NASA MSFC Oral History Interview
Steve Johnson Interviews – Apollo/Saturn Program

Sonny Morea
Interviewed by Steve Johnson
Huntsville, Alabama – Unknown, Circa 2012

Steve Johnson: I am talking to [Saverio F.] Sonny Morea, who was at Marshall Space Flight Center from 1960 to 1990. Sonny, tell me about your educational background.

Sonny Morea: I went to CCNY in New York [New York], City College of New York. I majored in mechanical engineering. At that particular school, they had an ROTC [Reserve Officer Training Corps] program. I always like to talk about this because in the ROTC program, two years behind me was Colin Powell. I always say that I take credit for everything he knows about the military since I was two years ahead of him in the program. I never met the man, by the way. (Laughs)

After I received my degree, [Angela Fiore] Ann [Spelling?] and I were married and we went out to California for a year. I worked out there for the North American Aviation group on a missile program. It was an intercontinental missile, a precursor to cruise missiles. It had the capability of carrying a hydrogen bomb five thousand miles and delivering it within a three hundred yard circle in Moscow [Russia], if need be. Because

of that experience with missiles, my MOS [Military Occupational Specialty] with the military changed from being combat engineer to ordinance. When I received my orders to enter the military, I was given orders to go to Aberdeen [Proving Ground, Aberdeen, Maryland] for my follow-on military education.

At the end of that, I was assigned to Redstone Arsenal in Huntsville, Alabama because that is where the Army was doing its missile work. That is how I got to Huntsville. That was quite a cultural shock for Ann and I. We went from a city of 7,500,000 people, New York, to a city out in Los Angeles [California], which was probably close to 12,000,000 people with the surrounding areas, and we arrived here on June 10, 1955 and the AAA book we had said the population of Huntsville was 16,500 people. It was quite a culture shock. We rented the last house there was in the entire city on Holmes Street. That is how I got to Huntsville.

In terms of what happened after I got here, that kind of leads me into saying something about [Wernher] von Braun.

Johnson: I know you were with the von Braun team working with the Army, talk about how you ended up being a part of the space program with NASA [National Aeronautics and Space Administration].

Morea: My first assignment was with the guided missile development division that Dr. von Braun headed up. When NASA came into existence and Marshall Space Flight Center became a major center of NASA, the entire von Braun team was given the opportunity to move into NASA or remain with the Army if they chose to do so. I chose to move with the von Braun group. It was from there that my career took a completely different direction than it would have had I stayed with the Army, military group here. After two years in, I was decommissioned. I had served my two year commitment with the Army and I was offered a position in Guidance and Control.

It was a liaison position at that point because I had been from New York, and on the Redstone missile, some guidance and control equipment was being furnished by an operation up in New York City, a place called Long Island City, as a matter of fact. They needed some technical liaison work with that particular company. I was picked up by one of von Braun's key people, the number three man at the time. He found out I was from New York and asked how I would like to do some technical liaison work with the company up in New York. I jumped at that opportunity. I got into technical liaison, technical management, type work in guidance and control. I never really enjoyed the work in guidance and control. My background was mechanical engineering and the closest thing in that overall project environment was an office called Engine Program Management.

When I got out of service, I kind of made the request of getting into propulsion, which would have been my first preference. The other preference would have been to go back to North American where my job was still secured by the fact that I had been in the military. At that time, the policy was the military guy got his job back when he returned from service. I could have gone back to Los Angeles at that time. We chose to stay on here because I was offered this job in propulsion technology work. That is how I got into the business of propulsion.

Johnson: Basically, you were with missile propulsion until Marshall Space Flight Center was created and the von Braun team moved to NASA and then you also moved to NASA, am I correct?

Morea: I moved to NASA at that time, yes, in July of 1960.

Johnson: You did so many things during your NASA career. Let us talk about the first thing you did, which was manager of the F-1 Engine Program. You did that for six years. Could you talk about the main technical challenges for what you were doing during this early period of the Saturn Program?

Morea: I was given this opportunity to be the manager of the F-1 Engine Program. There was a run-out cost on that program, close to one billion dollars, and that was in 1962 money. It was a big, big program and it was lengthy program. The thing that was probably the most important thing about that program was that without the success of solving a number of real hard technical issues, we never would have made President [John Fitzgerald] Kennedy's pronouncement of going to the Moon and returning safely within the decade. Specifically, the major problem we had was a problem that was referred to as combustion instability. This is when the fire, the combustion is going on inside the thrust chamber of the engine would go unstable very similar to the flame of a candle. If you see a flame on a candle burning, it does not just burn in a nice little comb, but it flickers. Part of the flickering is due to the currents in the room, but part of it is the inherent combustion that is going on in the gases and it causes it to vibrate.

