on the very, very, very, very, very tail end of the Apollo Program. I was in the Draper Lab, which had just been renamed from the MIT Instrumentation Laboratory, and I was in the backroom for both the Apollo 16 and 17 flights. And immediately after that, I was assigned to a group that worked on the Space Transportation System, soon to be known as a Space Shuttle, in the original Phase A/B Programs. I was initially supporting the two finalists, McDonnell Douglas [Corporation] in St. Louis [Missouri], and [North American] Rockwell [Corporation] in Downey [California].

Then, good luck struck again. I had this one brilliant idea about a guidance system, which eventually became a part of the Shuttle software design, and that gave me enough brownie points to give me stature at the lab. In 1980 MIT offered me a teaching position, so I was an assistant professor, second class, for six years. MIT decided that they didn't want to give me tenure, so that explains my entry into Orbital. Because there I was, knowing that I had to leave within a year because I wasn't going to get tenure.

I got a phone call from Dave [David W.] Thompson [Orbital founder and CEO (Chief Executive Officer)], and the first words out his mouth sealed the deal. His first words were, "Hi, my name is Dave Thompson. You don't know me, but I know you." How can you say no to anybody who starts a conversation that way? He told me that he was a few years behind me at MIT. We actually never crossed paths because I was, as a grad student, kind of lost in the bowels of the black hole of Draper Laboratory. That tends to isolate you socially from the main campus a little bit. We actually attended a symposium together and we liked each other's style.

Also, I didn't have many other choices or options, quite honestly. That's why I tried Orbital really. That was my next stroke of luck, because nothing would have told me that Orbital itself, and my ability to contribute to Orbital, would have been what it has been. It was totally unplanned, unpredicted, unexpected.

HACKLER: Can you overview briefly how your responsibilities evolved within the company?

ELIAS: Yes. I was hired as the Chief Engineer, and at the time Orbital had only one project. Orbital's role in that project wasn't even highly technical. It was more of a business development and a financial operation. As you probably know, these were the years of the

[President Ronald W.] Reagan commercialization of everything. The three [Orbital] founders conceived a scheme for an upper stage for the Space Shuttle. NASA had planned to develop a set of three that the Shuttle was going to have, and the founders approached NASA and suggested that rather than NASA funding its development, that they allow a private company, Orbital, to find funding for this development stage, then sell it both to NASA and others.

If you remember at the time, the Shuttle was supposed to be *the* national transportation system, therefore spelling the end of the expendable launch vehicles. They found this hungry company in Colorado whose expendable launch vehicle was going to come to an end, i.e., Martin Marietta [Corporation], to do the actual engineering and development of this upper stage. The Orbital team was more of a supervisor and a steward of investment rather than a detailed design. That was my first job.

Then *Challenger* happened [STS 51-L accident], and with *Challenger* the Shuttle no longer became a commercial possibility or alternative. There was a presidential directive that restricted Shuttle flights to government uses, and Orbital's big business went up in smoke overnight. Orbital, all 20 of us, including the receptionist and the assistants, were trying to figure out what to do next. One of the ideas was the development of a constellation of small satellites at low-Earth orbit that could be used—and I'm choosing these words rather accurately—as a signaling network. Not as a communications network, the difference being how much data is being transferred, but also the timing. If you have a burglar alarm system, that's a signaling device, not a communication device. If you have a videophone, that's a communication device, not a signaling device.

This idea of a so-called "remote asset monitoring system" was actually the brainchild of a recently-retired NASA employee, Bob [Robert R.] Lovell, who came to Orbital and suggested

that that was, in his words, "the last cookie left in the satellite communication cookie jar." We started thinking about that commercial development as Orbital's next product, and there was an issue at the time—mind you, this is 1986, 1987—with how to launch and release small spacecraft. We're talking about dozens, maybe three dozen, in low-Earth orbit. Very small, 100 to 150 pounds.

