

Interview with

Conrad Nagel

by

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at

**Launch Control Center
Kennedy Space Center, Florida**

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Mr. Nagel: We were looking forward to get the first one down here, Columbia,

(Yeah, I got ..)

Mr. Nagel: We were working hard to get ready for her

Dr. Butler: Hm, hm. Well, we are here in Conrad Nagel's office in the Launch Control Center, and we are going to talk to him a little bit about his his experiences here at the Kennedy, and and then try to focus on shuttle stuff. I guess I should introduce both of us here, Conrad Nagel, and I'm Dr. Orville Butler. What I like to is to begin by having you tell us a little bit about your background, where you grew up, your education, and and sum it up by how you got into the into NASA.

Mr. Nagel: Boy! (laughter) All in one sentence, eh. Well, I grew up in Chattanooga, Tennessee, and went to the University of Tennessee at Chattanooga, and got a degree in Engineering Physics and I was commissioned a Second Lieutenant upon graduation, went into the service for three years, at which time I was stationed in Huntsville. And at that time, of course, they were developing the Saturn vehicle, NASA was, and I was on the other side of the base as a first and later a second Lieutenant working in research development with the Army Missile Command, working a lot of with Thiokol in the development of some of the high performance boosters, and then later on working in some advance research stuff with ARPA on the missile intercept and that type of thing. So we spent quite a bit time there. I had gone to the uh Guided Missile school there, and was guided missile officer. Luckily I did not ever get deployed as such and had a great assignment there. Got to know a lot of people at the Army Missile Command who subsequently came over to NASA. And so, uh, I had a couple of friends that came down to Kennedy Space Center, and, through some phone

calls, I ended up down at Kennedy Space Center in July of 1965. Uh which was a great opportunity for me because we were just getting through the Gemini program. It was on the tail end of that. We were getting really heavily into the Apollo program, and I ended up getting an assignment to work on the Saturn I program which was over on the Cape launch pads 34 and 37, and I worked on a number of different jobs, when I initially got the space center, but what really got my start into the operations was working procedures, count down procedures, launch procedures, launching counting down schedules and the launch rules associated with launching the vehicle, so I became what we call a launch mission rule engineer, which meant we, integrated all of the rules into a single document that would be used on launch day for launching the vehicle and of course this was coordinated and distributed out through the people on the console. So following that, I did a little this time on S-IVB stage as the uh as the stage manager for launch vehicle and then we got back and involved the launch mission rules through a re-organization, and I had that job for about three years including all of the man space flights. Uh, so that was a wonderful opportunity to actually get to know a lot of people including the Launch Director since his primary focus on launch day is to make sure that we are obeying all the rules.

Dr. Butler: And the Launch Director at that time was Kapryan?

Mr. Nagel: The Launch Directors at that time was Rocco Petrone and Walt Kapryan, uh they were Launch Directors, both of those, and then after the transition from Apollo and Sky Lab, I ended up as a Site Manager for shuttle which was the VAB was my site for activation of the facilities for shuttle from the launch vehicle side. I worked for George Page at the time. And we had some interesting time with George, and they were good, and of course George ended up with being our first Launch Director for Shuttle, so that

that was very warm experience with him in addition to a lot of hard work. George demanded excellence and I think the fact that we were able to to have a great shuttle flight STS-1 in April of 1980 uh 81 was was really great tribute to the team that we had here at Kennedy because a lot of the hardware came down here and needed a lot work on it and, of course, at Kennedy Space Center, that hardware culmination was brought together. The facilities side of it for me for VAB, what we did. Some of the major jobs that we did in VAB, of course, was prepare the VAB for receiving solid rocket boosters uh from Thiokol. At that time uh we processed the solids through the VAB, and that was our, our where we processed. So we received them in on rail cars

Dr. Butler: Where do they process them now?

Mr. Nagel: Yeah, we process them, we've got a separate facility to process them now. We've taken them out of the VAB as far as the processing of receiving from Thiokol. But at that time we had to build new stands, work stands, and added new cranes in the VAB So there was a huge job for site activation for the solar rocket boosters. That was one area that we we had for site activation, the second thing for the external tank, again we hanged the tanks in the VAB up about two hundred feet up in, up in bays uh 2 and 4. So we did a site activation to be able to accommodate our tanks, external tanks. And then over in the integration cells which is high bays 1 and 3, we had major work that we had to do there to convert from Apollo over to the shuttle which is totally different configuration envelope of the vehicle. So we had major mods to do there to get ready for shuttle, and we got all of that done, and had a lot of interesting stories that could go along with that, but it was a it was real experience to see the big platforms come down from Apollo, reconfigured and most of that

work was done at the transfer aisle, so the transfer aisle during that time it was very congested,

Dr. Butler: Hm, hm.

Mr. Nagel: Today it's wide open, and except for GSE [Ground Service Equipment] that's in the transfer aisle for temporary storage, you know, that we used to live the flight hardware. But, during the construction phase in the VAB, it was a very very busy place for about three years.

Dr. Butler: I see.

Mr. Nagel: So, that was a great opportunity to go through that site activation experience and and being in charge and leading a lot of that from from an operations point of view.

Dr. Butler: When you did site activation, did they, when they did the site activation of of launch com, launch complex 39, they used a number of management tools, including one that's called PERT, Program Evaluation Review Technique. Did you still use that for the site activation for Shuttle VAB?

