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INTERVIEW WITH JAMES B. ODOM
INTERVIEWED BY ANDREW DUNAR AND STEPHEN WARING
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HUNTSVILLE, AL

1. Waring We're interviewing Jim Odom and it's the 26th of August 1993. Could we start off with a little bit about your very early career. How did you get involved in space work at Marshall? When did you come and what led you here?

2. Odom Got there quite by accident. I finished at Auburn University in 1955 in mechanical engineering and immediately out of college, I took a position with what was then Chemstran Corporation in Decatur just 25 miles from here. Worked there for 6 months and was drafted. Went through basic training and was assigned to an engineering group in Fort Knox, Kentucky. While on leave between basic training and my first assignment, quite by accident one of the personnel people at then ABMA asked me if I would be interesting in getting into the missile business at Redstone. Back then, my wife was still in Decatur so that suited me nicely. At that time, General Medaris had called on virtually anyone in the military and was staffing up the Army Ballistic Missile Agency, so when I reported to Fort Knox, I already had orders to come back to Redstone. So I got into the missile business like I say quite by accident, had no intention of ever working for the government. I knew Redstone was here but that's about all I knew about it. I

had all intentions of going back to the industry after my two years in the Army were up. I ended up assigned to the what was then called the launching and handling lab in ABMA which was kind of the predecessor of the group that went to the cape and set up the Kennedy Center down there.

3. Waring Was there any stigma attached to being in effect a draftee engineering?

4. Odom Not at all. Matter of fact it was a very unique program. The program was called Scientific and Professional S&P. It was really just in the embryonic stages. It was just being tried. To my knowledge, it was the first time, and I'm not sure it's really been done since, to where they would take people and actually working them in their field. That was rather unique in the military. I literally was doing design work which I thoroughly enjoyed. So that was part of the program and that was the one that General Medaris and Von Braun used to bring in military people. The group that I was in was about a couple of hundred people. There were about, as I recall, there were probably about 30 PhDs. There was probably another 50 or 60 with Master's level and all the rest had undergraduate degrees. As a matter of fact I don't think there was anyone in the company that didn't have at least a four year degree. It was rather unique. We did pull KP once in a while, training every Wednesday afternoon. I wore a uniform to work, but I worked

with, had an office and a desk right with the civilians. Other than the really nominal amount of military duties, I worked just like a civilian. To me it was a real win win for both the ABMA as well as those of us that had two years to serve. I didn't mind serving my time. As a matter of fact I felt like I should because I had been going virtually through school during the Korean War just getting deferment a quarter at a time. I would sign up the next quarter never knowing if I was going to get to go or if I would be drafted but I really did want to get my degree behind me before I went in which fortunately worked out that way. It was a rather unique program and virtually all the people had either engineering degrees or physics degrees that were in the company that I was assigned to. It worked out very well for all involved.

5. Dunar In general, were most of the people coming into the program from Alabama, Tennessee, . . . ?

6. Odom All over. What was really interesting and I'm sure you've run across this in your interviews, as is typical with GIs, he's never happy wherever he is, but everyone of them just couldn't wait to get out of the military to go back to Detroit or go back to Boston. I had good friends that I worked with from all over the United States, California, so it wasn't a locale driven thing at all. What's interesting is how many of them are still here today,

that have stayed right through since they got out, stayed on with either ABMA or moved over to NASA. So there are a lot of people and I'm sure you've interviewed probably several that came along.

7. Waring Like Kingsbury.

8. Odom Kingsbury is one. Bob Lindstrom is another one. Stan Rienartz is one. Jim Barnes was another. There are a lot of them.

9. Waring Another issue we're interested in is the relationship between Americans and the Germans who were often lab directors or fairly high in the organization. Could you discuss that?

10. Odom That was absolutely unique and that was another thing that I had no idea when I agreed to come back. I know Von Braun was here and I knew there was a number of Germans. I had no idea what positions they had or anything. Let me just say up front that working with the Germans not only was a pleasant experience for me, I obviously can't talk for anyone else. I thoroughly enjoyed them. They were extremely professional people, the most dedicated people that you will ever find and fairly people oriented especially Von Braun. They were absolutely, totally, dedicated to the job. Their professional integrity was just

impeccable and I believe that probably many successes that I've enjoyed was because of the association with those men. I worked directly under Germans almost, well for sure until the Shuttle program. All through the Apollo, I was working under one or more of the Germans. The lab directors were virtually all German during ABMA time. It was nothing but an absolutely pleasant experience.

11. Waring Could you talk about maybe some lessons that you learned from working with them? Did they see the role as sort of being the master to the apprentice?

12. Odom Quite a bit. They were very patient, the ones that I worked with. I can't say that that's true for all of them, but the one's that I worked with were people like Hans Shuter and Frederick Duark were extremely willing to take the time to explain as a rule why they wanted things done. A lot of times, us young guys, we didn't understand why and it was not until probably several years later, but they were coming from a world of experience with the kind of hardware that we were involved with. And it was an industry that didn't even exist in this country so working with them was a a real experience of just building the industrial base in this country that could even do the things that we were setting out to do because we didn't even know how to spell [106?] systems as an industry and they were leading us through that because they had already been through it, a

lesser scale but probably with a lot more difficulty than doing it during the war times. The things that I think we probably, or let me just say I learned the most from them was first of all dedication to the job, but more importantly the attention to detail and the rigor of design and testing and building systems that were muscular as opposed to very fragile. All you've got to do is walk through the Redstone, the Pershing, the Jupiter, and the Saturn Is, IBs and Apollo, and you'll see that. You'll see that. [tape on and off again]

13. Waring Lessons from the Germans, the dedication and the rigor of the hardware.

14. Odom That's something that I'm afraid our industry is not as well blessed with as it was. They were high on giving a person a job and holding them responsible of getting it done and I learned that at a very young age and that too is something that I'm afraid has deminshed with larger organizations. Excuse me just a second. [turn tape off and back on] Which question did we leave off?

15. Waring You were talking about how the Germans had assigned every individual specific responsibility.

16. Odom Yes. That I enjoyed because they gave you fairly good instructions. You knew if you had the responsibility

for a particular subsystem or a particular vehicle or a particular set of hardware and they'd also make sure that you'd have the resources with which to get it done, financial facilities, equipment. But, they expected you to produce and on time and make the schedule. Schedule was very important to us especially in the Apollo program and that was true even when we were in the ABMA. I learned basically responsibility very early on. I mean as a very young engineer in probably my mid-20s at time. So just in summary, my experience with the Germans was that I not only learned respect for them, but I learned a lot of work ethics, habits that I probably would not have gotten in a typically American industry.