One of my tasks was to look around and see what launch opportunities were available. I went to visit the big guys—General Dynamics [Corporation] that had the Atlas [rocket], and Martin Marietta that still had the Titan [rocket]. With the *Challenger* accident, ELVs [expendable launch vehicles] all of a sudden became useful again. We found it was very, very hard, but there was a small entrepreneurial company in Camarillo, California. George [A.] Koopman's company was called American Rocket Company [AMROC]. They were developing a small launch vehicle. They called and I went to visit them, and there was a bizarre event that happened.

Rather than receiving us with open arms, George Koopman, who was an interesting character, assumed that we were kind of spies that were trying to figure out what they were doing, and literally kicked us out of his office. There were other interesting facts on that famous incident. There were a bunch of other people employed by American Rocket Company at the time who then later had roles either in Orbital history or other history. One of the characters that I met for the first time that ill-fated day in January of 1987 was this guy that sat in a corner by the name of Mike [Michael D.] Griffin. That's how I met Mike, as well as others, but he certainly remembers that meeting.

I came back to Washington [DC], kind of cross filing that there wasn't any obvious way of launching these small spacecraft. Then one of the cofounders, another colleague, and myself

were at this very boring meeting in a hotel which happened to be across the street from where the [National Air and Space Museum] Udvar-Hazy [Center, Chantilly, Virginia] is now. The meeting was so boring that I started doodling on a piece of paper.

The year before, 1986, the Air Force had launched a small rocket out of an [McDonnell Douglas] F-15 [aircraft] and intercepted a satellite, blowing it to smithereens. Much like the Chinese did many, many, many years later from an aircraft. The thought of launching a rocket that could carry a satellite to orbit from an aircraft intrigued me. I sketched it, showed it to my colleagues, and we started talking without realizing we were in the middle of a meeting. Finally we decided the meeting was a lot less interesting than talking about a new launch rocket. We went back to the office, started talking to Dave Thompson and others, and of course that's what became Pegasus.

So my first real, serious role in the company was as the Chief Designer and Chief Technical Officer of Pegasus. I also kind of bluffed my way into being the launch panel operator on the [Boeing] B-52 [Stratofortress bomber] for the first launch. Being a B-52, we immediately thought of the famous movie *Dr. Strangelove* [*or: How I Learned to Stop Worrying and Love the Bomb*]. It became the official Orbital movie. Some of us even knew the script by heart, and we would repeat the script while watching it.

A couple of days before the first launch of Pegasus, while the first flight units were still unpainted, Dave Thompson showed up at NASA Dryden [Flight] Research Center [California], where we were sending the rocket, with a 10-gallon [cowboy] hat. I went, "Oh, no," and he went, "Oh, yes." So sure enough, there's this picture of *moi* with a flight suit, holding the hat like Major [T. J. "King"] Kong going down with the H [hydrogen]-bomb.

Anyway, that was an amazing program and shortly after that, actually during the Pegasus program, they rewarded me with the vice presidency. I was Orbital's first Vice President of Engineering. After that I did a number of things. I was, for a while, the Vice President of Programs, while we were still a few hundred people and had $100 million a year revenue.

When Mike Griffin joined the company, Mike and I did at least a couple, if not three, musical chairs. He started off as Chief Technical Officer and I was VP [Vice President] of Programs, and then he took the VP of Programs and I was Chief Technical Officer—which happens to be a title I have right now. So I think about it this way, ever since I joined Orbital I haven't really had a promotion. I mean, I'm in still the same job that I had when I joined 27 years ago.

Mike and I traded jobs, then he left and I started a small group called the Advanced Programs Group. This was 15 years ago, '97. That program grew mostly to develop the X-34 [aircraft], the research vehicle for NASA. The Advanced Programs Group started to give a home to the program. As time evolved, that group was chartered with expanding Orbital's market into two areas that it had not participated in before. One was human spaceflight, and the other was national security space. By that I mean the satellites and satellite systems that both the [Department of] Defense as well as the intelligence community buy from industry, and the big companies.

