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COMMERCIAL CREW & CARGO PROGRAM OFFICE
ORAL HISTORY TRANSCRIPT

FRANK CULBERTSON
INTERVIEWED BY REBECCA WRIGHT
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WRIGHT: Today is June 4, 2013. This oral history interview is being conducted with Frank Culbertson at the Headquarters of the Orbital Sciences Corporation in Dulles, Virginia, for the Commercial Crew & Cargo Program Office History Project. Interviewer is Rebecca Wright, with Rebecca Hackler.

Mr. Culbertson serves as the company's Executive Vice President and is also General Manager of Orbital's Advanced Programs Group. He is responsible for the execution, business development, and financial performance of the company's human spaceflight and national security satellite activities. Thanks again for taking time out of a very busy morning.

We know that you spent about 18 years with NASA before you left the space agency and went on to another career. Could you share with us briefly where that took you, how you ended up with Orbital, and why you chose to be here?

CULBERTSON: I left NASA in August of 2002 and went with SAIC [Science Applications International Corporation]. My first job with them was Program Manager for the safety contract at Johnson Space Center, which supported all the [Space] Shuttle and [International Space] Station operations. It had about 550 people on the program at that time, but it's much smaller now with the retirement of the Shuttle.

I spent a couple of years in that job, then I moved on to be the business unit manager for all the NASA human spaceflight business, as well as some of the environmental sciences such as the National Data Buoy Center, the atmospheric research, things like that that SAIC was doing. Then I spent a year as the Program Director for all of the global climate change programs in the company.

I left SAIC in 2008 and joined Orbital in August of 2008, and I've been here ever since. Initially I was Deputy General Manager responsible for all the human spaceflight systems in the company, including the cargo resupply service, and efforts that we made in other areas. Then, last September, I was asked to take over the whole business unit, the Advanced Programs Group, as General Manager. I still have the human spaceflight, and it also includes all of our national security space systems.

WRIGHT: Busy man. Today we'll only talk about one piece of it. When you came here, the work had already begun on the COTS [Commercial Orbital Transportation Services] program. Tell us what your first thoughts were, because this is a different way of doing business with the government.

CULBERTSON: Right. I'd actually been exposed to it a couple of years prior, when [G.] David Low was here. He was managing the effort to try to capture that business on the first round of COTS awards under the Space Act Agreement.

Orbital had a plan, that he had shared with me a little bit, and we were actually subcontracted to them for a piece of the work on the safety side. That was to provide cargo delivery based on a Russian system, similar to a Progress [spacecraft], but still using the Antares,

what was then called the Taurus II launch vehicle. Orbital had begun development of the Taurus II on its own, prior to any cargo efforts, because we saw the need for a medium-class launch vehicle to replace the Delta II that was being retired.

Orbital was not selected on the first round of COTS. SpaceX [Space Exploration Technologies Corp.] and Rocketplane Kistler were selected, and about a year later, RpK did not meet their milestones and NASA dropped them. It's a lot more complicated than that, but that's it in a nutshell. NASA had already spent about $32 million on them, so they had the amount that they had initially given to them and SpaceX, minus $32 available. Orbital put in another bid and was then selected for the COTS demo [demonstration] mission. Because of the lower amount of money and the shortened timeline that they wanted us to attempt to achieve, we only planned on doing one demo mission prior to beginning any cargo delivery, assuming that a contract would be let at some point.

We started almost two years behind SpaceX in developing the on-orbit system. This was in February of 2008, and then when I came on board in August we had already submitted the first round of proposals on the cargo [Commercial] Resupply Services [contract]. They there were doing best and final, and I was involved in some of the final reviews on that. We submitted in October, and then were selected in December for the actual cargo resupply service, along with SpaceX. There was a protest by a third competitor that went on for quite a while, but finally was resolved in our favor. In the meantime, NASA had us continue working. They had the option to either stop work or continue work, but because of the fact that they really wanted cargo capability, they told us to go ahead and continue.

They were going at some risk, but it all worked out in the end. At the time that they awarded us the contract, our plan was to fly an Unpressurized Cargo Module [UPCM], because it

was a little less expensive to demonstrate the capability to approach the Station and do a good rendezvous using our Service Module with an empty UPCM on the front end. When they awarded us the contract, all of our flights, our missions, were for pressurized cargo. At that time, after a lot of discussion internally and some with NASA, we decided to change our plan from Unpressurized to a Pressurized Cargo Module on the demo mission, which required some investment on the company's part. We felt that that was what we were going to be delivering, so we needed to demonstrate it on the first mission.