17. Waring How would American industry typically manage a project like that?

18. Odom With literally thousands of people, so much shared responsibility that no one is responsible for enough of any particular entity that they feel responsible to make it happen. In other words, our jobs now are divided up into such small increments that people look at it in American industry and say, "Well gee, if I don't get mine done today or next month, my part is so small it's insignificant." But what they don't realize is that it may be absolutely crucial, but we don't sense the urgency. I realize that's an awful summary answer, but I firmly believe it's accurate.

19. Dunar What did the German's think of American industry?

20. Odom They were impressed with the sheer size and magnitude and ability of the industry to put out a lot of hardware. In other words, in mass production we could out do them. I'm just comparing them to the Germans at that time and World War II obviously proved that. They were a bit surprised that we weren't further along in the missile business than we were. They had not really any way to calibrate the data until they got over except the two years at White Sands. Of course by the time they came to Huntsville, they already understood that. When they came to Huntsville, they were over their waiting period and their initial start up period and by the time they came to Huntsville, they were ready to go to work and make things happen. So they were kind of spring loaded to get on with the job. They'd kind of been in a quiescent mode for a few years at White Sands, not that they weren't busy there, but they didn't have the mission with which to go on and make a major program. They did a lot of training with us at White Sands, us being the U. S. counterparts.

21. Waring Could you describe the Marshall center's test philosophy during the Saturn era?

22. Odom Yes. I'll do it summary wise and if you want to pick any pieces of it. Because of the German influence, we had the philosophy both in the design was to build things relatively structurally fairly stout and so as not to roll so many manufacturing problems or flight problems or development problems into the basic hardware. We carried that until almost a stigma that we build things over-stout. But one thing that we had the capability of doing during the early programs and this was true up through Apollo, after Apollo this went away, and that was that we had the ability from a resources standpoint that if you had a critical system, a critical piece of hardware, a critical subsystem, we might carry two or three designs in parallel and we thoroughly believed in adequately testing at the component, at the system level and at the subsystem before you ever put it all into a vehicle. That was true for engines, it was true with the GMC systems, it was true for the guidance flap ons, to really ring them out environmentally and operational stress. We learned that to a large degree from the Germans. Being able to carry two or three systems in parallel and then picking the best one allowed us to, as a rule amenities, even technologies that were being developed in parallel that allowed you to pick varying degrees of stretch so far as the technology in this multiple systems that we carried in parallel. In doing that, we were able to like I say pick the best for the first flight application. That also was not capable to do back in there. You're lucky to

get resources for one system much less multiple. Trying to pick one is not always the most economical way to do it. To answer your question more directly, it was a very much a philosophy was to thoroughly test hardware before you got ready to fly it. That also was not necessarily done today.

23. Waring How big an advantage was it in the design and testing of hardware to have the so called arsenal system which you had technicians, machinists, blue collar workers on site at Marshall who could handle manufacturing jobs and things like that?

24. Odom I think it was a tremendous advantage. You'll find people that will disagree and our nation as you already know went away from that a few years later. It was a tremendous advantage to have the design engineer across the street from the manufacturing facility or a block away as opposed to two thousand miles. The ability to design and build the first in a series of vehicles in house and then bring the prime contractor in to basically sit with the designers and operate along with the manufacturing and planning all the way through the manufacturing of is a good way to do business especially when you're building the industry which is what we were doing. In other words, we had to build the infrastructure for our whole industry. Not only the facilities, but the industry was not there that had had experience with high pressure pumps, with the

pressurization systems, with the subsystems that we were dealing with, our industry had never done it. So in the '50s and especially the '60s, we literally had to build the industry with us along with the facilities at the centers at the launch site as well as in the industrial phase. So the arsenal system to me was probably the most economical way to get the industry up to speed. Now with the industry where it is today, I would not say that that would be necessarily true, but at that time, I don't think we would have made it without it. I'm biased and you can accept because that's how I came through it. I don't think we would have gotten it. Look at the Vanguard. It's a good example of trying to describe what you want to do and then handed it off, and there was no way those poor people were going to make that.

25. Waring I see that on your resume here that you worked on the S-II stage?

26. Odom Yes.

27. Waring What was your responsibility?

28. Odom At that time, I had left the laboratories and that was at that point I had decided to move over into the management chain, into a project office. I had the job of chief engineer and chief of testing for the second stage of

the Apollo in the project office so that was the job that I had there.

29. Waring Marshall had a lot of problems with North American. Could you sort of describe the essence of these problems? Were they just routine things?

30. Odom No not necessarily routine! At the time they weren't. In all fairness to Rockwell, there were two Rockwells. We were in the Space and Information Division I believe of Rockwell. We had the contract to build the S-II at their Seal Beach facility whereas Johnson had the contract for the manned and service module in the Downing facility. One of the real problems we had was Rockwell had never done the kind of welding that was necessary for the S-II stage. We had kind of been through the rigors at Marshall of building a 70" Redstone and up to a 105" Jupiter and then we got up to the combination of both of those for the Saturn I and then the IB and took another twenty foot jump. So we had been through a lot of that. We had a lot of problems convincing Rockwell that we knew anything about it. It was fairly characteristic of the industry of "Look, we've built aircraft. We've built thousands of aircraft" and that was true for almost all the contractors. It was true for the Boeings, the McDonnell-Douglas, and the Rockwells. We had a lot of trouble getting their attention to the detail that was necessary to effect flight quality

welds and the S-II had its share. Just the tooling in itself was a major program. Just building the Seal Beach was a major undertaking and then designing and building the tooling and pushing the flight hardware through there. It was a very tough program. The S-II was a lot more demanding in some respects than the first stage. The first stage was oxygen and RP1. That was the largest oxygen/hydrogen. It was the first time we had put multiple oxygen/hydrogen engines on it before. We had built the S-IV but with a single. So the subtleties of hydrogen in that larger vehicle was totally underestimated by Rockwell and probably ourselves too, but many of us had been involved in oxygen/hydrogen much more so than they and it's a totally different piece than your LOX RP. We had our share of problems. We lost virtually all the test vehicles as you're probably aware of. We had the common bulkhead as a good example of one that we just worried to death because here you're putting a very thin bulkhead, a couple or three inches thick with oxygen on one side and hydrogen on the other and any leak in either direction would be catastrophic. We really worried the design and the building of that. I remember Dr. Rees worrying about that. I think that was the one piece of hardware, of every vehicle we destroyed that was the one piece that stayed in tact! We couldn't hardly break that thing! We worried about it. Just designing and building it was an incredible job. There are a lot of things in the Apollo vehicle like that that we

had never done before certainly on that scale. The scale of the Apollo, the scaled jump of where we had done before, was darn significant. I think about, frequently, if we were trying to do a Saturn V today for the first time and I look back at the time period that we did it then, I would dare say it would take a minimum of two or three times if we do it today only because of funding and stability and just the sheer magnitude of the outside influences that you have to deal with today. It would be very difficult today.