Mr. Nagel: We had some similar tools that were like that and I don't know if it was called PERT at that time, but we did have similar tools, where we used the bubble charts, and had them all over the walls and we tracked them, tracked the activation process down through that bubble chart. Because there were a lot of contractors involved in this thing, a lot of construction contractors involved in it, and most of their contracts were written around schedule performance as well as, you know, Cost and other things, so we had some real challenges because of the integrated work force we had there for that activation process. So it was, it was very interesting. Our design engineering people led the design groups, very

strong design group at Kennedy Space Center for activation of all these facilities, and, I mean this was hundreds of millions of dollars worth of new construction to get these facilities ready. Our schedules uh were always tight, it seems like. And uh, So there were huge challenges to get all of the design incorporated, and of course design changes were very common at the time, there were lots things changing, almost daily or weekly, and so it was, the change process was huge, that we had to accommodate as part of our site activation, but we got there. (Laughter)

Dr. Butler: What was the major issued involved in the transition from from uh the Saturn vehicle to uh to shuttle.

Mr. Nagel: One of the things really stands out in my mind is when we first looked at bringing the rail cars into the VAB, we said, “Well, can we bring them down the transfer aisle?” “No, we don’t want bring them down the transfer aisle. Thats, we got the transfer aisle needs to be available for the orbiter there and we don’t’ want railroad tracks in the middle of the transfer aisle.” Then they looked at the VAB floor construction, and said it, it, its not going to be very easy to accommodate, you know, heavy rail cars down the center of VAB transfer aisle. So we said, “Well, can we bring them in the bay?” Well, there was issues bring them crossing the threshold where the big doors are, and needless to say after all of the flailing that was done, uh about how do we get rail cars into the VAB with solid rocket motor segments on them, the bottom line is uh that was accommodated and it went extremely well. Although there was a lot of questions about whether we would damage the flooring in the VAB. Of course a lot of the flooring was, we went through a transitioning getting across the thresh, the door threshold seems like to me was a monumental task that had to be. We worried that for weeks and months, it seemed like, before somebodys, finally, finally came to

the table, and said let's go get it done, and engineering uh the way they had done in a marvelous way in this program, pulled it out the fire and made it happen. And that that was a great thing to see that. When we uh when we first another little story that really uh gets my attention on the side is when we first bought the, we got the solid stacked, and we got the first ET mated, and the orbiter, we were waiting on the orbiter to come over, which was December of, uh, 1980, and I remember that very distinctly, because the orbiter was going to come over somewhere early December to the VAB. It was not ready to come to the VAB, they had not finished the tile work on it, and so we looked what does it take to get access on a hundred percent access to the orbiter in the VAB? And if you go over there today, you'll find there is a lot of the orbiter that is not accessible, uh without some supplementary platform stands, pick boards, et cetera. So we looked at that, and we came up with what we called a crotch platform which is really interesting. We built those down uh, in the LES shop and off at the construction sites and we actually put together a set of platforms in about two weeks to provide access to the whole aft end of the orbiter, so we can do tile in the VAB, because we knew that we were bring tile over from the OPF when Columbia came to the VAB for the first flight, STS 1. And that was a rid, working with those people who work with Iron, and just putting all that together, Gordon Ardley (phonetic) was a key player in that and he worked about twenty hours a day, I think, for two or three weeks just making that happen. And, of course, the orbiter came over. It took us about two days to get the orbiter up off the floor, mated it, because we had lots problems GSE. We'd never done this before, and but with help of a lot of patient people, engineering and some great technicians, uh we did get the sling set hooked up. We got the orbiter lifted over and mated up to the tank and which was a huge experience. We ended up cutting some platforms and everything else

just to get it done in there. But uh, uh, the guys with the torches were out there so it, it worked uh and it worked because of the team that we had, the dedicated people. And it just uh it was wonderful thing to see. People really come together, and this was our first experience with with the shuttle, the flight vehicle. We had done mock-up stuff, we had done dry-run stuff, but this was the real thing and when you get to the real thing, you found out that people ended up with passion to make this happen. And so we we got the orbiter down there, we got all of the access stands up there, which we had to lift into place and uh got access to the vehicle and continued the tile process uh in the VAB which was supposed to be completed in the OPF. And of course, we continued that tile process right on out through uh, the time we launched the vehicle STS 1. So but

Dr. Butler: so they did it even out on the pad?

Mr. Nagel: Oh, yeah, we did tile at the pad too. And, uh, it was, it was a very interesting thing. But one of things I remember that so clearly when that was because that was Christmas. That time when we had the orbiter in the VAB, and we, debated since we were really we were really pushing to get the vehicle out of VAB, so we said, “how much time we are going to let the people take off for Christmas?” Well, it ended up we gave most of the people a half a shift off on Christmas day and uh, that was uh just thinkin back, you know, for me that was very emotional too because we were out here working around the clock, seven days a week, same as they had been doing in the OPF, and uh, for the VAB, we had not experienced quite that level of work. And so we ramped up, they brought hundreds people out of the OPF to the VAB. This was the only spaceship we had at Kennedy at the time, Columbia. And, so the VAB became alive with people, seven days a week, three shift a day, for a little over four weeks from the time we received the orbiter, now it takes us about

five days, you know, and that's not even working around the clock for the most part. But that took us about thirty to thirty-five days around the clock to get the orbiter and the uh, the uh whole shuttle system ready to move to the pad. And, of course, when it did finally rolled out of VAB, boy, that was a great day for us. We were glad to see that thing go.

Dr. Butler: When a new vehicle comes to Kennedy, historically, er, it frequently comes practically in peach baskets, uh, and the processing people have put it together.

Mr. Nagel: Right.

Dr. Butler: Can you talk about that level with the first, uh, the first shuttle? Uh, you talked a little about tile, but what all was involved in processing the first shuttle?