That group grew from just a single program and miniscule size, tens of millions of dollars a year, to eventually becoming the same size as the other two groups the company had, the group that built all of their satellites, and a group that built all of the rockets, including the Pegasus that I had started back in the '80s. That job lasted 15 years, more than any job should last in my

opinion. So last fall, Dave and I agreed—actually I'd asked Dave for two years—that it probably would be a good idea to have somebody else do what I was doing. Last fall we did that.

I became the Chief Technical Officer of the company, a job that arguably I had had in the past, at least in title. Being the CTO of a $100 million a year company and being the CTO in a $1.5 billion a year company is different, but CTO nonetheless. Then somebody, if not younger, at least fresher than me managed the Advanced Programs Group. That's Frank [L.] Culbertson, the former astronaut. I think that summarizes my career path and what I did to date.

HACKLER: Thank you, that's a pretty good overview. Just out of curiosity, did you work with George [C.] Nield [Federal Aviation Administration Associate (FAA) Administrator for Commercial Space Transportation] when he was at Orbital?

ELIAS: I most certainly did. George Nield I think joined us about the time that the X-34 program started. I think he was one of the original Advanced Program Groups. It was a roster of about 70 people that included George Nield, Bill [William A.] Wrobel, who's now the [NASA] Wallops [Flight] Facility Director [Wallops Island, Virginia], and it included Frank [T.] Bellinger, in SES [Senior Executive Service] right now working at Wallops. A number of interesting directors.

HACKLER: Do you still work with him through the FAA Office of Commercial Space Transportation? Is that a relationship you've been able to maintain?

ELIAS: We bump into each other occasionally. He's also an AIAA [American Institute of Aeronautics and Astronautics] fellow, so we see each other every year at the fellows' dinner. I bumped into him—for instance when we were both at one of Burt [Elbert L.] Rutan's first little bunny hops, the SpaceShipOne [suborbital spaceplane] flights. We see each other probably more socially than professionally, because the relationships between the [Code] 700 [FAA Office of Commercial Space Transportation] and Orbital are very intense at the working level. Only occasionally we bump into each other. But we do we recognize each other, and we still remember the old days.

HACKLER: Going back to the origins of the COTS program, when do you remember first hearing about NASA's plan to use commercial services to resupply the [International] Space Station [ISS]?

ELIAS: Ever since we developed Pegasus we had been bugging NASA to do that. As a matter of fact, we made several unsolicited proposals to use Pegasus, because of its air-launch and low-cost attributes, as a way to bring small but very high-value cargo to the Space Station on very short notice. NASA listened to us patiently, but pointed out that the size of Pegasus and the frequency with which the Space Station—in the beginning, I'm talking about the early versions of the Space Station, not necessarily the ISS. It was back when Space Station Alpha and all those programs were going on. They pointed out that the actual need for a few hundred pounds of something next week was something that NASA had not bumped into.

We were thinking of a commercial resupply service more in terms of timeliness and response than in terms of bulk, because the bulk of the supply was being handled by the Shuttle,

thank you very much. We were constantly interacting with NASA on those issues, so when the first COTS initiatives were starting to become formulated, we were constantly in touch with NASA about what was going on. As soon as there was a formal RFI [Request for Information] out, we responded. As soon as there was a formal RFP [Request for Proposals] out, we responded. As a matter of fact, I brought with me our response to the 2006 original COTS competition in which we were not selected [demonstrates]. It's very hard to say when we first became aware, because we were constantly pestering them about that. It was a constant dialogue with NASA.

HACKLER: Can you talk about your role in developing that proposal and the design of the vehicles?

ELIAS: This particular proposal was not successful. It was submitted by the Advanced Programs Group, so I'm listed on the table of organizations and the head of the organization that would have executed the contract. This was when Scott [J. "Doc"] Horowitz was the [NASA] Associate Administrator [for the Exploration Systems Missions Directorate]. On the design of the system itself, my opinion on how to offer the services was not the one that was eventually selected. I did participate somehow, but the offering had two components, a new launch vehicle and a spacecraft.