31. Waring That answered the question very well. I could ask you some more questions about North American, but I think we should move on here. Could you describe the differences in approaches and philosophy in designing and developing hardware in the Saturn program as opposed to the Shuttle program?

32. Odom Yes. That's one that you could spend hours, but let me see if I can do that in a few minutes. In the Apollo, the nation had a mission that flowed right through Congress. It flowed to us, us doing the program. We knew exactly what the mission was. We knew when we had to finish it. There was total dedication from everybody from the President to the Congress all the way down to make that happen. That didn't exist on Shuttle. We had I would say virtually adequate funding to do it. We didn't have much time in today's scale of things to, but that's carrying

several systems in parallel helped us significantly with the Apollo vehicle.

33. Waring You had the money to do it.

34. Odom Right. Whereas in the Shuttle program, we went through the phase A studies and they indicated that we really should have a totally reusable vehicle or it was certainly leaning that way. We did the phase B studies and we finished the initial part of them that came up and said "Yes it really should be from an economy standpoint. It really should be a fully reusable vehicle." We ended up with what's referred to as the orbiter and the fly-back booster. We finished the phase B and presented it to Headquarters and turned to Congress. They said, "Yes, you really do want a Shuttle vehicle." At that time the cost was about 10 billion to do the fully reusable. They said "5 billion is all you can have." So we went back and extended the phase B studies, as I recall it was about six months, to look at what we could do to lower the development costs. Operational costs was not an issue. We said let that come out where it will. Coming out of that then was the external tank and solid rocket booster replacement for the fly-back recognizing full well that it was still a very complex development program and recognizing that that was going to drive the operational costs because you had one piece that was a direct throw away and then the large boosters you're

going to fish out of the water. We accepted at that point the notion that operational costs was not as important as development costs which when one looks at it in a longer view, that's not a very smart way to do it and we're suffering from that decision today.

35. Dunar Is that in terms of just long-term planning for the program?

36. Odom Right, long-term. In other words, the real runout cost of the total program is what I'm referring to because Congress was more interested and this was where we started really seeing Congress getting more interested in short term objectives than long term objectives. Apollo was a long term and I don't have to tell you the real objectives of the Apollo. I'm sure you've had those given to you several times but there's where, at least from my own personal standpoint, I started seeing more short term objectives taking precedent over long-term investments and long-term objectives. That was, in my judgment, a major difference between the nature of the Apollo program and the Shuttle program.

37. Waring Did you ever feel, obviously you couldn't do parallel development and that's a major difference of getting good hardware in the end. Did you ever feel you

lacked the money in the test programs to verify the hardware line that you were developing?

38. Odom I would say the testing probably didn't suffer as much as the basic design and concepts because we still felt like we had to do an adequate test program. I would say the testing suffered as much as did the configuration and the design of the margins for it.

39. Waring Andy, you had some questions.

40. Dunar In terms of what you mentioned before about the advantages of having development and manufacturing facilities then and the ET moving into a manufacturing program, were there things because of that that were unique that made you handle that differently than most of NASA's development programs?

41. Odom Absolutely. That's another one that you could spend days talking about. Let me just give you the fundamental difference. Up until that point in time, we build Redstones and Jupiters. We built Apollos. A large production program to NASA was like a dozen. It's true of space craft and that was the uniqueness of the Agency. It was to do things a few times and then keep moving to technology. I don't say that critically, it was just a fact. The different with the external tank was, it was the

first and really to date the only major production program, and I'm saying production where I'm talking dozens of articles dealt. The solid rocket motors were very similar but they were reused. So the ET was the only thing in the shuttle era that was expendable and at that time, of course when we started the program, we were going to be building 60 a year. So you can say, well that was dumb, but that was the plan because that was the basis for the economies was to have a high launch rate. We really did want a high launch rate. Whether or not we believed it was going to be 60 vs. 30 is academic. But in any case, it was still a very major production program. You just take each tank, you've got a mile and a half of welds. You've got about 70 thousand pounds of machined aluminum or kimmilled aluminum. Every weld is what we called a Class 1 or a Crit 1 weld where it if fails you loose the crew and the vehicle so the precision by which you had to build that thing was much like the S-II because it was LOX and hydrogen. Consequently, the requirements to set up a facility like Michoud was absolutely unique in the industry much less in NASA. I went outside. I got experts from industry, I became a fan of Demming when most other people didn't even know who he was. I went to the west coast and spent almost a week at all these conferences and that was in the early to mid 70s when most everybody else in this country didn't even know who Demming was because what I was looking for was the best I could find in the industry to help me put together not only

a contract but a production program that had a very ambitious learning curve, that could put out quality hardware every time and do it as economical as possible. We had people come in and help us with plant layout, with the flow of the materials because we had never done that to the degree that was required. You're talking literally millions of pounds of aluminium a year just to build the raw materials. Just the procurement, buying all those parts, getting them shipped into Michoud to where you didn't have to anything but put them together and weld them, it just had never been done. I really worried a lot about how to put that contract together and how to put the facility together. One thing that I consider myself extremely fortunate because very few people got the opportunity that I did on that one, and that was I went on to the Shuttle program right toward the end of the phase A study. I was in the systems engineering group at Marshall during the phase B. I had walked through all of the design studies, all the design trades all the decisions up to and including when we went up with the fly back booster, then when we came back and had to redo it and came up with the tank and the SRB as the booster approach. Fortunately having gone through that, I was selected to manage the ET from day one. I got to hand pick every person that went into my office. I got to pick the S&E people that were supporting my project because I knew them all. I served on the source evaluation board as the deputy. As the head of the source evaluation board, picked

the contractor for the ET. I personally helped negotiate the contract. I started the contract up through the design, the development, the facilities, all the way through and the building and flying the first six. There were very few people yet to see a program literally from an idea up through the first launches of the first flights. I consider myself extremely fortunate to have had that continuity through that. Incendintally, it's something I highly recommend and I do it when, many of the reviews that NASA's had is to if you have a person that you believe that is going to manage it, let him participate from the beginning through the source evaluation process because that continuity, is extremely important and you understand the contractor and you understand his bid, so when you negotiate that first contract, you know exactly where that contractor whoever the source election picks, you know why he has bid what he has, his characteristics and capabilities. Consequently I think that's a good way to do business but few people get to do that job.