The vibration of the gases inside that thrust chamber was something like 2,000 cycles per second, very, very fast vibrations. In so doing, it would emit greater and greater energy. The temperatures inside the thrust chamber would go up so high that it would actually melt the walls of the thrust chamber and it would eventually blow up. We had a number of cases where we indeed burned the hardware. We had an iron horse thrust chamber to try to resist that just so we could understand what was going on and the phenomena. It was a test chamber, three inches thick, stainless steel. It would burn

through that stainless steel in a matter of milliseconds. It was something that happened so instantaneously it would be totally destructive to the engine. We obviously had to solve that problem before we could go any further.

We solved that by putting together an ad hoc team of the best brains we could find anywhere in the country, not just at Marshall. We looked at combustion people at Princeton University, we had a gentleman, a professor, Luigi Crocco, an individual up at Lewis Research Center in Cleveland [Ohio], Dr. [Richard] Priem was up there. We had some people here at Marshall Space Flight Center that were members of that team, a fellow by the name of Bob Richmond, who is still alive, lives very close by, a friend of ours, and Jerry Thompson, who headed the team up for me. He has since passed away. We did have a group of about half a dozen to a dozen people, some came and went, but most of them stayed on on a full-time basis to solve this problem. They got together with the contractor, who in this case was Rocketdyne, and Rocketdyne had some of the very best people that they could conjure up in order to solve that problem.

They went about coming up with different ideas. They looked at the old V-2 engine, why it did not go unstable. They looked at various possibilities that maybe they could break the combustion up into small zones by putting baffles in them. What would be the baffle configuration? It resulted in having the build some pretty big hardware, much

of which got destroyed, with different variations on that hardware. At that time, we did not have any computers that would help us imitate what was going on. We were using slide rules and the back of desk pads to figure out what might be going on. There were no software programs anywhere that could simulate what was going on. It was a trial and error type of project.

We spent the better part of four years working that kind of problem and came up with a design that was finally stable. We proved it was stable by actually inciting a combustion instability. We actually put a small bomb right in the middle of the thrust chamber and blew it up just at the time we were firing up the engine. The engine would go unstable for an instant and immediately stabilize again. It was that kind of a program that we had. It ran close to forty million dollars to solve that one problem.

Johnson: Did that take a lot of testing? When I say "a lot of testing," I mean dozens and dozens of tests.

Morea: Yes, hundreds of tests. The reason for a lot of testing is that you could not afford to have this sporadic thing happen once every 100 times or something like that. If you did a limited amount of testing and you were very successful, if you made the assumption it would always stay safe, that might have been the worst assumption you

would have made because you would have killed a bunch of astronauts. Yes, there was lot of testing, a lot of repetitious type testing. There was testing done at Rocketdyne, at Edwards Air Force Base, where we had the big test facilities for testing the F-1 engine, and we had a test stand here at Marshall that was used to do some test work and some verification that we had solved the problem.

Johnson: When you made your first successful firing where you had the problem beaten, was that at Marshall?

Morea: No, it was at Edwards Air Force Base.

Johnson: You did, I would assume, repeated test firings at Marshall, even once you had figured out what the problem was?

Morea: Yes, we did.

Johnson: You were with the F-1 engine for six years, but, am I correct, when the Saturn V actually flew with humans on it, you were then working on the J-2 engine, the next engine?

Morea: Yes. The interesting story there is that just at the time I was available for reassignment, you could say, because the F-1 had proven itself in flight as well as on the ground. The project manager of the J-2 engine moved with Leland Belew over to head up the Spacelab Project. There was a vacancy in the project manager's office for the J-2 engine development. Simultaneously with that, the J-2 engine had a double flight failure. We had a case where one engine was going to have to be shut down because it was malfunctioning and a signal was given to shut it down from ground stations.