We worked with our supplier, Thales Alenia [Space], in Torino, Italy, and started the work on the PCM [Pressurized Cargo Module]. The Service Module itself is kind of the heart of the system, and that has been developed here at Orbital, based somewhat on our legacy of geostationary satellites that we've built for many years. It turns out it's a lot more complicated and a slightly different design, but some of the basics, such as propulsion and power systems, are similar to our geos.

That development was ongoing, and so we basically had three things occurring at the same time. One was the spacecraft development, essentially what the Space Act Agreement was covering was development of the spacecraft. That initial amount was $170 million, and then Orbital's investment was going to be everything beyond that. Earlier on, it was a much smaller number than it is now. The rocket [Taurus II/Antares] was being built under Orbital's own internal research and development funds, and that's grown over time too, and of course the schedule is stretched out. Then, the third piece of the puzzle was the launch site itself.

Before I came on board, Orbital had selected Wallops Flight Facility or Wallops Island [Virginia] as the launch site, after doing a basic competition between Virginia and the State of Florida on the commercial launch facilities. We were basically required by the Space Act

Agreement to do the negotiations and come with that capability, but we were starting from a green field. There was a slab of concrete where we were intending to launch from, and that was pretty much it. Working with the Mid-Atlantic Regional Spaceport [MARS]—which is under the Virginia [Commercial] Spaceflight Authority, who had hoped to bring in Maryland and North Carolina and Delaware and other Mid-Atlantic states, and Wallops Island and NASA, and with some support from Congress—we began the effort on developing the pad.

It was the responsibility of MARS, as we call it, to actually develop and build and test the pad, but we worked hand-in-hand with them because it was designed to support our rocket initially. Now it's designed to support multiple versions, multiple users. Right now we're the only user, so they've been focused on our needs. NASA was supportive of this because they were going to get a new liquid rocket launch capability out of it, a new launch pad on the East Coast that theoretically would not be conflicting with anything in Florida, but would give the country another site to launch medium-class rockets from.

They built the Horizontal Integration Facility, which initially was going to be a MARS facility but NASA decided they would do that and own it, and they still do own it. We provided a lot of engineering support and actually some investment on our side in the pad. All of that's a matter of record, but it became a fairly complicated three-way management process that we had to work through. You had senior people on all three sides that were trying to influence things and move things forward. For the most part, people worked together fairly well, but whenever you're worried about money and budgets are growing, you end up eventually getting down to the last few million dollars, and who's going to pay for that? So, we had a lot of intense discussions over the last few years. The schedule at the pad ended up driving the program more than anything else.

There were other issues we were having to work at the same time, but they were masked somewhat by the pad issues. The pad ended up being the long pole. We probably ended up about two years beyond our initial estimate of first launch, maybe a year and a half, by the time we finally launched. A lot of that had to do with designing the fueling system, which turned out to be a lot more complex than folks had estimated on the Virginia side for the liquid oxygen, the kerosene, all of the gases such as helium and nitrogen that had to control the systems and provide pressurization. It's all controlled by software, it has to all happen on a schedule at a certain time, in a certain sequence, at the right temperature, the right pressure, etc. It's fairly complicated, and that had to go through a lot of testing.

In the meantime, we were working issues with the rocket itself. The engines that we are using are AJ-26 engines that were originally built in Russia by a company called NDK, then SNTK, and now Kuznetsov [Design Bureau], who developed this engine for the N-1 Moon rocket that the Soviets were building back in the '60s. It was going to have 40 of them at a time on the rocket. It had four launches but no successful flights, primarily due to structural and guidance issues, not due to the engine.

The engine is actually one of the most highly-tested in terms of total test time of any engine that's ever been built, in terms of thousands of seconds of testing, really hours of testing. It's fairly well understood, and seemed to be robust. It certainly had enough thrust for two of them to provide us our access to orbit. Aerojet bought 37 of them back in the '90s, and they were originally going to be used by Kistler on their planned launch vehicle. One of them was actually tested fairly extensively for that purpose, but then they went under and the engines were put in storage.

