NASA JOHNSON SPACE CENTER ORION ORAL HISTORY PROJECT
EDITED ORAL HISTORY TRANSCRIPT

MARK A. KIRASICH
INTERVIEWED BY SANDRA JOHNSON
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JOHNSON: Today is July 19th, 2016. This oral history interview with Mark Kirasich is being conducted for the Johnson Space Center Orion Oral History Project in Houston, Texas. The interviewer is Sandra Johnson, assisted by Jennifer Ross-Nazzal. I want to thank you again for agreeing to talk to us. I want to start by asking you to briefly describe your background and how you first became involved with the Orion Program. I know you came from the flight control world, so that was a little bit different way of getting into Orion.

KIRASICH: Yes. You said be brief. I'll try, because it's a long story. My interest in human spaceflight started when I was a kid, when I was six years old and I watched the Gemini Program on TV. That's the earliest recollection I have of human spaceflight. I remember waking up early to watch the Gemini missions as a youngster. Then of course I watched the Apollo missions, and I watched the first landing and the first time humans walked on the Moon with my parents. That motivated me to become interested in science and math and particularly human spaceflight.

It was a goal of mine I would say from very early on to get into engineering and eventually work for NASA. I did that, and I arrived at NASA in 1983. It was the early part of the [Space] Shuttle Program. We were only seven flights in when I got here. I worked in Mission Operations [Directorate (MOD)]. I spent the first 23 years of my career in mission operations. It really is interesting the way my career worked out, because before I really even knew what mission operations was or what a program office was I would have said, "Boy, I

would really like to operate space vehicles," and I had that opportunity in mission operations, "and someday I'd really like to build a spacecraft," and then this Orion Program opportunity came up.

It was about 2005, 2006, I was a flight director at the time, and President [George W.] Bush had [announced] his *Vision for Space Exploration* and NASA started formulating its plans. I knew at that time after 23 years in flight operations, many Shuttle missions and many [International] Space Station [ISS] hours in the [Mission] Control Center, I knew this was for me. As the Constellation Program was being stood up, I knew I wanted to be a part of it. Then it was about finding the right place. Even though my background was in operations, I knew I wanted to come and build this spacecraft. Initially my background led to other opportunities, but I knew they weren't right for me, so I waited.

Eventually the Deputy Program Manager—at that time was called the Project Manager—position opened up, and I applied for it. I remember I was in Toulouse, France, when Skip [Caris A.] Hatfield, who was the Program Manager at the time, sent me an e-mail and said, "Can you interview for this position?"

I said, "Sure, I'll be home next week."

He said, "How about in a few hours?" I had my interview—I remember it was very late at night in Toulouse, France—with Skip. Then in May of 2006 I was selected, so that's how I came to the Program Office.

JOHNSON: Talk about those early days and those years actually before the Constellation Program was canceled, that in-between time, and what you were doing and what you were working through.

KIRASICH: When we started, the Constellation Program was standing up. It was really about defining what we wanted to be. In the NASA vernacular it was about writing our requirements and our mission goals and then codifying them in our requirements documents and our design and construction standards. We spent a lot of time with Constellation and with our colleagues from [NASA] Marshall [Space Flight Center, Huntsville, Alabama], who were building at that time the Ares I, and with our colleagues from the [NASA] Kennedy Space Center [Florida], defining the program goals. I will say at that time it had been a long time since the people here had built a new vehicle, so we were all operators in a sense. Some of us—I'll use myself as the prime example—some of us were a bit naive on the challenges of building complex new human space vehicles, and we spent a lot of time writing goals that we didn't fully appreciate how challenging they would become.

In parallel with that we ran a procurement competition to pick the contractor that would build the Orion vehicle. It was in the fall of 2006 that we selected Lockheed [Martin] as our prime contractor. Then what we had to do, we had to marry the Constellation Program to the Lockheed contract, and that took some effort. Lockheed, as part of the proposal, had a reference spacecraft design, and of course since while they were competing for the contract, Constellation had marched off in sometimes different directions with requirements, we had to merge the Constellation requirements with the Lockheed design. That took a few months, essentially from the fall of 2006 to the early spring.