42. Waring One other thing on the ET, it seems just that reading through the documents on the shuttle, that whenever it was required to trim weight on the shuttle, they looked first to the tank.

43. Odom That's absolutely natural because it virtually goes to orbit. It's only a couple of hundred of feet per

second out of 24,000 feet per second. That's all the short velocity is from orbital velocity. What that means is it's pound for pound for payload. In other words, for every pound of weight you take out of the tank, then you can carry one more pound of payload so it's very important to keep it light as opposed to a first stage booster like a solid. It's dozens of pounds ratio. Like I say, about two thirds of the way through the design, we went in and redesigned it to take out weight. They're looking at doing it again because there are new material with which to do it. That wasn't that painful because we kept the same diameter. We kept the same part size. What we had tested and we had data. That's one thing that I took a lot of heat for in our test program on the tank. We put literally thousands of strain gauges on every structural piece that we tested because what I wanted to know was how much margin every square inch that thing had from a design standpoint. Having done that then we knew exactly where to take the weight out because we had already designed it, we have tested it and we knew where the margins were with a high degree of accuracy. I took a lot of heat in those development programs from a lot of managers because I was spending too much money on the instrumentation and the structural test but I did not give in because I did not believe that was the most economical way to do it. Had we not done it, we could not have taken out the weight nearly as economically as we did and with the minimum risk. That's just another place where you can be

penny wise and dollar foolish at the front end of the program if you're not careful.

44. Dunar Now this can be done on computer simulations.

45. Odom We had a lot of simulations. They were not as good as they are now. We had an astron models, but what you didn't know was exactly how all of these loads, and the tank is a very complex because you've got roughly a million and a half pounds of load that is going into the back end of the orbiter that gets dumped into the back end of the tank whereas you've got the two solid rocket boosters that's hooking on up here at the top pushing with roughly 6 million pounds. But you've got most of the tank weight in the LOX tank which is forward. It's a very complex structure. It looks like a simple structure, but it's anything but that. Just because of the way the loads get into it both on the pad and the early part of the flight and the terminal part of flight. You have to be able to test all those conditions and do it. It was designed to take advantage of the increased properties in the alumina at the minus 420 degrees. What that means is, and the LOX tank is basically 280, but what that means is that you have to run the structural qualification program with hydrogen in it. That's very hazardous. That's very sporting. That was another complication to the test program is running that structural qualification and you're going to take it right

up to the design limits otherwise you can't prove where all of your margins are either good or bad. It made that test program extremely tricky, but fortunately . . . . [turn tape over 625]

46. Dunar A question I had before reading things on the ET was that weight was the biggest problem. I think what you are saying is that you had anticipated that, but that some of the other related things such as the structural analysis and so forth were maybe a more serious problem?

47. Odom: I wouldn't call it a serious problem. I would just say that the tools were not as sophisticated then as they are now. The tank from a structural standpoint so far as the facility and the tooling and everything came out just almost exactly like I had anticipated going in to the program. The thing that was the biggest difference was that when we designed the tank, we only planned to put insulation on the nose tip and on the hydrogen tank. We did not plan to keep the surface of the tank above 32 degrees. That was the killer. From a facilities standpoint, from a cost standpoint, was putting insulation on everything, all the pressurization lines, the feed lines, the brackets, all of that and it virtually all had to be hand done except on the [?13]. You think about insulating a third of an acre and it has to stay on because if it peels off and the problem was because of the fragile nature of the surface of the insulation in orbiter. If it created ice on it and then the

ice shed it off then it would damage the orbiter tiles. That was not known going into the initial design. Had it been we probably would have done things differently. Of course I'm sure you've run across, there were two critical technologies, and I'll call them technologies. Let me put it this way, very difficult systems on the shuttle. The solids were relatively easy. The tank was relatively easy. The tough thing was the orbiter insulation, orbiter tiles, and the main engine. We knew that. We knew that was were the long poles in the tent were going to be. That's why the tank and the solids ended up kind of waiting for those two to materialize. That's a very complex vehicle, still, to fly. It does not have the margins that the Apollo vehicle had. What it means is that you've got to fly it more carefully. You've got to know what the upper atmospheric winds are and in turn what the loads are going to be. You have to do that at every flight. Which we had to do it on Apollo, but it was a lot more forgiving. We had to worry about the winds, but not nearly the degree that we did, and still do, on the shuttle. There are loads of analysis that we have to run for every flight. That's a big expensive process.

48. Dunar: What was it like as a project manager working for Houston as lead center with the ET?

49. Odom: Had absolutely no problem with it. You'll get mixed answers depending on who you talk to. I had absolutely no problem. I worked for Bob Lindstrom who reported to the Center director. In other words, I knew what my roles were as far as the Marshall center. I knew my responsibilities to the Center and to Center management, but I understood that Bob Thompson was the program boss. That bothered a lot of people. It worked for me because of Lindstrom and Bob Thompson. A lot of people could have been in either one of those jobs, and my job would have been absolutely miserable. I had absolutely miserable. I had absolutely no problem working in that environment. Bob Thompson was just as fair to me as he was to Eric Phoen who was the orbiter manager. I didn't feel that I was put on or I had to take any particular risks or I got treated unfairly in the budget a bit more than I felt the Johnson elements did. That didn't bother me at all. It can work, but it's a lot dependent on personalities. It's a relatively unnatural environment to work in, but if all the parties involved want it to work, it can work. If there's anyone that doesn't want it to work, it's miserable.