Mr. Nagel: Well, of course, when when the shuttle arrives over the OPF, from Edwards Air Force base where it. If you go back and look at the pictures, we had stuck a lot of styrafoam on where the foam, or where the tile was eventually going to end up on the vehicle. So, if you look at Columbia when she first came in here, she was very ragged. And, and I think it was true for a lot of systems throughout the whole vehicle. We had a lot of work to do from one end to the other of Columbia. Aft, mid body and forward and of course, we installed the engines here and because when we ferried it across it didn't have engines in it initially. So at Kennedy Space Center that's what we do. So engines, APUs, and hooking up fuel cell systems and a lot of the avionics, you know had to be changed or uh or modified. So when we got Columbia here, I mean, we became a manufacturing center to a large extent. Now one of the wonderful things that happened as part of that is we brought a whole community down here with Columbia, from Palmdale, and from Houston and from Downey which was where Rockwell was at the time, our prime contractor for the orbiter. And so, I

mean, we had an army of people that converged on Kennedy Space Center when Columbia came down here. There were several hundred people that came with the bird. So, I mean, we just came down, and we essentially transferred the manufacturing capability from Palmdale down to Kennedy Space Center to the OPF. And we set up our manufacturing teams, and the vehicle we worked on it for a long time here before it was ready to roll out. And the design was good, and the workmanship was excellent, and the team was dedicated, and so I think we can say we had a great opportunity and great experience by going through that process. Like you said the same thing happened on the Saturn vehicle. The first Saturn we got down here, we had a lot of work we had to do on those vehicles.

Dr. Butler: You were you were involved in in the early Saturn processing process?

Mr. Nagel: Right. Right. I was here when we did Saturn and it its the same story, it's same thing with the Station, when we received the first elements for station, same thing was true. You know, we, we brought the thing down here, and the only way that we could make schedules is to assume a little more risk on the flight hardware by transferring it down here without it being complete. But we brought it in here, we brought the design organizations in here, design manufacturing, and we essentially completed the flight vehicles, spacecraft here for NASA, and we had a great great team to do that. So I mean looking back in retrospect like I was telling somebody the other day, when when I was out here on the Apollo program, and the VAB of course was not an ordinance facility like it is today. Uh, and when you over to the VAB, we had people that actually lived in the towers, next to their flight hardware, up to the 32nd floor in the VAB, all of those ... (both talking)

Dr. Butler: They they In the VAB they had offices or

Mr. Nagel: Yes, their offices

Dr. Butler: they had little apartments?

Mr. Nagel: Well, They, both. (Laughter) I mean those were the days when we didn't worry too much about over time. Uh

Dr. Butler: And of course back then ordnance was installed out at the pad.

Mr. Nagel: Ordnance was installed at the pad. But in the VAB, I mean, when we built Apollos, we stacked up the stack in the VAB, three hundred and sixty-five feet high, I mean those vehicles were huge, and so we had the engineering offices and quality organizations and technicians live right next to their stage, so you can walk out from your office across the platform and work on the flight hardware. I mean your office was less than a hundred feet from where the flight hardware was for Apollo. Today that's not true. We don't live, we don't have people living in the VAB. They live in other places and they report to the VAB for work on the flight hardware. But normally they are not there unless they got specific job to do on the flight hardware. For Apollo, it was totally different, and one of the things you saw when you worked on Apollo is when you went over in VAB, there were six thousand people living in that building. I mean, that is a very large building.

Dr. Butler: Hm, hm.

Mr. Nagle: And today you go over and you walk around the VAB, and you're gonna not see anybody, or if you see people, you see just very small groups, such is an ordinance facility. During Apollo, at the height of the Apollo program when we had three or four vehicles, launch vehicles in there, which was the Saturn V vehicles, we had eight or ten stages in there we were working on at one time--the S-IV, the S-IIs, the IUs, the IV-Bs, and all those stages, we were working on all of that flight hardware over there, I mean the lab

was full up, I mean, we got a lot of high priced laboratory facilities that were in the VAB too. So I mean the VAB was built to be, uh, totally self-sufficient in terms of being able to process the Saturn V vehicle, and and we did that. And, it's a totally different world back in the later 60's, then you found you know after we started to processing the shuttle there.

Dr. Butler: So after you started processing shuttle, you have, you had the actually processing moved out of the OP, OPF.

Mr. Nagel: Yeah, orbiter comes out of the OPF, Right.

Dr. Butler: And and it comes over to to the VAB, and the VAB now primary what you do is

Mr. Nagel: just mate, we mate the vehicle, we do a very little work on the vehicle and it's brought over, we roll it, generally rolled over one morning, and by the next morning the orbiter is up and mated to the tank and we were going through interphase tests, between the orbiter and the the ground side, the two umbilicals that are hooked up the tail service masts are hooked up out in the VAB from the mobile launch platform which allows the vehicle to communicate with the ground, and of course it also provides all the servicing that we do. And then we, of course mate the orbiter up to the tank, you know the mechanical mate points there and the electrical requirement. So actually, we have a very stream lined processing in the VAB right now. The orbiters mated, we go through a set of interface tests, and once we complete those interface test, we're ready to go out to the pad.

Dr. Butler: Ok, and once it is out of the pad, what happens?

Mr. Nagel: So within four days we were ready to go to the pad, ok. Or five days, depending on what kind of work arrangements we got. We used to, we've done it in four days. Brought the orbiter in, mated it, interface test, move to the pad on the fifth day.