After evaluating all options, Orbital decided that these were the most readily-available engines in the U.S. because there was no U.S. manufacturer building engines in this class anymore, which is unfortunate. The only other competing engine is being used by ULA [United Launch Alliance] under the import license of RD AMROSS and Pratt & Whitney [Rocketdyne] on the Atlas V [rocket]. They have established an exclusive right to those engines so nobody else is allowed to use them, which makes it difficult to compete. That's a whole other story you could evaluate.

Aerojet began bringing the engines out of storage, refurbishing them, adding the components to Americanize them basically, such as thrust-vector control, and electronic throttle control. We began testing them at [NASA] Stennis Space Center [Mississippi], which we also had a [reimbursable] Space Act Agreement with for engine acceptance testing. I believe it was the fourth one that we were taking through the tests when we had a test failure, and the fuel manifold line basically split apart. We shut the engine down immediately, so there was no significant damage to the test stand or even to the engine itself, except for that manifold line.

That was a major issue for us, and it turned out that that engine had a crack in it that was not detected by Aerojet. It resulted in stress corrosion cracking that grew under pressure, and it basically unpeeled the pipe and spilled fuel, which caused a small fire but no major damage. That of course brought the test program to a stop, and we spent a lot of time evaluating and then doing some additional tests in Russia.

Actually, before that we had a test failure in Russia on a similar engine, not exactly the same. They were testing at a high power setting and we believed, due to an instability in the fuel control, they ended up having a turbo pump separate from the engine. However, that was prior, and then they fixed that problem, and then we went on with our testing. The engines have had

some issues going forward, but we and Aerojet worked together to come up with a nondestructive evaluation program where we do X-rays and eddy current inspections, ultrasound inspections, to find where the cracks are. Then they're repaired by welding.

So far the welded engines have performed fine, and they appear to have found all the cracks in the ones that have any. One or two engines came through clean, but most of them have at least one or two cracks that have to be repaired, just in the interest of caution, to be conservative. That set us back a little bit in the engine development program, but we got back on track and the cores began arriving from the Ukraine. They were built by Yuzhnoye [Design Office] and Yuzhmash [A.M. Makarov Yuzhny Machine-Building Plant], which are the Ukrainian companies that built the Zenit [rocket] and also built a number of ICBMs [Intercontinental Ballistic Missiles] for the Soviet government back in the '60s and '70s. They built the missiles that caused the Cuban Missile Crisis, just as a historical fact.

WRIGHT: Thank you for that.

CULBERTSON: At any rate, they worked closely with us to make sure that the systems all worked together and did their own testing and delivered a good product. They began arriving by large cargo ship into Wilmington, Delaware. The whole process of getting those cores, which are probably close to 100 feet long and four meters in diameter, through Delaware and Maryland down to Virginia is quite an operation in itself, and probably worth a whole article. In fact, there have been some articles written about it because it's an Articulated Lowboy [truck] that has to be steered around corners with a rear steering wheel and a front steering wheel. These guys are

very good at it, but they go very slow through these little towns, and they do not go on the freeways. It's quite an entertainment factor for the locals there.

That's worked out, and we now have, including the one that we just launched—I believe we now have five cores in the country. As all of that was going on, in parallel, we were continuing to develop and built the Cygnus spacecraft. The Pressurized Cargo Module went very smoothly, working with Thales Alenia [Space], and they began building them right away.

We placed all nine of them on order right away. They just started building them on the right frequency, and they've done a really good job with them. The first one actually arrived almost two years ago at Wallops, and it's sat in storage since then. The service module itself, as I said, was based on our prior satellites, but much more complex. Like the Shuttle, it had to have significant redundancy, at least triple if not quad [quadruple] in some cases, because it needed to be human-rated in the vicinity of the Space Station.

It was planned to do an autonomous rendezvous. We would monitor it of course, as would NASA, fly up the R-bar [vector from Station to the center of the Earth] to the Space Station under its own control, and then stop 10 meters from the Station automatically. All of that had to be redundant and very carefully managed, so it required a lot of testing. The design had to be reworked a couple of times, as we discovered how complex this was compared to everything Orbital had done in the past. We kept NASA in the loop on everything we were doing. We were perfectly transparent to them. They attended all our reviews, and occasionally we would have helpful comments and suggestions. Occasionally, we would go to them for consultation if we ran into a difficult problem.

