

#5

INTERVIEW WITH BILL LUCAS
INTERVIEWED BY ANDREW DUNAR AND STEPHEN WARING
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UAH

Dunar 1: We've talked to you earlier about diversification in the post-Apollo period, but we didn't talk specifically about payloads and about Marshall's movement into payloads. We talked in broad terms I think about moving into areas of space science and so forth. I wonder if you could talk to us in a little bit more detail about how Marshall's interest in payloads developed and how that specialty came about for Marshall?

Lucas 2: I guess one way of putting it would be market survey or market response. Dr. Von Braun asked me to organize what later became Program Development which was the new business wing of the Marshall Space Flight Center. He jokingly called me his Vice President for New Business or Sales or something like that. We were coming down to the end of the Apollo program and hadn't given a lot of thought to what would be done next. At that time we thought the that Saturn program, Saturn V and Saturn IB, would continue to be launch vehicles for some time. Marshall's expertise was in the propulsion systems principle at that time. Although it was not entirely new for us to get into payloads, but we recognized that there would not be enough new launch vehicle programs to occupy the talents of the Center. We began searching and looking in the field. what is

there that needs to be done that we at Marshall can do.?

What do we have the talents? What do our talents match? I mentioned we'd been into payloads even before we became a part of NASA. The Explorer I, I assume that you've already written about that. Explorer I was built in conjunction with the Jet Propulsion Laboratory as a payload, a very important first payload. We'd done some other payloads in the early 60s, and then of course the Lunar Roving Vehicle is a pretty important payload that we developed in the late '60s. We began doing the studies, and we considered the talents that we had within the Center which were largely engineering talents. We did have a science component that was small but significant, and they had had an interest in payloads. We thought that utilizing the science component of the center that we had supported by a very substantial background would make a very good combination to work with the science community and universities to do payloads. Now, additionally we did not compete for small payloads. We thought that our expertise would lend itself to large systems. Saturn V had been a large system so we looked across the field for those things that would be in the category of large systems. At that time in the early '70s we were thinking about telescopes and the Space Telescope what was called at that time as the Large Space Telescope certainly qualified as a large system. That's why we went after that particular one. The High Energy Astronomy Observatory was another that we did in the decade of the

'70s, and that was again a large system. The payloads that we got into were for the most part large systems that would match the very substantial engineering talent that we had. That's kind of the philosophy that's led us to what we've gotten into.

Dunar 3: When it came down to the competition for some of these payloads, I'm thinking now in terms that things that come onto the scene in about 1970, '71, '72 in that time frame, about things like the Space Tug, HEAO, and Spacelab in particular. During that time, it seems just from looking at some of the documents that there was a combination of a lot of activity from the Program Development in this direction, and it appears some support from George Miller in particular at Headquarters earlier to try and to direct some of this business to Marshall. Is that an accurate reading of what went on?

Lucas 4: That's probably an accurate reading. George Miller had a high regard for the engineering talent of Marshall Space Flight Center. He could see as well as we had the limitations on the horizon as far as developing new propulsion systems. The Program Development Directorate worked with George Miller very closely producing what came to be known as the Miller plan. I think I mentioned that to you on a previous discussion. Most of the work for that was done at the Marshall Space Flight Center by Program

Development, and it was issued as that plan. Of course the science programs didn't come through George Miller for the most part. They came through the Offices of the Space Flight Science and Applications at that time. The Space Tug would have come through George Miller's wing of the organization at Headquarters. The Space Tug was a thing that was right down the line for Marshall Space Flight Center. It would be a propulsion system, and it would also be a payload that had to interface with the Shuttle system. One of the reasons that we got into Spacelab I guess was that the European Space Agency became interested in participating with the Program along about that time. They very much wanted to do the Tug and there was not way that was going to happen, not from NASA's standpoint but from the military's standpoint. That Tug was to serve both NASA's interest and the military's payload interests. The military certainly would not have been willing to have a foreign entity that they had no control over to be in the loop as far as their payloads were concerned. That's why I have said sometime that Spacelab was sort of a consolation prize. The Europeans very much wanted I think to get into the propulsion system with the Tug. When that didn't come about, they got into Spacelab. Here again, that was a natural for Marshall also. We had I believe that capital study will show that this was a pretty sensible and reasonable evolution for Marshall because of the things we'd done before. We'd done the Skylab. Skylab was a George

Miller program. I remember that sketch, you may have seen it, where he put on the chalkboard one time down there showing the thing tethered very loosely together and not hard-docked as it turned out to have been. Spacelab was this thing that Marshall was well prepared to fumble on because of its experience in Skylab. That was something that demanded the talents of Marshall in that systems responsibility out of Skylab, but it also involved welding in particular, making a large pressure type system low in weight and high in strength. Marshall had that expertise, and we did make some contribution to the technology in Europe of building that Spacelab which turned out to be one of the tightest space structures that had been built at that time. We had a natural background of getting into that kind of thing.