Out on the pad, when we arrive at the pad. Of course the mobile launch platform carries the vehicle out of the pad, and the mobile launch platform is hooked up to the ground interfaces at the pad and of course the the RCC communicates with the vehicle through the mobile launch interfaces, which go back up through the tail service masts to the vehicle, that's how it communicates with the vehicle essentially. And also when we we get to the pad, we hooked up the propellant lines, which of course we don't have in the VAB, but we hooked up all of the gases and propellant lines that we'd have to have to service and load the vehicle with cryogenics uh prior to launch. So we got whole different set of interfaces at the pad, in addition to the electrical and communication interfaces in the VAB. We not only have those at the pad, but we got our gases and our purges and some other things at the VAB, at the pad that we don't have in the VAB. Because we were getting ready to flight a vehicle. We also at the pad of course you have huge interface with payloads community. Because the first thing we do when we get to the pad, we roll the structure in around the vehicle, open the payload bay doors, and the payload has already been placed in the PCR, Payload Change-out Room, and we move the payload into the orbiter, do our check-outs, interface tests, and then we do our close-outs, and we close our payload bay doors, and of course on launch day, or a day before launch, we moved the RSS we retract the Rotating Service Structure, and away from the vehicle and the vehicle of course standing clean at that time.. And of course, weather protection is another thing, we have weather protection panels out at the pad to protect the vehicle on the site, and, uh, for the most part the vehicle is very exposed at the launch pad, particularly to the salt air environment that we have out at the launch pad. In the VAB its pretty much protected and has very little environmental stuff other than temperature changes that we have.

Dr. Butler: Hm, hm.

Mr. Nagel: But, getting through uh the Apollo program and transition over to the shuttle, great experiences you know, just a lot of things come rushing back to our mind. Uh, after uh after we got the initial uh vehicle processed through the VAB, not too long after that, I guess we processed half of dozen those through the VAB and I ended up with different job, we physically had to move out of the VAB, because it was then an ordinance facility. So we got an opportunity to move over to a set of old box cars, which I lived in for about five years. And during that time I ended up with another job. I became a branch chief for our long range schedules and our integrated schedules. So I got really involved from Site activation schedules, initial vehicle processing schedules and the VAB over into more of the manifesting of the vehicles, the detail schedules associated with test and check-out and the vehicle turn around schedules. So I had that job for about a year or so, and then I ended up over on the source board for the SPC which was where we were really may have the major transition from a lot of different contractors to single contractor. Of course, I was on that source board for a year. After that, I came back and we were getting into DOD interfaces, real heavily. I ended up on the director's staff in charge of a lot of site activation for DOD requirements.

Dr. Butler: What sort of requirements?

Mr. Nagel: Secure requirements, the secure requirement, the procedures, the training, that was a real experience for me, and of course that was major undertaking to uh to provide a secure atmosphere for the DOD payloads, which were secure payload at the time And that was, that was wonderful experience, had a great team, a lot of hard work, dedicated people, great interfaces with the DOD and so that worked, worked really well for

us. So I had that job for about a year and then in, I guess it was April 1985 I got called into the director's office and he asked me if I would like to be uh, a what we call a Flow Director, for Atlantis, which was still out California and, of course, it was a wonderful opportunity for me, uh, to be able actually be in charge of one of those shuttle, orbiters, and

Dr. Butler: The, the Director at that time was Sherer?

Mr. Nagel: The Center Director probably was Lee Sherer at the time

Dr. Butler: Ok.

Mr. Nagel: and, then Tom Utsman was the Director of Management and Operations, which was the shuttle operations directorate, and so he gave me the opportunity so I became the flow director for Atlantis,

Dr. Butler: And this was when Atlantis first came.

Mr. Nagel: Yeah, Atlantis yes, I was here to receive the Atlantis and we didn't break Champaign bottles over there or anything, but we had great celebration that day, which she came in.

Dr. Butler: How was its arrival compared to Columbia?

Mr. Nagel: Atlantis was beautiful, I am telling you. Uh, I am still very fond of Atlantis, because I was Flow Director for the first twenty launches of Atlantis and which was over a thirteen-year period, that we did that. But of course we went to the Challenger thing. But when Atlantis came in, she was just absolutely a spotless and pristine and it, even reminiscing about that day it was just so clean from both mold line was just absolutely beautiful, you know, everything that was flat was suppsse...

Dr. Butler: She was ready to be stacked.

Mr. Nagel: a sparkling line. Essentially ready to be stacked. We went through the we received her over in the OPF, and, of course, her sister ships were already here, and but we were we were on the short keys then. So we brought it in May of 1985 and then we launched in October, October the 4th of 1985 was the first launch. So, from the time that it got here until the time we launched was only about four months.

Dr. Butler: Hm hm.

Mr. Nagel: and that tells you how good the flight hardware was, I mean, it was essentially ready to fly when it came to Kennedy Space Center.

Dr. Butler: Is that true for most the other shuttles as well, apart from, from Columbia.

Mr. Nagel: Well, uh...

Dr. Butler: Or did they all have

Mr. Nagel: They were much closer to flight configuration

Dr. Butler: Hm hm.

Mr. Nagel: than Columbia, Columbia we struggled with, and of course, as your aware of, Atlantis at the time was the last one in the fleet,

Dr. Butler: Hm hm.

Mr. Nagel: So I mean it was the fourth one to come out of Palmdale. Uh, Discovery, I think, had come out about a year earlier, and Discovery was in very good shape too. So I mean it just got better and better and better and by the time we got to the fourth production vehicle, it was very clean, uh and we got ready to fly that first flight. And, of course, first flight for Atlantis was a DOD flight, and, uh, which was one of the reasons that I had gone through the DOD process, uh to learn about all of the interfaces we had to make

sure that we were crisp with our DOD counterparts, and I think they were very happy with uh with where we ended up with with all of that, all their requirements and accommodating all their requirements, so.