On the new launch vehicle side, 2006 was about the time when rumblings of the impending demise of the Delta II [rocket] were first starting to be formulated. Delta II has been a workhorse of U.S. launch [services], originally developed at [NASA] Goddard [Space Flight Center, Greenbelt, Maryland] but then extended throughout the government community,

including DoD [Department of Defense]. Perhaps its most stellar program was launching the early GPS [Global Positioning System] constellations, both the first and the second one. It was an old design and it suffered from some of the same problems that the good old small NASA launch vehicle, Scout, had when Pegasus replaced Scout.

Our initial interest in also building national security satellites was threatened by the demise of Delta because our forte, and quite honestly the only size spacecraft that Orbital would be competitive in, were spacecraft the size that Delta could launch. Whereas if Delta disappeared and the only launch vehicles our community used were the bigger ones, the ones that Boeing and Lockheed produced, those would naturally launch much larger spacecraft. The other established launch companies were much more competitive in building billion-dollar national security spacecraft than we were.

We saw the demise of Delta as a threat to Orbital's future and its future in the national security arena, as well as in things such as Space Station resupply. We embarked on this program that eventually resulted in the Antares launch vehicle, partly to satisfy the requirements of the original COTS solicitation, partly as a defensive move to make sure that the government had a Delta II replacement. I did have some hand in the configuration of the rocket, however we had been convinced that our credibility in the development of a spacecraft able to rendezvous with the Space Station was so low that unless we did something like what we did in this proposal, which was go to the Russians and buy Soyuz spacecraft, then we would not be considered credible. Indeed, this proposal assumed the use of a modified Soyuz spacecraft.

As you probably know, we were not selected. SpaceX [Space Exploration Technologies Corp.] and a company called Rocketplane Kistler were selected. Soon after though, Rocketplane Kistler came to us to ask us to be their engineering talent pool for their system. It turns out that

we had previously evaluated the Rocketplane Kistler concept because we thought that perhaps instead of developing our own Delta II replacement we could avail ourselves of the Rocketplane Kistler system, and therefore still be able to launch Delta II-class spacecraft without having to develop a new rocket.

Believe it or not, when you have to put your own money behind it, you don't develop a new launch vehicle because it's fun. It is, but you have to have a substantial business reason. We were looking at alternatives, and when we evaluated the Rocketplane Kistler concept, in spite of the amazing authority that the organization and George [E.] Mueller had—George Mueller, one of legends of the Apollo Program—in spite of George Mueller himself, that program had so many questionable characteristics that we shied away from it. So it was with great surprise when they came back to us and asked us to be their lead systems house.

We looked at what they had committed themselves to do under COTS and the resources they had, and it just didn't click, it didn't compute. We suggested to them that they tone down their commitments to NASA to try and fit within the financial bread box that they were in. And of course they felt that they couldn't do that. They had committed to do something, they could not go back. So eventually the sword fell on them and they were unable to find the financial resources to do what they had committed to. By that time NASA had already given them $30 million, but it was the nature of the Space Act Agreement that either party could go away at any time with no hard feelings. NASA went away having spent $30 million, and Rocketplane Kistler kind of disappeared.

NASA reopened the COTS competition, of course with $30 million less. Then we rebid, and on the rebid I was successful in pushing through my concept for the spacecraft, which has an important characteristic. On the COTS solicitation, NASA specified that they were interested in

three types of cargo to be carried to and in one case from the Space Station: pressurized cargo, unpressurized cargo, and return cargo. Both the original Orbital proposal based on the Soyuz spacecraft, as well as the SpaceX proposal, proposed the use of a single spacecraft able to perform all three types of cargo transportation services.

The only problem with that approach is that for a spacecraft capable of doing all three things to be even vaguely efficient, you have to have a pretty good idea of what the ratio of amounts of cargo of each type—any one flight, or all of the flights—would have. If it turns out that pressurized cargo ends up being twice what you thought it was going to be, and return cargo half of what you thought it was going to be, then all of a sudden your spacecraft is very inefficient because you're carrying up all this return capability that you don't really need.