Then we set about the task of getting to what we called the preliminary design, which culminated in the Preliminary Design Review. At the time our first two missions were going to be missions to the International Space Station. We spent a lot of time optimizing the spacecraft.

We needed to come up with a design that could do the International Space Station missions but was extensible to exploration, so we spent a lot of time balancing the mission objectives.

At the time we had a very active, and passionate Administrator, Mike [Michael D.] Griffin, who was really smart. He had a vision for what Orion and Ares and what the program would be like. I remember at the time we spent a lot of time balancing our work with Mike's vision. That took several iterations.

JOHNSON: You said it took a lot of time to balance the goals with his vision. What do you mean by that? How did that work? How often did you talk with him?

KIRASICH: At that time we talked with Mike a lot. In fact there was one Christmas, and I forget which year it was, it might have been 2009, where in the last couple of weeks before the Christmas break we actually made three trips to Washington, DC, and [NASA] Headquarters to work out details of the design. Mike finally agreed we were good enough, and then he left the Agency!

When we selected Lockheed Martin to be our prime contractor, again this was in 2006, the nation had a goal to retire the Space Shuttle in 2010. We were only four years away. People knew in general that it took longer than four years to build and certify human spacecraft. There was a concern at that time in late 2006 about the gap between when the Shuttle stopped flying and when Orion would first fly, so our original goal for Orion was to close the gap, minimize the gap.

It was all about flying fast. That's when we signed the contract with Lockheed. Many aspects of the contract enabled that. Incentives were associated with flying quickly. Lockheed

Martin's corporate contributions were associated with that. The spacecraft technical requirements all lined up with that. That's the contract we signed in 2006.

In the ensuing months after we had a contract, the vision changed. It was no longer going to be about closing the gap. We couldn't get the development money we needed for the Ares rocket and the Orion spacecraft to close the gap, so the goal morphed from flying as quickly as possible to building the vehicle we wanted. It was called the generation vehicle. We were only going to get a chance to build one vehicle. A program manager has to balance. He can balance technical performance, cost, and schedule. Initially it was all about schedule. We wanted to make the schedule, we would get the money we would get, so our free variable was the requirements, we would adjust requirements to make the schedule.

It changed when we found out the money was going to be fixed and less than we needed to fly quickly. When the money was going to be fixed and limited, Agency policy changed, it was about performance. It was about building this generational vehicle. It was actually almost the opposite of what we had just spent many months lining up. In this scenario, funding was fixed, we would build the generational vehicle, and we would adjust the schedule to fly when we were ready. So this then moved us. At the start of the Program, we were trying to close the gap, we were really trying to fly in 2012, 2013. We almost immediately moved to 2014, 2015, because we couldn't get the money we needed to fly as quickly as possible. We knew we would have one shot at this, so we changed the approach to build the vehicle of the generation, if you will. It was a change in the Agency strategy for the vehicle we wanted to build.

What that did was we started marching off in a certain direction. It was working very fast. All of a sudden it became about optimizing the design, all aspects of it. I remember even the hatch. The hatch had to be the largest possible hatch you could possibly build. We had

several iterations on the hatch, and eventually it was limited in size by the locations of the primary structure longerons were. We used up all the real estate in between the longerons. This is one example – we had many many more. All of a sudden everything about the spacecraft had to be the best.

Other things. We had a metric called habitable crew volume, and again this was going to be a generational vehicle. We wanted the crew to have as much room as possible, so we optimized the internal layout of the vehicle, our electronics and other systems, and how we laid that out. Another very interesting example. When the contract was proposed Lockheed was the prime and then different contractors would provide major systems. Each of the contractors would propose a controller for their subsystem. We had what I would call a very diverse avionics system, where it was a central computer that had to communicate with a bunch of different controllers, each built by different contractors, and we said, "Boy, for an exploration vehicle where mass is really really important, that's not an optimized vehicle."

We came up with what we called a PDU [Power and Data Unit] architecture where it was going to be one common controller that would be distributed at certain key points around the vehicle selected geographically to provide the best interface to all these subsystems. Then we had to take the smarts from each one of these unique contractors and make a generic box that could do these sorts of things. We spent quite a few months iterating the design. In fact when we did our first Preliminary Design Review we found it wasn't good enough, so we went back and adjusted a few things.

