

INTERVIEW WITH THOMAS J. "JACK" LEE #2
INTERVIEWED BY ANDREW J. DUNAR AND STEPHEN P. WARING
MSFC
SEPTEMBER 1, 1993

1. Waring . . . beginning, how did you get involved in the space business in Huntsville?
2. Lee Me personally?
3. Waring Yes.
4. Lee Well, it's kind of interesting. Is this part of the history?
5. Waring Well, it fits in with the formation of the Center and how the personnel was a factor at Marshall.
6. Lee I guess I got interested in the missile business in a job I had as a student trainee between my sophomore and junior year. I worked at the [?] Air and Naval Missile Test Center in California. It was armament kind of missiles. You know, ground to air. That's one step up from the airplanes. They're not as engineering as the University of Alabama. The following summer, I worked at Hays International in Birmingham which was more oriented towards the airplanes. Then when I graduated, a friend of mine, actually my roommate had worked up here for a couple of

summers, and he invited me to come up to see the place with him. He'd agreed to come to work and to finalize that so I rode up with him. I didn't know too much about Huntsville and about Marshall Space Flight Center, what Marshall had, or the Army Ballistic Missile Agency. My interest was in being a Nabcat. I was going to go into the Navy and fly jets. At that time they were reducing the number of pilots and it wasn't easy to get in. The people who were actually getting in were having to wait a long time. If they had advanced ROTC in college, they may have to wait for four or five years to get to be pilots. There was not as big a demand for jet jockeys. That's what I really wanted to do. I came here. It was not too far from Birmingham where I lived and spent most of my life until I went to college. So I came here as kind of an interim thing, but I was impressed with what was going on when I came up. After the first few days, they threw us right into the work because at that time we were trying to get the Jupiter missile fielded. They were understaffed and you didn't have to have a great [29?] to be able to be in a position of doing something. It was a minimum of busy kind of work where you got thrown right into giving responsibility, much more than you would do today. I never thought about ever leaving after that, and that was 35 1/2 years ago. It's been something interesting to do. If I ever got to the point where it became kind of routine I would have been able to change jobs and still stay in one place. Change jobs, get more interesting, and it's been

that way ever since I can remember. I didn't come here to stay. I came for an interim period. I liked the way they operated. They knew what they were doing. They happened to be, timing is everything as you know, by the time I had two years experience we became a part of NASA. By the time I had five years experience, we were really thinking seriously about putting a man on the moon because we were at that charge. It's just been one challenge after another. It always it made it better. It never got routine. That's how I got here, and that's the reason I stayed. At that time, graduate engineers started at the GS-5 level. I was a graduate engineer so I started at the GS-5 like everybody else. It was the top step of the five. Not very much money.

7. Waring Did you start working in the lab or were you working in the program?

8. Lee No, I started in the lab. At that time it was called Launching and Handling Laboratory. The purpose of it was to design launchers and handle the vehicles. The Army, with the Redstone and Jupiter, they were mobile so you built you're launch pad and moved it around with you. All the Air Force and Naval, other than submarine stuff, were fixed phased launch pads, but the Army had to be mobile. So their was a laboratory that just focused on designing those launch pads and the propellant transfer systems that go with it,

the liquid oxygen and kerosene at that time, and the check out. It all had to be mobile. Part of the check out stuff was done with another laboratory. We put it in a mobile form. We did the launching and the proponent transfer and the handling. That's how it got its name of Launching and Handling. The actually launch operations of using this was down at the cape. That was another laboratory. They were more operational. After we became part of NASA, we went away from this mobile launch requirements. We actually transferred to Jupiter, which I was working on at that time, to the Air Force. It was a contest in the early and mid 50s between the Air Force, the Navy, and the Army on who should be responsible for ballistic missiles. The Air Force clearly had the intercontinental missiles. Nobody challenged that. They also had, felt a requirement for intermediate range ballistic missiles which the Army did do. That was the ballistic part of it. And also the Navy because of the submarines. Well the Navy and the Air Force won out, and the Army got out of that phase of that business was developed in the Persian. That stayed with the ABMA when we became part of NASA. We actually had the Air Force people, blue-suiters, here and the people who had been responsible for developing this. We then transitioned that program into them. The Army never fielded the Jupiter. It was fielded by the Air Force and then went to Italy and Turkey. If you remember the problem with the Cubans, part of what Kennedy gave up in that time was those intermediate

range ballistic missiles that were circling in the range of the Soviet Union. I never knew the specifics, but I don't think they ever brought any of that hardware back. Even the engines. None of us ever had an opportunity to fire it. It never came back. I don't know whether it got salvaged, chopped up in scrap or what, but it was gone. That lasted until I guess the early '60s, '61 or '62 when that happened. By that time, we had become part of NASA, and we were focusing on going to the moon. The reason NASA and Marshall Space Flight Center got considered in this whole business of NASA is the capability that we had in developing of large, at that time, large ballistic missiles. They couldn't deal with the Air Force that was tied up from a defense standpoint so that wasn't a job that you could take from the Air Force. You could take from the Army in that area, and that's how the Von Braun team came to focus for transition. Even as early as 1958, we were looking at large systems. When the 1958 Space Act came about, there were people at that time, it wasn't very well publicized, the thing about manned flight and large payloads and orbiting from a simple standpoint. We had on the drawing board, and in 1958 already tested what we considered at that time a large booster, and that was the Saturn I. The way we did that was, if you look at the Jupiter and Redstone, we built the Jupiters and Redstones here. [he's flipping pages and such] The first one we built right here, and we had to use the arsenal concept. You can see that the diameter of that is

