

**INTERVIEW WITH JACK LEE
BY STEPHEN P. WARING AND ANDREW J. DUNAR
APRIL 9, 1993
MSFC**

1. Waring . . . through the history office.

2. Lee Yes, that's another thing that's made it a little upset because it was supposed to be written as a history, and that kind of stuff just doesn't fit. Maybe in some general part of the foreword or separate in it's own reflections and all that.

3. Waring Well, a lot of people like yourself who have had long careers with NASA should be encouraged to write memoirs, but you're right, for a project history it should be more traditional.

4. Lee As far as the competency of the individual and the gathering of the facts, Doug Lord really did a good job. I was happy when he was commissioned to do that because I didn't think there was anyone who had been in NASA who could have done a better and thorough job on that task. There's no question about the facts that he had. He did a good job of researching that. That's a long time ago, and I may not remember all that stuff myself.

5. Dunar To start, if I could just ask how you became involved in Spacelab?

6. Lee How detailed do you want that? If we don't finish by the time that we have to finish here, I'd be happy to do it again. If I start wandering, and it's not relevant, just tell me. In 1972 I was the Assistant to the Deputy Director of the Center. That was Bill Lucas at the time. I was his technical assistant. I got that job because I was the previous Deputy Director's Assistant. That was Eberhard Rees. When Eberhard Rees became the Director of the Center, Lucas became the Deputy, and Lucas asked me to stay on. Shortly after, Dr. Rees was replaced by Rocco Petrone who I had worked with at the Cape for a lot of years and knew well. Rocco impressed on me the need to get out of the staff kind of position. I'd been in it for two deputies. When I took that job it was with the understanding I would be there for two or three years, learn the system, and then I'd go back into the Center. The changing of Deputies caused me to stay a little longer than I had anticipated. It was Rocco's idea that I should get back in the Center, and he discussed that with me. At the time, there were two particular projects that were being in definition, in the Phase A and Phase B, that were under consideration. One called the Tug, which was an upper stage that didn't pan out. It was further behind, it was less well-defined and

left less assured than Spacelab, and Spacelab was the other. At that time, we called it the Sortie Can.

The intent of the Sortie Can project was, by that time we had gone pretty much into well-defining the Shuttle system - the requirements for it including the air force requirements and its configuration and what its basic capabilities were going to be. The thing that was missing to help support the program and for utilization was the ability to have a manned capability or laboratory environment on orbit other than what was in the cockpit. In other words, we had this big payload bay out there. We had the habitability for it with the astronauts crew. They ate and slept and shaved and drove the airplane in the cockpit, but there wasn't really any volume for doing real science. It was suggested either by here or by Headquarters, I suspect by here, that we need to put something, I think it may have been suggested by George Low at the time, that we needed to put some pressurized container in that big bay out there where the astronauts could have a laboratory environment. It was not intended at that time to be anything elaborate. That's the reason it was called a Can. It had the minimum capabilities. It was to be obviously pressurized and have the same environment they could have in the cabin, but it was really simple, maybe a rack of something and there was no big substance. Just to be able to extend the cabin for all practical purposes for scientific use.

We were given that assignment here at Marshall for I think the principle reason because it did not, was not at that time considered to be an integral part of the Shuttle, of the orbiter. So it shouldn't have effected the design development issues of the orbiter which the Johnson Space Center had, and it was a separate payload so it could be considered a payload that could fly like other payloads. The primary reason I believe was because it was in fact a pressurized structure. Our history in the propulsion development around propellant tanks, caused us to have an expertise here that is recognized within the agency because of how to design, develop, and qualify and have the in-house expertise to insure that a pressurized structure in orbit was sound. In other words we had that technical capability. I think that's the reason that we got it. That was a real drive for us to have a structure to go in the bay. It could be pressurized. It could be man-rated and be on orbit. We had had some experience at that in the manned part of the system with the Skylab. We were in the process at that time of managing the Skylab so we were in the manned systems. We were in the pressurized structures. So we got the assignment here.

The way we performed that definition is we used the relatively newly-created Program Development organization. That was 1969 when we established that. That approach to defining new programs was to go through what we called at that time phased project planning, phase A, phase B, and

phase C. Phase A was the concept that we usually did in-house. Phase B, depending on the money available and the contractors' interest and what have you, we could either contract that out or we could do it in-house. The Phase C/D, the development phase, we would go into full scale development. Here's a case where because of availability of our people, I think you've seen what happened in 1970 we were actually going through reductions, we got the assignment through the Phase A the Sortie Can and the Phase B in-house. That's where I come in.

We had established at that time what we called a Task Team which was not unusual for every new program after 1969 that we wanted a definition of. We went through the space project finding and we established a task team and put it in our program development organization. In other words we take people out of different organization and make up a task team. We had a lot of freedom with these task teams because we didn't have to conform to the usual civil service grade structure. It was a temporary ad hoc thing, and if you had to have all GS-15s, that was acceptable. Very good flexibility in being able to bring the right people together quickly and focus on a particular effort. This particular effort was the Phase B for the Sortie Can. They needed a project manager for it. Actually they had a manager at the time. He was given a special assignment to look into some safety aspects of the Skylab before we flew the Skylab. So, Rocco asked me to take over and become the manager then.

What we did then was perform the Phase B definition which pretty well goes into detail and design, but we did it in-house. I had a small staff of people in PD, and then I drew on the whole of the engineering capability of the Center to put down the details of the design. In that same time period, we were pretty far along on the completion of that Phase B, so that we could either try to build it in-house or go to contracting out.

If you remember back in 1969, then President Nixon had Agnew put together a Space Task Group. There were three of four things that they came out with. One was that we needed to develop a reusable system which turned out to be the Shuttle. One of the three of the four was that we needed to internationalize space. That was kind of in the flavor of this. At the time that we were doing the Spacelab, it was always considered to be an in-house U.S. development. There was, and I wasn't involved in this but they tell me that there had been some agreements, I don't know if they wrote them down or not, but there had been some agreements, I think this is in Doug's book, between NASA and I think then ELDO, which later became ESA, that the Europeans would participate in this Shuttle program and internationalizing it by developing this little Tug, this upper stage. Something happened in the process, and I wasn't involved in it, that because of the National security aspect of the Shuttle, and they were really heavily involved in establishing the requirements of the Shuttle and the need

for any upper stage for whatever purposes, it was decided that the U.S. had to renege on that agreement or they never were able to follow through with it. So at this time period, here was a case where we were backing out or were not able to, those may be too strong of words, but for whatever reason we were looking for a program to do jointly.