Along the way we had to brief a number of reviewing panels, such as the ASAP [Aerospace Safety Advisory Panel] and the NAC [NASA Advisory Council] and other safety

groups and review panels, but we did not have the same level of oversight that NASA would normally have on a NASA-owned program. We own the spacecraft and the design, and we were going to provide them with a service. They had a great deal of interest in how it operated near the Station, of course.

In fact, they had a lot of interest in how it operated from beginning to end, but early on in my job overseeing all of this, I had several discussions with senior NASA folks and mid-level folks about, "I appreciate your suggestions, but it's our design, and we'll make our own decisions on the PDR [Preliminary Design Review] and CDR [Critical Design Review] and decide what's the safest, most efficient, and cost-effective approach. Thanks for your input."

WRIGHT: Was that a defining moment between the Space Act Agreement, compared to a traditional contract?

CULBERTSON: This was still during the development for the Space Act Agreement because again, it was our spacecraft, not theirs. As they like to say, they were an investor in it, and so they had a vested interest. They wanted us to succeed so that we could begin delivering hardware, but at no time was it ever intended for any of this hardware to be handed over to NASA like we would in the past. Even satellite science, our communications satellites, are delivered to the customer on-orbit, and there's signatures associated with that.

This one is never delivered to anybody, we just deliver the cargo. It's the same as putting a package on a UPS [United Parcel Service] truck and having it go to somebody's house. You don't ever own the truck, you just count on the package getting there. That was a defining

moment where we had to make sure everybody understood their own boundaries and what was appropriate and what wasn't. It's worked very well.

Alan [J.] Lindenmoyer's [Commercial Crew and Cargo Program] Office, particularly Bruce [A.] Manners [NASA COTS Project Executive], have been great to work with. They are very similar to the Shuttle-Mir Program Office in that they're very small, they're very focused on what they need to do, they don't have a lot of bureaucracy associated with what they're doing. They're very good at listening and providing advice and insight, but they don't interfere, particularly once we set the rules.

The ISS Program is like the ISS Program was to the Shuttle-Mir Office, in that it's much larger with a lot more attempts to be involved, and of course a lot more requirements to meet. They started imposing themselves early on because the demo was going to the Station, and we did have to meet their requirements. They are a much bigger bureaucracy, but still very good to work with and have been very helpful. Kathy [Kathryn L.] Lueders was the [Transportation Integration Office] Program Manager on their side, until she moved to a new job, and now Dan [Daniel W.] Hartman is there. They both have been very easy to work with, and we're all pulling in the same direction on all of this.

They have a contract they have to manage, and we have to manage our side of it. We occasionally get into the normal business disputes over things, but it's not acrimonious by any means. As we went through the development of the Cygnus, there were always challenges, and lots and lots of testing that had to go on, and problems to overcome such as sticky latch valves, software that didn't work exactly right. We had some graduation exercises we had to get through in order to say that, yes, we really were ready to go to the ISS, including joint tests with

the NASA simulators, with our system, our actual hardware, to ensure that it all played together and operated as designed.

Then, we had to get through the Safety Review Panel [SRP]. As a vehicle carrying payloads to the Station, we had to satisfy all their requirements. Eighty percent of the effort to get through the SRP was based on collision hazard and closing that hazard out. You can get the details on our competition and where they got to, and how long and how close they were to launch. We finished the Joint Test 4, as we call it, which satisfied all the software requirements about three months ago, so essentially four to six months ahead of flight.

We completed the SRP about two months ago, so we've satisfied all of their requirements there and we don't really have any open issues. We just need to get the launch and get to the Station. When we briefed the Aerospace Safety Advisory Panel and the [Thomas P.] Stafford Commission jointly, the feedback we got was, "Now we're hearing stuff we understand. You guys came in and you talk like aerospace engineers. You speak NASA, and you're well organized." They really appreciated it.

We made it through those reviews fine, and they could see that we really did have our act together. We just don't make a lot of noise about it. Our folks are very proud of being professional, being on time, getting the job done correctly. I got feedback from our very first trip to Houston to work software. Our guys showed up well-dressed, in lab coats, and working with the NASA folks. Had a test plan ready to go, not everybody does that. Then when we briefed the review panels, of course we showed up in coats and ties, and we had a clear PowerPoint [presentation]. We knew how to communicate with them, and it also indicated that my program managers and our leads were managing things well. They had a good handle on the issues.