Dunar 5: Let me ask you a little more about the relationship with the Europeans at this point in development. Did you conceive of the relationship with ESA as it developed as a manager-contractor relationship or as a partnership or how did that relationship really

Lucas 6: It was very much, by necessity, a partnership relationship. Europeans were very sensitive about that. They were supplying most of the money so you couldn't think of it as a contractor. That was pretty much of a demand on management and the leadership of the program on the one hand

act like we had a contractor but not let them know that. In other words, we had to give them a lot of guidance, but we had to do it in a capital discrete way rather than like you would work with a contractor here. If you didn't like what they were doing you'd say "Hey don't do it like that, do it like this." Well, we couldn't work that way with the Europeans. It was a partnership basis, and therefore pledged ahead of demand upon the relationships. Not only were we dealing with a different culture, but we were dealing with ten different cultures. All of them different from ours and quite different from each other although they're cultured together than to us. They didn't do things the same way.

Dunar 7: From the documents it appears that there at times when individuals from NASA, not just from Marshall, [?108] who were working as liaison officials with ESA who at times were sort of kept at arms link and did not get involved in day to day work by certain agreements. Did that become a problem or was that unusual?

Lucas 8: I think that was somewhat unusual. There were instances like that, but I don't think they were sufficient in number or consequence to attribute a lot of thought to. They're a different culture. If we had someone who was a bull in a china closet that would have moved in he probably wouldn't have worked with some of the American contractors

either. I try to look at it from our perspective too. Assuming the shoe was on the other foot. They had some fine engineers and fine craftsman and they had not had experience specifically in what we were about, but they're a proud people and you had to take that into account in dealing with them.

Dunar 9: Were there other cultural differences that required adjustments on either side.?

Lucas 10: What do you mean other cultures?

Dunar 11: Well you said that there were adjustments ^{that} might have been made because of these cultural differences. Were there other examples of that sort of thing where ESA operated differently from NASA for example? Where either party had to make some adjustments in order to work together?

Lucas 12: I think that pervaded the whole thing. I don't know that I could cite this moment without thinking quite a while specific examples of how that would be. Their approach was probably a little different than ours. One of the things ~~that~~ was probably not so much cultural as it was the contract itself. There were ten different elements of ESA, and they participated in the program to the extent of their overall program. For example, the country A would do,

let's say they would put in X amount of dollars and it turned out that they could do this Y piece of hardware to sort of match their dollars. Let's assume that they weren't performing very well on it. You couldn't just cancel it out without giving them something. You couldn't just say, "Hey, you're just not delivering so therefore we'll cancel that and give that to Country B over here." No way. "You could give it to Country D, but you've got to give us something that's matching what we already had." That made a challenge I would say, for them and for us.

Dunar 13: That sort of decision also it seems places NASA whether it wanted to be or not in the position of being a manager rather than a partner do you think?

Lucas 14: It placed NASA wanting to be a manager, but we still had to be a partner. We still just couldn't say flat out, for the reasons I just mentioned, "Hey they're not delivering over here, and this is holding up the program. We're going to be late. Get rid of it." We couldn't say that. We had to persuade them that this was not delivering and wouldn't make, work through they system and see what they could do about it. It's just a much less direct than the contract relationship.

Dunar 15: In the late '70s, both ESA and NASA were victimized by budget constraints that forced some

reevaluation [?150]. How did you work together with them in order to resolve some of this budget area problems?

Lucas 16: They were help[ful] in many cases in our budget considerations because frequently the Director General would appear before Congress in defense of our budget. That was helpful in that regard. I don't know that we ever, well they didn't have a central government, they had ten different governments. We, as far as I know, don't recall having done that. We did try to work through their entire system to impress upon them the importance of having the resources when we needed them.

Dunar 17: Do you find it more effective to work with the countries that were represented in ESA directly or with the companies that they were contracting with or work through the Director of ESA, and then have him tell the delegates?

Lucas 18: We had, you do both of those things just like you do in this country. There are certain considerations that require top management, policy type of matters, and then there are others that are day to day operations within a prescribed framework. We did have to work with the director general on certain policy matters, but ~~one~~ ^{ONCE} those policy issues had been decided, you worked directly with the country and the contractors involved. For example, our people were sometimes stationed directly in the plants in

those countries doing the work. You were there by their good grace. You couldn't just assume that you were taking over. When we had a project office at a place, there was a project office for ESA there also. Whereas you didn't expect the project managers that had to become involved in every little thing that went along. If there's any disagreement they would have.

Dunar 19: There are some indication in the documents again about barter arrangements or follow on production for the support. It wasn't clear from what we could find whether these were successful or how this all worked. Did that materialize? I know to deal with some of the problems of actual production of a number of units for example?

Lucas 20: Well yes, I'm sure it did. ESA, I don't know whether ~~that~~ ^{they} were that [181?] but they at least believed and wanted to believe and they sort of counted early on that there would be a lot more of these units than were. They were going to finance the first one or so and then after that they undoubtedly had the visions of delivering several additional units at a fee. That never materialized. It really wasn't a reasonable assumption in the first place. It was probably reasonable to have assumed that there were more than there were but not as many as they projected.

Dunar 21: It was never a contractual thing?

Lucas 22: Never a contractual thing to my knowledge.

Dunar 23: Did this work together with ESA on Spacelab contribute to the relationship that fell between, I'm not sure it did, let me rephrase it. How did this relationship contribute to the cooperation on Space Station?