In 1972, there was a meeting at Wood's Hole where Dr. Fletcher presented to the user community and I think there were probable some internationals there, this Sortie Can concept and invited the users to recognize this capability and help us put together a set of specifications and requirements. I'm going back a little bit now. Maybe I should tell you the first part, and then I'll tell you how we got into where we are. This particular program, Spacelab or Sortie Can at the time, became a viable candidate for us to work with the Europeans. We asked them, I'm not sure about these dates, but it was in either early '73 or late '72, we made the offer to this ELDO which later became ESA, an option of would they like to cooperate, participate in this. They began to study the possibility. What we gave them was what we had determined what we had determined as requirements from this Wood's Hole session. We gave them what we believed were going to be the interface capabilities available from the Shuttle, and things like that - environmental control, so much power, so much heat rejection, so much volume or data capabilities. We then offered them our entire effort, what all we had done in the

detailed design, if they chose to do this. In other words, the deal would be that they would pay for the development of it, and we'd provide them with all the data that we had generated thus far.

Then we began our deliberations with them, not necessarily to influence them, but to be able to give them all the information they needed to make a decision. It took them a very short time. I think it was either in early '73 when we started that exercise and by the fall of '73 they had done enough in-house study with two consortia, I've forgotten who made all those up. MVB was in charge of the Germans and Erno and the Brammen headed the others. They had comparable aerospace industries in all the different countries that made this. They actually went through their what I would consider a mini-phase A and a pseudo phase B to understand what they'd be signing up to. They had some understanding of the cost, the resources. The ministers and the countries had to understand kind of where the geographical distribution of these funds would be and what they got out of it. In a very short time, they went through this and then decided that it was good deal to sign up to. We then signed a memorandum understanding, I believe that was also signed in 1973. If you don't have copies of that I can give them to you. We never changed that. From that day even to day. That MOU was reasonably straight-forward and simple. It was specific enough we understood, and we never had an opportunity to try and change the MOU. That's kind

of how we got into the thing. They did in fact, when they accepted to do the job, we turned over all the detailed designs that we had done as part of the task team.

My role then became a little bit different. We weren't doing in-house design any more. We were more focused on what we considered a program function. Marshall was identified as the lead center for working with now ESA, the European Space Agency, on completing this project. We established counterparts. The Istek facility in North Bank, Holland was their Development Center. Their project manager, my counterpart was located there. They established an organization somewhat comparable to what we would, and then we began to define the detail requirements. Those things that we jointly had to approve - requirements, documents, plans, and so forth. From that point on we established for all practical purposes, we identified the kind of requirements that we would have imposed on ourselves to be able to be able to build a manned system.

The thing that the Europeans had not done, we had a lot of joint cooperative projects in the science area, they, ESA, had never been involved in a manned program. Their ESA organization, they're comparable to NASA, they were missing those types of requirements and specifications and [169?] types of things that we kind of took for granted in the manned program. We had twenty years from the Mercury to the Gemini to the Apollo. So we had that established within our agency, and we understood the language and what it took to

develop manned systems. Also, our aerospace industry understood it to. Those things were kind of common. In other words, we had a [174?] and a base line set of understanding of what it takes to develop a manned system. The Europeans didn't have that. That's where they required some help. We had a couple of opportunities and fortunately we chose the right way. One, we could have given them all of our specifications and said, "Here are the NASA specs. You impose these on your contractor." Or, we could give them our specifications and say, "These are the kind of the things we require. You then take what you need out of that. Maybe you want to add some things, take some things away, but these are our set of requirements and in certain areas, we're going to judge the adequacy of what's developed on the basis of this in the areas of redundancy, qualification limits, standard things that we were going to use as test cases to be able to determine whether what we were going to fly was acceptable." They pay for the development. They adhered to our requirements. We had a lot of discussion about this when it came to the money and our interpretation of what was right, what was acceptable, or what wasn't. Never had any disputes. We were always able to solve them either between the Centers or no further than Headquarters for sure. It never got outside the state department or started appearing having dispute clauses and that sort of thing.

The requirements were pretty simple. They had to meet the basic requirements that we would have imposed on ourselves for a safe system, and they had to meet the established user requirements. Those use requirements were developed jointly between us and them. They had a usury community over there that could look at the capabilities of the Spacelab, and they determined what their requirements were going to be. We did the same thing here. It was just an independent group of people who represented about seven different disciplines in science and what those requirements would be. We were always bound by a couple of things.

7. Waring Was the science group people from Marshall's Space Science Lab or where they academic scientists?

8. Lee That group was headed, and he's in the book, and I've forgotten his name. He'd not with the Agency now. On our side, it was headed by an individual out of the science group at headquarters. He had on his little working group representatives at the disciplines recognized, that represented all the disciplines on that group. We did that for two reasons. One, for them to, first up, it gave them what we thought the Spacelab was going to be capable of. They way we did that was we started what the orbiter could do for us. The orbiter bay was only a certain size so you had to remember how big a module you could put it. The orbiter had so much power available to us so you had to be

limited to that much power and comparable heat rejection. We used the orbiter system for data management and communication downlink so we're limited to how many bits that we could use. Those things were pretty straightforward, pretty simple interface.

We then took that, we had done this and ESA did, we took those capabilities from the orbiter and designed a Spacelab that required certain house keeping kind of, for instance so much of the power had to be used for house keeping. So much of the heat rejection had to be used for the house keeping. So much of the computing capabilities had to be used just be sure that the subsystems on the Spacelab itself could be monitored, activated, and controlled. That then left so much power, so much volume, so much heat rejection, so much data capability, so much computing capability strictly available to the user. That's what we advertised. We put together a thing called a Payload Designer's Handbook. I believe it said this is what the Spacelab will do.