So my approach was to develop a unit, a hockey puck, that contained all of the spacecraft devices and systems—propulsion, electrical power, avionics, communication, etc.—and that hockey puck would be attachable to one of three different types of cargo-holding devices. So that on any one flight you would ask the customer, "Hey NASA, would you like pressurized cargo on this flight, or outside cargo, or return cargo?" Then you are able to match the unknown future demand simply by adjusting how many of the flights use the pressurized cargo can, versus how many of the flights use the unpressurized platform that carries external, versus how many carry a capsule that, because it's a reentry vehicle weighs a lot so you can carry less cargo. That's the fundamental architecture. That was my concept, my design.

As it turned out, when we were successful in being selected as the replacement for Rocketplane Kistler, NASA gave us an initial order for eight flights, all of them pressurized cargo [under the Commercial Resupply Services contract]. Counting on the fact that SpaceX has the return capability, obviously the ratio of pressurized cargo to the other kind of stuff was

different from what they thought originally. Thank goodness we had this approach where we could offer them, if they so wanted, all pressurized cargo.

That was my role in the recompete. Similar to the original competition, the proposal was submitted by the Advanced Programs Group, so I was listed in the proposal as the head of the organization. I think on the original proposal Dave Thompson signed the proposal letter to Scott, and I signed the proposal letter for the recompete.

HACKLER: What sort of discussions and negotiations did you go through with NASA in the course of that COTS competition, the second round?

ELIAS: It was a Space Act Agreement, so it was not subject to the normal due process that a FAR [Federal Acquisition Regulation], a regular contract has between the government and a private company. There were a number of rather informal exchanges between C3PO, the Commercial Crew & Cargo Program Office headed by Alan [J.] Lindenmoyer, and a group of both internal and NASA team members, as well as some consultants that they had. They came to visit us and we gave them oral presentations on our approach, and then we had an afternoon session one day where they wanted to explore how we were going to finance this caper. Their previous failure, Rocketplane Kistler—some people can say they were trying for too much technically. In other words it was several bridges too far technically, but mostly it failed because there was no way they could raise the amount of money that they needed to do that.

They kept asking us questions about how we would raise the money, and we kept answering that we didn't have to, that we had the money in the bank. For some reason, that message took two or three repetitions to sink in. When it finally sank in to Alan Lindenmoyer

and his financial consultant, it was like a eureka moment. Their eyes kind of, "Oh, you mean you're not going to go out to the market?" I said, "No no, look at our financial statements. We have the money in the bank to do it." It was as if this huge load had been lifted, a sigh of relief. All of a sudden the great black cloud on top of the COTS program had been released. That was perhaps the key interaction.

Who was the Source Selection Authority for that? I think it was still Scott Horowitz.

WRIGHT: It was Doug [Douglas R.] Cooke the second round.

ELIAS: You're right, yes. I'm not sure there was an explanation of selection, because the Space Act Agreement is a lot more flexible than the regular one. My personal feeling—we're talking about feelings here—is that setting aside all technicalities, the single biggest reason why they selected us in the second round of COTS is that we didn't have any financial risk, and they had just been burned badly by an organization that essentially didn't have a lot of substance from the financial standpoint.

HACKLER: Earlier we talked a little bit about George Nield and the FAA Office of Commercial Space Transportation. You also worked with the ISS Program Office and their visiting vehicle requirements. Can you share with us about your relationship with that NASA group?

ELIAS: Certainly. Both for them and for us, it was kind of a new experience. We started with a little bit of a head start because we had a number of people, starting with [G.] David Low at the time, soon joined by others, that had substantial Space Station and NASA experience. I myself,

as I mentioned, worked on both the Apollo Program and the Space Shuttle, so we knew that the process of gaining confidence for spacecraft to operate near the Space Station was something that was very hard to codify in a document like the famous IRD [Interface Requirements Document].

The IRD was probably an initial attempt at explaining what operating near the Space Station and human spaceflight was to somebody who had no background experience, kind of trying to simplify things. In that sense we of course read the IRD very carefully, but we soon realized that that was just a framework, and you actually had to do a lot more than simply check the boxes on that IRD.