50. Waring: Why would you say it's an unnatural sort of work?

51. Odom: Just because the nature of NASA centers are to be as autonomous as they can, and because each one of them has

a different role. Then when you marry two of them together, especially if it one where's there high competition between the two centers which there automatically is. You can have the same thing in universities, not just because it's NASA or because it's government. It's just kind of human nature to be protective and have your own turf. That was really the first time we had kindly integrated as much as we had. In the case of the Apollo program, the lines of responsibility were really pretty clean both in the management structure and in the hardware. There, it was a pretty clean interface between the Apollo module and the IVB and everything down from there to the launch pad was a Marshall responsibility. The interfaces with the launch pad were relatively straight forward. As opposed to shuttle, those interfaces got a bit more complex, both management wise and hardware wise. Then the space station is kind of the epitome of complex interfaces. The lead center process can work and it's the same thing with Hubble. It was pretty difficult up front. I didn't have that much problem when I took over the program. Some of the Goddard people did, but I had no problem getting the support I needed from Goddard. It can work, but a lot of it's dependent on all levels of management.

52. Waring: Let's move to Hubble. You came into the Hubble program in a very different situation from the ET. You were in the middle of the program, and the program was virtually

in a crisis. Could you describe what it was like your first month as project manager?

53. Odom: Yes. I came in as I recall in 1983. The program had gone through numerous reviews. It had just gone through really a kind of do or die review. It had come out Headquarters had decided that it would support it. It did want to continue it. It had relatively good support from the Congressional committees. Everybody wanted it to go, but they were not sure how much money it was going to take or how much longer. I had had absolutely no contact with the Hubble at all. Fred Speer was a good friend of mine, and I knew Fred had a program off running it, but I sure didn't have a dog in that fight. I was totally considered with Shuttle. When they asked me to take it over, I had kindly gotten to the point, Shuttle would probably never be routine, but building tanks were pretty routine. Lindstrom had asked me to come off the tank and kind of look across all the shuttle elements from a production standpoint. I enjoy production. So I said "OK I'll do that" because it was about time I made the change. The tank was getting fairly repetitive. Not that that was bad, but it was not the challenge that it had been. So, they asked me to take that over, and I had no idea of the problems that it had. In all fairness to the people, and it became very obvious to me the first week I was there, from day one, the program was extremely more complex than perceived in the phase A and

phase B and even into the C/D than was predicted. The requirements on virtually every subsystem, and I mean structures, GNC, power, the computer systems, not to speak of the instruments and the least of which would not be the optics, was pushing the state of the art every step of the way. Much more so than I think everybody really realized. But, to me the more crucial problem that my predecessors had to deal with was an absolutely fixed number of people that could work on it within the agency, especially within Marshall, and it was totally insignificantly funded. The schedules were much tighter than were realistic for the amount of technologies that was being pushed by virtually every subsystem. When you put all of those things together, it just says you're going to have a problem. That to me was the genesis of why that problem, in other words they were doing all that they could with the resources that they had--the people and the money. Frankly, when I look back now, I think they did a remarkable job ever though they didn't get credit for it. At the time I came into it, I spent the first month just really looking at the whole program, building a whole new program from then to launch, and basically rebuilding an entire budget. You can imagine how welcomed we were when we went to headquarters and to the congressional committees and said well "Gee, we've already spent 700 million and we're going to need 400 more when the 700 was already more than what the original estimates were." You can imagine how much I looked forward to hearing that

message, but we got the money, and we got a schedule. I had absolutely excellent support from Headquarters, from Goddard, from the science community, from the science working group that I had that was helping advise me and the management relative to all the instruments, and the science effect on decisions that we were making on a day to day basis. That was a very demanding group. It was a very challenging group, but one that I thoroughly enjoyed working with. I had never worked with the science community. I hadn't even been involved with the science community since the early 60s, and I enjoyed that. But, it was a very demanding program. At the time, I'm sure you've already run across this, if you look at the time the Challenger accident happened, by that point in time we were going to be launching later that year. It was pretty obvious to me when Challenger accident happened we wouldn't be launching for quite some time. That was another one where just the test facilities to test the individual instruments, the individual subsystems in many cases were almost as complex as was what you were trying to test. That's especially true at Perkin Elmer in the optics, and that's one of the reasons we missed it. It's just because the fidelity, just to give you an example, if you just look at the entire structure, you can't see it in that picture, but if you look at the internal structure that all of the optics and the instruments are hanging on, that entire whole back end of that structure has to be maintained at 7 [I think that is 7

and not 70, S.K.] degrees plus or minus 1/10th of a degree. That's true when one side of the instrument is in the sun and the other side is in darkness, and as you go in and out of the light and darkness twice a day or twice every orbit, you've got to be able to keep all the structures that same temperature. Well, no one could maintain structures at that kind of temperature and especially composite structures because that was at the front end of the composite capabilities in this country. There's hardly anything that you can touch on that thing that is not extremely demanding. The unfortunate part about it at the time for example, and that's the problem that you get into with programs that stretch out that long, is the computer that we picked early on in the program was an absolute antique by the time we flew it. That really jeopardized the flexibility that we had, but we never could quite could get enough money to replace it and start over again because it was neither enough money or time with which to do that. We had to launch with an extremely limited computer from a compute standpoint as well as a memory standpoint. They've been able to work it extremely well. As a matter of fact, it's worked much better than I was afraid it would just because of the amount of limitation on the memory. It effects the amount that you can load on it, the amount of programs, and the amount of changes that you can put in to it in real time as you're operating it. That was another one that we did not contract very well. We made another fundamental, in my

judgement, mistake early on and that was to take all the systems engineering responsibility on within the government with the manpower limit that we had. Those two were absolutely incongruent. The program suffered for that until we redid the program and then gave Lockheed a lot of the systems engineering responsibility. By that time, the hardware was already designed and built. When I took the program over, virtually all of the subsystems for all practical purposes were built. We had not started putting them together. We had just started integrating the optics at Perkin Elmer. We had just started integrating some of the basic structure at Lockheed. The job that I had was to basically finish up the building of the subsystems and integrating them all together and getting them checked out through the environmental facility and the environmental testing. That's fundamentally what happened in '83 to '86 when the program stretched out.