This science working group had two functions. One, is to put together a joint payload between us and the Europeans that would use those capabilities on the first flight. The other was to be able to keep track on how the Spacelab was doing relative to meeting generic kind of scientific problems. In other words, if we all of a sudden one day we were going to provide say 3KW of power and because the Spacelab guy who would be me in this case decided we really

wanted a bigger subsystem and do more non-science stuff, we're going to take two of those KW away and that would only leave the science guys one KW. This group had to make an assessment of that and get an opportunity to complain about it. There was a check and balance to make sure that what we were establishing as a vehicle or a capability was in fact going to stay that way. We had to make some adjustments. We didn't come out exactly like we had first specified, but through the understanding, we had to give a rationale for why we'd do these things and it was generally agreed. The reason for that was not as much for the science guy's benefit, but you had to back up and see what the quid pro quo of this whole Spacelab business was. One was for sure if they put up that much money they needed to get something for it. They got two things. They got the benefit of twenty years of experience and knowledge to help them get into the manned space business and the other was that we agreed to buy a Spacelab. A Spacelab was made up of a lot of pieces, but if you ask for a Spacelab you're going to get a pressurized module. You're going to get so many palates. We agreed to buy one under two conditions. These were really straight forward and simple too, and it worked for us for ten years. It had to meet the specifications and requirements. This went back to the user. If we'd had a Spacelab that had no user capability it would not have met it, so we were driven by being considerate of the user requirements on the outset. So we agreed to buy one if it

met the requirements, met the specifications. That's for safety as well as utility. The other is it had to be at a reasonable price. What we got for it, was we got the Spacelab, the first operational Spacelab given to us. In other words, once it was designed, developed, and completed and shipped here, NASA took over ownership of it. Then when we bought the second one, we took over ownership of that one. That was kind of a simple way of saying who got what. We got a lot of hardware for a minimum investment. They got into the manned space business which allows them now to be much more independent in their Space Station work today and they got some revenue for their own investment needs. It worked out really good.

9. Dunar There was some disillusionment on their part wasn't there in terms of an expectation at least that there would be more than . . . ?

10. Lee Well they did and I don't know whether they expected more from the U.S. I think they expected more from other countries. I believe that, you could probably interview them to get to the straighter story, but I think that at one time, I'm talking about my counterpart. He believed that once you got this developed, you would be able to market it. For instance the Japanese might buy a Spacelab or the Russians. People outside the ESA community might, but that never did happen. The thing that helped

break down I think what the original intent was is when we started this, we believed that the Europeans would continue to establish science requirements. In other words we did it for the first one. We got over 50 experiments on that one. What we thought would happen would be that they would continue on the science program that would develop the experiments for the continuation of flying the Spacelab. That never happened that well. We have D1 and D2 missions, but that's one or two missions every other year. That became pretty obvious to us reasonably early in the development of the Spacelab program, before we even got it finished because we could see their budget for the future and where they were going to focus their money and it wasn't in the science side of the experiments to be able to fly on Spacelab. It was obvious pretty soon to us. That was one disappointment on our part because we saw more utility of Spacelab and the benefits of science for both sides. They've always been reasonably cooperative. Cooperative programs I'm sure we shared even in the missions just sold as theirs. They shared that data too. From the science standpoint we thought we'd get more than that.

11. Dunar One of the things that has interested us in terms of this relationship with ESA is that it's an unusual relationship. In a sense it is a partnership and in a sense NASA was a contract manager. Can you comment on that?

12. Lee That was a sensitive area. In fact one of the first things we had to get new people or even our original organization adjust to was that they made it very clear that ESA was not a contractor of NASA. We honored that. It was difficult sometimes because I found myself being the judge on the imposition of certain requirements. The way we established the program if you look at all the key documentation, anything that was really significant in that respect, it was not a NASA document imposed on them to adhere to. It was a document that we signed up to together. If you look at all the requirements, all the program plans, we would develop some. We decided early which ones we would develop, which ones they would develop, and then we jointly approved them. In that respect, it may have had NASA requirements in there, but it was something that we, and I didn't have the prerogative of changing those without their approval. We never imposed things I don't think unreasonable. We realize that. We clearly did not, and this had over some objection of the people in NASA. A lot of people wanted to give them our specifications and say, "That's the way you've got to do it, and you don't have any interpretation of that." I didn't chose to do that. We found that would have been a contractor to government relationship. I think we worked that out reasonably well.

Some of the people in ESA today figure that NASA got a better deal than they did. The people that I worked with at the time and even today, they are in a much better position

because we went through this. We got a better deal in some respects because we based the procurement of our second Spacelab on the dollar evaluation. Fortunately about the time we were about to buy that, the value went in the right direction for us against all their currencies plus the interest rates were in our favor. So we got a lot more I think at the time we actually bought the hardware than we thought we did, but that's the way we set the program up. We used a measure where we took all the currencies and established a base, a norm for it, and then if the value of the dollar went up, then we got more for our money. It could have gone the other direction by the way. What that allowed us to do is we bought more hardware for the money. They ended up with the money. We just got more for our money than we originally planned. I don't know how we could do a program differently like that. It could have been recognized as a failure from the outset because of what you are saying. They were putting up their money and here big NASA was going to try to control them. It had the right people and the right interest and areas where we really needed to control, they recognized we needed to control too.

13. Dunar Were you ever constrained in working with your counterpart, did you ever have any feeling that you had to wait for him to work out the agreements between the different nations participating in ESA? It would seem that they would be terribly complicated.

14. Lee We probably could have done the program a lot faster if it had not been for things like that. The separation, the communication made it more difficult. I suspect that we waited on them more than they waited on us because our Congress, we weren't spending that much money so we didn't have all the hang-ups with the Congressional budgets today. Their's was more of a parliamentary process so quite often we would have to wait for a year. Ministers don't meet, and you don't call them together to deal with it. ESA did a good job of scheduling and so that you weren't waiting necessarily on Parliament. We had some other things that helped us along this way. Had the orbiter been completed and ready to fly when it was originally planned, there would have been a lot of publicity I guess about the Spacelab not being ready to fly. We kind of slipped together. That worked out pretty good.