JOHNSON: You were mentioning that you changed to optimizing the design and not the schedule so much. Was that okay with everyone? Was that accepted by the [NASA] Administrator?

KIRASICH: It came from the Administrator. I won't say he was happy with the movement in schedule, but he accepted it because he wanted the right design. But as a program manager, when you have a large team—and our team was large, thousands of people at the time—you find you don't just send out an e-mail and say, "Hey, today we're going to change from going fast to building a generational vehicle." It was the job of Skip and I. We had to turn the team's direction, and that took time and effort.

We had to communicate the Administrator's vision to the team, and that did take some effort. There were people who came on and were really excited about building this vehicle and flying soon, and we had to slow the team down and say, "No, we're going to head in a different direction." It was fine with the Administrator, but our challenge was more about getting the team on board with the new direction.

JOHNSON: Since you talked about your background in flight control, I was wondering, what did you bring from flight control into the Orion Program? Were there any similarities or anything that you felt was important as far as teams and working with different people to bring into this program?

KIRASICH: I'll say a couple things. First of all, at the time I thought there was more than I actually did bring, i.e., I had an awful lot to learn about building a new spacecraft, but nonetheless there were some skills I had that helped. There are two great things about the career I had in mission operations. First, in operations you tend to learn a lot about systems engineering. You're can't be totally focused on any one system, you have to learn how the entire

spacecraft operates. You really have to understand how the whole vehicle operates and how a system in one area can affect operations in another area. I'll call it a principle of systems engineering, and it's very important in a program to have an understanding of that.

Secondly, especially it's often been called, the Mission Control Center, a leadership laboratory. From the day I first arrived in mission operations, my career was about being a part of and/or building teams. I remember my first team – where I was a member of a three-person team that we worked on the night shift. There were some really important principles then I learned, just about first of all getting your team together and establishing a common vision, and having a strong relationship. We would go out after work together. Very simple principles. Then when we finished a big sim [simulation] we would go out and celebrate, so recognizing major accomplishments. There were a lot of principles about leadership that I learned in mission operations that really helped with transitioning to a project office, and in particular, starting up a new project. I think that the tools I brought in with me were what I will call a systems engineering, systems vision of a vehicle, and also general principles of leadership.

What was harder for me, and I think many of us, we forget when you're in an operational program, and we were in an operational program with the Shuttle for 20 years at the time, you become very good at something, it becomes an automated process and you don't fully appreciate how much the automation helps. When you start from scratch from a blank sheet of paper it's much different. I don't know if it's harder. It's a different job. It's not an operational job. That was a transition I and many of my colleagues had to make. We hadn't built a new vehicle from scratch in a long long time. We thought we were smart because we had operated a vehicle a long time, and we did bring that knowledge, but just because you know how to operate a vehicle well,

there are skills you have to learn to be able to build a vehicle from scratch. That was the part I was missing and we learned together as we moved through those early years.

JOHNSON: In 2008 we got a new President [Barack Obama] and then after that a new Administrator [Charles F. Bolden]. Did you have a sense that things were going to change? That it was going to be canceled in 2010?

KIRASICH: No, I did not. I remember the date, February 1st, 2010, and we had this announcement, "Hey, on Monday there's going to be the Administrator's telecon." We came and listened to it, and I was shocked, and I think most of the team was shocked. A few of our leaders had known over the weekend.

We did expect some amount of change, but not cancellation. We knew because at that time Skip Hatfield had left and Mark [S.] Geyer was the new Program Manager, and Mark had been in the Space Station Program during a transition. During that transition there wasn't a proposed cancelation, but Mark knew with transition comes change. Mark told us we would likely have to adapt, but we did not fully appreciate how much we needed to adapt!

Mark had talked about we will likely have a new, slightly altered, vision, and we will likely have to change. We had talked in general terms about it, but certainly not many of us were prepared for the magnitude of change and adaptation we would have to go through. I would say I was certainly very surprised by it. I think most of the team was extremely surprised by it.