Interview with Thomas J. "Jack" Lee
September 1, 1993

6

the same as this. What we did was we used the same tooling from a diameter standpoint to make up these as alternating liquid oxygen and kerosene tanks. In the middle, what you can't see is a 110" diameter Jupiter tank, and we used the same tooling there which made it longer. The object was to be able to get, see if we could cluster these, clustered engines, and be able to get that kind of capability. We used the engines in this first thing with Jupiter. So we really made it up with pieces that we knew as consistent. We had to worry about base heating. One of the problems with base heating, multiple engine starts, feed system, everything before had been relatively with single engines that we'd dealt with. It gave us a quick and dirty heavy life capability and also proved the multi-engine business. In that same time period through another organization called ARFA, we were being funded, the army was being funded in conjunction with the Air Force to develop the F-I engine, a million pound thrust engine. There's five of those in that. In fact, we were flying that in the 1959 time period. We were testing it a short duration out in California at that time. We had started the makings of the capability to get to this very heavy life even while we were still in the Army. Having that knowledge and that background then made us a good candidate to be a part of NASA. They had already in 1958 brought the NACA centers, the National Advisory Committee on Aeronautics, in. It brought parts of the NRL, the Navy Research Laboratory, in, and that made the Goddard

Space Flight Center in Greenbelt. They took from the Army, the Marshall Space Flight Center, well now it's Marshall, with the Von Braun team and the Jet Propulsion Laboratory. That was the make-up of the basic part of NASA in addition we had to have a place to launch and that would be Kennedy Space Center. The Manned Space Center from Houston came in later, but it was more from an operational standpoint. That was our part of the big picture for NASA and it was because of our expertise in developing large systems, mainly from what we had done in-house over the years. We added that dimension to what NASA's final goal was.

9. Waring As Marshall and NASA moved deeper into the Saturn program, the role, programmatic management functions changed in the Agency.

10. Lee It changed probably more dramatically within NASA than any other centers. Research centers were pretty much organized like they were research oriented, and they weren't too much into the project business. Marshall was the first of the centers that really had to make a transition from what it was to what it had to be. That transition was pretty straight forward. It was from doing the work in-house, developing and building and then turning the drawings over to the contractor to produce. That's the way we did it under the arsenal concept, to being able, because we didn't have the capability nor was it the intent of the

administration and NASA to keep this in-house. It was a major national program. It clearly required a lot of aerospace industry. We wanted to do that without affecting the defense obviously if you required a lot of aerospace industry to accomplish this. In doing so, we had to go from a kind of a doing group to a kind of technical management. If you look at the first of the organizational charts when we first became part of NASA, you'll see us organized pretty much like we were with ABMA. That worked well for us because we did in fact build the first stages of each of those Saturns in-house, even the first stage of the Saturn V was produced over here. We built on that capability. We did this in conjunction with a contractor. We had a prime contractor at the time with Boeing. For them, Crysler built the first stages of the Saturn I. We needed two other stages. We needed a second stage which was totally contracted out, and that we didn't do in house and couldn't do in-house. We needed a third stage, the S-IV stage which had to be contracted out. Therefore, we had a little bit of both. We were doing the early part in-house which we transitioned with Boeing and actually moved them to Michoud when the production took place and they then ran that. The problem was how do we do the second and third stage if we don't do it in-house ourselves? How do we make the transition to starting with a contract and being technical monitors and managers of that to insure the requirements from that and that we had the proper oversight to insure

that that took place? We weren't organized for that in the first organization you'll see when we became part of NASA. The most symbolic part of that was what later turned out to be a very large program office and control organization within Marshall was named the Saturn Systems Office which was intended to be that program office but it wasn't staffed with the authority and the people to be able to be held responsible and accountable for insuring the contractor is managed. That was probably the first real, not that we couldn't do it. We had, even within the Army when we had built the stuff in-house, we only did the first ones. We contracted out the final design, but we proved to ourselves, and then we transitioned. So it wasn't that we didn't have the business sense or management capability or procurement capability, it was just the way we applied it. That was necessary to make a major change in an organization. That would be the first real significant thing that I think Marshall did relative to being able to line up to be not an in-house doing of everything of our projects to one of taking that expertise and being able to technically manage and business manage a contract. This required some adjustments in our people. It required us to look and think more systems oriented, to think more technical management oriented, in fact we had to build the business management capability and fly this technical systems capability to pull that off.

11. Waring Some people called this the Air Force system.

12. Lee Well it could be because we tailored it after what the Air Force had done and we got that education from a guy named Sam Phillips who was Air Force. He was assigned to be the Apollo Program Manager. He was in Headquarters, but he was the business manager and the manager of the program.

All of our project people here and within the other centers were responsive and responsible to him on the program basis. He patrolled the schedule, the money, and the requirements. The Center management like the Von Brauns became a part of a management council with a board of directors to insure that the right expertise was applied and that it was consistent with where the overall requirements. The chairman of the board was George Miller who was head of our office of Manned Space Flight at that time. The change in the organization was pretty significant because it was obvious on the organizational chart that we were doing things differently. What was at one time, early all the laboratories and then the Saturn Systems Office kind of stuck in one area up here, it was a dramatic change even in the organization. We showed the technical capability with our Science and Engineering director and on an equal par basis was what we called then our Industrial Operations which in essence meant that's the interface with the contractor. Those are the people that are going to control the requirements and the dollars and bring together the technical expertise in these

laboratories with directing if you will that contractor. At that time, the technical capability was significant because in some cases we had more intelligence because of what we'd done here than the contractor did. That helps us you be a smart buyer. That's the kind of transition we had to make. Project managers quite often had to make a decision. Contractors say do it this way and technical people say do it this way. It wasn't always obvious always obvious. It really put the emphasis on the importance of the decision maker in the project management. To insure that that transition took place, and we had the right, even after we organized, the right attitude, or the right approach to dealing with the industry in that fashion which we had to assume that we didn't that much. I think we were better prepared for that [205?]. The first head of that was a guy named Bob . . . he was a Vice President at Aerojet.

13. Waring Bob Young.

14. Lee Bob Young. He took a big cut to come to work for NASA, but it was necessary we thought or the Agency thought to bring that business experience because he knew how to deal with them. He was a very intelligent guy. He understood the business business. He understood the missile business. I think he kind of set the course of what a program office is and a technical management organization ought to consist of. We retained that organization almost

through the Apollo and even into the Skylab days. If you'll look at that organization you'll see that we had a lot of project offices, but there was only one real program office. That made it easier for the center. One program. One major program here at the Marshall Space Flight Center, and that was Apollo. Even though we had three stages and two engines, actually three engines, to develop. We actually managed the development of the Centaur engine at that time, and we used it in one of our early flight phases. So there were four engines to develop and three stages, but it's all Apollo. It's all going to the same place. There's some commonalty in the interfaces, and some commonalty in the requirements. When you see that, you'll see project offices set up in that way. I think that served us well. That made us develop a systems management capability which we still retain today. I'd declare it's still a good one. At the same time were able to retain the technical in-house capability. On the Air Force part, Sam Phillips was Air Force, and the systems management approach was tailored after the Air Force in areas like traceability, configuration management, in the business management. Those were pretty well tailored after Air Force program.