Unfortunately, the wrong engine got shut down. A good engine got shut down, a bad engine was still working and it eventually shut down safely, which left the cluster of five J-2 engines in the second stage down to a cluster of three. Those three engines continued firing successfully, continued burning, and they just burned longer because there was extra propellant on board that the other two engines that failed would have consumed. The three engines continued firing for a longer period of time, it provided the necessary energy to place the upper stage, the S-IV-B with the capsule with the astronauts and everything else, put that into orbit around the Earth.

The next opportunity for the J-2 engine was in the S-IV stage, which was an upper stage engine, which was now in orbit around the Earth. It was supposed to prove that it could not only fire the first time to circularize the orbit around the Earth, but it had to fire a

second time to provide the payload going to the Moon on a translunar trajectory. That particular test was to prove that engine could fire after it had been fired once before, could it re-fire again in space. In fact, what happened was it did not fire, it had a failure. That same engine had a failure in the S-II stage and it had a failure in the S-IV stage.

That is why we say it was a double failure, but it was the same failure, as we found out. It was at that point that Dr. von Braun, his office, decided we needed to get an experienced manager to handle that J-2 problem. They asked me to assume responsibility for the J-2. I moved into that project office. It took us about two and a half years of understanding what happened and fixing what happened. It was a simple kind of a problem, but, nevertheless, you had to prove you were solving the correct problem. There was quite a bit of testing on that as well, but it was not in the same sense of urgency that I had when I was running the F-1 engine in the combustion instability days.

It turned out it was a line that was breaking, which was an auxiliary ignition system line. The ignition in the J-2 engine was started by introducing propellant, oxygen as well as hydrogen, which was the fuel, and igniting that with two small lines coming into the thrust chamber. One of those lines was breaking, so it was not getting a flow of a combination of those two fuels that we could ignite. It turned out the line was vibrating

and it was cracking. Once we fixed that line so it was a good, solid line and would not vibrate and crack, we had the problem solved. That is what happened on the J-2. I spent about two and a half years on that project, as I recall.

Johnson: Once again, lots of test firings.

Morea: Lots of test firings here as well as down in Slidell [Louisiana].

Johnson: You spent these years on engines during the Saturn days. Did you have to develop any new tools or come up with new materials?

Morea: In the F-1, there were a number of new materials that were involved in that because of the temperatures we were dealing with. I imagine there were some on the J-2 as well, but that was not the thrust of my responsibility. When I inherited that project, it was fix a problem and that was the problem I had to deal with. The F-1, of course, had some of the new Inconel steels and had turbine blades that had to be tested with new materials to be able to sustain the high temperatures we were dealing with. There was some material research that had to be done. Those by no means were the critical ones. The critical thing was combustion instability, no question about it. That was the showstopper of the century, of the decade.

Johnson: You did several years of work on engines and then you helped develop the Lunar Rover.

Morea: About the time I was learning to relax, I was out at Rocketdyne and we were having our final major review of the engine to make sure it was ready for flight. I get another call from Dr. Wernher von Braun's office and was offered a new position to head up a new project that NASA had given Marshall, and that was the development of the Lunar Roving Vehicle. My initial response was somewhat negative. I came back and said I had spent more than ten years as a manager in the propulsion area. I know propulsion. I do not know much about cars except I drive one. I guess Dr. von Braun's deputy said he would call me back. He called me back the next day and said von Braun said anyone who can solve program problems involving a one billion dollar program surely will be able to solve a problem that only costs about $40,000. (Both Laugh) That is how I inherited the LRV [Lunar Roving Vehicle] Program. You do not say no to Dr. von Braun. He selected me to do this. He wanted me to do it, so I did it.

Johnson: It strikes me that the Lunar Rover, you were developing a vehicle for a place that no one had ever travelled. If you were to categorize the problems, was that the problem?

Morea: No, there were several problems with the LRV. It was not just that we did not know anything about the surface of the Moon. That was still a time when there were scientists saying the dust on the Moon might be twenty feet deep and it will swallow up the whole LM [Lunar Module] and swallow up the LRV. After surveyor landed there and proved it was a solid surface, those kinds of fears were allayed. Certainly, there were temperatures on the Moon that were extraordinary. They would vary from plus 250 degrees to minus 250 degrees Fahrenheit, depending on whether you were travelling in the shade or travelling in the sunlit portion, depending on whether you were in early morning or whether you were at noon time, where the sun location was.