But, spaceflight's hard, so we've been working through all the challenges to get to where we are. A key decision we made early on was to try to keep the production going in order to meet the original intent of the contract, right from the very beginning. We knew there would be delays in the demo because of launch vehicle and launch pad issues. We were ready to go on the demo over a year ago, spacecraft-wise and PCM-wise, but the pad was slowing us down.

We kept working, kept the team producing the next spacecraft, so we actually have five spacecraft in various stages of production. Three of them are complete, and two more are going through assembly, and we'll have more coming about every four months. Our intent was to make sure that regardless of what delay we had up front, we could meet the period of performance to the contract to complete by the end of 2016, which is when the contract expires.

If we don't launch by the end of 2016, NASA's going to have to reopen the contract and renegotiate with us because prices will change, various other things will have to change. What they would do in that case is force us to slow down, which means I've got to take people off the contract, and there's no guarantee they'll come back if I have to either lay them off or reassign them. I'm trying to keep things going at the pace we were originally contracted for. We don't have total agreement from NASA that that's what they're willing to support or do. However, I'm trying to protect the situation that some of the other cargo providers may not always be there, so if somebody else falters, we can fill in.

We actually do have a task order that requires a launch "on need," meaning they can call us up on a six-month call, and we could launch as much as three months early. So we're building to support that. We're actually building a little faster than that so we can support a much higher flight rate. I think in the end they'll need it, but they've got budget pressures.

They're being criticized by the [NASA] Inspector General for paying us without having flown our demo mission, which puts them in an awkward situation.

The problem is that the folks writing those criticisms don't understand how commercial business works. If you don't pay periodic milestone or installment payments, you can't do the production unless you go take out business loans, which adds to the expense of the whole project because you've got to pay interest on them. If the government pays progress payments, then we can keep the production going and then we're ready, at the end, to launch whenever they say.

We'll have hardware ready to go probably before they're ready to receive it, but that's a better position than having us wait on it. We feel bad about being late on the demo mission, but we're ready to go with everything beyond that, and we think it's important to be in that position, which demonstrates we have the capability to do a lot of stuff in parallel. That's not always the case with other providers. All of the components for the first three missions are essentially ready to be gathered at Wallops. Not all of them are there just because of space limitations, but we can move them in every two or three months as need be. The others are on track to meet all of our needs on a fairly aggressive schedule. If NASA needs us, we'll be there.

Getting the [Antares] test flight off was a major step for us because NASA had decided to withhold cash payments to us on certain things until we flew the test flight, because of the criticism they were receiving from politicians and others. They're very sensitive to that obviously. There would be certain elements of the space community in favor of what we're doing, but others are totally against it, and then there's others who would like to just see us go away. They're trying to balance all of that, so we had to delay some payments for a while. Once we flew the test flight, they did in fact pay us for things they'd already ordered from us. We're

concerned that they're going to respond to that kind of pressure again in the future, and we're going to be cash poor.

We're actually significantly negative cash on this program because NASA has a higher percentage of payment holdback, despite the fact that they've got a schedule that starts two to two-and-a-half years ahead of launch of paying us, it never totals more than—I don't know if I can say the number or not, but it's only a percentage of the actual cost of the mission until we actually get to the Station. We've got a lot at risk until we actually launch and get to the Station, and neither the press nor the politicians seem to be able to understand that, no matter how many times I explain it.

NASA is paying us on a fairly aggressive schedule so that we can maintain one, but they're not paying us what we're spending, so we're significantly cash negative until the very end of the program. We are taking a significant risk. The other aspect that people don't seem to understand is that if we were to stop producing, or to walk away from this, or be terminated, we would owe NASA significant amounts of money that they have paid us already. It's certainly not a low-risk proposition for the company to do this on a commercial basis.

People might ask, "Why are you doing it if there's no profit upfront and very little profit at the end?" That's because this is only for the first eight missions. The Station has been forecasted to continue to at least 2020, maybe 2028, so as we get better and more efficient at production and NASA has a higher and higher need for cargo, there should eventually be a fairly profitable business there.

It's not going to be wildly profitable—it'll always have low margins because it's NASA—but there will be some positive for the company. It'll allow us to continue building

Antares rockets that can be used for other purposes, and we'll establish a track record that we think will be attractive to other users. The Cygnus itself can be used for other purposes, too.