There were interesting reactions across the team. We joke about it now. Some folks immediately went to Don Pico's [Mexican Restaurant] for the rest of the afternoon to celebrate what was our program. There was another group of folks who stayed up till 2:00 a.m. that night

because they wanted to figure out how to react to this, and they worked really hard on alternatives. The reactions were very different.

Again, we had very good leaders here at the Center at the time, because I will tell you Mark Geyer, who was our Program Manager, and Mike [Michael L.] Coats, who was the Center Director, they knew we had to get the team together really quickly. That very next day we called an all-hands. We are a multicenter team, and I remember we had people from all over the country and they all dialed in. People say hindsight is 20/20, it really is. At that time very few of us had lived through a program that had been proposed for cancelation before. None of us really knew what it meant. Mike Coats and Mark talked about it, told us everything they knew. Mike Coats said, "We don't know how this is going to come out, but Presidents usually get their way." He was setting expectations for the team.

At that point there were not specific directions. We were never canceled. We were proposed to be canceled. That was a key thing. That is one thing our leaders did recognize. It was a proposal to be canceled. Mark said, "Until this is clarified we're going to keep doing our job." Mark was really good in defining this direction. That becomes hard though because when the President proposes that you'll be canceled and we're here saying, "We need to keep doing our job," not everybody's able to keep functioning in that environment. It was difficult for the team members.

I remember the first four months after the announcement, Mark and I spent a huge amount of time on the road talking to the team. It was valuable for I would say two reasons. Number one, we shared with the team everything we knew at the time. There were things we could do, there were things we couldn't do. For example we could not cancel the contract.

Similarly, we could not initiate new contracting actions. Until this was straightened out we had to tell the team, "Keep doing what our current direction was."

Meantime, we heard a lot of very good feedback from the team, what their observations were, what their perceptions were. We heard all sorts of things, but it helped Mark and I get grounded. It helped us develop potential alternative directions. I would say quickly after that it became clear a theme at the time was—and it is funny because we had been, "Go as quick as you can," then, "Build the best spacecraft," then it became about reducing cost, being affordable, and moving quicker again. I won't say we did a 180, but it was about 120 degrees. We went all the way around the circle, first it was about schedule, then performance, now it was cost that mattered. We had to change direction, and it became about affordability.

What we did, and I remember it was in this very office, it was on this very whiteboard. In the policy Mike Griffin left us with, it was not only about building a generational spacecraft. It was having the generational spacecraft on the very first flight. EM-1 [Exploration Mission 1] was going to be the spacecraft. Mark said, "We have to listen to our leaders and understand what they're telling us, and we need to change and adapt."

This was the really positive part about Mike Griffin driving us for the best possible design. We had a really flexible design that could do a lot of missions. It could go to ISS. It could do exploration missions. I will say coming out of Mike saying, "Build this ideal spacecraft," it helped us. What we had to do, we had to adapt that very good design, very flexible spacecraft, to what our bosses were saying at the time. That was "You're not going to get as much money."

Again in hindsight it's easy to talk about. At the time we were feeling our way through it, but affordability became the term. We had to cut our annual cost. In fact in absolute terms

starting the next year the amount of money we received every year was about 50 percent to 60 percent of what it would have been under the old plan. So we had to adapt. We had to take everything we were doing but we only had 50 percent to 60 percent of the money to do it.

Once again I will say we had another inflection point. We went from fly as fast as you can, close the gap, to build the best generational vehicle possible and be done on the first flight, to adopting a strategy called incremental development. It's a pretty simple concept. At this point we had been going down this path of the best vehicle first time out for three years, and now we were telling the team, "We're not going to have the best vehicle, because we can't afford it. We've got to start out and fly soon with a vehicle we can afford."

That was challenging. We had the very first debate here on this chalkboard. We had Scooter [Scott D. Altman] from the Astronaut Office, and I remember he was really important, because he didn't understand it at first. Again, we all wanted to build this ideal vehicle, and we had to convince the team, "No, we can do this a different way, we can start out with a simple vehicle and then build up."