15. Dunar In the late 70s, there was budget pressure both in the U.S. and in Europe. To what extent did that influence . . . ?

16. Lee We didn't relax our requirements. We didn't change the basic MOUs. We didn't change the contracts. Because of what it was doing, from an international cooperation standpoint, that actually worked in our favor. It was very difficult for Congress to not support the Spacelab program

because it was an internationally ongoing thing. It was working good, and we really weren't asking for that much money. The big spenders at the time was the Shuttle as you know. Because of the slips on both sides, we were able to distribute our funds to cover costs in the long run. We were able to distribute those. Any one year funding didn't stand out that much. We did it kind of under the banner of the Shuttle program so it was a separate line item, but we had some place to go to be within the Shuttle program to make these adjustments. I had more trouble, from a budget standpoint, with NASA than I did with Congress. We had an Associate Administrator John Yardley who really believed that we were supposed to get all this for free. In fact in my first meeting with his Administrator and Deputy Administrator, Dr. Fletcher and Low, when we told them what our requirements were in the form of manpower and dollars to get prepared for operating this thing, they really had not considered that. I think they believed that everything was going to be funded and all of a sudden the Spacelab would show up. After we went through the presentation, I think they understood that. In fact Dr. Fletcher was quite involved in the program. He didn't spend an excessive amount of time, but for the size of the program, he put a lot of time and effort in it. So did John Yardley.

17. Dunar I'd like to pick up on a couple of things you mentioned earlier. One of them, you were talking about the

in-house development. I'm wondering why the decision was made to develop Spacelab in-house in light of the fact that there was an awful lot of pressure at that time in the Shuttle development to put it out to contractors?

18. Lee You mean in the Phase B part of it?

19. Dunar Yes.

20. Lee If you look at our manpower during that time, we were coming down. It was a matter of dollars again. It was actually cheaper for us to use the manpower, in house manpower and our technical capability, than to contract it out. It was a matter of dollars, and in our case, we had the manpower available. If we had of contracted it out we would have two different problems. One, we would have to maybe have continued some additional RIFs or lay off some people or attrition increased which is not a desirable thing. The other thing would be that we would have to come up with new money. It was done there because it was the simplest way to do it.

21. Dunar I can see from Marshall's perspective why you'd want to do it in-house, but I'm wondering if there was pressure from headquarters. Did headquarters agree . . . ?

22. Lee I believe that's the way we were told to do it. We may have suggested that, but I think the direction came for us to do this or do that.

23. Dunar Also, you mentioned about the flexibility that you gained from using task teams especially about the civil service requirements. This is when all the RIFs were going on and there was a lot of pressure because of those early requirements. Did the task team concept expand in NASA because of those civil service restrictions or because . . . ?

24. Lee I don't think it played into it. If you remember when we established the Program Development as an organization in 1969, the main reason for the Program Development at that time was to be able to act as the entrepreneurs and the innovators and the definitions of new things for business purposes. We didn't have such an organization after the Apollo, and we found ourselves a little bit short sighted. The Skylab which followed Apollo was kind of a back of the envelope thing. It was a quick and dirty arraignment. It didn't go through the kind of definition you would require today. George Miller, Associate Administrator, was faced with a relatively large aerospace population that had been developed and oriented toward manned flight systems. We had the in-house capabilities along the same way, and we didn't have a

program after that. All of a sudden there's Apollo, and then nothing from a manned standpoint. Recognizing that in the 1960s, Von Braun and the Center management decided we don't need to get in that situation here. We need some separate group of people that are looking to the future, that are understanding where the requirements are going to be and getting ourselves prepared so we go through and finish one program we can have the foresight at least and the planning to go into another program. Not just to keep us alive but to be able to not loose, go through these dips of letting off everybody one day and then when you finally figure you can do something else, you bring it back. He felt that was the shortest way to be able to get to where we wanted to go in space exploration. He saw that if we didn't do something like this in the future, we would go to Apollo and then we would have to downsize and quit for a while. In fact, after Apollo, we went for some time without a manned space program. That's not good for an agency. For sure if you want to explore space, get outside lower orbit, and go to the moon and Mars, you've got to develop an infrastructure to plan to do that. That was what the PD was for.

I don't guess we invented phase budget planning, but the way we chose to do it was to put a small effort into a very conceptual things, you know the real way out thinkers. A lot of those are going to fall out because they are too far out. Then the next phase would be that those that look

more practical and fit the Agency's near-term and far-time goals, then you go into a more detailed design. Again, comparing it to where we want to go in the future, you understand the costs, the schedule, and also how it fits into the science side, and then you go into the phase C/D. That just happens to be the way that we did it so we didn't have to build up a large PD organization of 300 or 400 people just sat there doing those things. We had a base of about 150 which had been about the same since we started. Then on these task teams, we would bring in other people to audit them. Sometimes as many as with MPD for short periods of time, maybe 300 people. Then you have an opportunity to do a couple of things. One, if the phase B doesn't go, all of a sudden the agency decides they need to disperse the guys back and nobody's lost anything. If they do go, you've got the base for program organization. You don't have to keep all those people, but you can at least have, you try and identify people who can in fact make a phase into a program office. You don't lose anything that way. They've already established their contacts with the science and engineering directors, with headquarters, with procurement, and that then becomes the new physical program office. We chose to do it that way. I don't think it was in any way to justify

25. Dunar It was just a side benefit.

26. Waring Do other NASA Centers have anything similar to the task team approach?

27. Lee I don't know of any other Center that has an organization like this. I was surprised a little bit because it has worked very good for us, and other Centers have recognized that. Other Centers have an office like this, but they don't have it as organized to go through this process on a routine basis like we do. Every Center has their long-range planner, but they do it more, not on a continual basis but as they see the need.

28. Dunar The task team concept then came out of Program Development?

29. Lee That's the first time I've seen it.

30. Dunar Later there were task teams used at the Agency level weren't there? Was that because of what had begun at Marshall?