Lucas 24: I think it was a natural follow on. It was clear that ESA could build the Spacelab eventually without us probably, but they didn't have anyway to fly it. Certainly if that were true of the Spacelab it would be true of the space station. Space station was too much, is too much still for one country, even our own I think, to finance at this time. In essentially we had established the possibility of working together with them on Spacelab which turned out, the product was excellent. Since that had been established and I think in the process of doing that project, there developed a mutual respect that led to their agreement to go ahead with the Space Station in that fashion.

Dunar 25: To shift gears and moving away from ESA. When Spacelab became operational, how were experiments selected for Spacelab?

Lucas 26: There were certain agreements even before we flew the first one. You mean between Europe and the United States?

Dunar 27: I was thinking more within the United States between getting involved with government agencies and universities and types.

Lucas 28: Well we had some Spacelab payload working groups who adjudicated between the various experiments. There were a lot of things that went into it. The kinds of experiments that were going to fly had to be judged worthy by the science and payload community. In other words, you couldn't just kick off some obviously good science and put on some little pet project you had.

Dunar 29: That was done then at Marshall?

Lucas 30: Yes. It usually met there. They could meet other places, but it was worked out of Marshall, the payload working group. They would select experiments that were worthy or establish priorities for these to fly. Then there had to be some compatibilities done. For example, what experiments can you do on the same payload? Would you generate some electromagnetic radiation from one that would interfere with another you know? The compatibility of the experiments had to be judged and the utility requirements,

the amount of power you required and whether you needed to be looking at the sun, or looking somewhere else, or looking in space. That became quite an art in itself in determining the compatibility of a payload mixture. You first had to make the gate of having a worthy experiment that scientific peers would judge to be worthy. Then from an engineering standpoint, you had to determine whether in fact it could fly on this particular one.

Dunar 31: How did the interface between payload mission plan and shuttle operation management work in the relationship between Marshall and Johnson?

Lucas 32: I'm not sure you mean how to work it. It had to be.

Dunar 33: How was it coordinated?

Lucas 34: Of course the Johnson people participated in the payload working groups as well, but after a decision was pretty much made on what was going to fly in Spacelab for example, there was an interface working group between the Spacelab and the Space Shuttle itself and that interface working group had to determine what was compatible. [break to answer the phone]

Dunar 35: We were talking about coordination between Huntsville and Houston.

Lucas 36: Yes.

Dunar 37: Let me ask you questions in a couple of other areas too. There were questions early in the development of Spacelab where it appeared that Marshall might be, at least from Houston's perspective that Marshall was stepping into areas of their concern such as working with astronauts for example. Was there a controversy over that or did they accept that?

Lucas 38: I don't know that I would characterize that as a controversy. I think that concern was expressed at least as some levels. They were concerned about that. There was some concern expressed initially about Marshall controlling what went on in Spacelab itself, the mission control so to speak. There was some concern expressed about that. During the first few, I don't recall how many now, but the first one or so Spacelabs, the mission control from Spacelab was down in Houston. The Marshall people went down there in space provided in the mission control center by Houston and controlled the Spacelab from that point. That is controlled what was going on there, gave directions to the astronauts of doing that. There was some concern initially about that. Here's Marshall doing this and this is "our job." But now

you see that that's entirely out of that. The control center is up here in Huntsville. There's also concern about the Europeans wanting to control their payload from Europe. There's some concern about that. It's one of those things that steeped partly in "let's don't change our birthright here or anything, let's go ahead and do it like we've always done." I don't look upon it as a big issue. It's one of those things that would be almost predictable. You get over them and you look back and wonder why that was that ever a problem at all.

Dunar 40: There was also, I know Dr. Rees was concerned early on as Marshall was developing this expertise in payloads that Houston would try and to take a piece of that work. It's been that Marshall would have to always be wary of this. Could you elaborate on that or I'm wondering if the documents are an accurate reflection of what his concern was.

Lucas 41: Well if he signed the document I'm sure it was an accurate reflection of what he thought. I don't think he would sign otherwise. I guess that would be a natural thing to worry about. When you are competing for a new assignment that might in any respect be considered someone else's, there's always some concern. I'm sure the concern might have been that if we say that we have say a 100 people that can work on this particular mission, in a sense we expose a

100 people. Someone else says "Hey that's our mission in the first place. Give us those 100 people, and we'll do it." That was probably the context in which he wrote that.

Dunar 42: So there was more concern over more people rather than assignments? It boiled down to a personnel issue? This was a time of course when there were RIFs and so forth.

Lucas 43: It would be a people issue. That was if you remember, well you probably read, you young fellows don't remember that, from 1968 through 1978, the whole agency was going down for that matter. Marshall was going down more than anybody else. Rees retired in 1973 so it must have been in the heyday and the height of that kind of thing. When the agency, for example, was given a target, this is how much you have to reduce, then the agency has to decide how it's going to do that. So you go around and "Look at here, I have this many people here and they're doing this job. Now how many people does it take to do that job." There was always a concern, some risk associate with saying that you could do another job because you had to identify the numbers of people you could use for that job. If you had those people available, it might imply that you didn't need them so if a RIF comes along, they go. Just like we said. Now, we'll say you've got enough History professors to teach X numbers of courses, and you say I want to add three more courses and so the administration might say "Can

you handle that?" You'd say "Yes" and the administration might say "Well in that case, we'll cut off one professor cause we're not going to add those." That's the rational that was used with it.