15. Waring So, about the time the Center and the Agency was going through this transition, did you make a decision to move from laboratory sort of work?

16. Lee No, I did it before. It happened when this laboratory, the Launching and Handling Laboratory that I mentioned, when we became a part of NASA, we didn't need that laboratory any more. We were always going to launch from the Cape or someplace that was fixed. The Kennedy Center was already established. We tend to split that organization initially. It was in late 1959 and '60. Part of the people started supporting the Cape and another part because, mainly because we had the people. We were assigned, what we called then, the Light and Medium Vehicles Office. In that was two vehicles, the AGENA for which NASA had a requirement. The Air Force had developed it, but NASA had the requirement for it in the Lunar Program, early Lunar Orbiting Program, and also the planetary program, the Mariner series and that sort of thing, and the Centaur. We weren't program oriented, but we became the Light and Medium Vehicles Project Office. It was necessary at that time for us to, I was one of the younger people in the group, necessary to have some presence at the contractor plant in California in San Diego. It wasn't difficult for me to move. I didn't have a lot of household goods except my wife and a small child. I determined that that's probably where NASA was going even at that time. We were beginning to focus more on the management program than doing things differently in-house. I took that opportunity to stay with this Light and Medium Office and took up residence for a couple of years out in San Diego. The two reasons I did

that was 1) to learn more about management and how contractors operated and 2) it was a new vehicle. It had a lot of firsts. The Centaur was the first liquid oxygen, liquid hydrogen, upper stage, first one to restart, first full gimbal guidance system, first one to ever use insulation that came off during as a staging arrangement. It was just a lot of new stuff. I'd worked in the ground support equipment all the time, and I really didn't have a good feel for the launch vehicle, the flight part of the program. I had an opportunity to do two things. Waring 1) I was still young, and they didn't expect too much of me and in that case I'd only been there two years. That gave me the opportunity to learn both of those things. One, how the contractors operated because they had done this, [268?] had been in the business with the Air Force on the Atlases and had been quite successful with them. I used that as an opportunity to learn, and I did. I learned a lot. First off, when I left here, I believed that the source of all knowledge about everything associated with space resided here. We were first in a lot of things. I learned that the contractors approached things a little bit differently, and they also had a lot of knowledge and had become experienced in it. So you learn both sides of it. You see how the government can operate and how contractors can operate. It was done for learning purposes.

17. Dunar Other NASA centers had resident managers offices. Was there anything unique about the way Marshall operated its resident managers offices or the unique capabilities they had?

18. Lee There was one thing that always seemed to come up in discussion about your charter, what you were responsible for. It didn't affect me too much in the Centaur office because I wasn't in charge. We had another resident manager. It came down to exactly how much authority one has. Do you represent the project manager? Do you have the authority to direct the contractor? What contractual authority do you have? Different resident offices used it differently. Some of them even referred to their offices as liaison. That seemed to be denigrating to some of us because being a resident managers office sounds better than a liaison. Liaison means you pass messages, and so we were all looking for something that put us with more authority. I would say that Marshall, even today, may be, more because of the type of work we have, may be more inclined to put a competent resident office at a contractor's plant than some of the other centers. We seem to do more of that than others. Even when we have programs in Europe we have a resident guy over there. It's kind of our mentality to have a presence at that location.

19. Waring Could you describe what people in the '60s at Marshall meant by penetration?

20. Lee We had a thing called, that Von Braun coined as automatic responsibility. You've probably heard that. It doesn't work as good today, but it worked then because there's a lot of unknowns about this, really. You haven't been proven. You hadn't done what we've done today in the development of the hardware and the flight of it. So Von Braun's approach was that everybody out there has got some intelligence whether it's just because they're smart or just because they're exposed to a lot of things. They ought to have an opinion about and you ought to be able to listen to that opinion if you're concerned about whether it's a question of whether something's exactly right. I don't feel right. We didn't do it according to speck, or what have you. Using informal organization to the fullest given in the reviews. He welcomed anybody that had a point to be made relative to the flight success or the success of the hardware. That's just the mode of operation that we use. We used that during the arsenal concept the same way there, and we used it throughout all the programs I knew about. Penetration meant there that, with some judgement, you were free to look at whatever was going on within the design or development to the depth that you thought you needed to to assure yourself that it was going to be right. Some people went further than others. That's never been defined

exactly. If you go all the way back, if you're talking about understanding a transistors you could go back to the where you mined the germanium. In some cases, by the way so it's not completely out of the question, in tracing the problems, we've had to go back to the raw materials. That's one of the things that the Air Force system of configuration identification control did for us. It allowed us to be able to understand where it came from so you don't have to guess if you have a lock problem or if you have a component problem. You ought to be able to go back and figure out if it's something generic or is it's a bad design or what have you. Penetration meant that we all had the same objective. Nobody ever questioned that. Nobody had in mind to try to be a hero necessarily. Nobody had in mind that we were going to hold a contractor up. We had the objective of in the case of getting to the moon, and everybody feels comfortable that they are a part of that. Then you are free to look into what ever concerns you. That was the penetration and ultimately what came out is automatic responsibility. It worked well for us. It doesn't work as well today unless if you already know the answer. It does work for us well in areas where we are really uncertain. If you had past experience, you ought to be able to build on that sort of thing. Penetration in a lot of cases is not near to the depth of that we looked at back in those days. Those things were new, and we didn't know what happens to hydrogen. We found new things like hydrogen griddle and

stress corrosion. Those are new terms that came up. We were developing materials, lightweight materials like aluminum, to be able to have the capability to give us the weight margins to be able to apply these things. We were really in a technology and research phase of the program and as such that penetration was felt to be necessary, and it served us well.