We stayed late one evening. We drafted this concept on the board. Then we picked a team member. Her name was Kathy [Kathleen E.] Schubert, she was from the [NASA] Glenn Research Center [Cleveland, Ohio]. We said, "Kathy, this is this concept that Mark and I have. We need you to actually make a plan out of it."

Again that was the concept. We're not going to have the beautiful vehicle in one fell swoop on the first flight, we are going to have incremental building blocks. Kathy really fleshed that out. That essentially evolved into what we have now, EM-1, EM-2, where EM-1 is not fully human-capable, EM-2 becomes the basic human systems, but there are still additional

capabilities we need, like a docking system and automated rendezvous that come later. It was this more incremental buildup of capabilities.

There were a couple other things that were happening at the time. We had a test flight. The Pad Abort 1 test flight was the very first demonstration of our abort system. That, on that February 1st date, was scheduled to be conducted that May [2010]. We had made great progress since 2006. We had an abort system ready to be demonstrated.

I can recall that of course the team had this really really great flight test ready to go. A lot of effort, a lot of money spent on developing the very capable launch abort system. Again Headquarters wasn't sure we should do that flight test. Another part of the job that Mark and I had to do was we felt that it would be important to do that flight test. One, because we'd invested a lot of time and it was important to the team, as well as it would provide a lot of data regardless which direction the Agency went. We had to go to Headquarters and eventually that decision to proceed with that abort test had to be concurred on by the Administrator.

We were approved to do that flight test and sure enough, it was beautiful. Three months and a few days after this proposed cancelation, it was a real picker-up for the team to have such a great accomplishment. I remember we used to joke because we had this beautiful video. The abort system performed flawlessly. Because we were still in this not sure, are we canceled, not canceled, we used to watch that video over and over many times throughout the summer because it was really motivational to the team.

As the summer played out, we had Kathy working on incremental development, this phasing in of capabilities instead of having everything on day one. Then there were two other key points. One occurred around the end of July. There was a meeting. We were in Building 1 and the news came via the Constellation Program at the time. We were coming up on the new

fiscal year, and again the President's proposal was to cancel us beginning with that fiscal year, so in that proposal we would have begun terminating that October. We received word at that time that there was actually a clause written into the congressional bill the prior year that said you couldn't terminate any contracts.

First of all, somebody—by the way it wasn't me at NASA—somebody somewhere had enough inkling that this might be coming and put a clause in the appropriations bill that you couldn't terminate any of these Constellation contracts. The more important thing was we found out on that late July date—I think it was July 25th, I remember some of these key dates—that we were not going to be canceled on the 1st of October, but our budget was going to be cut. We found out on that day we were going to survive for another year and our budget I think at the time was $1.2 billion. We were supposed to be $1.8 billion, but there were other pieces too like space suits and MOD. It would have been over $2 billion in total. We found out we'd have to operate at $1.2 billion.

That was really key. We then took that back, and now we had a number to match to the concept. We knew we had to be more affordable, and then we got the team, and I would say we were able to get more specific. There was one more key idea that came in. I think it came in after. I think this would have been the September timeframe. Again, you'd have to understand how we got there. We had been on a go as fast as you can, and then we slowed the program down to make the best spacecraft possible. So if we were getting $1.8 billion a year, we weren't going to fly until 2015, and this was 2010.

Then all of a sudden somebody says, "You're going to get cut, you're only going to have 60 percent of the money." When we first looked at it, even with a reduced spacecraft, that date 2015 went to 2016, 2017. It just was horrible. When a few of us, and particularly Lockheed

Martin, our contractor, looked at what happened to the launch date, we felt strongly, "Boy, we don't think the program could survive, and we don't think it's in our best interest to have that plan, to not fly EM-1 until 2016, 2017." We said, "Let's come up with even what we'll call a further scaled back test flight." That's where Exploration Flight Test 1 [EFT-1] came from. Then we said to ourselves, "Let's decide we want to fly on our first goal. We set a launch date. What can we do by a certain launch date?" We took Kathy Schubert's concept. We said, "How can we scale back the first spacecraft, EM-1? What can we fly?" That became the EFT-1 spacecraft.