Dunar 44: Another concern that he had, there was a question, again this was in competition in terms of who would handle the contacts with the customer in terms of Houston saying that they had control of the orbiter that they should handle this and Marshall saying that since they had control of Spacelab that their interface was more direct. Can we call that the case?

Lucas 45: Yes.

Dunar 46: Could you . . . ?

Lucas 47: Well there's not much more to it than what you said. Houston at that time seemed to want to control every interface with the Shuttle. The question is whether you have as we say communication to the Shuttle, to the Spacelab, or whether we just have a bent wire so to speak that runs through there. Ultimately it came out to be the logical thing that is if Marshall's going to control the Spacelab, they need to control the people directly and then meet the interface with the Shuttle. You don't need to speak to someone in Houston to speak to your customer in the

payload. You speak directly to him and because you've got an interface to control, you can not get more power than there is provided there or you can't get more of this, that, or the other thing. If you happen to say I have to say I have to have an orientation of the Shuttle where my payload points to the sun, well that has to be worked out before you start. If someone else wants to look at something else, the Earth for example, you can't look at them at the same time. It probably appears more weird to you than it does to me that you'd have that kind of thing, but it was primarily a matter of turf, protecting turf, that people have brought up. Here again, a lot of that generated below the decision making level.

Dunar 48: At working level then because they had to actually had to exercise these responsibilities?

Lucas 49: I think a lot of it, I wouldn't say that none of it was at the top level. There was undoubtedly some, but I don't think it was ever that pronounced at the top level because when it came down to the decision making about an issue, people armed with the same kind of data could say the same logic. The logic I think is as I just said that as long as the Spacelab meets the established interface with the Shuttle, the why should the people responsible for Spacelab go through Shuttle management to get to Spacelab?

That's the way it turned out to be. I like to think logic prevailed.

Dunar 50: In 1976, NASA took steps to initiate backup Spacelab studies in light of what was called, and this is from a memo from Yardley, "current concerns with respect to Spacelab schedules and alternate performance capabilities." What were the concerns about performance and schedules here? Do you recall? I'm wondering was it just concern about ultimately the possibility that there's a question about whether ESA would be able to deliver on time?

Lucas 51: To deliver on time. They had some problems, and we sent more people over there ultimately than we planned to. There was some concern about whether they were going to be able to deliver or not.

Dunar 52: Was this related so Shuttle schedules at all or was this strictly on delivery schedules for Spacelab from ESA?

Lucas 53: Spacelab delivery schedules of Spacelab from ESA but that was to fit into the Shuttle manifest.

Dunar 54: Shuttle schedules are going to be the question now. Did that later become a question because the number of

flights that were anticipated for Spacelab were much larger than what really materialized.

Lucas 55: That's right.

Dunar 56: Was that related to Spacelab at all or was it more related just to where the Shuttle ended up?

Lucas 57: The numbers of Spacelab flights?

Dunar 58: Right.

Lucas 59: The numbers of Spacelab flights were based on projected payloads and also Shuttle schedules. Those things are usually base upon bigger eyes than one should have. If you polled the scientific community you'll find that they have enough payload ideas that they could fly for ever, but if you ask who's going to pay for it, that's another matter. Establishing the manifest early on, not a great deal of attention was given to who's going to finance those payloads, but the question was do these payloads actually exist? Is there enough good science out there to be done that would warrant a certain number of flights and if so how many? That's the kind of thing that would provoke the numbers of Spacelabs that were programmed or manifested. There's also an element of cost of shuttle per flight. You make a certain investment in Shuttle and you want to

advertise it over a certain number of flights so the more flights you had the lower cost of operation appeared to be. That probably had something to do with it. Let me put it this way. There was not pressure in the early days to limit the numbers of flights. That came about in the cold reality of dollars, budget. When you're developing a system to do a job, you don't go out and say "Hey, you don't want to fly do you?" You go out and find out how many payloads there are that the scientific would declare worth of it and then worry about paying for them later on.

Dunar 60: There was some tension that developed in the late '70s I guess was largely a matter of these additional units for ESA. Did that in any way color the early development of Space Station or were those issues pretty much divorced?

Lucas 61: What issues are you referring to?

Dunar 62: There was some resentment on the part of ESA that they were not able to have what they had understood to be their right to have more Spacelabs developed. As a result there was some tension between ESA and NASA over that issue. This was about the same time of the early Space Station studies. Did those issues color one another at all?

Lucas 63: They probably did some. I'm talking off my memory here, and you people have looked at a lot of

documentation since I have. What I recall is that ESA, just as we said a few moments ago, anticipated being able to deliver a lot more of these Spacelabs for pay, for revenue generators. We didn't need that many, therefore we didn't buy them. Naturally that disappointed them I suppose. It might have colored some of their thinking as participating in the space station. It undoubtedly color some eyes somewhat because you don't want to get someone in the loop that you can't expect to deliver. That should be said in the response to your earlier question about why we wanted backup. If you commit yourself to a way of doing things and then you become totally dependent on it, then if somebody doesn't deliver that you don't control, you're in deep trouble. So what if we had committed all the country here Spacelab flights and we had a Shuttle ready to fly them but no Spacelab. Then you're in trouble. That's always hazardous part of dealing with an entity that you don't control. They could quit any time they wanted to. We could deplore it. We could elevate it pretty high in the governments of the countries, but you still might not have it. That's a tricky business in this program, and that's why you don't like to get someone in the loop that you can't control, over whom you have no authority.