Dr. Butler: Now was there a, you you talked about the development of of DOD interfacing,

Mr. Nagel: Right

Dr. Butler: was there a time period or or a shift for primarily NASA civilian contractor product flights to more interaction with DOD, you know obviously DOD had always had always had interaction with NASA.

Mr. Nagel: Right.

Dr. Butler: But was there a

Mr. Nagel: Oh, yeah, it was huge. We had we had a lot of guys here who were who were in their military outfits, and both enlisted and officers. They were part of our team and their presence was very strong. One of things that was going on same time as we first got into the shuttle launches, and it increased was the number of DOD people we had here in the processing side, because at the same time, we were out there modifying one of the launch pads at Vandenberg to be able to complement the whole east coast and west coasts

Dr. Butler: Hm.

Mr. Nagel: launch capability. I mean it was fully our intention that we were going to start launching shuttles off the west coast.

Dr. Butler: For the Polar flights?

Mr. Nagel: for the, for the DOD flights. And, I mean, we were well along in that process before Challenger. We were within about a year or two of launching the first vehicle out of Vandenberg when Challenger happened.

Dr. Butler: Hm hm.

Mr. Nagel: So, I mean, we were not only doing a lot of rapid fire launching at Kennedy Space Center of the shuttle, we were out working with DOD and NASA had a huge cattery out in California, interfacing with our DOD people, and then the contractors were moving people back and forth between the site activation at Vandenberg which was a follow up to site activation here and, uh, the developing of the launch capability out there and while we were launching here. So lots of things were going on, I mean, we had already, I mean, the schedules were in place to start moving the vehicles back and forth between the east coast and the west coast. So all of that was pretty well uh cut and dried in terms of planning. We were well down the path.

Dr. Butler: So we had a growth in in DOD's programs and launching here

Mr. Nagel: Hm hm.

Dr. Butler: with plans to to launch eventually out at Vandenberg,

Mr. Nagel: absolutely.

Dr. Butler: with DOD. Uh...

Mr. Nagel: It was huge, it was huge.

Dr. Butler: And what happened.

Mr. Nagel: Well, uh, for me, my life became absorbed in Atlantis.

(laughter) Believe it or not because I mean uh that became part of my life, that was like one of my kids and so, uh, but we got Atlantis here and we got her to flight the first time. Of

course it flew flawless and, uh, I always like to think about, you know, how good it was. And so we launched on October the 4th, went up and flew a short mission, just few days, and I think we were on orbit about four days. Anyway, we, uh, we did our DOD thing and delivered their satellite where we said we would. We came back and landed Atlantis, after the first flight, we landed out in California, because when we these first shuttle flights, you know, for about the first five or six years, we we were very uh uncomfortable landing in Kennedy, so everything landed at Edwards, so we landed in Edwards, and brought the vehicle back home in about a week. So we flew, we brought the vehicle home, brought it back to the OPF. Thirty days later, it came out of OPF, went over got on the stack, went back out on the pad. About twenty days, we launched from the pad, and on November the 27th, we had the second flight of Atlantis. So we flew in October and we flew again in November. And that was when were talking about launching twelve flights a year. And, in fact, we were in launch rate of twelve flights a year,

Dr. Butler: Hm hm.

Mr. Nagel: and, uh, we had all kind of customers. You know we had commercial customers. Our second flight, we had three satellites which were commercial satellites and we took those up and uh delivered them. They were great. So I mean here we were the first flight was a DOD, the second one was commercial satellites. I mean we were in business here with the shuttle and doing just what, you know, it was assigned to do. And so we start preparing for the next flight, and in the mean time we were getting ready to launch believe it or not, we were going to launch the liquid hydrogen Centaur out of payload bay. So we were well along through the processing of getting ready for launch Galileo out of Atlantis, which took a Centaur upper stage to be able to kick out of the the vehicle. And I

can't believe that we did some of things we did but we were going to load that payload bay up full of hydrogen, liquid hydrogen and oxygen, and have a satellite on top of it. Uh, a little bit of cavalier to say the least looking back in retrospect.

Dr. Butler: Did they have a lot of of, did they take greater risks back then?

I know, uh

Mr. Nagel: No doubt about it. We took a lot of risks. And, uh, of course before, as we were preparing Atlantis we had landed, lets see we flew on 27th of November and we landed a week later, so around the first week of December. Atlantis was up and rolling again, uh, at the time, you know, we generally took off Thanks-giving day, maybe all day and Christmas Day, maybe all day. But to tell you the truth, I mean, we were essentially three hundred sixty-five days a year here around the clock at the time to launch twelve, once a month. And of course, in the mean time, we had, I think, two other launches, uh from the time either one or two other ones, and of course then there's January the 28th of 1986, is when we lost Challenger. And, of course, that was like, we couldn't believe it. And uh

Dr. Butler: Where were you or do you remember where?

Mr. Nagel: Well, I remember very distinctly where I was that day. Of course, you know, we all took time out to go watch the launch of the vehicles and that was a hard day for me, because I ended up on the top of the RCC with the crew families. Which was an experience I don't want to have it again, of course. And but needless to say it was an experience, which is very vivid in my mind for that day. And, uh, it was very sad occasion for us, because of that experience that we had. From there of course, I mean

Dr. Butler: At at at at that time you were still in charge of Atlantis?

Mr. Nagel: I was, yeah, Atlantis was my vehicle, Jim Harrington was my counterpart on Challenger.

Dr. Butler: Hm, hm.