31. Lee They may have been task teams, but

32. Dunar Maybe that name was used, but it didn't mean exactly the same.

33. Lee When the Agency decided to focus on certain programs, not just the ones at Marshall, but say all of a sudden the Agency wants to look at Space Station. Today, the redesign group up at Crystal City is in fact the task team. They're doing exactly the same thing we do here as a task team. They bring the right people together from all places, and they've had the objective to narrow it down. I guess we didn't invent the word task team. We used it in our phase project planning. I don't know if we can claim that we invented that. In fact, I don't think we can claim to have invented the phase project planning concept. That's the first I've ever seen it when we did it here, but I suspect if you'd look at other agencies they probably had something similar. They may not call it phased project planning. I know that today almost everybody goes through some phases of definition of concept before you go into full scale development.

34. Dunar The phase program development predated Marshall's concept of program development though didn't it?

L; We really formalized it in program development. We've had other groups like that too. Advanced projects and advanced planning groups who did some parts of this sort of thing. We never organized if focused at the center level like PD is. It has served us well. We've made some

adjustments in the organization, but we haven't found a better way to do it yet.

35. Waring Were there early versions of these task teams? Was a lesson learned from using a matrix sort of organization under the Saturn program?

36. Lee That's a good point. I haven't thought of it that way. It really only works under a matrix organization. It works best under a matrix organization because you're drawing from, to do the early definition you're drawing from across the center, and you establish that kind of program infrastructure because that's the way we operate when we went to a full scale program. I haven't thought of it that way, but that fits. There's no change in the management philosophy from a task team, as far as dealing with the Center, when you go from a task team into a full program. That may have been thought of when they

37. Waring It may have been just a natural response since that's the way other projects were done, just carrying that over into a planning version.

38. Lee Before this, we were transitioning from a one program Center. We then started focusing more on the matrix. We had to learn how to use the matrix organization. They went together really. Even the Skylab, you could

almost say at that time that was a one program Center too - one program where we spent most of our time and effort. It did two things for you. One, it got you in the business of recognizing future requirements and planning for it which in essence does diversify you. Diversification then builds on a matrix organization. They kind of work together. If we were only dealing with one program today, our PD would be a lot different. It would probably only be a very small group and they'd only deal with one single program at a time. Even today, they look across the board at science and other interests.

39. Dunar What were the major technical challenges with things to develop in Spacelab?

40. Lee From a technical standpoint, the most challenging technical thing to me was the subsystem that stayed in the Spacelab and that was the instrument pointing system. That was new and different and proposed requirements that we hadn't done before especially in flying on the Shuttle. It became part of the Spacelab program late. It was an add on as part of the program. The environmental control system was reasonably straight forward. There were a few little innovations there but nothing really to the state of the art. The designing of the pressure structure was not that significant. We understood how to do that. We weren't too weight limited. The data and communication systems was

pretty straight forward. We did [turn tape over 622] I would say that the instrument pointing system had the most new [623?] system. It had the most new stuff in it, and so it was probably the most difficult out of all the projects.

41. Dunar In working some of these through with ESA and the Europeans, just from looking at some of the documents, there seemed to be a good deal of sensitivity on ESA's part for on-site management for example. Having people there that were watching over their shoulder.

42. Lee You mean the NASA people?

43. Dunar Yes.

44. Lee That's right. We didn't have a lot there. We had a resident office. We later put a person in [628?] office where they developed the IBS. Then because of the assembly and the final product integration at ERNO, we had an office there. That was a little bit to comply with part of the joint agreements we had had before of our involvement in reviewing the qualification acceptance data and that sort of thing. I'm sure they impressed on me about large resident people. We had a lot of people there on travel, but we had a relatively small staff. I don't remember having a problem with them there. I had a problem with NASA a little bit because NASA headquarters wanted to impose, we had to leave

and they wanted somebody out of headquarters to be the representative over there. I felt that they ought to be out of the Centers, but we worked that out.

45. Dunar That theme is something we've noticed too especially in this particular period. There seemed to be an effort immediately post-Apollo for headquarters to assert more authority over the Centers.

46. Lee That happens, and it's a natural enough thing by now in conservage of time, but initially, when we first number of program, our headquarters is very sensitive to how people other than the headquarters international affairs or the program people deal with the internationals. Maybe that is the result of some experience where agreements or commitments were made, and later they had an effect on their world program. Initially, their headquarters assumes the lead in the initial negotiations, the dealings and the agreements. I thought they were a little bit too independent initially. Once we got the agreements and things settled then the running of the program which was originally straightforward. We had level 1. requirements. We had requirements to obviously keep our bosses in headquarters informed, but we didn't have to go up there for approval unless we violated those. It all settled out. I found the same thing when we started the Space Station program. In fact a lot of the Centers who had been used to

dealing with the same people in Europe on Spacelab all of a sudden had to get these directives from headquarters you're not supposed to talk to these guys. That kind of offends you. I had gone through it on Spacelab, and I understand that. As the program gets defined and more cooperation comes out between the working level people. It seemed like it lasted longer than it really did. Once we got into the program we didn't have that many [660?].

47. Dunar Were you pretty independent then from headquarters in terms of when the program was running?

48. Lee Yes. The major documents of implementation, if you look back today, they're approved by myself and Hanks Stubert who was the Project Manager at the time. It was a level 1. set of requirements which were pretty high up that were controlled between the Program Director in Headquarters and the ESA Program Director who was located in Paris. We kind of looked at them as Paris was their Headquarters and Washington was ours and the two field centers then implemented the program. That's only kind of a front-end parochialism and possessiveness that gets you into thinking that you're going to be always having to go through headquarters to get something done. That's leveled out.

49. Dunar Another area of some conflict I guess was with JSC. One issue I know that came up was the question of

interfacing with experimenters. JSC argued that they ought to have controls since they were managing the system and Marshall

50. Lee It took us a while to establish the responsibilities. Clearly Marshall had the lead and were the representatives of NASA. However, you've got to recognize that the Spacelab is not good for anything unless it goes into the orbiter, and the orbiter was their responsibility. So we had, in some cases, we had tri-agreements between myself and the project manager at JSC on interfaces because we can't change those interfaces without the orbiter's agreement. Once we establish it, they can't change it without our agreement. Actually we had more than three signatures on that. It was established that way. The difficult part was nailing down what that interface really consisted of. You have to recognize what came out of this rather naturally. We were developing the orbiter at the same time we're developing Spacelab. The Europeans were saying, "I've got to nail this down because I've got to get on with building the Spacelab to meet you guys one day." The orbiter guys are saying "Hell, I'm in the middle of this development. I can't tell you exactly what that's going to be." We had a lot of discussion about that, and finally it was recognized that instead of always letting the orbiter drive the interface, at some point we've got to establish that this is what the interface is going to be and let it

drive it some of the orbiters if necessary. If you can't do it then we'll come back and change it. Once we got that established, it worked good. We did have a disagreement with JSC on some of the testing concept. They have a thing called a SAIL down there. It's an Avionics Integration Laboratory that looks, it doesn't look like the Shuttle, but the functions look like the functions of the Shuttle.