21. Waring Marshall was working under, well NASA as a whole in the Apollo program, was working under an unusual requirement which was the end of the decade deadline and having a time deadline imposed by the President was something unusual for a NASA program or a meaningful deadline. Could you describe how that affected the work?

22. Lee It makes it easier. We did then than it does today because the whole Agency was focused on it. You didn't have competing programs. You knew that you had all the resources available to you if you needed them to be able to pull the thing off. The other thing you had which was really gratifying, you had some very good leaders. I'm not saying that you don't have good leaders today, but they had demonstrated performance. Bob Gilruth at JSC, and Von Braun here, and Vivas at the Cape. Like George Miller, very intelligent guy. Sam Phillips and people that you had confidence in that you knew that had the authority and had to go to Congress for money. We thought they had the

authority to make midcourse corrections, change directions. You know the famous deal when they decided Apollo XIII to go around the moon. Those guys got together right here. Chris Kraft and Gilruth, the two people that came here and talked to Von Braun about that. They worked together on major things like that then they presented it to Tom Paine, and I guess he went to the President, and it was agreed to. Today to make a major change like that, you've got to go through all the Congress, all the staffers. You can't make decisions like that. No matter how good of leadership you've got what I consider more impediments to be able to do that. Look at Space Station. If they'd had of given that charge, they would have left that up to the leadership, and if we'd had to stay within the budget, then we'd be on our way. There's just too many more people and more people that you've got to report to. I think that gave us confidence that whatever these guys would come up with, and they were thinking up all the time. How's the best way to go about this to meet those schedules and the kind of problems we were having. They probably looked like real show stoppers at the time, but when you have a propulsion problem or have a materials problem, you knew you could call on the best name outside the agency, and you'd get the job done. You just had a feeling of confidence that you're going to have the resources available to do the job and you're going to get the support of the country. They made me feel reasonably comfortable. I wasn't that high up in the

organization. I never doubted that we'd wouldn't be able to do it. I'm pretty that the higher ups had a lot of questions at the time, because it had never been done. But I had that kind of confidence in this country's ability. It never entered my mind that we weren't going to be able to make it.

23. Waring One last question and then I'll turn it over to Andy and Space Station. Another part of the leadership at Marshall came from the German rocket experts. Could you describe their engineering style, their management style?

24. Lee Well, Von Braun, we'll start with him. He was just a good at dealer with people. He could deal with politicians. He could deal with the junior engineer. So it starts kind of with how you view your leader. Sure a lot of the Germans disagreed with him on certain points, but they come to agree ultimately on the way to go and then ending the chart. The Germans were very good technically. No question about that. It was probably more difficult for them to make this transition from say the arsenal concept to business of systems management than it was for others. That's probably the reasons that most of them stayed in the laboratories as part of the Science and Engineering Directors. I think that's the way that they probably worked in Peenumunde. That's obviously the way they worked when they came here with the Army Ballistic Missile Agency. That

was a change. From a technical standpoint there was no question.

25. Waring What made them so good technically?

26. Lee I think it was just because they got an early start. Part of it was their lessons learned. They had some beauties in Peenumunde. They learned from practical experience. They had enough failures to know where you've got to meet precision and where you've got to focus things. They dealt with those. They also recognized when there was a problem beyond their knowledge, they easily recognized that somebody else had that whether it was straight from a laboratory at MIT. They capitalized on that, and they used it. It wasn't something parochial, "I'm the smartest guy." It was having the added intelligence to be able to recognize when they had a problem that they couldn't solve. I think it's because their whole lives have been around space even before they came here and that interest and their personal experience. They all had the same goal for space exploration. I think that made them as good technically. That doesn't say that there weren't equally as good technically as people who weren't in the German group if you define them. As we went from ABMA and started into this expansion to a larger center, I think it was in the 1950s that less than 3,000 about 2,700 people when I came and the year before that it was probably maybe in the 1500s and the

2000s. Once we got into the Apollo programs in the 60s, we went to 7200 civil servants so what you're going to find is that there weren't any more Germans coming in, but your expanding, and that made that transition. The only complaint, I don't know if it was a complaint, but they weighed heavily on your past experience. That usually meant how long you'd been in the business and that usually means age. They had to in some of our cases because we didn't have enough people. There were a lot of young people coming in when I came in so younger people had to take the responsibility. I would say they were more inclined, they had more confidence, if you wanted to give them responsibility if you were older than younger. I think that's just the way they were brought up. We got out of that, had to when we went to 7200 people, and we didn't find all the older people to do that.

27. Dunar Something you just said that brought a question in my mind. You mentioned that most of them stayed in the labs, I wonder if because of their training and their background . . . ?

28. Lee They felt more comfortable there. They did. There were a few that got into the program offices, but they were more in the engineering area even then. You didn't find too many that shifted to the program there. They felt more

comfortable in the laboratories and doing the technical hands on kind of stuff.

29. Dunar When we talked with them, they talked about that technical training and the advantages. Is that maybe one of the disadvantages that they don't have the managerial background?

30. Lee I think it was evident, and like I say, they weren't making anymore Germans. It just comes out that way! Even though some of their children were here. What we did is we went to 7200 people, we had to build a bigger organization and that automatically brought new and different people in. Even in the Apollo, they were getting up in age even then.

31. Dunar You made a comparison a little while ago between some of the managerial problems of Apollo and how much more complex things are in Station. Maybe that's a good place to pick up. A number of people we've talked to have commented that the programmatic issues in Space Station are so much more complex than the technical issues.