We defined the EFT-1 spacecraft to include the systems that represented the biggest development risk to us. The heat shield, some of our mechanisms, some of our avionics. We felt it was important for two reasons. One, we felt it was programmatically important to keep the program moving forward, and we had to show progress. Secondly, we thought there'd be a big technical benefit that we would learn how to build these systems that represented the biggest development risk to us.

That's where EFT-1 came to be. Again you can look back in hindsight. Here's where I'm a little bit sketchy. We once again turned the team around and said, "Hey, we're going to start work on a spacecraft called EFT-1." We could do that, we could build a spacecraft, because that was within the bounds of our contract. But remember, what we couldn't do is initiate any new contracting actions, because even though we knew we weren't going to be canceled there was still the ban on writing new things. Mark and I had the authority to change our existing contract. Instead of building this EM-1, we're going to build this thing called EFT-1, which was different. It was still the same high risk systems, but it was only the minimal set.

What we couldn't do is we couldn't buy a launch vehicle. Something that is not very well known to the team, we were motivating to the team, "Hey, let's go build this EFT-1," but within the Agency it was about a year before we actually had an approval to fly the EFT-1 spacecraft. It was still valuable work because we were designing these systems, the thermal protection system, the heat shield, the primary structure. We were putting out drawings, we were beginning to build it. But there were a few of us, Mark and I, Cleon [Lacefield], the Lockheed Program Manager, who recognized boy, we still don't know where this is leading, because the Agency hadn't told us we could fly it. I think that came about a year later. We rationalized this EFT-1 test flight and we were allowed to go buy a launch vehicle. Then we negotiated the Delta IV Heavy.

There was a step I left out. At the time there were many of us career NASA people who believed in the exploration mission. We wanted to build an exploration spacecraft. Then there was our Agency policy makers that set policy. They were still of this opinion that NASA ought to be about commercialization and they didn't see a role for this government exploration vehicle. We had to define what Orion was. Congress, in the new appropriations, they came up with a new name called Multi-Purpose Crew Vehicle [MPCV]. But even then it was unclear what it was. What was that vehicle? Who would be the prime contractor?

Once again we had to rationalize, and we had to take a story to several decisional meetings at Headquarters, with the Administrator, Charlie Bolden, with the Deputy Administrator, Lori [B.] Garver, and we had to rationalize why MPCV would be Orion. It'd be a different implementation of Orion, but we still felt Orion, our basic flexible design I talked about earlier, our prime contractor Lockheed Martin, our team, the way we had structured Orion, we still felt that was the best way to move forward.

I would say it was a very difficult sell, because again it was a question of policy. At the time the people who were setting policy believed NASA should be more about enabling the commercialization of space. But, I will tell you there were several really intense debates. Again, we had to explain why was Orion was the best way to do these exploration missions. We had a very good technical presentation at ultimately what became the decisional meeting. Because it was such a very good technical presentation and it really rationalized why, if you're going to do exploration, this design we called Orion would be the best solution, at the end of the presentation the Administrator, Charlie Bolden, says, and this is an approximate quote, "Well, it sounds like the physics is the physics and it can't be disputed." Charlie was agreeing that we had made a very strong technical case.

The Deputy Administrator's response at the time, Lori Garver's, was "That's true, but physics is only one of the figures of merit." Even though we were agreeing on the physics, again she was back to this cost and is this really what we should be doing. In the end at that meeting Administrator Bolden turned to Mark and said, "How much will it cost you," on that day, "to do this, to get to EM-1, EM-2?" Mark gave a number, and that's when Charlie said, "Okay, MPCV will be based on Orion." That was the decisional meeting and how our basic design and our contractor Lockheed Martin was going to be able to become the new MPCV vehicle.

All of this, the definition of EFT-1, incremental development, getting the Agency behind this exploration spacecraft, all that was transpiring. That occurred in this year in between. Actually it was about 18 months before everything resolved, in between February and the following fall of 2011. Fascinating time.

JOHNSON: Yes, a lot of different things going on during that time. You mentioned that you had those meetings to communicate everything that was happening early on with the teams. Did that include the contractor teams too?