Mr. Nagel: And, of course, he was in the firing room that day, because flow directors assisted the launch director and that was a part of our job. So normally we were in the firing room. We were, we had a console position for our launches, for our vehicles and so Jim was in the firing room that day. But that was a hard, that was hard day to get over and, of course, it's very vivid in your memory if you went through that thing like we did. And but we, we did, manage to go through that process of looking at where we were, how we ended up there. There were a huge numbers of changes that happened as result of Challenger. And, of course, the president was involved in that, President Reagan at the time and made some major major policy changes, that we would no longer fly commercial satellites on the shuttle and we were no longer flight DOD flights on the shuttle and that they would be transitioned out. And of course we did we have flown some DOD flights since Challenger but essentially they were to clean the books of stuff that had been designed to fly on the vehicle and re-design would be very expensive for the satellites. And so we we flew a number of of DOD flights, later. But essentially today, that's all history just like commercial satellites on shuttles for the most part are all history. And so with that change, and the direction coming out of the president, we proceeded to figure out what we needed to do to make this vehicle more safe, reduce the risk and at the same time build another vehicle which was Endeavor to replace uh Challenger. And that was, that was a very, that was a hard twenty-seven months from the time that we lost Challenger to the time that we flew

Discovery again. There were hundreds and hundreds modifications we did to all of the hardware.

Dr. Butler: Hm hm.

Mr. Nagel: Of course the boosters had to be totally re-designed in terms of how we mated the segments and closed out the segments and took care of the o-rings, you know, to keep them toasty warm on a cold day. Uh, so there were there were just a huge numbers of changes in all of the vehicle

Dr. Butler: Hm, hm.

Mr. Nagel: Flight hardware as well as the ground side to reduce risk, to increase our safety margins, uh engines--major changes in the engines. So from from one end of the vehicle to the other, there were hundreds and hundreds of mods which were accommodated, and of course we were up and flying again in about twenty-seven months or so. Discovery went first. Atlantis was the second flight on return to flight at the time and then we we proceeded with our manifest. Tried to catch up we had lots of payloads that were backlogged as result of being down for over two years.

Dr. Butler: Now these would have been satellites that that had been backlogged before the change in policy.

Mr. Nagel: Right, right, so we had, I mean it was a mass confusion in the in the industry too, as to how all these commercial guys are going to get airborne and how the DOD guys are getting airborne as well as the scientific uh requirements that we had placed on the shuttle. So there was a lots of scrambling around for about three years there, or even longer. And, of course, had major changes in our management structure and, Dick Smith was our Center Director here

Dr. Butler: Hm, hm.

Mr. Nagel: when we lost Challenger and shortly after that he was replaced by General Forest McCartney who was our Center Director that led us through the process of getting ready to go fly again. So, we got up, we got flying and had a lot of successes. Uh ...

Dr. Butler: What what was after after you lost the commercial satellites and and DOD projects, what were the primary missions?

Mr. Nagel: Well, they were most scientific. We had a number of planetary things that we kicked out—Ulysses, Galileo, figured out how to do that even without a Centaur upperstage, used a sling shot technique uh which was... It took a lot longer to get it where they wanted to go and but they got there and had a great mission. And, I think, uh, the fact that we had that back log probably uh uh there wouldn't be that kind of backlog uh if we kept flying,

Dr. Butler: Hm, hm.

Mr. Nagel: but the fact that we didn't fly for almost two and half years.

Dr. Butler: Do you think you could ...

Mr. Nagel: Then we had a backlog.

Dr. Butler: Do you think you could have returned to flight quicker?

Mr. Nagel: No. We couldn't not, because we we did some really huge modifications. First the boosters had to be re-designed, so that was major big deal. We put into the crew bail out capability, which was a big deal, and we made major engine changes to increase our margin of error. So the answer to the question based on the number of design changes that we had, hardware changes, certification requirements, uh no way.

Mr. Nagel: How did how did Challenger change orbiter processing after a vehicle comes back from flight? Why don't you talk about uh what the processing process was prior Challenger and what became after Challenger.

Mr. Nagel: Prior to Challenger, we were we were processing vehicles, it took us about one month to get through the OPF. Even less. I think we did as low as maybe twenty-six days. Twenty-six days in and out of the OPF, it was around the clock, three shifts a day, seven days a week, uh is amazing, is amazing. Four days in the VAB is amazing, less than twenty days at the launch pad, uh when we think about today, think about then, it's amazing. Today our baseline, our our our aggressive baseline today is eighty days in the OPF, eighty days vs. twenty-five, twenty-six to around, a long OPF flow prior to Challenger was thirty-five or forty days, that was a long flow.

Dr. Butler: Hm hm.

Mr. Nagel: I mean if we were turning out, we we expected to have the vehicle out in thirty days, ready to go fly again. Today, uh, a short flow is eighty days. We have done some aggressive flows since Challenger, the most aggressive flow that we had was sixty-five days, that was very very aggressive flow since Challenger. Today our baseline is aggressive flow is eighty days, typically we take about ninety days today to turn the orbiter around. Why is that? Well, there're a lot of reasons. Our work force is totally different today then it was then. We've got about half the contractor people here at Kennedy that we had prior to Challenger. Our NASA work force today is about one third of what it was prior to Challenger. Our, our processes are more rigorous today, we do more tests and more check-out today than we did prior to Challenger. In theory, we were looking for a vehicle that was an aircraft type style vehicle that we were going launch. We tried to mold the shuttle vehicle

into a lot of that. The shuttle and the orbiter specifically is not an, is not an airplane. It is, it is a spacecraft.