32. Lee They are.

33. Dunar Could you comment on that?

34. Lee To start with was just the way we tried to organize it, and the reason for that is not all known to myth. I suspect that when we first started the program that it was believed that Space Station was going to be "the" new program. We'd had our Apollo in the past, and Station was going to be the new program that we were going to focus around. I think it was though to be and some people in NASA maybe in the administration that they would get the same kind of interest on the part of the Administration, the public, and the Congress that the Apollo did. In fact I remember President Reagan saying in ten years we're going to have a space station. Well, that's past already, and we haven't done it. In order to be able to ensure that we didn't have any problems with the political group, the decision was made, and this is my opinion, the decision was made to spread this thing among four center1. Waring Johnson, Marshall, Cleveland, Ohio and Maryland with the Goddard Space Flight Center. Once that decision was made it forced us into splitting up the Station to the point where now it was difficult to have system control of it. From the day that decision was made we couldn't agree on exactly how to pull the system together. What came out of that was the Restin which was not a bad intention. It was a reasonably good idea to try. It was a little bit parenting the, to what we thought we had in the Apollo. That kind of systems management was done in Headquarters in the Apollo. It was done under Sam Phillips. He kept the overall system

requirements, but they did in fact look at it from an overall systems standpoint. They let the Centers then do their thing. The interfaces on the Apollo were much cleaner. The top of it was the spacecraft and that was the Johnson Space Flight Center. Everything else down below was Marshall Space Flight Center in areas which we knew so we had a clean interface. They did this with the Station which in instance doesn't have those kind of clean interfaces. To break it up into four centers then you establish new interfaces which are complex. To make it even worse, each of us had our own prime contractors and that made now not only physical and technical difficult interfaces but now you've got interfaces between two prime contractors and now between NASA and which NASA. Is it the NASA for a piece of hardware that interfaces between what we're responsible for here and Lewis. Then you've got two governments involved, two prime contractors. The Restin group, from a systems standpoint, never really, in my opinion, got control of defining the program at the systems level so that was clean. So you ended up with a lot of government and contractors in between these interfaces. Today, we're going with a single prime contractor. That's going to be some transition to get there, but that eliminates the government between those interfaces. We'll have one prime contractor, and the contractor deals with that. You don't have to have a government approval in between. Everybody that has been working on the Station under that arrangement were doing

good work. It's just not an efficient way to do business. If the decision had of been made say, and I thought it would quite honestly with you in 1983, that Marshall Space Flight Center and the Johnson Center would do this, we could have defined an interface between us I think that we could have worked. Now we've only got three centers involved. We had four at one time, and that started the complication. I believe it would have worked out differently. Some of us thought that we'd already had an arrangement between us and JSC on how that was going to be split, and we were ready to go with it. Then this other came in and destroyed our little plan.

35. Dunar You participated in meetings in August-September of 1983 where some of these discussions were going on. It seems just from what I've read in those meetings, there was an awful lot of tension between the Center Directors and Headquarters. The Center Directors were coming together in effect to try it seemed to demand that Headquarters allow management to be in the centers.

36. Lee I don't know what the problem at headquarters was other than the fact that any time we started a new program like this, and they're a little nervous about what their role's going to be. In addition, I think we knew pretty much from the outset that it was going to be an international program. That's one area, in any

international program I've ever been involved in, in the front end Headquarters gets very possessive of any kind of dealings you have with the foreign countries, and maybe they should. [turn tape over 635] They want to get that finalized so that it is clear what the relationships are. Every program I've ever been in, Spacelab was the same way. They tried to hold me at arms length until they had that all nailed down because they wanted to make sure that the understanding between the countries and the agencies was there before they turned us loose to go build hardware. That might have been some of the influence too was just knowing that it was an international program. It was going to be probably a different kind of cooperation than in any international program we had before. I think that had been established. They were going to be more independent or autonomous. In fact one of the questions was, "Are we going to develop the station that would be independent in case the Europeans, the Japanese, the Canadians don't show up, we still have a space station or are we going to make it integral?" It was pretty well decided, and they wanted this too. They didn't want to be something stuck on. They wanted to be an integral part of the program. That's the way it is.

37. Dunar Were you involved because of your experience in Spacelab? Were you involved in some of the discussions with the Europeans?

38. Lee Not as much as I would have liked to have been and thought I should have been. There again, this is part of the changing of the guard. It was a different group of people who were working on Station in the international side. They had held on to that pretty parochially. We had a good, and still do, have a very good relationship with ESA on Spacelab, and I don't now wether they may have felt that that would have been a threat to them when they got their Memorandum of Understanding set up. They did interview me on two or three different occasions. They asked questions about the kind of problems, what they should be looking for, and that sort of thing. But I was never invited to work with them directly on MOU.

39. Dunar Treated you more as a consultant?

40. Lee Yes.

41. Dunar The relationship between Johnson and Marshall then, at I guess probably early in '84 after the decision was made to give the advanced power package to Lewis, then there was a period when Jerry Griffin was trying to put together a split. Is that the period you were referring to in the course of the agreement for . . . ?

42. Lee It was before that. When we'd concluded that we were going to be the two centers, Marshall and JSC were going to do this thing, and that made it easy. Then when it started breaking out, then it came apart. It didn't make an easy split between the Centers.

43. Dunar Once that became kind of the requirement that Lewis would be involved

44. Lee Lewis and Goddard.

45. Dunar Goddard too, but I guess Lewis was probably the biggest problem though.

46. Lee Yes.

47. Dunar There was a time, Luther Powell had a recollection of coming very close to an agreement during that period before it was turned over to Culbertson. Do you remember that period?

48. Lee Agreement with Lewis?

49. Dunar Agreement between Marshall and JSC on terms of how it would be split given that Lewis would have a part of it.

50. Lee I don't know specifically. I'm pretty sure there were things like that going on, but I don't remember all the options that were given to us. It didn't look like there was going to be an easy way to do it. That's one of the reasons that the Restin thing came out is now where do we manage this thing from because we've got all these centers that need to bring this thing together. That then started that exercise.

51. Dunar From Marshall's perspective is it easier to work with JSC as a lead center or with Headquarters or with Restin running the program?

52. Lee We don't have any trouble working with Headquarters. That worked good in Apollo and people like to think about that because they all have the same interest, and we want to make sure we complete the program. As far as Restin, we didn't have any trouble with Restin other than the fact the way the program was split up into fourths and the three prime contractors made it difficult for anybody to pull together. If we had one single prime contractor, and we were thinking about that before we came to where we are today. This time last year, we had all agreed that if we could just get one of the contractors be a prime integrating contractor that we would, we never talked about moving anything in from Restin. It was discussed at that time, but that would have worked well too. The only problem we ever

had with Restin was they never seemed to understand exactly what their role was. I always felt that they had the overall system responsibility. They ought to be concerned about this whole system and establish requirements for that - recognizing how the system was split up. That's what they should be doing, and they were the only ones in the country, in the world, that could be doing that. They had that assignment. But from the outset it seemed that instead of doing that particular job which was essential to the success of the program, they organized themselves, the management did, in a way of getting too involved in the next level down. That creates a problem between the work package manager because he's now being told what he ought to do in detail instead of being given overall systems requirements. It's not that these guys shouldn't get into the details, but when they were doing that, I think they missed the boat of not being able to control the overall systems. That's the only complaint I ever had with Restin, and I made that point frequently. But again, nobody else was doing what I thought they ought to be doing. They weren't either.