Dunar 64: It seemed, this is kind of an impression, in the late '70s early '80s after some of these budget crunches came and as it became clear that NASA would not take more

units that the working relationship seemed to be a little better. Maybe ESA was more subject to penetration from NASA? Is that accurate or not?

Lucas 65: I think the relationship did get better along that time, but I don't know that I would attribute it to that. I think the working relationships got better as we had more experience with each other. We learned them. We learned more about them, and they learned more about us. Mutual respects developed. I think that attributed to the better relations as much as anything. In addition to that, you might have considered it had to become more in a sales mode. We needed to sell them. We thought this was in the bag, but it doesn't turn out to be like that so we've got to continue to cultivate them. To sell them would be my assessment of improving relationships.

Dunar 66: I think that's what I wanted to know on Spacelab. Stephen

Waring 67: Well, we'll turn to Hubble. I also think there's some order to the questions but not much so we'll probably wander around.

Lucas 68: There may not be much logic to my answers!

Waring 69: Let's begin at the beginning. Goddard obviously had become one of NASA's major Center's for doing science, space science projects, astronomy sort of projects. Why did Marshall become lead center for the Space Telescope rather than Goddard?

Lucas 70: It was not because of the science particularly but it was because of engineering. Goddard pretty much had its hands full at the time. Marshall had an in-house talent that Goddard didn't have, that is engineering large systems. I believe the principle factor is that Marshall had a large systems engineering capability available that could do this large project. Goddard was not eliminated from the science. Goddard was still responsible for a good amount of the science anyway. It was a I think appropriate recognition of respective capabilities.

Waring 71: My impression from reading some of the documents is that headquarters was initially very divided about whether Marshall or Goddard would be the lead center.

Lucas 72: I think that's a fair assessment.

Waring 73: Do you know why that seems to be the case whereas in other cases it seems more clear cut than it was? Headquarters officials seemed to have debated it pretty . . .

. . .

Lucas 74: The people who were responsible at Headquarters for the Space Shuttle, the Office of Space Science and Applications, but sometimes its the office of Space Science and sometimes the Office of Space Science and Applications, but Goddard was one of their Centers. You see the headquarters had certain program offices in Headquarters. Some of them had Centers that were primarily responsive to them. Like Manned Space Flight had Houston and Marshall and KSC. OSSA had Goddard and JPL. The OAST had the old NACA centers, Lewis, Langley, and Ames. In the first place, Goddard was the Center belonging to the office at Headquarters who was responsible for the Space Telescope program. It's not unusual to think that they would have some prejudice in favor of Goddard. The second thing I think is that some people there see this to be primarily a science project and therefore nobody questioned that Goddard was more heavily committed to science than was Marshall. I think those people who saw it as a science program thought that Goddard should do it. Those people who saw or grasped the significance of the systems engineering involved saw it as a Marshall program. The period at that time, Marshall had more available resources to do the job than Goddard did. That's as good an assessment as I can offer.

Waring 75: That's a good explanation. That clarifies that. A charge that occurred in the '80s as the cost of the Space

Telescope project grew was that Marshall and Goddard had deliberately underbid one another to become lead center. Usually there's very little documentation for this charge. Could you assess whether that's accurate?

Lucas 76: That sounds to me like Headquarters Monday-morning-quarterback. If there was an underbidding, that was not unique to the Space Telescope. It could be applied virtually to every project since the late '60s where we had to bid [?541] dollars. It was not a Center responsibility only because Centers didn't get the programs financed. It was Headquarters, so usually whatever cost that was represented as the going in cost, was a figure that was agreed upon by the respective Center and its Headquarters office. So it's not really being sufficiently faithful to the facts to blame this on one center underbidding the other. Maybe that happened? It may or may not have happened, but that was not the reason for the primary overrunning cost. The reason for the overrun cost was several fold. First of all, we start out with a Large Space Telescope. It's going to have a 3 meter mirror and then after we got down the road a ways, we turned it to a 2.4 meter mirror. It was first going to be launched on a Titan and then it had to be made compatible with launching on the Space Shuttle. The principle reason was that the complexity of the telescope was grossly underestimated. A telescope like this had never been made before and has since not been

made. The people who were going to make the space telescope, or who eventually turned out to be the makers, had the best experience available in the country to do that, but they had never done anything of this size either, or of this complexity. There are a lot of reasons for ov this com probably, but it is too simplistic to blame it on Goddard and Marshall bidding against each other for the program. Because it had been through the same program office up there.

Waring 77: Right. That's a good point you made especially about the Headquarters getting involved in the decisions [?581]. Could you asses the relationship between Goddard and Marshall during the project? An impression that I have gotten is that Goddard tried to use its control over scientific instrument development and the ultimate operations as a way of trying to get more control over the development of the whole Space Telescope system. Do you think that's the case that Goddard was continually trying to expand their role especially using their science element to get more authority?