51. Waring What did you call this?

52. Lee SAIL.

53. Waring Is that an anachronism?

54. Lee It's a Shuttle Avionics Integration Laboratory, SAIL. What they imposed as a requirement on us early was when we finished the Spacelab, because of the complexity of this interface, and there's a lot of wires together, we were going to have to bring the Spacelab from Europe to JSC to put it in that SAIL to do a functional check of it because they're so interrelated. Then take it to the Cape and launch it. We said we're not going to do that. What we did, and it kind of drove our GSE by the way. What we did is we designed our ground support equipment for the Spacelab, to check out that interface, to look exactly like the orbiter. We already had those functions done within our own GSE. You could have took it out any time. When we got

to the Cape, we went one step further and imulated the computer interface systems in the Shuttle. We actually imulated them down at the Cape before we took it down to the orbiter. Never had any problem at all. That argument didn't last long. but it wasn't really practical. It was a good thing for the people who run the SAIL to play with, but it just didn't work. On the experiment side of it, we cleared the way pretty fast. Everybody was cooperative I think once you recognized the practicality of it. They have this thing called a carrier which is no good unless it goes in the orbiter so it's got to fit. You've got to have those responsibilities established. The Spacelab, once it's sitting in the orbiter with all the subsystems running, doesn't do any good unless there're some experiments in it. The way we designed it is that interface between the user and the experimenter to the Spacelab is completely independent of anything other than the Spacelab itself. We established that reasonably soon. JSC would be responsible and assure that they assured what Spacelab was doing in the orbiter from a safety standpoint. We would then assure that what these experiment guys were doing were not going to affect the Spacelab which affected safety. That's kind of the level of responsibility. Today, we're using the same set of requirements. The safety specifications that they use when assuring the Shuttle is going to be safe for whatever is in the bay, we used to insure that the experiments in the Spacelab is going to be safe. That

argument didn't go on long, and that's the way we operate today. We did establish initially that the science operation of the experiments in the Spacelab would be done down at JSC initially. They gave us a room down there, but it would be manned by Marshall Space Flight Center. That's the way we did it initially. They finally needed the room for other things and that's how we just moved the Field Operation Control Center up here. Today, it's a very clean interface. Houston has responsibility for the Shuttle and its safe operation including the interface or whatever's in the bay totally. We have responsibility for all the science that comes out of the Spacelab, and it comes direct. We run the science operations. Today, all the science that's in Spacelab is being run from here. We're connected with JSC to insure that any kind of problem that comes up, we work it as a system. Those interfaces fell out pretty fast.

55. Waring Was JSC jealous of losing? They didn't define this as an operation's responsibility.

56. Lee Some of the individuals did. Early in the game, Chris Kraft, he was the Director at that time, established, and once he established this it stuck even though some other people didn't like it, is just because it was in the orbiter, just because it was on orbit, didn't mean it had to be operated out of JSC. He made a I think a good set of requirements there that allowed the orbiter not to get

itself to integral with the experiments and payloads that you had to run it from down there. The orbiter is a transportation system. You've got to do a lot of things from a science standpoint, but you ought to be able to put stuff in that bay, take it up on orbit, and have it be operated by someplace else. That concept helped us immensely with the Europeans because they have their own payload operations control center in Europe and they did not want to have to come to JSC to operate their things. We had some experience at this, and I think it was one of the reasons that it was driven so. In the Skylab, we did it that way. We operated all the experiments. That was very time consuming. There's a lot of people to have to move to Houston. It really ties up the operation, and it's changing. In other words, you've got your operations people down there, it would have to be a lot more people that have to be knowledgeable and experiments in a new set of experiments on every flight. That's a little bit too much imposition on anyone. He recognized immediately. He established to let the science guy, he ought to be able to do his own thing. He doesn't need NASA people to be in the middle of that. That was kind of the concept with Shuttle and it worked as well.

57. Dunar You've mentioned some of these already. What do you see as the principal advantages that Marshall derived from working on Spacelab? You mentioned for example moving

into operations, broadening space sciences, and diversification.

58. Lee From Marshall's standpoint, we control the hardware. We've got hardware. We've got capability that not only allows us to fly a lot of other people's experiments, but we develop experiments too. It makes it easier when you have a carrier with that responsibility and also have a science development responsibility. Things like the microgravity experiments that we developed. If you didn't have a Spacelab, we would have trouble with that. We wouldn't have a place to do it. If you limit it to what some of the, the flight deck is very limited. Just from a science standpoint which we're interest in, it turns out to be a good deal. It's no better for us than other science disciplines in the Agency, but principally it is. I would say whether it's an advantage or not, we have gotten more involved in operations with the science stuff which that can be an advantage or disadvantage. I think principally, it's more for the Agency than just for Marshall, but if they're going to stick Marshall in there it would be because of our own experiments.