53. Dunar One of the people I talked to at JSC was the biggest mistake they made when they set up Restin was that they hired a very large staff and that immediately generated all sorts of requirements from centers.

54. Lee Yes they did, and these guys, the staff they set up were into details. When they got down into the component level and when you're doing that you're not looking at the big thing and that has a tendency to sort of grate on the guy that's in the field because now he says "you're micromanaging me." Any project manager feels that way if he feels he's micromanaged. He doesn't feel comfortable about it. That's true. I think that came out.

55. Dunar Given all of these organizational problems in everything and the very complex interfaces that you've mentioned, how did you work through these interface problems? In other words, having to work with contractors that in effect couldn't talk to each other

56. Lee Well they could. In the last year or so, we recognized, the contractor recognized the problem. In fact the kind of discussions we had were "Look if you guys don't make this thing work, it's not going to work and you're going to be in trouble." Therefore, they were getting attuned to the fact that they almost needed to take over and start working together and work the problems and not have to wait for these formal directions that had to be approved. I understand they did a good job of doing exactly what they were supposed to do, but any time you have a complex system like this and you've got to put a government, at least one or two government people in between two contractors to do

even the simplest kind of thing, then you're inefficient. That's just the way it works. That's where the prime contractor mode should eliminate that. We were going to have the prime contractor responsible for doing that and now the government can get out of that. It's not as an official contractual approach, but you're not going from one contract to another and having to go through this bureaucracy. It's just not an efficient way to do business.

57. Dunar Was it a mistake then in the beginning for the centers to insist on having that integration role in-house?

58. Lee If we had done what we said we were going to do and done it right, we wouldn't have had the problem. We didn't step up to that job. Instead we focused on our own little work packages and then Restin had to get a system contractor to try to do that integration. Had the government, NASA, say "OK we're going to try to do that job of the system integration," it would have worked better. You would have at least taken some of the people out of this loop from an integration standpoint. In fact that was the approach we were thinking about taking at one time was we'll do the systems integration. NASA would do all of what say Grumman is going to do and now what we are expecting the prime contractor to do.

59. Dunar It seemed too and I think this was an interesting problem I think of that period of '84 or '85 to whether the integration would be done at level B or distributed at the level C packages. Would it have worked if it would have kept it at level B?

60. Lee I think it would have come closer to working. Sooner or later I think it had to come to a prime integrating contract. One of the contractors that we have that would have had to step up to be the integrator or you would have had to keep the Grumman contractor, and I believe one of the hardware contractors would have been better. I think you would have still evolved to one of the prime integrating contractors. I think the government would have forced that because they don't have anybody to talk to or direct.

61. Dunar OK, we've talked a little bit about the management things, but could you talk a little bit about what you consider to be the major technical challenges on Station?

62. Lee On Space Station? Well, there's no new state of the art stuff. The technology is all there. The biggest challenge that I would see from a technical standpoint is in being able to bring the pieces together in a fashion that we can verify them to a point we're satisfied that when each of

the pieces are delivered and they're put together in orbit or at the Cape or what have you, that they do in fact function properly. We've still got that problem. Rocketdyne is going to deliver a power system, and it's got to fit with the hardware that we're providing and Johnson's providing. We provide the hardware that's got to fit with all those. It's still going to be an end item kind of responsibility for delivering hardware, and I think here our success is being able to refine that down to the point where what we deliver is simple enough that we can understand it's going to work together when we put it together. There's an additional complication now in that same respect on how we deal with the Russians. We've seen a lot of proposals, but if there's a significant involvement on the part of the Russians, then there's that new interface that's got to be verified before you'll ever launch. From particularly a design standpoint instead of a technical challenge it would be to bring this thing on a cost that we can provide. That may mean having the flexibility to being able to adjust requirements to the point where we can do things differently or cheaper and still meet the overall requirement. I don't see any real strong technical problems. There's little things like they had problems with the batteries. We'll work that out. There's concerns about how much influence the Shuttle attitude control plumes affect the solar panels. Those are all workable. Mostly the big technical challenge is being able to satisfy the design requirements and do it

within the cost I think. The one that is still hanging out because, well its requirement's a little bit nebulous, but it's kind of a go do thing and it's also money, is how much meteoroid debris protection do we need to put on this. That's still open. We had that concern from the day we started. Today we still don't have that refined to the requirement that we need to be designing to. If the designs are the worst kind of speculation, then it's going to cost you a lot weight to protect. That's more of a programmatic decision, but it's a technical decision on what you want to protect against. What probably after so many years you'll want to insure that. Again, that's kind of a go do thing. I really don't see things we can't do. Nothing seems to be hanging out there.

63. Dunar From the center's perspective, there are a lot of approaches you could take in answering this, but what has really been the impact on the center of this constant concern about money?

64. Lee It's kind of been the same to us as to other centers. What it usually means is that you have funding instability. When you have funding instability, you have increase in cost. That increase in cost gets reported, and then you get criticized for it. I would say it's more programmatic. I don't say its affected the moral of the center. This whole restructuring of the system and knowing

it's going to be a different configuration and not knowing what part of what we've done already is applicable. That kind of uncertainty makes people not feel happy and comfortable. I don't know whether that relates to a lower moral. It says you're more concerned about the thing and probably not having about as much fun this year as you did last year, but I can say that about myself too. I don't consider my moral as low. I think we are still reasonably sure that there's going to be a pressurized module within our work package and that there's an environment control system that's going to be done here. We're using quite a bit of our facilities. I see us and our own people seeing it as we're not doing any less than we were doing before. The only thing, the problem is the money. We know that the overall cost of the Station is going to come down. That means everybody's dollars are going to come down and that means we have to again find ways to do it with less money. That would be the biggest challenge.