We were initially a little naïve in how we approached the issue of avionics redundancy. We thought we could reuse a lot of what we had from other spacecraft programs. As we attempted to do that, we ended up with an avionics architecture which was hopelessly complex. And much to our amazement, the folks down at the ISS Program Office started suggesting to us ways in which we could simplify the problem a lot, at the expense of abandoning some of the products and devices that we already had. The trade was, "The good news is you can do this in a lot simpler way. The bad news is you're going to have to develop some new stuff to do it a simpler way."

The relationship started very well, in the sense that there was obviously a desire by the program office to help us and make us succeed. At the same time it was obvious to us that the program office itself was kind of trying to figure out what to do with this beast. I think the relationship was one of—I don't want to say the blind leading the blind, that's an exaggeration—but of two organizations. One that knew a lot about commercial low-cost space, the other that

knew a lot about traditional government procurement and tests, and both trying to find a way to do things in a satisfactory way.

There was a lot of iteration, but overall—we haven't approached the Space Station yet, but we've gone through a lot of mission simulations and all of the avionics in the spacecraft have talked to all of the avionics in the Space Station. So far things are looking very, very promising. The people I'm talking about are the bigger Space Station Program Office. The COTS program office in particular, my view is that their main role and their main utility was as a lubricant for this machinery that is the ISS Program Office and the Orbital Cygnus—that's the name of our spacecraft—to mesh together without grinding and without noises. So that's part of what they did, and in that role they've been extraordinarily effective.

Their other role has been one of identifying and marshaling the ordinary NASA resources, outside of the Space Station office, that could somehow help the combined NASA Space Station office, Orbital, COTS program to work. For instance, on the first launch of Antares, they scrounged unique devices to for instance measure the sound environment around the rocket to characterize the environment around the rocket that the spacecraft will experience during launch.

Some unique high-speed tracking cameras with which we could follow the flight—and thank goodness nothing bad happened. As a matter of fact, everything went amazingly well, but had we had any anomaly, that high-speed imagery would have been priceless. That's a little bit of what the specific that the NASA JSC COTS program office did for us, and still does.

HACKLER: I know there are many more areas where I'd like to pick your brain, but I'd like to ask Rebecca Wright if she has any topics she'd like to ask you about.

WRIGHT: I was just going to ask one. You also developed this partnership with the Mid-Atlantic Regional Spaceport [MARS, Wallops Island, Virginia]. Tell us why you feel that was such a value to Orbital, and for future space launches.

ELIAS: Not any single reason, but a variety of reasons combined. I think I like to claim paternity of the idea of using Wallops. There was certainly a political element, I must be frank about that. At the time we had been very close to [Maryland] Senator [Barbara A.] Mikulski's office. She has been always a great friend of Orbital, dating from the time when one of our groups was actually headquartered in Maryland. She was also a friend of Wallops. There was a certain political element, but that by itself probably did not have sufficient cause for me to suggest or for the rest of the team to concur in the selection of Wallops.

Because Wallops has a lot of drawbacks. It is underdeveloped compared with, say, the Florida coast, that has all sorts of facilities and supplies and transportation. Wallops was, and probably still is, rather underdeveloped. On the other hand, we had had a very positive experience dealing with Wallops [Flight Facility] as a launch range for several Pegasus flights. I think at the time we were about to have a Minotaur flight from there. We knew that Wallops as an organization, because of its size and its culture, was closer to what Orbital is as a company, organization, culture, and so on.

Also, at the time Florida had kind of been taken by storm by SpaceX, but still it offered a lot of advantages. It certainly was easier to transport things through Florida than it was to transport things to Wallops. Florida had an existing infrastructure. Perhaps the pebble that tilted the balance in the direction of Wallops was we wanted some financial help from the various

states' space-promoting organizations. Space Florida, in the case of Florida, and the Mid-Atlantic Regional Spaceport in the case of theoretically the combined Commonwealth of Virginia and State of Maryland—but the Commonwealth of Virginia is the 800-pound gorilla in that partnership. So most of the help that we could get from MARS really had to come from Richmond [Virginia] and not from Annapolis [Maryland].