Lucas 78: I don't know that I would say that's the motivation for it. In fact that is about what happened. When I say I wouldn't use that motivation, Goddard had the responsibility of the sciences. They had as has scientist has certain requirements that have to be met. The

requirements imposed for the science did in fact control the development itself, but I don't know that that's bad. It has to be undoubtedly some working relationships that were not as good as they might have been. It would have been far better management wise to have had the total management in one place and then have subordinate managers. You know you have level 1, level 2, and level 3. It would have been better to have had that management more crisp than it was.

Waring 79: Because as it was Goddard and Marshall were almost on the same level?

Lucas 80: That's right, and Headquarters up above here with their own Program Office didn't have the resources to manage that job. I would say it was a flawed management scheme from the outside.

Waring 81: Was it a headquarters decision that Marshall/Goddard would be [?625].

Lucas 82: Yes.

Waring 83: Do you remember who or can you say who? [626 turn tape over]

Lucas 84: . . . Office of Space Science and Application at the time.

Waring 85: OK.

Lucas 86: You're talking about the science part of it and how this decision was made. I well remember Jim Fletcher was down at the Marshall Space Flight Center at the time he was administrator of NASA. We were eating lunch together, and we were talking about the Space Shuttle. That's when we were competing for it. He said, "Well you know, why should this be Marshall's. Goddard is right there in the middle of John Hopkins and all the other universities around the Washington area. Who does Marshall have?" We said, "Well we have UAH," which at that time didn't have a reputation in astrophysics or astronomy!

Waring 87: Not really equivalent I gather! You mentioned the Program Office at Headquarters. Did Headquarters oversee the Space Telescope the same as in previous projects? Was there less penetration at first than say in other projects that Marshall was involved in?

Lucas 88: There was less. OSSA didn't do it the same way Manned Space Flight did. I used to characterize OSSA as undermanaging and overworrying. They were not set up to penetrate. They penetrated sporadically, but not consistently. They didn't have the resources at that time.

Waring 89: Why was that the case? Because they were used to working with scientists rather than contractors?

Lucas 90: I think so. Scientists and smaller projects.

Waring 91: After '83, they did increase the size of their program office?

Lucas 92: Yes, but I don't think they ever made their Program Offices equivalent to a good strong Program Office in Manned Space Flight.

Waring 93: Did you see this as a difficulty early on or only as the project got considerably underway?

Lucas 94: I'm sure I didn't see the difficulty early on as I see it now or would have during the project. We thought we could work with the system, but in retrospect, if I had seen it I don't know that anything would have made it any different. We really needed the work. Marshall needed the work.

Waring 95: There was considerable lobbying of Congress by the scientific community to get support for Space Telescope. Did Marshall participate in an indirect or indirect way in that lobbying campaign?

Lucas 96: Yes we did. Before we were assigned Space Telescope, one of the elements in our assigning was that we employed a top scientist, a top astronomer in Bob O'Dell who had formally been the director of the [?658] Observatory at the University of Chicago. Bob was in that community and was a close associate of McCall and Spitzer from Princeton and others around the community. Marshall did participate in that fashion.

Waring 97: Primarily through O'Dell?

Lucas 98: Through O'Dell.

Waring 99: Another major decision that was made early on in the project was the decision to go with two associate contractors rather than a prime contractor and a subcontractor. Who made that decision? Was that essentially a Headquarters decision?

Lucas 100: Yes. There's some background associated with that. That was a bad decision of course in retrospect. Even at the time, you could see that. There was some perhaps reason for that. I think maybe it was thought at one time that that would be a lower cost way of doing it. There's also, early on, the Perk and Elmer company had been involved in the Black World, a highly classified project and

it was not easy to penetrate that organization. I think that may have had something to do with it also.

Waring 101: But they didn't think the prime contractor would be allowed . . . ?

Lucas 102: There were extra people running in around there. I'm not sure that I remember all of the ramifications that went into that. If it sounded simple enough at the time, but it wasn't.

Waring 103: Among the initial plans for the Space Telescope, there was one design that called for to be integrated as part of Spacelab. Do you recall that design? Perhaps that was too preliminary? It was never seriously discussed.

Lucas 104: That one escapes me.

Waring 105: It was a very early development. It may have even emerged at Langley for who knows what reason I'm not quite sure.

Lucas 106: I don't know. That doesn't ring any bells.

Waring 107: The Space Telescope was designed for repair in space. It was probably the first major system that was

designed for repair in space. The justification at the time was that this would this be a way to reduce development costs. Looking back, do you think that logic made sense? Do you think that designing the Space Telescope for repair reduced development costs or did it add complications? What's your opinion about that?

Lucas 108: It depends on what slice of time you evaluate. It made it cost more at the time it was launched. The cost would have been greater to design for repair means that the time you launch it costs it more. But if you look at it on out years when you're using it that you could go up there and recover it or correct something on it like we're going to do, then it's a different matter. So it depends upon how you look at it or when you look at it. If the ultimate design goals are reached and that is that you can replace instruments in it, after a period of twelve or fifteen years you decide you want to put an updated instrument in it, if you can go up there and do it, it will look like a very good investment.