54. Waring: I have several follow up questions to parts of this. Through late 1982 and early 1983, Marshall did all sorts of studies of Perkin Elmer's management. Marshall was extremely frustrated with the way Perkin Elmer was running the project. Could you comment on that?

55. Odom: A good bit of that was in front of me before I took it over. It didn't all go away. We had a problem with Perkin Elmer of getting them to basically plan the work in

adequate detail. In other words, to look downstream at everything that had to be done--getting all of the bits and pieces of hardware to all show up at the right place at the right time to put it all together to get all the right people together, all the right inspection people, all the right technicians, all the right engineers available at the right time to make things happen smoothly. That was a bit unnatural for them. They got a lot better. They spent a lot of time, put a lot of people up there in the plant with them. By the time we got around to really totally integrating all of the big optics into the structure, they had significantly improved that process. [tape interrupt for phone call]

56. Waring: . . . about Perkin Elmer. A broader issue, a broader problem in the project at the time that you were taking over was a problem of communications. Some of the scientists that were involved and later journalists and historians who have written about the project have argued that the problems were so serious and yet the project was so important that there was an unwillingness to talk about the seriousness of some problems. Did you experience communications problems, or do you things those, well, could you assess the communications in the project?

57. Odom: I think the way you stated the question is probably fairly accurate. I think the problem was that

problems were not as openly discussed, and I'm talking about my predecessors, as they normally would have been because there was not the resources with which to solve them in a very timely manner. While I think a lot of the problems were recognized, the management and the project, and this was true both at Goddard and Marshall and especially at Marshall, did not perceive that they had the where-with with which to fix it in a very timely manner. I can see how that would be absolutely frustrate the science people. That wasn't their problem. They don't fix these hardware problems because they've been working on this instrument now ten years and were still ten years from flying. That's a terrible situation for people to be in. That was my perception when I took over is that people had not been as open with each other as they would have normally because I knew these people. I knew that had they had the resources, they would have fixed a lot of problems that were perceived or even known. But they just didn't have the resources to do it. After we rebaselined the program, we put enough people on, we put enough resources with which to go start dealing with those problems. I spent a lot of time in those science working groups. There are roughly about 30 of those people that would come to the science working group meetings, and I would listen to them very attentively, and I would try my best to deal with their problems and deal with the hardware problems. There is one thing, in my judgement, that I have not seen in any of the history of the books, but

if you look at the interfaces, I'm talking about the physical interfaces, between all of the subsystems on Hubble, they're probably the most complex set of interfaces that mankind has ever done. I'm talking about relative to hardware at that point in time. It was by far the most demanding, one of the most complex systems that mankind has built. I say that, I can't say it unequivocally, but certainly with any that I have come in contact with personally and I've seen an awful lot of the spacecraft that this country has built both in and out of military. While there were individual instruments and individual systems that might have been as complex as some parts of this one, if you look at total requirement all the way from the pointing to just the structure, it is very, very difficult. The optical train that is through that thing is extremely complex. Just to pick two, and it had dozens. I think, if you look at the interface, what we called the interface control documents that was built early on in that program, they were done to me as good as I have ever seen in any program. This was done ahead of my time, so I don't take any credit, but during the time that I had the program was when we put all those things together. We found virtually notes, square pegs and round holes when we got ready to bolt, connect up all this all the hardware, software, and data system and all of this, which says that that part of the program that was done back when the people were criticized so for doing so poorly, there were a lot of

things that were done right. We benefited from those after I took over the program. I think a lot of those people, in my judgement, took a lot more heat and a lot more punishment and a lot more criticism than was warranted. If you'll look at what they got, what they achieved with the resources they had, they did a darn good job. I mean it's pretty easy to come in at 400 million to finish the program, but if they had not done an awful lot of good engineering, good analysis, and good planning, then we would have never finished the program. I totally take my hat off to the people that did that. I'm not saying that wasn't difficult, that what we had, but we had a different kind of job. Ours was getting it all put together right and checked out.

58. Waring: Right, that's an important thing to understand, and I'll try to communicate that when we talk about that chapter. Just another question about the communications issue. A perception of many outsiders following, people outside of Marshall, following the Challenger accident, following what happened with the detection of the Hubble mirror problem is that Marshall has communications problems and what would be another common stereotype about Marshall, Andy?

59. Dunar: It's a closed versus open.

60. Waring: It has a closed culture.

61. Odom: Are you talking about communications within Marshall or between Marshall and Headquarters?

62. Waring: Within Marshall . . . .

63. Dunar: They're all interrelated. I think both issues come out.

64. Odom: I've heard that, and I'm sure that there is probably some basis for that. It's a relatively conservative group when it comes to how we run our programs versus how we run our programs versus how other people run them. There is probably some truth to that, but if you really want to look an any government agency or any of the other centers, you could find some of the same thing. One of the big differences was the amount of visibility that Marshall programs got. I mean you take the Langely and the Ames and those people or they have a problem with a wind tunnel the community doesn't know it unless it's really bad. Whereas most of the programs that Marshall has had, the press knows about it. We've been, I think, fairly open with the press, and consequentially we get a lot of abuse from them. If you asked me if I would do it differently, to some degree, but I'm not sure how much differently I would do it if I were doing it again. Because a lot of that time, the press was looking for something to write about. Little

problems got to be big problems. When you do that a few times, you get a little bit protective. Just to give you an example, and I could give you many, when we had the first static firing on the pad for the shuttle, and I could cite you this on every program, but this is kind of in the middle of what you're writing about now. We had already had some of the tanking tests and we were having really the first static firing, the first engine firing. This one particular day, I was assigned to interface with the press down there which I don't mind doing it. In fact I kind of enjoyed it, and I saw a real heated argument between one of the photographers and the Cape people who were assigning what camera would be at what location. Of course there were literally hundreds down there. I was just standing there. I wasn't addressing me, but I was just observing the really heated argument going on. This guy had already been out and placed his camera out at the pad. Course he was back at the press area. The more he looked at it, the more he didn't like the slot that he had picked, and he wanted to move his camera. The guy kept telling him, "Look, it's too late." I mean we had already tanked, so it was much too late for him to go move his camera. He kept asking him, "Well what's wrong with where it is. I mean you've picked it, and it's been there for days." He said the bottom line was, "I'm not interested in seeing the facility. I'm here to watch it blow up, and that's all I'm interested in." It was all I could do to keep from hitting that guy. There in, there