Both organizations proposed to us the funding of the new infrastructure that would be required, either at Wallops in the case of MARS, or Florida in the case of Space Florida. Space Florida was going through a transition period, both in their leadership as well as in their relationship with the state. Essentially the proposal they presented to us required really a financial miracle, very similar to what NASA found in their hands with Rocketplane Kistler. They were going to go to this investment bank, which were going to give the organization a loan. Whereas MARS at the time proposed to us direct funding from the Commonwealth. The Commonwealth would issue some bonds which I think were tax free, and those bonds would be used to fund MARS.

So that, plus the geographic proximity, plus the political support, plus the good experience. We've operated from the Eastern Range in Florida, we've operated from Wallops, we've operated from Vandenberg [Air Force Base, California], we've operated from Kwajalein [Marshall Islands]. I mean, we have a lot of experience with ranges. My analogy was that in Florida, at the Eastern test range we would be the 200-pound spider monkey. If we operated out of Vandenberg we'd be the 200-pound chimp. If we operated out of Wallops we'd be the 200-pound gorilla, in that we would own the range and their priorities and attention.

It has happened, although right now we're faced with a rather ironic circumstance. We do have a range conflict at Wallops—between two Orbital flights! The one to the Space Station

this fall, and the one to the Moon, the LADEE [Lunar Atmosphere and Dust Environment Explorer] Program. And the NASA LADEE office and the NASA Space Station office are at odds. I think each one thinks they have priority. So sometimes you have to be careful what you wish for. All of these things put together made us decide in favor of Wallops and MARS.

HACKLER: We don't want to take up all of your time this morning. Could you share with us, what do you feel was the biggest challenge for you in developing these vehicles for ISS resupply?

ELIAS: If your question is specifically limited to the vehicles, you probably know that the availability and supply of these AJ-26 engines is an issue. We originally thought that the inventory that Aerojet had accumulated in Sacramento [California] would have had a much higher yield than it appears to be having. Then, on the spacecraft side, I already mentioned the avionics development. We did have a false start and we had to recover from that. I'm happy to report that I think the recovery worked.

However, both of these vehicle issues were overshadowed by the unexpected and, in retrospect, kind of pedestrian problems that we've had in setting up the launch pad and the fuel farm. There was nothing wrong with the equipment or design, but implementation had a lot of issues. Bad welds, valves that didn't work, resonances in the fueling system that caused it not to operate. The problem with all of these developments is that one tiny little thing can delay this much bigger development. So I'd say that the number one challenge we had was setting up the launch pad and the fueling system, and the origin of those problems was not as good an

engineering job, both in the design and the actual construction, as we did on the rocket and the spacecraft.

WRIGHT: We do want to ask—we were talking to Mr. Thompson about the [fiscal year 2011 C3PO budget] augmentation. It's rare to have someone say, "I think we're going to have more money for you, would you like to have it?" Could you share with us how you learned about that?

ELIAS: We learned that SpaceX had asked for more money, so we essentially went and said, "Wait a minute, you're already giving us much less money than you gave SpaceX. Now you're going to give them more money without giving something to us?"

NASA said, "You guys are right. So what do you propose doing?"

I said, "Well, given the breadbox of money that you guys gave us with COTS originally, all we thought we could do with the NASA money and our own money was one demo [demonstration] flight." And that first flight carries a spacecraft.

SpaceX, on the other hand, had promised three flights, for a little bit more money admittedly. When we heard that SpaceX was going to propose a reduction in the number of flights from three to two in exchange for $100 million more, we said, "How about if we give you one extra flight for $100 million, and that flight will not carry spacecraft, it will just be a flight of the rocket itself?"

NASA said, "That sounds like a really good idea," and that was the deal.

HACKLER: Thank you. Are there any last thoughts or reflections you'd like to share about your work with the COTS program?

ELIAS: No, just a reminder to everybody that we haven't rendezvoused with Space Station yet, and to paraphrase opera, the play isn't over until the fat lady sings.

HACKLER: We certainly wish you the best of luck. Thank you.

WRIGHT: Thank you.

[End of interview]