There were some technical issues there, but they were issues that lent themselves to being solved. We know how to solve a high temperature problem, you just use materials that can resist those kinds of temperatures. A rubber tire would not work on the Moon, plus it was too heavy anyway. We knew we could build a metal tire of some type. There were all these problems, unknowns, solutions that we could pretty well handle. The biggest problem of all, strangely enough, was the fact that we had to design and develop this vehicle and man-rate it all in a seventeen and half period from the time we signed the contract with Boeing and General Motors. As you know today, just designing a new model for a General Motors car or Ford or anything like that is usually a four year endeavor with all the technologies we have and all the knowledge we have.

We had to do this car in seventeen and a half months and we did not know the environment we were operating in very well. That was the challenge. It was doing it in seventeen and a half months. On top of that, of course, we had a budget constraint. We did not have much of that in the F-1 days. If we had a problem in the F-1, we had the money to fix it. If we had a problem here, it was going to be called an overrun. It was not a politically good environment to be in when you have to solve a technical issue like that.

Johnson: When you finally came up with the final design, it is a very simple, almost straightforward vehicle without any frills, so to speak.

Morea: No frills, but it was not simple. (Laughs)

Johnson: It was deceptively simple.

Morea: Yes.

Johnson: All along, did it seem you were headed that way, or did it seem like it was going to be a lot more complicated than that? What you ended up with is a pretty sparse-looking vehicle.

Morea: Yes, it is very sparse looking, but it is deceiving from the standpoint of complexity in that redundancy was an absolute must. We could not take a chance that we were going to leave two astronauts abandoned somewhere because the vehicle broke down. We had to have duplicate batteries, each had the capability of driving the entire EVA [Extravehicular Activity] mission. We had to have separate electric motors in each of the wheels so we basically had four-wheel drive. We could lose one wheel and the other three would continue to operate. We could lose a second one and the remaining two would continue to operate. We could actually lose three of the four motors in those wheels, and the last one would continue to operate. It would not go very fast, but it would still provide mobility to those astronauts. It was things like that. We had to have a navigation system onboard. On Earth, we could use a simple compass. There is no magnetic field on the Moon, so you had to use some kind of gyro system. Then you had to initialize the gyro using a sun line. There were a lot of technical issues that were complex, but solvable, but you only had seventeen and a half months to deal with all those issues. That was the challenge.

Johnson: When you tested rocket engines, you fire a rocket to test it. How do you test a vehicle for another body in the solar system and there is no Moon surface on Earth? What was the main test you did to make sure it would work as advertised?

Morea: The first thing we did was we built a 1g [Gravity] trainer, that is a vehicle that can operate in a 1g environment. The vehicle we built could not operate in a 1g environment. First of all, it could not weigh more than 450 pounds. You visualize two astronauts, each of whom weight close to 400 pounds on Earth with their gear, their oxygen tank, their suits, and that sort of thing. You had an 800 pound payload right there on top of this vehicle that only weighed 450 pounds. You had to have some testing on the wheels. We simulated craters, bumps, rocks, and that sort of thing down at the Army Mississippi Tank Facility. We used a carousel that had all these lumps, bumps, and rocks on it. We had this wire wheel over this carousel at this high speed to see how long it would take before we would rupture some of the strands on it. It was testing of that sort.

The trainer, of course, in order to give the astronauts an opportunity to get a feeling for how this might drive on the lunar surface, we designed that trainer to be able to be supported in our normal 1g environment. The problem was what it would feel like when they hit a rock. There was a machine we invented, it was down at Johnson Space Center, where we actually offloaded five-sixths of the weight of this trainer using a series of pullies and cranes and lifting part of the vehicle off the ground. You never lifted the whole thing, but you lifted five-sixths of the weight off the ground. Then they would drive the vehicle. When they hit a rock, it would behave like it only weighed

one-sixth as much, which is what it will weigh on the Moon. That vehicle would bounce up and they would get a feel for the operation of the vehicle in a one-sixth g environment because the gravity on the Moon is only one-sixth that of Earth.

Johnson: All this work on the Lunar Rover, you mentioned a couple of times it had to occur pretty rapidly. The engine work, I am assuming there were some deadlines considering a promise had been made to put men on the Moon within the decade. Talk about the pace of work. All the projects you worked on, was the pace fast? Were there deadlines that had to be met?