were a lot of press that that was their only motive of covering NASA activities was to uncover the problems, manifest the problems, regardless how big or real they were. I'm sure a lot of us got pretty tired of hearing it. I don't say that as being an excuse or a reason, but you can get tired of hearing that kind of attitude for people who have absolutely no responsibility. There's a real difference, and I go back to that because of the attitude of the Germans, is they were willing to take responsibility, but they were willing to assign responsibility. It's like the ham and eggs story. It's a real difference where you're contributing an egg on the part of the hen or you're contributing ham on the part of the pig. That's a real, when you're in that responsibility, I'll tell you one. Turn your recorder off. [tape off] I can say for the example of one, that I never felt like any problem that I had was filtered, or sheltered or not passed up to the top or if I wanted one communicated down, I never had a problem with it. Now you could say maybe you're unique. I don't think so. I'm sure there were cases when there were problems that when major incidents happened that probably one could find well gee, but you can find that in you're own family where you think there are excellent communications. If you're really cool, if you take one given day or one given week out of any given month and you penetrated far enough, you can find that there was not communications between you or your wife or your kids. But, to take that and say it's an absolute

generic and it's an absolute policy or it's an absolute rule of doing business, then I would highly resent that.

65. Dunar: We've run a lot longer than we anticipated. We unfortunately haven't gotten to space station. Would it be possible maybe for another time for a little while.

66. Odom: What time is it?

67. Dunar: Four o'clock.

68. Odom: Do you have time to do it?

69. Dunar: Sure.

70. Odom: If we don't do it now, we won't get back time to it. I do need to make a couple of phone calls.

71. Dunar: Sure. [tape off] Maybe we could pick up the space station story by touching on something you said before in terms of the complexity of interfaces in Space Station as compared to the earlier programs. Could you elaborate a little bit on that?

72. Odom: That's, I guess in my judgement, is probably one of the things that as an agency, and this was done a lot by all centers involved, is the way we put together the

organizational architecture: the way we put together the subsystem architecture and then divided those two up among the centers, among the contractors. We created an almost impossible management and engineering job because I came from the school that the fewer interfaces you can have in a hardware program, between centers, between contractors, the more straightforward the easier it can be. First of all space station doesn't limit itself to doing it that simplistically. So there's hardly any way you can divide that thing up and not have numerous interfaces, but you don't need thousands. I think that's something that we did early on in the program that significantly complicated the design, the contracting, and the managing thereof. I think had we done a better job of simplifying those interfaces early on we would have made the job significantly easier, but like I say, you can only carry that so far because it too is a very complex system. I personally believe that we had about the right configuration up front. If you really wanted a facility to do something for the research community, for the science community, and there I'm including atmospheric scientists. I'm including the outer space scientists, astrophysics as well as the microgravity. I personally believe the system should have accommodated all three of those, and that's the way we started the program. That's a short way of saying that we had a lot of places for flat funds to put instruments that would both look out, look back at the earth, as well as perform the internal science,

and I'm oversimplifying just to call it microgravity, but those that are man tended and that would need the microgravity environment which you would have access to it, but with the crew. I still think that's the right space station that we should ultimately have. It's unfortunate that early on we underestimated what the real cost of that would be. You can say "Well if we had, had Truly known what the cost would be we probably would have never gotten it started" which is probably true. I look back at that. That's just unfortunate, but I think we could have done a better job of simplifying it. It's still very complex. It's still a very difficult program to do. After numerous redesigns, we've backed away from a lot of capabilities that I had hoped could stay in it, but a lot of those have been given up in the interest of the economy. I think the Space Station in my judgement got caught at a time, I shouldn't say even got caught, it came about at a time when the nation first of all didn't know what it wanted to do either nationally or internationally. I think the program, in my judgement, started right with the international environment, international partners. I personally regret to see the way that we have really diminished the commitments that we made to our international partners. I for one, I take commitments very seriously, and the time I had the program was at the time that we formally signed all the agreements with the Japanese, the Europeans, and the Canadians. Those are, and most people don't realize, those commitments are

treaty level commitments, and that you just don't do without a lot of thought and commitment. To just back away from those just because we can't decide what's important to us, I think is a bad testimony for our nation. I come across pretty strong in that area because I was personally involved in getting those agreements. Most of them, the architecture was done before I took over the program. The early implementation and the formal signature took place while I had the program so that probably means more to me than maybe even some of the people in the same position that I had. That bothers me to see us walk away from those commitments. It bothers me more to see us as a nation unable to make commitments and make plans for longer than two years.

73. Dunar: One of the things that you worked on as associate administrator was developing the associate contractor relationship. As I understand it, and I have probably a pretty superficial understanding of it, but it was a matter of getting the contractors to be able to speak directly to themselves rather than going through NASA people. Is that . . . ?

74. Odom: Yes, let me describe that a little bit because a lot of people never really understood what I was trying to achieve. Had I stayed I'm not sure if I would have ever made it. We'll never know, and it's probably not even important, but we had a very similar arrangement in the

Apollo program. We had what was called tie contract, but there we had an associate relationship between our prime contractors. I probably need to describe it, and you won't want to write this much, but so you'll understand what an associate contractor role really means. If you three prime contractors, like we had in the Space Station as far as the work packages were concerned. The way it was set up was the government ran each one of those contractors, and the government was basically responsible through Grumman, with Grumman for the systems engineering. Any time there was an incompatibility between a Boeing contract or a McDonnell Douglas interface, the government was right in the middle of that. In other words, Mac Dac had to tell Johnson, "look I have a problem with this interface," and let's say it was with Marshall. Then the project office at Johnson comes to the project office at Marshall and says, "Hey look we have this incompatibility." Each one of them then would go study that problem and the contractors would come back to the government. The two governments would get together and say "Look, here are the alternative solutions," and go pick the best one to solve that problem. That's a very time consuming process and what I was after, see this is manifest literally hundreds of thousands of places where you have these interfaces, and what I wanted to do was put into the contracts the responsibility that if Boeing and if McDonnell Douglas had a problem, their first responsibility was to go very quickly, find the most economical way to fix it,