WRIGHT: Are you already looking for those potential customers?

CULBERTSON: We've been looking for them for a long time, but partly because of the nature of this endeavor, and maybe the facts of some of our hardware—and we don't market the same as other folks. We're not going to promise something we can't be certain we're going to deliver. We don't have any other orders yet for the Antares. We've had lots of feelers, lots of inquiries, but I think until we actually get the demo flown and get to the Station, it's going to be hard to convince people.

We've also been hit with a double whammy, in that budget cuts and the sequestration hit at a very bad time, where people are not able to commit funds for new programs right now. We had anticipated a number of things coming our way by this summer, but the situation being what it is, particularly in the DoD [Department of Defense], nobody's willing to go out on a limb right now. We're having to wait until all of this passes and people are actually able to say, "Yes, that's the right size we need and you can fly at the frequency we need."

I think they're also waiting to see for sure that our engines will work, because they are 40 years old. They've been reworked, and there were issues during testing. Rightfully, there's a little bit of a skepticism, "Is it going to be good for the long term?" We've gained a lot of confidence on the engines based on recent testing, as well as the test flight itself. The engines and the core performed superbly. They hit all their numbers. I mean, we were holding our

breath for four minutes there, but it worked and put us at exactly the right trajectory at the end of the first days that we were expecting.

We gained a lot of confidence with that. Obviously we have to continue to keep our eye on the ball for every single flight, but it looks like the system is going to be on track to be successful. Beyond CRS, if we want to fly other cargo missions or for other customers, we do have to increase our supply of engines, so we're working with Aerojet as well as other companies on a competitive situation to provide us with engines beyond CRS.

We have enough to go a few flights beyond CRS, but beyond 2018 let's say, we need to have other engines online. There's time to develop that and there's options being explored, such as restarting the production or a new engine out of another company. The unfortunate side of that is that the only engines anywhere near that class that are being produced in the U.S. are the Merlins that SpaceX produces, and it takes nine of them to meet the need. As far as I can tell, they don't have any excess capacity, nor are they interested in selling them to anybody else.

We have to go overseas to get any engine supply in that class, for blocks of kerosene. We're working on all of that. We're not sitting on our hands, we're planning for the future. I'm fairly confident we'll have a good solution, and we may have two solutions. There are a couple of competitors out there that are looking at ways to provide us with engines. There's a couple of U.S. companies that are starting to get more interested in doing something in the U.S., because I really think we need to expand back into that capability.

As far as what's next, the demo mission is planned for August or September. I don't know when you'll be publishing this, but by the time you do, we'll hopefully have flown. We've had lots of interesting discussions with the customer on how to execute a lot of this, and I'm kind of fortunate in that I know all the players and they know me and we trust each other. We know

what we can argue about and what we can't. When one side or the other wants to go a certain direction, we've both got it figured out pretty well ahead of time. We're able to arrive at solutions fairly quickly.

I requested the launch-on-need capability for a number of reasons, and finally the Station Program said, "Yes, that's probably a good idea." They came along, and it kept some milestone payments on schedule and gave them justification to keep doing that. It's a good capability to have if somebody falters. We're in an interesting discussion right now on when to launch the next mission.

As it turned out, when we were getting ready to launch the [Antares] test flight, because we were still delaying a little bit as we went through the hot fire and the wet dress rehearsal and on and off the pad, etc., there was a [NASA] mission called LADEE [Lunar Atmosphere and Dust Environment Explorer] that was supposed to launch this coming summer. They're launching on Minotaur [rocket], which we actually provide the services for. It's an Air Force orbital launcher, and it's also launching out of Wallops at the pad right next door. We thought, "They'll launch in August, we'll launch in the spring, and in the fall we'll conflict."

After we and NASA spent a good bit of money modifying a small facility up there for fuelling our spacecraft, we found out that LADEE had declared they were going to use that facility, and that they were reserving it for four months, which meant we couldn't get in there to fuel our spacecraft for the demo mission, which would have prevented us from launching when we wanted to. We got a call from NASA—this is the Science Directorate versus the Human Exploration [and Operations] Directorate—and interestingly, NASA's not as well coordinated internally as we would all hope. We end up being the conduits between the various directorates.