Morea: Yes, they were all on the critical path of putting a man on the Moon. For the F-1 engine, the critical path was the F-1 engine. There were a number of other issues on the vehicle, obviously, the development of the payload, the LM, that sort of thing, and they all had their issues as well. If we did not meet our critical milestones along the way, we would not have gone to the Moon. Among all the critical milestones in the development of that engine, the one that stands out as being the most important was the combustion instability one that I alluded to. There were others in there, but that was the biggie.

Johnson: Did you feel pressure?

Morea: Always.

Johnson: For most of a decade.

Morea: For the full six years I was under pressure for that F-1 engine, all six years of it. Inevitably, every Christmastime, we had a turbopump explode. It seemed like it was keeping time or something. We always had a turbopump issue around Christmastime and we would have to get a bunch of people out to Rocketdyne to inspect the hardware and find out why and what came apart.

Johnson: Talk about the work hours and shifts you had to work. It sounds like the days may have been long.

Morea: The days were very long and the weekends were very long. We worked whatever hours it took during the day. We did have a two hour problem between ourselves and the west coast because they were working different time. They were working Pacific Daylight Time and we were working on Central Daylight Time. That was a two hour problem. They were still working when most of our people would go home around 4:30 in the afternoon and it was only 2:30 out there. They were busy working and doing their testing up until six o'clock their time, which was eight o'clock

our time. Many a time, we would have to rush back to the office, take the telephone calls, and find out what was going on and talk about the failures, what we would do next, that sort of thing. The hours were not standard. If you got in an eight hour day, you were very lucky. Most of the time, you were looking at ten, twelve hour days.

Johnson: How about the work environment? Was it a pleasant environment? Did you enjoy what you were doing? Did the people who were working with you enjoy what they were doing?

Morea: It was a very pleasant environment. Everyone knew how important this was and they knew how important the whole decision of going to the Moon was. They did not want to let Dr. Wernher von Braun down in any commitments he made. He was an extremely supportive leader in the whole thing. We all felt like we were doing something so important. Who else would have been given the opportunity in their lifetime to send men to the Moon or a different planet in this universe? It was quite an accomplishment and we felt it as we were doing it. We knew how important it was.

Johnson: You talked about having plenty of money during the engine work. You talked about maybe not having so much money with the Lunar Rover. In general, how did you control costs? Did you think about that, that we have to do this cheaply?

Morea: The control of costs was a little different on the two projects. Because there was this tremendous commitment on the part of the president that we do this in this decade, and the support Congress had for it, they were fully behind it. We did not have the problems we have today between the Democrats and the Republicans, everyone was behind this thing, we had the money when we needed it. It was not a major issue. The control came strictly from the fact we had people assigned within the office who dealt with keeping up with where the money was, how it was being spent, and the performances we were expecting, the accomplishments we were expecting. Were they being accomplished on time and within those costs as they were estimated? It gave us a feeling for whether we were going to be overrunning our contract or not.

Back in those days, we also had cost plus contracts that were very prevalent. What that was is the contractor did the job and whatever the cost came out to be, the government basically paid for it and they got a fee on top of what they were initially getting for the price of the technology. By the time we got to the LRV days, money being so tight and the government realizing how much waste went on within government contracts in this cost plus fixed fee environment, they began to say we ought to incentivize contractors to save money and still accomplish the technical objectives. That was one of the big managerial issues I had to face, how I could control costs and still get the technical job done.

One of the things I thought was rather unique that we did was we developed a multiple overwriting incentive contract. It was the first time NASA had ever done this on any contract. It really came from within the body of the people in my office who were looking for creative ways to solve problems. This was a managerial problem they were helping to solve. What we did was we signed a contract with Boeing and ultimately they fed that down to General Motors, their subcontractor, said they estimate this job to be $18,500,000, which is what Boeing proposed in their proposal. If you overrun 100 percent of your costs, you will get zero fee, you gain nothing out of this thing other than the prestige of having done the job. If you accomplish the technical issue but it is so late that we cannot fly the vehicle, you get zero fee. The third one was, if we get to the Moon and the doggone vehicle breaks down and we strand an astronaut somewhere, you get zero fee. He had three ways to make no fee. He had to perform technically, he had to perform cost wise, and he had to perform schedule wise. That was a unique kind of a contract that, as far as I know, was done only once and we did it on the LRV contract.