59. Dunar How were experiments selected for Spacelab?

60. Lee The first one was done jointly. There was a little user group here and a user group in Europe did their thing,

but they also got together. The two science working groups decided on which experiment to fly on Spacelab, and they decided on the basis of science and the return. If you had one instrument that was a big power hog, and didn't do much for science, it didn't get a high priority. It was a balancing of the program so that the Europeans got about the same amount of power, weight, and volume that the U.S. did. It was pretty well done, but when you look back at it. I think there were over 50 experiments, and they covered a lot of disciplines. That was the way they were selected. Today, it's based on what requirements, user requirements are there. Let's take the mission we've got going now, the [786?] mission. They use some of the same experiments every flight, but you're doing it over a ten year period, so it's kind of well-established. The space sciences laboratory missions, we launched one of those and are going to be another probably on the 3rd. There will be some of the same experiments going on there, but some adjustments. It just to accumulate life sciences type of data. The U.S. microgravity lab, the one we flew last year, there'll be another with upgraded and new experiments. Developments kind of pick disciplines, and as the funding is available, the requirements are more than we've got money for, so the funding is available to develop the experiments. Then we integrate them into these missions. You don't fly an astrophysics mission with a microgravity mission because microgravity usually is man tended and requires a

pressurized module. Astrophysics requires the palate. You've got to kind of group them into different things. The [798?] mission we're flying now, the only manned involvement can be done with the flight deck. That's part of the job of our people here is to take those experiments and all the requirements to try to maximize the use of the experiments of each time and the science return by the way we package them. There are a lot more experiments than we've got flights to fly them on right now. Now we're just trying to get them up or not.

61. Dunar What are the implications of the way in which the Spacelab program developed for the origins of cooperations with Europeans on Space Station?

62. Lee I think it's one of the best benefits they got out of Spacelab. By the fact that they were establishing their border plates and their requirements for manned systems. They have that now within their agency. Their aerospace industry has that. It put them in the position that we had a different kind of relationship with them on Space Station. We're not at all the same. They're now more equal partners in it. We're just starting the Space Station. Like with Spacelab, you might have called them equal partners but it would not have been that way. We would have been in much more control of interfaces and their hardware to insure that just from the safety standpoint alone because they put up

the money. I think it made them more independent and more prepared to be equal partners, and I think that's one thing that people who have complained maybe about, these Europeans who have complained about not getting their fare share out of Spacelab I think today in recognizing where they are they ought to say that it was considerable. It was a reasonable investment back in those days. They gained a lot from our experiences. They didn't have to go and reinvent the wheel.

63. Dunar In your experience in working on Spacelab, what was the biggest problem that you had to overcome?

64. Lee Technical problem or problem in general?

65. Dunar Either.

66. Lee They come from two different categories. My first biggest problem was getting our own agency to recognize that there was going to have to be an investment on the part of NASA. That was a shocker of them not recognizing that we were not going to get all of this for free. That was where I started - in the hole digging out from that. The next was I'd say the geographical distance causes. We could have done it a lot faster if they had been in the next state. That caused you some concern. The language thing didn't come to me. They adhered to the English real well there.

67. Dunar Were there cultural differences? Just different ways of doing things?

68. Lee Yes. We had some advice on how to deal with that from some friends of mine who had worked with Europeans. We worked more with the Germans because they had more of a lead in it and our counterpart was German. It was very important to them with the way you establish your relationship with them. It's on a confidence level. They seem to cooperate better if they have respect for you and competence than if you write it down and if you sign something. Once you've established that and recognizing that then we would change people here, bring in new people, then I would take them, if they were senior people replacing others, I would make a point of it I would take the new guy and introduce him. Take him over there, and introduce him first to my counterpart in their senior management and then I would give them the opportunity to always say the first time, "I'm not sure if he's going to work out." Then I'd say, "Well I understand, but let's give it a little time here." Every case where they had said that, I know there was two cases where I had to replace a deputy, and I had the same reaction. Once they got involved with them and got their confidence built up, everything was great. For example, one of them that I brought on as a deputy the first time I went through the same exercises and they said "I'm not sure he's going to work." As it turned out, we actually sent him to

Europe for a year during the critical part of the program. There were some problems between ESA and their prime contractor. They were having communication problems. They couldn't seem to get with it. My deputy who was over there for that year, they actually asked him to be an mediator for the two groups. They scouted a hotel in [865?] and got both sides on the table and my NASA guy. It went from "We're not sure if he's going to work out" to that kind of confidence. I'm trying to think, when you leave I'm sure I'll be able to think of more problems.

69. Dunar Was technology transfer a problem?

70. Lee No, we overcame that pretty fast. It could have been a problem because of the way you interpret what technology transfer is. I was having a problem with that initially because we were stamping things for criteria, and we didn't get an understanding when we had to go through the state department and what meets technology. I asked George Low who was the Deputy Administrator at that time, I told him it was giving us a little bit of a problem. What we needed was a relatively simple definition so that everybody could adder to it. He gave me one, and we adhered to it and never had any problems. That is, if they need something, because we're in this together, and we're going to use that hardware and we're going to buy one one day, if they need something, some technology to insure the success of that

program then give it to them. That means that even if you know, I said, I gave him the example, I said, "I know they want this and they're working on the Spacelab program, but they're also going to use it on a launcher system." He said, "I understand that," but that's something you have to live with. Just accept the fact that the primary reason is to make sure this is good. I use that definition throughout. I never had any problem at all. Legally, I might have gotten in trouble. The state department may have had something to do with it, but I thought that was a good straightforward definition. That's the way we did it. There were some things that were asked for that didn't fit that mode so we didn't give them to them. Never had any complaints about the ones we turned down.

71. Waring You were talking in the beginning of the project that as manager you were faced with sort of two ways of working. One would be treating them more as a contractor and laying out specific requirements. The other was more of a partnership and giving them latitude. Was there a debate within NASA or Marshall about the merits of those two?