65. Dunar This process is become so political. Has it drawn center management more into the political arena? Do you find you're having to talk to Congressmen more than you did otherwise?

66. Lee Not because of the restructuring part, but I would say we're having to do more educating if you will about Space Station in general. If you look at what's happened in

the last two years, it's not the restructuring Congress is concerned about, it's the overall cost. Two years ago, there was a good debate about whether why Station. A lot of it was focused on why we should be spending this money on other things like housing and veterans. NASA's not against spending money on housing and veterans. We think the requirement for the country ought to be balanced. This last year, it was a little bit different argument. There was an addition to what was used two years ago. This time they started, and they'd done a lot of homework, and I'm talking about opponents of the station. Now that everybody agrees that you need it, is it worth it. Now you say all the good things about what it's going to do for future space exploration. What it's going to do for potential application. Now let's look at the cost of it and see if it meets a reasonable test. Which was a very good debate this past year if you happened to listen to them. The opponents as well as the proponents did I think that as we go forward, it's going to be even more difficult because there's additional intelligence being gained all the time, and I think the debates will probably be even more interesting next year. They will come up next year for sure. Then restructuring part hasn't caused us to deal more with Congress. It's more the encouraging, not encouraging, but educating them on the benefits of it. In that respect, I think all the centers, all of NASA has done a better job than we've been asked to do. We can't lobby, but we can

give information about parts of it. We've done more of that on Station than I ever remember we've done on any program here, and we've been asked to do that by Headquarters.

67. Dunar Is there still some disagreement within NASA in terms of using money for manned programs vs unmanned?

68. Lee Yes, and you're always going to have that. That's been nothing new. That started back in the Apollo days. The cost of the Apollo and what science was out of it. I think the scientists looked after Apollo that there would be more emphasis on science and less on the manned program. There has been more emphasis on science, but it hasn't decreased on the manned program. If you look at, see the Shuttle is demanded by men and look at the cost of Space Station. The science people are always going to say that you're spending more money on science and less on the manned program. That's going to be an argument as long as we have a manned program. You have to look at it from a different perspective of if you didn't have men in the program, then would science be able to support a viable space program? I think we don't want to test that but most of us believe that it wouldn't hold the program if we didn't have enough emphasis on manned. There's always going to be a requirement to drive the cost down, and we're trying to do that.

69. Dunar One of the issues that I guess has caused problems between JSC and Marshall is that of managements of the Space Station and as I understand it is the difference in philosophy on what would be the better approach. I wonder if you would comment a little?

70. Lee Well there's always a difference in philosophy. I think the approach that was taken initially is we didn't think was necessary, and it's very costly. It cost you not only a lot in development, but it cost you a lot in software, for operations. It's one of those things. I think you'll find that out of all the configurations that we have talked about from restructuring that are possibilities, and some go a long way to taking out a lot of stuff, the one thing in common in all of them is a change in the data management system to a simpler system. That's going to happen. So if you say well Marshall was right and JSC was wrong, I don't think it looks that way. It's just if it costs you a lot to develop and costs you a lot to operate and then you have to look at that against the requirements. I think everybody came up with the same concern and a new solution would to be simplify it. That's going to happen.

71. Dunar Has that been agreed to or is it in the works?

72. Lee All the configurations that are viable that I've seen today, that's the common one is the simple data management system.

73. Dunar I wonder if in the beginning having to decide to divide work packages the way they did, by systems, would it have been better if perhaps they divided it by hardware, or would that not have worked either?

74. Lee I think it would have been better. We started out with a little bit of, it compounded itself. We started talking about systems that goes across a lot of hardware. The reason that we should have been able to detect that it probably wouldn't be as easy to pull off as we thought is that each of the contract, work packages 1, 2, and 3, let's take our work package. We have a little bit of everybody's stuff in ours. One of the things, you've got to have an end item. You've got to have something that you're buying off that the contractor is responsible for. That means the Boeing contractor is responsible for. The more of this dependence and interdependence on somebody else's stuff to be able to end up with an end item is complicated. I think we would have been better off to have, not to get away from commonalty. We could have some commonalty especially in the hardware, but I believe we'd have been better off if we had identified those pretty clean interfaces and that module feed delivered acceptably that we could run tests on and say

"we know it's going to simplify that interface." It's too intertwined. Knowing that we had three different contracts that then made it more complex and made more of this interfacing between contractors and the government in between. We complicated it all.

75. Dunar Part of this is just being an outsider and not quite understanding how some of this works, I'm wondering in terms of controlling interfaces. I know they used the same sort of system that they used in the Shuttle with the interface control documents. There's also architecture control documents.

76. Lee Yes, that's where the overall systems, it's got to be compatible with the architecture and then has to be compatible with the interfaces when it goes across two pieces of hardware.

77. Dunar Do the architecture control documents have priority then over the interface control documents?

78. Lee Yes, because the system's got to work.

79. Dunar Those come first then?

80. Lee That's got to work, and now it's got to be then put into hardware and the interface between the two pieces of

hardware, but it's got to be compatible with the architecture.

81. Dunar If you're making a major change, do you do it through the ACDs first and then the ICDs have to respond?

82. Lee Yes, or you can go another way. If you have to make a change in the hardware that effects the architecture, then you've got to go through that system too. You can't make a change that's incompatible.

83. Dunar Right, but one doesn't drive it necessarily because you could have a change in either part of it that would force a change.

84. Lee Right.

85. Dunar When Houston had the lead, the program office there would have made those determinations ultimately, right?

86. Lee Yes.

87. Dunar What is going to happen now?

88. Lee Well with the host center which is a different set up than we're used to in lead center, and I don't know

wether we'll pull it off. The plan now is to have the host center have a program office that is relatively autonomous and independent of the rest of the center. It's planned to have it's own procurement office, and everything with the possible exception of maybe personnel actions. It's almost like each of these people in the program office will be dedicated to that program office, could even have Headquarters badges on them for just sitting at a center. The difference between that and what you do today in what we do as lead center is you use the institution to do the program. You use the local procurement people. You have a small program office, and your matrix themes to it. This is to establish, it's almost like putting them in a different building over there and the only benefit of being at a center is having the lights done and the maintenance for the building, a roads and commodes kind of thing. Then they operated free and autonomously. We've never done this before, but that's the scheme for host center as opposed to lead center. That made it very clear that the center management at that location is not going to be in the loop programmatically. He just keeps the lights one and toilets going.