regardless of where it would cost, which one it would cost more money. That was not important to me at the time, but to flag it early, put the responsibility on them to come back to the government with one or two solutions and let the government pick the best solution rather than being in the chain and getting all of these things in series. That was the fundamental thing. I was trying to simplify the numerous interfaces and to expedite that process. Fortunately or unfortunately, most of the people in the contractor teams and in the government had never operated that way. It was strange to them. To do it, you had to modify the contracts because you had to put the incentives into the contracts for them to come in because a lot of times a contractor may come in with a solution that may end up taking resources or money away from his contract. Well that's absolutely unnatural to come in with that kind of recommendation. I wanted to put the incentives in to where they didn't loose money just because they came in with a solution, but the government would have saved money in my judgment for getting the best solution quickly. A number of the contractor people understood that. I don't think a lot of people in the government, the people that came in after me had ever operated that way and didn't think it was necessary, and that's their call. I don't have any ill feelings because they didn't care. Had I stayed I would have pushed that to the fuition or failure one whichever came first. I could not see a logical way to manage that

program the way it was set up. That was the least trauma that I could see rather than going in and just completely redoing each of those contracts at that point in time which would have just shut the program down and moved it another year or two. That's probably more than you wanted to know about it. There a few people, DOD does that occasionally. They did it more years ago. Few people have done it lately don't know why because [end of tape - switch to part II] . . . for the Apollo vehicle not for the whole program. This was more for the Marshall three stages and engines contract.

75. Dunar: Just an aside on this. A couple of weeks ago in Houston I was talking to some people in the program integration office, and they said one of, that it's a real shame that after you left that they did abandon the associate contract. They said they thought it would have solved a lot of problems.

76. Odom: That's interesting because there weren't a lot of people at Houston that understood it.

77. Dunar: They felt pretty strongly I think that problems came as a result of when you left that a lot of this was not followed.

78. Odom: I find that interesting.

79. Dunar: I'm wondering then too I guess one of the implications of this might be, and I'm not sure. I may be reading too much into this, but I'm wondering if you feel than that maybe the government should not do systems engineering and integration?

80. Odom: That's a very difficult thing to do. If the government, anyone can do it if they have the right resources with which to do it. We have depleted the capabilities, the engineering capabilities in the government to the point that you can hardly have enough of the right skills to be able to put on a major program in any center, and that's true almost for any government instillation to do that any more. We could do it in the Apollo program a lot easier because we had designed a lot of that hardware early on and built some of them. So from that standpoint, the arsenal concept lends itself to having more muscle from a technical, from an engineering, from a hardware standpoint, but that's been gradually eroded over the last couple of decades to the point now that if you really want, to me, a good systems engineering job, you should go buy it, make it very clear, have the right relationship between that contractor and the other contractors. A lot of debate is should you have the systems engineering contract be one of the hardware suppliers. We did that in Shuttle with Rockwell. I've seen it both ways. It can work. You have to be a lot more critical of the management of that hardware

and that integrating when its within one contractor because it's awful easy for them to take advantage of the other parties. But if there's credibility in the contractor there's credibility in the management teams. It can work. By and large it's probably the better way rather than have someone that doesn't have any hardware responsibility. It's awful easy to be purer than the Pope when you don't have a hardware piece of it that you've got to make schedules every day. There are good arguments both ways. I would personally typically come down on the side of the integrator having some piece of hardware. It just keeps your system a little bit more in balance, but you have to manage it, and just know that you've got to watch that very carefully.

81. Dunar: When you went to become associate administrator, most of the splits between centers and so forth in contracting I guess had been pretty much completed. There was probably some legacy of such intense competition and bitter rivalries I think between the centers involved. Did any of that linger and affect the program?

82. Odom: There were some vestiges of it, but it wasn't a problem for us. We had plenty to do to get on with the job, but at that point in time most of that was kind of behind. There were a few people that were still bent out of shape. They probably still are, but that was not that big of a

problem. I had support from Johnson and Kennedy and Lewis. That didn't bother me.

83. Dunar: Was there any problem with a Marshall man taking control of the program?

84. Odom: That probably bothered a lot of people I would imagine that you would expect. I'm sure it bothered some of the Johnson people, but it never bothered our relationship. To me, the other thing that was and in my judgement we did not do very well was the nature of the integration contract that we had with Grumman. We never gave Grumman the responsibility for integrating the Space Station. They were basically on almost a task type contract. We would tell them each day "We want you to work on these things, and these things, and these things." That's a little bit of an over simplification, but we never gave them the responsibility. I tried to, and they wouldn't take it.

85. Dunar: Was that because initially the centers had fought so hard to keep control of that?

86. Odom: I think that was the notion that effected, and I didn't realize that contract was that way until I [212?], but I really had not been involved in Space Station hardly at all. I mean I'd heard in the halls discussions that were going on, but I really had not been an integral part of the

discussions going on between the centers. It was, I think, an injustice to the program and to Grumman and to all the parties of the way that we structured that contract. Who did that I have no idea, but that was not done well in my judgement.

87. Dunar: Did you find that you were spending more time trying to save the program, budget problems of course were breaking at that time, trying to save the program rather than trying to run it? I guess did you have a chance to really do any restructuring or were you just trying to salvage the program?

88. Odom: It was not unusual a lot of weeks I'd spend 70% of my time on the Hill just briefing, briefing is too formal, just sitting down with Congressmen and staffers and just keeping them posted on where the program was, where it was going, how we were doing, how the schedule was coming, how the budget was coming. This was not just at budget time, but all through the year. A lot of weeks I would not go up there at all, but there would be a lot of other times, I spent an awful lot of time, and that's absolutely necessary to do that. Turn your recorder off, let me give you one other thing. [tape off]

89. Dunar: Some of the things I've read and the people I've talked to, there seems to be some sort of consensus that in

Space Station, the technical challenges did not match the programmatic challenges. The technology, I mean there were new things but it was more or less linear from the things that had gone on before, whereas the programmatic challenges of running the Space Station program were really the main challenge. Would you agree?

90. Odom: I would totally agree to that. To me Space Station, while it was an engineering difficult job, it was not a technology. I mean we worked to keep it in it, to use as much existing technology. In other words, there's really not an SSME or Shuttle insulation that we had say in the Shuttle program. That's not to say that the life support system is not demanding and the power, it's not saying there's not engineering stretches in there, but they're not really technologies that you have to develop that's main stream in getting it jobs. To me, the management job was significantly more difficult than the engineering job. I would totally agree with that.

91. Dunar: I think those are the major things. You've been very generous with your time.