72. Lee There was some debate within the working levels here because some of our guys felt it would have been the easy way out to just say these are the requirements. We know they work. These are the specifications. I know how to follow those. I know how to make an assessment of these

whether they're meeting them or not. It makes it easier on me to let's just given them to them. That for me didn't fit part of the intent of what we were intended to do. As far as getting them into position to be in the manned space program. It could have worked I guess but it would not necessarily have been practical and sometimes economical for their aerospace industry to try and take our specs like that. They may not fit them. We developed them kind of together here. I thought that was an imposition on them that we didn't have to do. Plus, I really didn't want to sell myself by doing that and ending up with having a much larger civil service work force on this side to be able to do that kind of monitoring. I'd rather, it comes down to what we use today, didn't use the words at that time, of giving a person a performance specification. This is what I want to come out of it as opposed to a detailed specification. I saw it better to let them have the flexibility of working against performance specification which is what we should be grading against instead of me having to have to follow along with all the detailed specs. We saw in some areas, I can't think of what they are right now, that they didn't apply. Now, I'm faced with another administrative detail of having to go through and waive all these stacks of specifications. I believe that we would use our good judgment on those specs when it came down to assessing what was really required, whether it was right or not. I thought we could look at their plan and the results

of those plans to get a set of general specifications included that it was acceptable in our [922?]. It worked out that way. Now, part of our problems we had kind of late in the game because we did it this way was that we weren't in the position to impose certain detailed things like qualification requirements. One of our ways of making flight ready assessments is we go through and determine if everything has been qualified to a certain level. We found that when we defended them in general, we told them what the kind of thing that we were going to be looking for. When we went from ESA to the prime contractor and then to the subcontractors, the suppliers, it lost something in that. We found pretty late in the game that all the formal records had not been kept to the point where you could trace down to the piece part had in fact been qualified to our specifications. We had to put a concerted effort in it and we worked with them in developing data and the data that was available and made our own judgement that is was in fact qualified. It wasn't a real problem. It took some extra effort on our part. Another area that we interjected ourselves out of necessity was when we do programs, we lay out what the requirements are in quite a bit of detail, whatever level of detail you need. Then you have what you have a verification matrix. We say, "We're going to verify that requirement this way." Then we have another senior that says it was in face verified that way. They didn't have that systematically laid out where it was

understandable. Here's a case where we did some additional people to our load of work with them to lay out that set of requirements, how each thing is going to be verified and then from that you kind of effect your acceptance testing to insure that whatever got missed some place atn the component level, you could at least pick it up in the substance. For me, that was a normal way of doing normal business stuff. We had a lot of work in being able to get the interfaces squared away, but that's the front end kind of thing. I can't say that the working relationship was bad. It took us longer because of the geographical location. From the technical standpoint, the IPS's were difficult. The fact that we got the hardware for a reasonable cost, I can't complain about not getting our money's worth there. They were always responsive when there was design problem that had to be fixed. I don't really pick out any one thing where we advanced the state of the art that had no set business of using. It took us a lot of time. We put a lot of effort into it, but I don't any one thing made such a big difference.

73. Dunar There probably is sort of a general perception that NASA got a better deal.

74. Lee I think we got a good deal.

75. Dunar Has that affected at all the way in which the relationships have developed on Space Stations? Are they a little wary?

76. Lee No, I believe that's over with. They got a different kind of problems on Space Station with the restructuring and where they fit. They've got money problems too. I don't gear any relationship back to Spacelab. It's all been positive. In fact, one of the individuals we worked with called me the other day from ESA, and he worked on Space Station today. He was getting irritated I guess and disgruntled about the inability for us to get interfaces established. He remembered how we did, establishing control, with Shuttle. He actually took the interface document to the program manager I understand and put on his desk and said "That's the way you ought to do it." So, it's been positive more than negative. When you leave I can probably think of a lot of things. I worried a lot in the program a lot of different times. Their arrangement over there was their geographical distribution between the countries was if you exceed 20% of the budget that's been allowed by the ministers, then that country has the option of getting out. There were some times that we knew that they were going to exceeding the 20% and were not sure, this is back to the waiting thing, we didn't actually wait, but the waiting period concerned us. We knew that we were working towards a continuation with the possibility of

getting to the ministerial conference that that country would back out. Those kind of things bothered me until we got the engineering model finished. Once we got the engineering model finished, I knew we could complete it. The reason it bothered me was I didn't know, we had two options. One, the other countries pick it up or they don't. Then we've got a Spacelab that we put a lot of time and effort into and don't have a [999?]. I didn't know how that would work out because the agreement was that there wouldn't be any change of funds other than procurement at that time. So there was no way that I could help them. We found some ways to barter to help them and help ourselves too. That kind of thing was kind of a continual concern that we had gotten ourselves depending on the delivery of the Spacelab for NASA's use and here we had to totally depend on somebody else.

77. Dunar The barter arraignment that you mentioned, was that strictly a way to get out of that problem or were there other reasons for bartering?

78. Lee It was a way to help them and get some stuff for us too. We recognized that we were going to have to develop certain component test equipment say in this country for the long term. They gave me the test equipment, and I gave them components. There was a lot of commonalty in the system. The environmental control system components and the same

with the orbiter. I was able to give them flight components to go into Spacelab that they didn't have to go out to pay for, and they then gave me the test equipment. So there was not exchange of money. If we'd have done it strictly by the book, they would have to increase, there cost would have gone up to buy these things. My cost would have gone up to develop something we'd already developed. It was that kind of bargaining. That might not be legal either, but we did it.

79. Waring Was there hardware that applied directly to Spacelab or were there lessons learned from Skylab that applied to Spacelab?

80. Lee I don't know if there was any direct hardware. There were some lessons learned in things like fan noise and how it interfered with work. We learned this after we got onto Skylab. There were lessons learned about how you not let the water lines freeze up and that sort of thing.

81. Waring Was Spacelab designed for repair?

82. Lee No.

83. Waring Because the missions would be short.

84. Lee Yes, because of the shortness of missions. If you're going to bring it back in seven days. If it's going to take you three days to fix something, the cost of being able to make that just didn't seem practical. We took out the repair stuff, however, the scientist from Vanderbilt, Taylor Wang, who's in microgravity, he had a problem with his experiment on orbit. He pulled that thing out and took it apart. It looked like an explosion in a heat kit factory, but he repaired it and got it working. It was his own experiment, and he was familiar with it and didn't take a lot of special tools. Spacelab itself was not made to be repaired in orbit. That is a different thing for Station. We've got to be able to repair that.

85. Dunar Do you have any other questions or do you think we're just about at the end of our time?

86. Waring I think we're at the end of our time.

87. Lee Well, I'd be happy to, if I can help with anything else let me know.

88. Dunar Thank you.

89. Lee Is that the kind of stuff you wanted by the way?

90. Dunar Yes absolutely. It is very helpful. This summer we'd like to get with you again if possible.

91. Lee Very good.

92. Dunar Thank you very much.

93. Lee Good luck.