That had some disadvantages, as we learned later on. Once you start running into an overrun problem, you do want to pour money into the thing. Then Congress finds out there is a major overrun in a program somewhere, so they start looking into what is causing this major overrun on a contract down at Marshall Space Flight Center. We put together the presentation to show them how we negotiated this thing with the

contractor and that instead of getting his normal fifteen percent that most contractors get with the government, he was getting basically zero. Congress was so impressed, at least the staff was, that they actually called off the GAO [Government Accountability Office] Office. They never investigated the program because of that, because they were so impressed with that. They could not understand why a contractor would sign such a contract. That was one of the goodies that came out of that whole thing. That is one of the things we did from a managerial point of view to control costs. It was actually this overriding, multiple incentive contract we had. He had to perform and still control costs.

Johnson: Obviously with the different engine problems you had to fix and even with the Lunar Rover, I would assume there were a lot of dead ends, a lot of things you tried that did not work. How did you recover from the dead ends? Was it a matter of persevering?

Morea: Persevering is the best response to that question, yes. We continued to go. We had to persevere on the F-1 because the whole program would stop if we did not solve those problems. We had to persevere. We had to put the money in, the testing in, the different approaches to things. Of course, that was basically a contractor responsibility,

but the government put together its own teams and helped support them. Wherever we had any capability to support them, we would.

For instance, on the LRV, the deployment of the LRV was a very tricky thing. This was a car that was the size of a Cadillac that had to be folded up into the size of a Volkswagen. That was one of the technical challenges of that program, where do you test this automatic deployment in a one-sixth g environment. Marshall had some capability here in the laboratories. Rather than have the contractor build a facility to do this kind of testing, we brought it inhouse here and the contractor could use our facilities for the testing. It was innovative thinking like that in the managerial areas as well as the technical areas that got us through this whole thing.

Johnson: To ask if there were surprises, once again, t almost goes without saying, of course, there were surprises when you are trying to figure out problems where no one has ever tried to figure them out before. Were there any major surprises in any of these projects, or in one project, that jumps out in your mind? Did you expect surprises in these different projects?

Morea: There was one major surprise that happened on the lunar surface after we got there. This was on Apollo 15. They deployed the vehicle and put it on the lunar surface.

They tried to start up the motion capability. They had power to all four wheels for locomotion. They moved the handle to the forward motion position and it would go straight ahead. They tried to turn and the front wheels would not steer. Again, this redundancy thing I talked to you earlier about, we had to add redundant steering. Not only did the front wheels steer, but the rear wheels could steer. In case one broke down, we had the capability of coming back on and EVA with the other set of wheels.

That is exactly what happened. On the very first EVA, before they ever left the Lunar Module, they tried to steer and the front wheels would not steer. Now the question was should we let them go with rear wheel steering. We did and the rear wheel steering worked fine. They parked the vehicle at the end of the first EVA, left the vehicle, went in and did some sleep time. On second EVA when Dave Scott got on the vehicle, click, click, click, all four wheels were working and both sets of steering were working. He made the comment on the air, which is in the recordings, "Hey, I bet some of you guys from Marshall came up here during the night and fixed this steering, did you not."
(Both Laugh)

We never figured out what caused that. It was glitch that a number of people had some theories for. I personally think the checklist they used, if you look at their gloves, the thickness of the fingers is so much that any switching they do can actually impact the

switch next to it if they are not careful. Even though they did the right switching at the right time, I suspect they tapped one of the other switches and did not notice it was in the wrong position. That is just my theory. I do not know what happened. I do not think anybody knows today what happened on that. The next morning, they got out there and it worked just fine. That was the biggest surprise. (Laughs)

Johnson: Can you talk about the difference between Marshall and some of the other NASA centers? Do you remember rivalries?

Morea: Yes, there were rivalries. I am not sure they were unhealthy. Competition is always good, even competition amongst centers is good as long as it does not get ugly.

Johnson: Did it ever get ugly?

Morea: I think only at lower levels somewhere it may have. I do not think it ever really got ugly. I think the toughest one I actually experienced was on the LRV because the LRV because a Marshall project and because the initial Phase A studies were conducted out of here. I suspect Johnson Space Center felt a little left out because this was a vehicle that was going to contain the two astronauts and they felt that was their prevue from a managerial point of view. The decision as to who was going to develop this was made

in Washington [District of Columbia] and Dr. George Mueller made that decision. Once a decision is made like that, any animosity disappears. Johnson Space Center realized they had to integrate this car into their Lunar Module, it had to be folded, and they provided us with a great deal of specifications that were necessary that we meet in order for them to be able to accommodate it. That was a very good, close working relationship that developed on that whole thing.