It has some characteristics that when we flight it as a glider coming back in, but that's the only time. It lands on on a landing gears which is like an airplane. It is towed like an airplane. But when you get there, that is the end of it. Even though, it's got a lot of avionics which allows it to land, it's got all of the the landing aids which allows to land as a glider. Its gliding in like a rock almost. But it does a great job, and we can put it down exactly where we said we're going to land it—within just few feet of where we predict its going to land, it's going to land. After being at Mach 25, it goes to zero in about uh ninety minutes; from Mach 25 to zero in ninety minutes, and that is huge. Airplanes don't do that. And so I mean we looked at the transition that happened uh between Challenger, before Challenger, after Challenger, and where we are today. Uh economics are very very important to us today. We have reduced the cost uh on this program to about forty percent of what it cost us when we returned to flight. What it was costing us to fly the vehicle, uh, and what we, what we are doing today. It's huge, the changes that have been made. We've stretched out the schedule, but we're still meeting the manifest up until the time the we had Columbia accident.

Dr. Butler: So the length of the time was not just a measure of increasing processing, it was a measure of budget cuts and increased processing and and being a little bit more careful about the processing process.

Mr. Nagel: We have we have continue to change the flight hardware, since the first day that vehicle arrived at Kennedy Space Center.

Dr. Butler: To what extent

Mr. Nagel: That's all parts of it..

Dr. Butler: To what extend does the shuttle get quote, unquote re-built after a flight.

Mr. Nagel: On a normal turn around when we're not doing a lot of mods for the vehicle. If we do a standard eighty-day flow, which is what we have today. Eighty to ninety day flow. When we do that there is actually very little of vehicle that is changed during that flight. The major changes happen in the payload bay. To accommodate a different payload, we would put different systems in, different GS, different support structure in the vehicle to support a different payload, uh locate launch rungs, keels in different location, obviously interconnects with the flight hardware depending on whether it got power requirement or not power requirements, and there's major changes that go on there. On the flight deck, there are very little changes that are made from one flight to another during a normal turnaround. Now if we are going into a mod period, that's a totally different story, but from flight to flight to flight, the forward and aft compartments very little changes on the vehicle.

We change the the engines out after every flight, as your aware of. I mean that is one of things that came out of Challenger. Prior to Challenger, we flew the vehicle, we flew the engines more than one time, you know, we went in, inspect them, purged them out, clean them up, made sure we didn't have any issues, lined that thing up and she was heading to the pad again with same engines that she just flew with. By design. Today, we don't do that. We change the engines out after every flight, they're changed out. We change pumps after every flight in the engines. I mean that's part of the process today. And again, what we were looking for is reducing risk, increasing margin, how do you do that. So it's, it's

its a totally world today then what it was prior to Challenger and it probably will be some what a different world after Columbia. By the time we finish up with the investigation and the improvements that we'll make to flight hardware, reducing risk. And we're we're going to work hard to do that. We don't ever want to loose a vehicle again. I mean, it's hard enough to have lost one a second time. The first time was really tough. Nobody ever thought it would happen. And I think the second time around, in my own mind, somehow, I felt like it might happen again one of these days. I didn't expect to happen like it happened.

Dr. Butler: Hm Hm.

Mr. Nagel: You know, to tell you the truth, when this bird lifts off at the pad, it's a controlled explosion. When she comes out of the pad, I mean, it is literally a controlled explosion, the solids light up and the engines light up and you've got seven million pounds of trust. Lit up back there pushing that vehicle up all of a sudden. And it's just, an amazing thing that that we see out at the launch pad every time one of these birds launches. The risk is very high when we hit T-0, and we light up everything, there's lots of dynamic things that can happen there.

Dr. Butler: So you are more concerned of of having another Challenger type of accident.

Mr. Nagel: I would be more concerned about the first micro-second when we light everything up there.

Dr. Butler: Hm hm.

Mr. Nagel: that something can come loose. Because I mean everything is experiencing huge g-loads are uh on that vehicle and the pressures and the temperature, I mean everything is dynamic. The pumps are running, screaming I should say. The hydraulic

pumps and and it's just is a very very dynamic situation when we lift off out at the launch pad. And it it just demonstrates our our design capability and our technology of today, how we can harness that power and focus it to push this vehicle out into space. And, uh, man, it's great, I mean uh to to work on the program like this and to go through this experience and to see the transitions that we've gone through, although some of them have been very very painful. They have been very meaningful in my life, because, I mean, I just feel very privileged to have been in all the different jobs that I'd been in from the first time that we launched a Saturn vehicle with an Apollo capsule on top of it, until, you know, today when we're uh again looking forward to get on return to flight and and realizing that we are going to move on with our program and it is a great program, it is a great adventure. I mean there probably is no adventure that mankind has ever had, that would rival what we experienced here, or what I've experienced here in this program.

Dr. Butler: Hm hm.

Mr. Nagel: It has been a wonderful wonderful experience for me of of almost forty years. I can't image any job that I would have rather had then where I've been for the last four years of my life.

Dr. Butler: Some newspapers have, uh, you know there's been lots of speculation after after Columbia about whether or not we could have detected the whatever caused the actual demise or not and whether or not we could've sent another shuttle up there to rescue had we decided there was something amiss. In some newspapers that have reported that we did have the capacity to send up a rescue mission. In term of processing, would that have been possible?

Mr. Nagel: Theoretically that would be possible. In real life though I think we would question why do we want to send something again when we don't know what happened the first time.

Dr. Butler: Hm hm.