KIRASICH: Oh yes. I thought I understood leadership. Again I told you I came from mission operations, where you learn leadership. But boy, that time after 2010 really stressed leadership. I'll just tell you, in hindsight they're funny stories. Again our team at the time was thousands of people employed by hundreds of different companies across the United States in every state across the country. People would pick up a newspaper and it would say something, because a certain member of the administration would say something. A person would read that and say, "Hey, I read Orion is X," whatever the X of the day was that they had heard.

Meantime, Mark and I were concerned, while we were trying to figure out what direction we wanted to go, we were trying to keep the team pointing in whatever direction that was on that day. So communications became very important, because you don't realize when you're proposed to be canceled, and things across the country in various newspapers show up. It's very easy when you're a 25-year-old engineer designing a structure at a small company in—pick a location. Sacramento, California, where we had folks. That day in Sacramento there was a newscast about Orion is going to be terminated. That person is worried about his future and his livelihood and his passion. Communication and getting out and talking to the team and explaining to them, "Here is what we know. We are going to continue. We have this amount of money. Contracts won't be terminated; they can't be terminated." Trying to keep everybody on board was one of our main challenges, so we traveled a lot.

There was another. It was a very very interesting story. Again it's just the kind of things you deal with in this kind of a situation. Again one of our Agency leaders came down and we had an all-hands in the Teague Auditorium. Boy, I don't know if I want to tell this story. This is a very interesting story. I think the leader thought he was trying to help. Change is hard. Again this is a point in time we didn't know where the change was going to take us. It was a very uncertain time. I think he was trying to help the Center change.

This leader said, "Hey, you got to stop wearing your Constellation shirts." Then he told a story about a marine in Afghanistan. He told the story of a village in Afghanistan. The camel was a key element of the livelihood of the village because the camel did transportation and all this kind of thing. The camel was very important to the village. The story went that there was a mama camel who was pregnant at the time and the fetus had died. So the whole village was threatened. Now remember our leader was talking to thousands of people at the Johnson Space Center.

The intent of the story was the marine saved the village because the marine ended up terminating the pregnancy by pulling out this dead fetus. I think the leader thought he was helping, because the idea was you get rid of this thing that's about to kill the village, and the marine was a hero in the village. The idea was we had to get rid of this program, Constellation, that is hurting the village, NASA. But it actually had the opposite reaction because what the leader didn't recognize was he was comparing everybody that had been in Constellation to this dead fetus—yes, it was a very interesting day.

Again, Mark and I would respond to that. Mark and I would respond to all these stories and what's in the newspaper, and keep the team motivated and moving forward. I don't know, what do you think about that story?

JOHNSON: It's pretty interesting.

KIRASICH: It's things that people just—the hard part and the technical part of the job—don't realize the team dynamics in this cancelation transition.

JOHNSON: Sensibilities and worry and everything, stress.

KIRASICH: Right. Yes. Livelihoods. People had dedicated, number one, a lot of people, their dreams, livelihoods. There are all sorts of emotions in anything. If you live through something like that you cannot forget it.

JOHNSON: Moving toward when the idea for EFT-1 started taking shape, did you also include Lockheed Martin with those? Or were they in on those meetings?

KIRASICH: I would say again the incremental development, it came on the NASA side. The option to fly early, that actually originated on the Lockheed side. They proposed that to us. Again, it was another one of those things. We had to look at it from all different angles, and we got on board with it, because then we recognized the value of number one, getting the team focused. It got the team focused. It got us working on the hardest technical problems. Again, it provided us an early milestone. It wasn't going to be '16, '17. Eventually we flew December 2014. I forget our initial date. I think we were going to try to fly in 2013, but we eventually flew in December of 2014.

In hindsight I would tell you I think the EFT-1 was really a great decision because first of all we designed all these high risk systems for the first time. We burned down a lot of this development risk. An example was our heat shield. Nobody had ever built a five-meter monolithic heat shield before. We found that there were manufacturing problems. We found really close to when the heat shield was supposed to be ready that it had cracks in it that we had to repair. If that would have happened later before the first crewed flight that could have been a really big deal. We were able to adapt for the next flight. We learned a lot of lessons.