Waring 109: There were decisions made very early on to go with a repairable

Lucas 110: Yes. That was from the start. We had done repairs on other things were there was a design for that and we sort of learned that if you're going to do that you'd

better design it that way in the first place. I think that it was the right decision to make. I believe that ultimately before the Space Telescope is over, that it will help, will show [?705].

Waring 111: Was that a design concept that came primarily from Marshall?

Lucas 112: I don't know that I would say that. Marshall was a part of it, but I wouldn't say that that came from Marshall to upgrade it. I just don't know who to attribute that to. There were a lot of people involved in that as in every other aspect of the Space Telescope. Maybe you could look back in the archives and find who it was.

Waring 113: Obviously the scientists were thinking about having replaceable instruments and then there were some black boxes of engineering systems that were also

Lucas 114: Right. Marshall did know from its experience to that day the importance of deciding before you cut the hardware that you're going to do that. We knew that from experience. But who decided who could be called the inventor of a refurbished space telescope in orbit I just don't know. I'd like to take credit for it because I think it's good idea.

Waring 115: Initially, Space Telescope plans called for developing building an engineering model and then a flight model and then a full scale Space Telescope. That method was replaced with a protoflight concept. Obviously a protoflight concept was a response to budget pressures. Was that initiative, again did that primarily come from the Project Office here in Marshall or was this just Headquarters?

Lucas 116: You can bet it didn't come from Marshall because Marshall cut its teeth on programs where you had several pieces of hardware. Like the shuttle program. You had the static tests, and several test articles, and test flights, and so forth. I think we had seven units in the Apollo program, a large of units anyway, before you could declare a flight worthy. It was not thought to have that many, but the cutting back was a response to budget. The "all up" concept so to speak was a response to budget.

Waring 117: Could you talk about how that decision to go protoflight affected Space Telescope development? Were there perhaps some unforeseen ways in which that affected engineering choices?

Lucas 118: Well I don't know that it affected engineering choices. It said that you only had one cut at it. You couldn't test, refurbish, and test again. You had to do all

of your thinking before you cut any hardware and didn't have a chance to do it again, so it affected it. It undoubtedly reduced the cost because it reduced the amount of hardware that you had. Here again, thinking of cost at launch time. Certainly it reduced that cost, but the fact that one didn't have a chance to test and redesign if necessary affected the program certainly.

Waring 119: Could you describe the role of academic scientists in the design and development of the Space Telescope? Do you think there was greater involvement than in some other science programs that Marshall had been involved in? I'm thinking in particular of bringing in Bob O'Dell and all these committees, and I believe you had special consultants to your office?

Lucas 120: Yes. There was greater involvement of scientists in designing the Hubble Space Telescope than anything that the Marshall Space Flight Center had ever participated in. Without any question.

Waring 121: Was this due to the inherent complexity of the project? Was it because Marshall had few astronomers in the space science lab? Would this have been done any way even done if Goddard had developed it?

Lucas 122: I think so. One of the things that I believe, the scientific community I think liked it this way. One of the reasons I attribute that Marshall was able to work with the scientific community is that they didn't see us competitors whereas Goddard viewed us as competitors somewhat. I think in something as important as the Space Telescope is, as all encompassing as it is, one of a kind to serve for years and years and years, under any circumstances you'd involve a lot of the scientific community. It's your customer, your user.

Waring 123: Now I'd like to turn to some questions about some of the management challenges and contractors. Could you assess the performance of both Lockheed, Perk and Elmer, just an overall general assessment about how well they performed on the project?

Lucas 124: Perk and Elmer was a new experience to Marshall. They were probably, from the corporate level, the least responsive contractor we've ever dealt with. Their top management really didn't give a lot of attention, it appeared to us, to this program. They were customized in selling other kinds of things. They did the Black Program and certainly weren't penetrated much in those programs. Then their other business was pretty much a consumer kind of thing, instruments. They turned out a lot of those. When the project got in trouble, normally you can go to the top

management of a corporation and get action. That was not the case at Perk & Elmer. When the project people went, when I went, when the administrator went, they just didn't respond very well. In that sense they were a difficult contractor to deal with. They eventually did a pretty good job we thought until we launched and found out that they had shortcutted some things that they shouldn't have and didn't produce the quality of mirror that it was alleged they produced. Lockheed was a more responsive contractor than was Perk and Elmer, and I think overall did a better job.

Waring 125: They were more accustomed to dealing with these sorts of projects?

Lucas 126: Right.

Waring 127: Why to you think Perk and Elmer was unresponsive? Because this was a challenge that was so new to them and they were slow to react?

Lucas 128: I don't know, which I guess is one of the short answers. The longer answer is that it probably didn't constitute a sufficiently significant part of their total business base. Secondly, they knew that there wasn't this capability as much as anywhere else and who is some little upstart at NASA to be asking us about this kind of thing. We're the experts in optics.

Waring 129: They felt their technical performance was good even if they were moving slowly?

Lucas 130: Yes.