They had just kind of unilaterally declared this, and so the Station Program got involved. You can imagine their reaction, "You're going to do what to our spacecraft?" They ended up asking us to accelerate our delivery to Wallops, which we did, and they said, "Can you be in and out of that facility in a week?" I said, "We can do it in less than that," and we did. We had our best people on it. We got in there, we got fuel, and we got out.

Everything was fine and safe, but then they didn't show up. They were delayed but didn't tell anybody. They thought we were going to cover for them. They're not making their August launch date and because of the amount of work we needed to do after the test flight, both on the pad and on getting the next rocket ready, we were slipping into late August, possibly September. They decided they were going to move into September, right in the middle of our launch window. That caused another conflict, so we've decided we can work some overtime and we can actually get off by the end of August.

We don't have complete agreement with all the people involved that we can launch in August and they can stay on the pad and launch in September, but I think it'll work out. However, the Space Station Program was working an issue with the Japanese on the HTV [H-II Transfer Vehicle] arrival date. The HTV launches out of Tanegashima [Space Center], Japan, and the Japanese own the proximity system that we also use for communications with the Station. We have some of their hardware, and then there's hardware on the Station. We can't both be there at the same time.

The Japanese have a rule that they need possession of those bandwidths and that hardware 30 days prior to their launch to get everything all set up, so we can't launch or dock during that timeframe. Then they want to keep it that way for 20 days after undocking. We're

not sure why that requirement's there. The Station Program's been trying to shorten that. That moved out ability to dock to September 12th, and LADEE wants to launch on September 6th.

I said, "Look, we're going to be ready on August 29th, we're going to launch then, and we'll just wait on orbit until you're ready to receive us." Of course, that got everybody all spun up. "No, you have to launch three days ahead of time and go straight there," and I said, "No, we don't actually." We don't have people on board; we don't have any perishables on board. We were going to carry some apples and stuff, but we'll see.

It'll give us a chance to both test this system out and give our team more time, and we can sit there and wait until you're ready for us, 1,000 kilometers away. The initial reaction was, "Well, we've never done that before, we can't do that," but eventually we've convinced almost everybody that this is a good idea. Our team loves the idea because first of all, we can go ahead and get off the pad and get ready for the next one, which is coming right after it in November or December, and we need the time to get both the pad and the rocket ready. And it gives us more flexibility. If the Station does have a problem, we can now prove that we have the ability to loiter and wait until they're ready to receive us.

If we were to launch on time, say, three days ahead, and then right after we launched they had a failure on a computer, or the arm [robotic Canadarm] had a problem and they couldn't grapple us, we could sit and wait until they fixed it. We know, by analysis, we can wait at least a month, maybe more, with the fuel we have on board, to actually make an approach. This gives both sides a lot more flexibility. Once I got them to calm down a little bit, they actually started liking the idea on the NASA side. I said, "We can do this on every mission, basically. We'll launch when we're ready, you take us when you're ready, and we don't have to tie the two dates

together so tightly." If we had something perishable on board or something that had limited life, batteries or something like that, we'd have to tighten it up, but we can do it either way.

This also gets us ready for secondary missions that we might want to do after undocking. There's a number of people who would like to fly other payloads, and we already have contracts for a couple of them that we will execute after undocking, after we're safely away from the Station. One's a fire experiment with [NASA] Glenn Research Center [Cleveland, Ohio]. They want to evaluate how fire behaves in various materials in zero-G [gravity], in an environment that's away from people. Eventually they want to look at extinguishing capabilities. We've got a contact for three of these experiments, starting to work on five. That'll require staying on orbit extra time, so we want to make sure we can control the spacecraft and do all the things we need to do.

That's going to be a good exercise I think, but we're now looking at things we can do after undocking because it's a relatively short docked period. See if we can test out other capabilities, such as a shut off a control system, and see how it does with less capability. Then eventually reenter it. Of course our spacecraft reenters and burns up, rather than being recovered.

We actually have a good relationship with a team in [NASA] Langley [Research Center, Hampton, Virginia] that's been developing an inflatable decelerator and reentry system called HIAD. HIAD stands for Hypersonic Inflatable Aerodynamic Decelerator. Actually, it's called HEART [High Energy Atmospheric Reentry Test] now.