However, I would have to say that Johnson Space Center, when the decision was going to be made in one of the last management council meetings, this was in May 1969, just before we landed on the Moon in July, the center directors from Johnson were saying how much it was going to cost in terms of being able to accommodate this vehicle. They were going to have to offload critical fuel for hovering time of the LM while they selected the landing spot. They felt like that was a risk to the astronauts and might cause an abort of the mission because they were running out of fuel. There was a director up there called Dr. George Mueller who listened to that and made the hard decision to go with this vehicle, but he imposed on us as Marshall Space Flight Center the requirement that it had better be ready on time for Apollo 15 or we go without it. There was no incentive on the part of any other center to accommodate this vehicle.

If the Johnson people felt so strongly that they did not want to accommodate it, they could have very easily have screwed things up enough that it would not have flown on that vehicle. They cooperated with us tremendously during the development days. That is why I say I do not think there ever was a time when we had some nasty relationships. [James] Jim McDivitt was in that meeting and he was one of the astronauts who stood up and said we had better not go with an LRV, I would much rather have fuel to hover the LM. That was his point of view of it. I was in that meeting and it was interesting to see George Mueller taking that kind of heat from the astronauts and saying we were going to do it.

Johnson: How about Dr. von Braun's involvement in the various projects that you worked on? Did you see him a lot across the board?

Morea: Probably more than I needed to or wanted to. (Laughs) You had a lot of interaction with von Braun. Von Braun was everywhere all the time. He had this characteristic of leadership that he got out of his office and he spoke to people, he toured the facilities, he went into the laboratories. He had this system of weekly notes where we on a weekly basis would tell him the four or five important things we did that week or were involved in or concerned about. We would send that up to his office. He would spend his weekends reading every one of those notes. Inevitably, he would

communicate with you on those notes. He would jot down a little message back to you, some were of a personal nature and some were of a technical nature. He was always there to help.

He also had another leadership characteristic that I felt was quite unique, people to him were the most important product he had at the facility. He and I both were pilots. I used to fly my family down to Birmingham [Alabama] and we would have a Sunday buffet at the Holiday Inn motel there at the airport. One particular Sunday, I had just flown in and was waiting to get picked up by the Holiday Inn courtesy car. I was standing at one end of this fixed space operation building, it was a building probably 100 feet long in that area. As I looked out the window, I saw this twin-engine airplane come in and park way down at the other end. Who comes out of that airplane was von Braun and his wife and I believe Peter [von Braun] was with him, his son. There were three of them.

He comes out of the airplane and comes into the building at that far end of the building. I am with my wife and my children at the other end. Von Braun always looked around a room before he proceeded. I guess it was a habit of his from Germany or something. He always wanted to see who was in the room. At that distance, this was back in the days he had just given me the job of being the F-1 engine manager, he looked down the hallway and he recognized me at the other end. He grabs his wife and his son and says,

"Come on, I want you to meet somebody." He brought them down and introduced his family to us. He met my wife at that time. Niceties passed and then he got picked up by someone from where he was going and I got picked up by my courtesy car.

Just that one gentle thought on his part to involve a nobody that worked for him and say, "I know that man, I am going to go say hey to him." He so easily could have walked away, been picked up by his driver, and I never would have thought anything negative about it. It would have been so easy. Contrast that to another incident I had many years later with another center director where we were both on the same line at the Officer's Club for an Easter buffet. He was directly in front of me. We both said hi, and there was not another word or comment that transpired during the entire time we were on that line. It was like I was never there, nonexistent. [It was] completely different. That is why his leadership was so great. He was a humanist right down to the wire.

Johnson: Talk about the integration of all the different parts, projects, and designs. You worked on the engines, you worked on the Lunar Rover, when you put all this stuff together, I am not sure what you can say, but I have to believe it was amazing to see all these things, all these various projects by these various groups, go together and work.

Morea: Yes, it was, and that was certainly a major challenge. The way that was done was probably not unique to any other major project. Certainly the construction business has had to have similar kinds of things. You have to be sure that things will interface properly, so there was a whole office set up by Marshall Space Flight Center, which involved itself with the interface, all the parts, how they had to fit, who was being held to what weights, what dimensions. These were control documents that both parties had to attest to and sign to that they would meet that interface properly. Whether it was a performance interface or a mechanical interface, it did not matter. It was on an interface document that the people who had to interface with another group would have to sign off on and say we will meet that requirement. When the interfacing took place, the problems were absolutely minimal.