89. Waring Essentially it's a way to reduce administrative overhead costs in two ways. One by cutting out some of the center administration, and also by reducing the headquarters level staff?

90. Lee No, I think the real driver here was to make the lines of management cleaner.

91. Waring Right.

92. Lee At some point that's got to get a little messy. I can understand how that works. We don't have any problem with that today, but when it comes to the next level down when you're matrixing, you know engineering people out of this center, out of Lewis Research Center, and out of Johnson, somebody has got to manage that and you can't have a program office sitting in Houston and trying to manage a matrix organization down here. There's got to be some group that establishes what the requirements are and that looks at that because in matrix you may have a hundred equivalent people matrix, but you may be touching 300 people. So you've got to use the institutional organization to cause that to happen or you're going down at Houston trying to talk to 300 people and integrate a quarter of man here and a quarter of a man here to get his answer. That's the part that you have to sooner or later get into the institution, and I don't think that's been brought through yet.

93. Dunar You mentioned early that one of the key decisions here was the decision to bring in Lewis as another partner and certainly that was terribly important, but there's been

a lot of changes in other iterations that the Station has gone through since. Have there been other key decisions do you think that have been forced on . . . ?

94. Lee Well, they also brought Goddard in, but we got them out. That was a key decision. I guess the next key decision was to bring in Grumman for systems integration contract. That was a key one. It hasn't worked out, but it's difficult to bring an outside contractor in to be systems engineer on somebody else's hardware, but that's kind of what we've done.

95. Dunar Grumman was reluctant to assume the amount of responsibility they would had to have to really do that job . . . ?

96. Lee You'd have to ask the Restin people about that. It just, it put them in I think kind of a difficult position because you see it brought an outside contractor in to try and integrate the three other prime contractors who are developing hardware. In time it would have worked out as you get more familiar with the program and yourself more established. That didn't work efficiently initially as you wouldn't expect it to.

97. Waring NASA had used integration contractors before in terms of the Apollo program. What was different about them?

98. Lee I think the interfaces were a lot different. For instance when, we had Boeing [?960] to look at the overall thing, you had pretty clean interfaces and what they really said was you wanted to make sure that the whole stack was integrated together. You wanted to make sure that it was compatible for the launch pad. That was really more like an oversight thing. Most of the work in identifying and clearing those in the crew of the interfaces had already been done between the contractors before they ever came up here. They came up here late. The automatic checkout equipment for the whole thing was originally given to General Electric. They developed the hardware, and then I thought that they had the systems responsibility until we brought Boeing and [971?] in later and that was primarily for that purpose. They did a lot of other things other than integration. They did a lot of programmatic kind of integration - configuration, identification kind of stuff and looking at and ensuring that the paperwork was in order as opposed to doing real systems engineering with

99. Waring Design requirements?

100. Lee Yes, because they came in pretty late. We already had it designed by the time they got in. It was more insured that they had a paper trail. They were located at every center. That's the kind of stuff they did here - programmatic integration and schedule and stuff like that.

101. Waring Is that essentially what Bell Com?

102. Lee Bell Com was a little bit different. They dealt with a little more technical kinds of things. They were kind of George Miller's contractors. They didn't have the overall responsibility. They were kind of tests of wherever you had a concern to look at. Now it's everything from guidance to avionics to what have you. I think he did those on a task specialty. They were much more technically oriented. They really did look at the technical aspects in the areas where Miller thought that there would be another set of eyes look out.

103. Dunar Because this was such a high visibility program and the Center Director or rather the Administrator of NASA was very much involved probably I imagine more so than most of the programs . . .

104. Lee Which one? Spacelab or Apollo?

105. Dunar Well in terms of Space Station. Was there a difference that you had when you had a change in Administrators? Did Beggs in other words take a different approach maybe than Fletcher?

106. Lee Well it was Beggs who got us broken up in pieces, and he didn't stay long. He didn't do us any real favors by getting established that the cost of the program was \$8,000,000,000. I think that's been well recognized. Who came in after him? Fletcher I guess.

107. Dunar Well Graham was there for a little while and then Fletcher.

108. Lee Fletcher spent more time on getting the Shuttle back in the air than he did on Space Station. Then when Truly came on board, he didn't spend as much time on it either. I'd say the one center director who spent the most time dealing with Space Station has been Dan Golden. That's pretty obvious because you go through an exercise to restructure like this, it takes a lot of time. That, plus going through restructuring exercise and having to try to convince the Congress they ought to vote for it, I'd say he spent most of his time on Station. Golden has spent more time than any other administrator just maybe because of the situation. When Truly was there, I don't think he, we went through the budget cycles, and we hadn't identified the

overrun when, well he was leaving when we did that. All of it, the real impact hit recently.

109. Dunar With the restructuring, will center responsibilities in terms of systems responsibilities remain the same or will there be changes?

110. Lee I'm not sure about that. With this new organization and the host center, it has not been well defined to me exactly what the center's responsibility in detail is. That's mainly because a new program office in Crystal City who's pulled this together. They're actually advertising for replacements for all practical purposes for all of the existing station people. So it's a new organization, a new way of doing business, and it's not clear what's going to be expected of the center. I think ultimately there's going to be more involvement and support of the program than maybe they anticipated. It's not going to be an easy thing to take existing contracts, fold them into one, figure out what you've done in the past you want to keep and then try to make a new system out of it. I think there's going to be more involvement from the government than maybe the people who are talking about this new way of doing business, at least initially. For instance, we have, there are a number of facilities that Boeing is using today as part of the development, here at Marshall. They're the only facilities available to do this.

They estimated that way. Whether the new approach is to try to be different from that, I'm not sure.

111. Dunar But having the facilities may drive them in the direction?

112. Lee Well it will.

113. Dunar I think that's about all that I have.

114. Lee Good luck.