Even more important, and we didn't recognize this at the time, more important than the technical, we learned how there's a life cycle of getting engineering drawings and engaging the supplier database and assembling parts and testing parts. Again, in an operational environment, since we had not developed a spacecraft of this magnitude or complexity in many many years, it was something that very few people on the team knew how to do from scratch.

For example there were thousands of drawings that had to be completed and signed off each drawing required concurrences by up to 10 people. Each one of these drawings was critical, so that drawing could be sent to the machine shop in Indianapolis, Indiana, so he could machine a very complex part, so he could get it to [NASA] Kennedy Space Center [Florida]. I think none of us—some of the people on the contractor side who had done it, they understood it in concept, but nobody understood the magnitude of getting these thousands of drawings out, because again it was a big, complex spacecraft.

We didn't do very well. It was very hard to get our drawings out on time. It was for all sorts of reasons. In a previous generation drawings were literally hand-drawn. Information technology came such that now the entire process was all done on computers. That seems great,

except once again we had such a large magnitude. The computer system, which was big enough for everybody else – smaller programs at the time, wasn't big enough for us.

You don't realize at the time. We didn't even know it. How we started to figure this out, I remember Mark and I and Cleon Lacefield, we went to Denver [Colorado] for a meeting. While we were there for the meeting they wanted to show us the output of their CAD [Computer-Aided Design] system, their drawing system. We said, "Great." It was about 4:30 at night, it was the end of the long day. We went down. The engineer was a young engineer who was so proud of the part he designed. He wanted to call it up for us.

We're there. He initiates what should have called up the drawing, and it didn't come up, and 5 minutes later, 10 minutes later, about a half an hour went by, and the drawing didn't come up. Of course everybody's embarrassed. Cleon is embarrassed, Lockheed is embarrassed, this young engineer is embarrassed. We come to find out that this drawing had overloaded this computer system, this commercially available computer system couldn't handle the size of our drawings. That was just a symptom.

It was just a very interesting thing that we had. We worked with the software vendor; we increased the memory on these drawing CAD stations. But, it was very basic problems that we worked through to enable the infrastructure to build Orion. Guess what. The next time around on EM-1, none of those problems. The drawings are hitting their schedule.

Another interesting example was down at the Kennedy Space Center. The first time we tried to weld our propellant lines. Propellant lines in human spaceflight systems, we have these cleanliness requirements, because you can't have these types of systems, they can't have FOD [foreign object debris]. Everything from clogging filters and slowing up flow to actually potentially causing real problems in your system. So we have extreme cleanliness requirements.

We couldn't meet that. The way it would work, you would get this piece of pipe and you would flush it to try to clean it, and then you'd take a sample. The samples we would take were always an order of magnitude above what our limit was. So it took us a very long time, 30, 60 days, to figure out what was wrong and why it wouldn't work.

We worked through all these things. It wasn't only about the technical thing, it was about the process of building a spacecraft that the team learned. EFT-1 really, I would say we reduced technical risk in some of our riskiest systems. But even more important, we, this big contractor-NASA team, learned how to build a spacecraft, to get the process right. Then we flew the flight, and it was magnificent, and for the team that survived and lived through 2010, it was just a huge pick-me-up when we saw how well the flight worked.

JOHNSON: Yes, because nobody had built a spaceship in so long since Shuttle. It'd been a long time for people.

KIRASICH: It was really an electric day, the day we flew.

JOHNSON: It's about five o'clock. We can stop for today and maybe we can schedule another.

KIRASICH: I suddenly realize I hadn't thought this through. I recollected a lot as we were talking. I wish we could go back. There are some earlier things too. I didn't talk about the multicenter aspect of Orion.

JOHNSON: That's actually one of the questions I have.

KIRASICH: It's been so long even for me. I forgot some of the things that drove us, like that early on. That was 10 healthy Centers. It was another thing that drove us in a certain direction.

JOHNSON: We can talk about that the next time if that's okay.

KIRASICH: All right. Good. Thank you.

JOHNSON: Thank you very much.

[End of interview]