They've tested it on a sounding rocket on a subscale, but they want to test it on a full scale. Theoretically, we could fly that in between our Pressurized Cargo Module and our Service Module. It takes about a meter, and you separate the two after you exit the orbit burn, it inflates

and it basically is like a wok bowl around the leading edge. They made a model and I called it my "wocket."

It gives you a conical leading edge to enter the atmosphere with heat-resistant material, and it'll slow you down to basically parachute speed. We don't have a parachute installed, but the analysis showed that it's large enough and the rubberized fabric is inflatable, and it actually will bring you down relatively slowly and probably survive to the surface of the ocean. It might be recoverable, we'll see.

WRIGHT: It would be great to check out how your spacecraft did.

CULBERTSON: Well, it could be a lifeboat for the crew if we ever get to that point. We're looking at all kinds of possibilities to both justify additional work up there as well as looking, since we're a business, for revenue-generating things to do too. Also to service the Station, because the long-term goal is to go beyond low-Earth orbit and use the Station as a test pad for all kinds of hardware and technologies that will support going to the Moon and on beyond that.

We think our system will support people in lunar orbit. Even on the surface, we could deliver cargo to L2 [Lagrange point]. We've already established that very clearly with a team at JSC, and they like our spacecraft for that purpose. We have to add a little more fuel and maybe some more shielding, but it's designed for 15 years of life, based on our geos [geostationary satellites], so it can stay in orbit a long time. You could even make a habitable module out of it if you put in a life support system. It's very similar to the MPLM [Multi-Purpose Logistics Module], just smaller.

We're looking to the future, and we think it's important that we provide this cargo service to the Station so that it can remain viable and remain on orbit indefinitely, and that they can have six or seven people up there. Without our cargo capability they can't do that, and they need everybody who's planning to deliver cargo to keep delivering cargo. We see ourselves as a key part of the future, and I remind the team of that periodically. "You know, some day you're going to tell your grandchildren that you enabled exploration of the Solar System by doing this, as small as it may seem."

It's not small to the company. It's a huge effort for us, but it's very exciting. Sitting in the control center, waiting for Antares to launch and watching the team—I was Mission Director, so if something went wrong, I was the guy.

WRIGHT: We have just about a minute. Tell us about your feelings that day and what it felt like to watch that rocket go.

CULBERTSON: It was great to be back in a control center, first of all, and of course we had a couple of aborts. That's very familiar feelings too. That spaceflight, that was fantastic to be that involved in it again. Dave [David W. Thompson, Orbital founder and CEO (Chief Executive Officer)] asked me specifically to take that role. He also asked me to be the spokesperson at the press conferences. I don't know if you saw any of those or not, but that was like *déjà vu* all over again. Some of the same people in the audience actually, and all the same questions.

I think we at Orbital showed them that we can do a good job. Three or four people in the press came up to me and used the same words of, "We're happy to see a company that exhibits a quiet competence, and you guys are doing that in a great way." If we had problems, we

explained them thoroughly. If we didn't launch, we told [the press] exactly what went wrong and what our plans were. I even had to push the NASA guys and say, "they want to know, arrange something here and let's talk to them." They made the trip out here, let's make it worth their while. They're not always our enemies. Being a part of that team and watching them work is just, I mean, it's what I live for.

WRIGHT: Do you feel that this is more of a partnership than it is a customer arrangement?

CULBERTSON: Yes, it's a pretty good partnership. It'll always be a business arrangement to a certain extent, but we really do depend on each other to do our jobs right, whether it's NASA, MARS, or us. Everybody's got to do their job right, and it's like the contractor team on the Shuttle or on the Station. Yes, you had a business relationship, but you had to make that secondary to getting the job done because human lives are at stake. In this case, the future of the company's at stake. This is our biggest contract ever, so we have to make it work.

You're not really thinking about that during the countdown and the actual launch itself. You're thinking about, "This is our hardware, it really needs to work. Did everybody do everything right?" Apparently they did on this one. We've just got to keep the same team focused and keep them operating at the same high level, and keep the others that are coming behind them motivated to do the same.

It's a lot of fun to be here. I'm really enjoying my job now. The National Security stuff is very exciting also, and there are some complementary aspects to them in terms of the complexity and you need to be absolutely right and absolutely successful in everything you do. I keep reminding the team that the future of this human space program depends on them.

WRIGHT: We look forward to the next launch and all the successes that are going to follow.

[End of Interview]