Waring 131: As the OTA part of the Space Telescope was moving slowly in '80, '81, '82, '83, did you feel that Marshall had good penetration of what was going on at Perk and Elmer?

Lucas 132: When you say good, that has to be relative. I never thought that we had enough penetration at Perk and Elmer. As a matter of fact, we were precluded early on from having more than the given number on that. We never had enough penetration that we had in most any other project we ever did. We had as much penetration as we were allowed to have given the resources that we could devote to it, but we did not have penetration consistent with the other projects that we'd done. We were somewhat victimized in this by the thought that "Hey we've got to learn new ways of doing things to lower costs and let the contractor do it. They know how to do this job and let them alone and don't overlay them with a lot of government types that run the cost up." It proves one more there is no low cost way of doing a job half way. This is just a costly business to do a new first time invention,.

Waring 133: In reading the documents in that period between 1980 to 1983, there are some of these same issues that you just mentioned. That is that the very difficult technical challenges of doing a new project like this and then there were the management challenges of running any sort of development project. Had Marshall ever encountered a contractor where Marshall employees essentially had to teach the contractor how to do project management? That seemed to be largely the case. I remember reading a lot memos from Bill Sneed to you in which he went to Perk and Elmer.

Lucas 134: Not to that extent. Marshall has often helped contractors technically and even to some extent from the project management standpoint in the early days particularly when we were all learning together, but I don't recall any case where the deficiencies of project management were equivalent to what we encountered in Perk and Elmer.

Waring 135: I'd like to quote to you. This is about the optical systems failure, the aberration in the mirrors. Were there discussions about the quality of the mirror that raised this issue as a possibility that the testing, was the feeling that the testing being done was rigorous enough to spot a problem like that? Was that always your impression?

Lucas 136: That's always my impression. I never heard anything to the contrary, from my own people or from the scientific community either.

Waring 137: A lot of the information appears have been contained within Perk and Elmer about the problems. This is a quotation from the NASA report on the optical systems failure. I'll just give you the sentence and ask for your comment on it. It says, employing most of the problems on Perk and Elmer obviously, it says, "Contributing to poor communication was an apparent philosophy at Marshall at the time to resolve issues at the lowest possible level and to consider problems that surfaced at reviews to be indications of bad management."

Lucas 138: I think that's an irresponsible statement. Naturally it's good management to solve problems at the lowest level possible. That's just good management. You always try to do that, but to say that problems that surfaced during a review, what it said "considered bad management?"

Waring 139: Yes, to consider problems surface at reviews to be bad management. That is that the lower levels didn't resolve them. They were surfaced at a review at a higher level.

Lucas 140: I'd say that that's an incompetent statement because that's the reason you have reviews. If you didn't expect to do that, why have reviews? That's the whole purpose of the review was to force out if possible oversights or short falls particularly as involved the total system. That's why at the reviews you had everybody involved. You had Marshall, all the other centers involved, Headquarters, the science community, everybody. That's where some problems did surface and get resolved. That's a totally negative statement there that I consider just an incompetent statement. Do you know who made that statement?

Waring 141: This was in the official report that was headed by, I want to say Lou Almen, I think but I don't know. It was probably a committee.

Lucas 142: It was probably a committee that wrote it and you often have put something negative in I suppose. You couldn't exonerate NASA entirely and I don't think NASA should have been exonerated entirely, but to pick on that for the reason for it is the bad thing. Of course this happened after my watch so I didn't ever see that when it came out.

Waring 143: The review came out seven years after the mistakes had been made.

Lucas 144: Right, so I don't know about that, but there are a lot of things you could say about it that probably contributed to this sort of thing. Even if we had spent a lot more money, we still would have been in the position of having to depend upon the experts in the field. Marshall is not the expert in grinding large mirrors, nor is anybody else other than Perk and Elmer and Eastman Kodak.

Waring 145: All the scientists who had a career stake involved, they were participating in the review process?

Lucas 146: Sure, but they weren't experts in grinding mirrors either. They were using mirrors and so it's one of those things that I don't know how it got through the Perk and Elmer system. I haven't read the report. The fact that it did though, the report should have found some reason how it got through.

Waring 147: Right. There were some management problems. The details are complicated as you can imagine, but the people who were actually doing the grinding were not having their work sufficiently checked by other experts. There were quality assurance people who were sort of seeing if they were doing the right procedures, but the quality assurance were not optics experts. They had more general engineering, general management backgrounds. The assumption was a flaw of this kind was impossible and the main device

that was used to test it was part of the instrument that was doing the grinding so the flaw was built into the test apparatus.

Lucas 148: I remember well, the review teams would show these beautiful [912?] patterns which were supposed to indicate the quality of their work. You looked at the results and they looked good. Of course it turns out that at the time the report was written we thought the sky was falling, but now the Space Telescope is doing a fine job. It's made discoveries far beyond what we anticipated.

Waring 149: That's just about my list.

Lucas 150: I think, going back to one of the early questions about building to refurbishment, if we hadn't of done that, it probably wouldn't be possible to do much in propulsion as we do now or compensating for that grinding problem that we had.

Waring 151: I think the idea has been the most unchanged plan since I've been [928] months old, changing the lenses on the next instruments to compensate for the flaw on the mirror. [stop tape 931]