Johnson: It worked as it was supposed to.

Morea: It worked as it was supposed to, right.

Johnson: Talk about the contractor experience in your work. Was it good when you worked with contractors?

Morea: I was so fortunate to have worked with one of the best contractors around, and that was Rocketdyne. They knew what had to be done. There was cutting edge technology. They were some of the best brains around, some of the best technicians they had in that field. It was a great team that we worked with, not just the technical guys, but the managerial kinds of guys as well. There was humor involved in a great deal of the mangers. We met many times after work. We shared dinners. It was always enhancing the relationship and enhancing the trust we had in each other. Much of the work was done by telephone. You knew the guy at the other end of the line and you had complete faith in him. Lots of that was very efficiently done that way.

Johnson: How about NASA Headquarters? Did Headquarters help or hinder in all the different projects you worked on?

Morea: In my area of responsibility, in both cases, F-1 as well as the LRV, I had nothing but help from NASA Headquarters. The F-1 engine, until I took it over as the manager, was being run by a fellow by the name of Oscar Besio [Spelling?], and he was in a propulsion office up at NASA Headquarters. He was a very knowledgeable guy, very pleasant guy to get along with, and he would come down and meet with us all the time, participate in our meetings. If there was any problem money wise or anything like that, he would go back and make sure he greased the skids so things went smoothly up

there. I had no problem at all from that standpoint. Certainly the backing I got from George Mueller was phenomenal, the biggest backing being the approval of the project over and above the disclaimer from another center.

Johnson: How did you feel when the Saturn V finally flew?

Morea: Elated. I had this complete feeling of can you believe this? I cannot. It is amazing. (Laughs) It was total disbelief that we were able to pull that off.

Johnson: Did you sense in those days that you were making history?

Morea: Absolutely. In fact, that is what kept the esprit de corps [Morale] what it was. It was because we were making history. The technological advancements that were required to do this could only have been done in prior years by acts of major war. Here we had a peaceful representation and we were doing some outstanding work.

Johnson: We know how much recognition Dr. von Braun and the German rocket team got. Do you believe the rest of the workforce received the recognition they deserved? Did you receive the recognition you deserved for the hard work you did?

Morea: I think I did during the time Dr. von Braun was there. Things changed later on. (Laughs) While he was there, I got more than the recognition that I deserved. I was most appreciative.

Johnson: You continued working on propulsion after the Saturn days. You did not really work on the shuttle, but you worked on propulsion. Were the challenges different during the Saturn days than they were later, as far as your career is concerned and the work you did?

Morea: Yes, because I became more and more involved with technology work and less and less involved with project management work. It was certainly management involved in the technology world, but it was different than having to meet a schedule. It was more research oriented and I was dealing with different kinds of people now than previously. By kinds, I mean they were more research oriented, they were more inquisitive in terms of how things work and why do we not try things like this. There were things you would do technology wise that did not result finely in success, but more knowledge than success. The other thing is that later on in my career, the age of the computer came on board and we were now able to simulate so many things, made the job so different. The Shuttle Program had the benefit of the technology world of

computers. We did not have that in the early days of Saturn. We had a slide stick that we wore around our belt buckle as a sense of pride that we were an engineer. (Laughs)

Johnson: That actually brings a question to mind. Is it a little bit amazing to realize what you were able to do with what would be considered in the twenty-first century to be about the most primitive computing tools known to man? Are you amazed at what you were able to do with the lack of current computing?

Morea: Looking back now with twenty-twenty hindsight, I do not know how we did it, frankly. It is absolutely incredible.

Johnson: When you look back at what was accomplished, bottom line, how does it make you feel?

Morea: It makes me feel extremely proud and the world is a better place because we did that, especially this country. It always took wars to make major accomplishments in technology. It is terrible. Humanity would have to wipe out humanity. Now the spear became a gun and a gun became a cannon and so on and so on. We did not have that in the space program. Yes, it was a political race and we certainly felt a military threat from Russia that we had to exemplify that we had better technology than they and how

could they possibly be ahead of us. All of that was in there, but we did not have to go kill each other like we did in prior centuries to advance technology. That was a great sense of pride that I was a part of something that was so great in the development of humanity.