Mr. Nagel: And you would have, you would have to take the second risk, you would risk a second vehicle and crew when you do not understand what happened to the first vehicle. And I think, personally, it would have been very unwise to try and do something like that. In theory, it could have been done. But having not understood what happened to Columbia, uh, and why it happened to Columbia. Had we even known that we had a cracked RCC panel or a hole in an RCC panel or a separated carrier panel in that area. What ever the bottom line was as to what the root cause for the failure was, if you know understand that, I don't think you would've committed another vehicle and crew to flight without understanding that first one. There's prob, I mean, we can speculate on a lot of things today. I think it's going to be very interesting what the CAB comes out with, when they come out with their report, their recommendations for us. I am sure they're going to be right on target for a lot of thing. I mean how many things in life can you say I have absolutely done the best I can do for months and months, weeks and weeks, days and days, hours and hours. And there's not many of us that can't look at where we are in our day to day lives, that we can't do something better. And I think we we are going to find out that that we could some things better. And I expect we are going to do some things better. We are going to put some things in place, which is going uh reduce the risk a little bit in some areas, and uh enhance the probability of success. And I think that where we want to be. I certainly want to be there. I did not want to experience any of the things—the Apollo accident that we

had, that I was out here for, the Challenger accident that we had, that I was here for, and now Columbia, I did not want to experience any of those things. I tell you I have tremendous confidence in this team. We have a group of dedicated people that I don't think there's any group of people on this earth that's more dedicated to doing a quality job than we have here at Kennedy Space Center and throughout the program. We just got, just got some people who uh have passion about this program.

Dr. Butler: Hm hm.

Mr. Nagel: I mean I love this program, I had given my life to this program. And I am not alone. There are hundreds and thousands people who can say that because this is where we wanted to be and we had been very privileged to be here.

Dr. Butler: You mentioned you are part of Apollo the

Mr. Nagel: The fire, when we lost the three astronauts.

Dr. Butler: Uh where were you?

Mr. Nagel: That was hard. Well, that particular day we were doing a dry we were doing uh CDDT, a dry CDDT which we actually was like a dress rehearsal for launch. We were getting ready to launch those three men. We didn't know that they were in a fire trap. But they were, they had a pure oxygen atmosphere that we shouldn't have. And of course we changed all that after the accident. But I was on console that night, you know and I had just, I had just left and that particular night we were having a revival down at the church and I had gone down to the church and and after church was over they announced that we had lost three astronauts in a fire and I was in total disbelief because I had left out here about six o'clock that night. I had been on console all day long and I said "how can we have lost three astronauts when they were doing a dry run." I didn't realize at the time that we had

oxygen atmosphere in the spacecraft and a spark had ignited that oxygen. And of course, it burned up. And that was a hard lesson learned. We learned a lot of lessons off of that. And because of those lessons learned, I mean we went a long time before we had another accident. And a lot of that was incorporated into the shuttle vehicle, specifically the orbiter, you know, the crew module. So, it was, that was that was a hard experience. And every each of these are hard experiences for people who dedicated their lives to this program. But, uh, we will move on and we will launch again uh in the next year, and we will be successful, and we will go where we ought to go. Because man is destined to go into space and we're going to go there.

Dr. Butler: I'd like you to go back now, and talk a little bit about, about some of the people you worked with. You you mentioned Rocco Petrone, what was Rocco like.

Mr. Nagel: (laughter) He was tough. (Laughter) Great leader, uh very forceful, thorough dedicated, detail man, turned over all the rocks, Rocco, anybody that ever worked with him, they will never forget working for him. He was very dictatorial, he was aggressive, and like I say, if you work for him, he had he expected you to tow the line just the way he would tow the line and make things happen. And things did happen under his command. We moved you know to to the first Apollo launches. And he led that, he led that team, and that was huge, to bring together this contractor team and this NASA team to uh to land man on the moon in less than a decade. That was huge. Rocco played a leading part of that at Kennedy Space Center. And so you know he was he was great leader, great leader.

Dr. Butler: Did you interact much with Dr. Debus?

Mr. Nagel: Never really interacted with him. You know you were you were aware of him, because again he was he was pretty aggressive too, you know, in terms of his leadership skills. And Dr. Gruene, whom I worked for in launch vehicle, on the launch vehicle side, did interact with him a lot, he was much gentler person. A lot of leadership skills, extremely smart. Surrounded himself with a lot of smart people.

Dr. Butler: Debus or Gruene

Mr. Nagel: Sir?

Dr. Butler: Is this Debus or Gruene.

Mr. Nagel: Gruene.

Dr. Butler: Ok.

Mr. Nagel: Yeah. So, he represented the kinder gentler side of the German culture. (Laughter) But that it was it was a wonderful experience working with those, those Germans and then of course going through the transition over to,uh, to uh to shuttle. But it it's been really great. Uh, I can truly say I've worked with a lot of wonderful people, a lot of leadership skills. George Page stands out in my mind, as one of the heroes in the program. It has been fun.

Dr. Butler: Hm, hm. Well, I think we got a signal there that we were running out of time.

Mr. Nagel: Yeah.

Dr. Butler: Uh, thank you for taking the time to talk with today, uh and what we'll do is we we'll take this, and get it transcribed, uh let you take look at it.

Mr. Nagel: Okay.

Dr. Butler: And that might be some additional comments that you want to fill in or or we might have few additional questions that that we've missed.

Mr. Nagel: Okay.

Dr. Butler: Uh.

Mr. Nagel: Send them over.

Dr. Butler: Okay, we'll do that.

Mr. Nagel: Thank you.

Dr. Butler: Thank you so much

Mr. Nagel: Thank you.

Dr. Butler: Hm, hm.

Mr. Nagel: You have a great day.

Dr. Butler: You too.