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INTERVIEW WITH STAN REINARTZ
INTERVIEWED BY STEPHEN P. WARING
10 JANUARY 1991
HUNTSVILLE, ALABAMA

1. WARING: Let's start by your explaining to me how you came to Huntsville and what sort of job you first had in the space program.

2. REINARTZ: I came to Huntsville entirely by accident, courtesy of the U.S. Army. I was ROTC student at the University of Cincinnati. Following graduation worked for six months with Armed Coat of Steel and then was called in to perform a two year tour of duty. Spent four months at Aberdeen in the Ordnance Area Training and was then assigned to Redstone Arsenal, ABMA, which I knew nothing about. Or a little about although I had always had an interest in rockets in the early experiments when they were launching the V-2's after World War II. [I] served primarily in the Project Control Office of ABMA, working among one of the people that I worked for that also became involved in later years, Lee James, who was a Lieutenant Colonel, maybe a Colonel. [I] had worked there for about a year and a half and then, at the end of that time was offered an assignment to work with Bob Lindstrom in a very small part of a nucleus of what later became the Saturn Program Office and we were located in one of the laboratories at that time. There were just about four or five of us. And went to work on the Saturn Booster, the S-I stage, which was a cluster booster at that time and we were just in the very early phases of it.

I had been involved with putting the Jupiter C's into storage, working with the Development Top Screw and we had the capability to put up the satellite, but were not permitted to do so until late in 1957, then launched it. I had been involved somewhat with the Explorer Satellite. Then after a period of time in there, we formed the Saturn System Program Office and I was the assistant to the Saturn I manager which was Bob Lindstrom at that point and worked in that area of the Saturn I and later the Saturn IB was added.

We went through the business of the upper stages and the selection of hydrogen and oxygen for upper stages and all that activity. Ended up as the Deputy Manager of that program. Lo and behold, Bob Lindstrom went to work to industry, later to come back in 1969 and Lee James came in five years later and he was the one that said you ought to stay here. I became Lee's Deputy for about a year and a half. Then went off for about a period of nine months to a year and headed up a Saturn IB CENTAUR project office. We were going to put the CENTAUR stage from Lewis on top of a Saturn I-B for high energy applications. Because of the requirements for a planetary mission, after about a nine month period, they determined that it was not a suitable vehicle for that purpose. So we stopped the efforts in the fall of 1965.

3. WARING: Was using the CENTAUR as an upper stage for earth orbital missions?

4. REINARTZ: No, for planetary missions. It was a third stage on top of a Saturn IV vehicle, which was an S-IB stage, S-IVB stage and then the CENTAUR for the third stage. It was high-energy planetary missions, escape velocities and so forth.

5. WARING: One more question. They decided not to go through with that mainly for budgetary reasons.

6. REINARTZ: No, it was primarily as they got a better understanding of the atmospheric conditions, somehow it is just escaping it me right now which particular planet, but based on the atmospheric conditions that they were going to encounter and what residual energy was going to have to be to be able to get a lander on and so forth, we really, for what they wanted to do, the size craft they wanted to send, the energy level we could get and so forth. It really wasn't budgetary, it was a cancelation of further technical understanding of the system that they wanted to do and said, "Hey, what we have isn't quite matched to what we

want to do."

7. WARING: Was it too powerful?

8. REINARTZ: No, it was inadequate basically for what they wanted to do at that time. It didn't have enough energy level. So, this was actually went into about the tail-end of 1965. I moved over there in January of 1965 and we set up a small project office. We were just really getting started in that nine, ten month period and they terminated that portion of the program. Of course, the CENTAUR was an existing stage and the other parts were. But it was the marriage of them together that we had started working on.

About that time was when Apollo Applications, which was the genesis of the post-Apollo activity, which was evolving at that time. So I got involved and we set up an Apollo Applications Office. They had the fellow that was the Deputy, I believe, or Science and Engineering group at that time, they decided to make him wear two hats, which was Dr. Jerry McCall. They put him as head. I was Deputy of the Apollo Applications. We went through the process, then, of evolving a program of which one part of it was going to be a workshop, which per the sake of easy name, was called the "wet workshop" because at that time we really had no program. That really never actually went to Congress in the sense that we went with the Apollo or later went with the Shuttle, or later went with the Space Station. It was more of an evolution and we ended up spending substantial amount in the life of the program, I believe it was about two and a half million dollars, and never from the Congress a "given program." This is the beginning, middle, end type of thing. It started out sort of small in a planning sense, got to be quite large in a planning sense and then collapsed back down to only the Skylab Program. At one time we had as many as thirty-something flights which included circumlunar flights, additional landers on the moon, George Mueller, who was then heading Manned Space Flight, I believe was one of the best individuals ever in that spot. George was a very patient, continuing, ongoing, very bright

but patient individual, who would just keep pushing and working and finding a way to keep things moving forward. He didn't have the background that somebody like Webb, with all the political things, but he found a way to make it work. Of course was a survivor of the Apollo fire, so he was a person that could survive.

9. WARING: Was the idea from the very beginning that you had to find a diplomatic way to get through the funding process, and one way to do that was using old technology?

10. REINARTZ: That was the idea. The problem was that the Apollo Program was set with a very narrow objective in a sense, moon and back safely and so forth. While you are there we will gather some scientific data, which was really secondary, which we did. But that was a secondary...because as your chapter probably said, "Kennedy said, tell me what we can do and be first." The only thing that they could guarantee that would be first would be going to the moon. A space station they could not guarantee we would be going first. Going to the moon and coming back with a man, we said, "We can beat them on that." That was the driver backing that. So we had this very narrow objective. Yet, we then put together all this technology, all this transportation hardware. The question was how best to utilize that and where could we go from there. George Mueller envisioned a program based on that industrial hardware capability and management team and so forth, to do some of the things that all the greatest studies have continually said that we might do. He didn't set up a commission or any great thing. It was done in a small way, but included revisits to the moon, a circa-lunar landing. It included a space station of sorts, which would include earth observation and many of the things that continue to be talked about today as what we would like to do.

So this was in the 1966, 1967 time frame. We decided with this they needed to have an integration contractor that would support Marshall in this activity and would perform certain portions of this job in physically integrating and analytically integrating these

various hardware that were going to fly on top our Saturn I-B's and Saturn V's. We went through a process of selecting a contractor. We actually selected four for a Phase B, a final study phase. I think it was IBM, Lockheed, Martin-Marietta out of Denver, and one other, I believe, the fourth one escapes me.

11. WARING: McDonell-Douglas?

12. REINARTZ: It must have been for...not it wasn't General Dynamics or Grumman, so it must have been McDonell-Douglas. I believe we had four. We kept them on-board for a year. No I am sorry. I am getting into the Source Evaluation Board. I was chairman of the Source Evaluation Board for that. We had four of them that were sort of close together. I went up and made a presentation to Webb and they selected such Lockheed and Martin. So scratch the others. The two that were selected for Phase B were Lockheed out of Marietta (GA) and Martin Marietta. So we went for about a year with them doing some further study, then got a proposal for them to do this rather big program that I think at the time when they bid on it had something like nineteen different missions that they would be the integrater of this hardware. It was a pretty big job. Shortly after awarding the contract for the Phase C-D, or for the implementation phase, the money, this was when the crap started coming in about the middle of 1967, when they started talking about the 1968 budgets and things like that, that the money just wasn't there. In the meantime, we were pursuing the very first thing was this "wet workshop" of which the idea was to take the upper stage, the S-IV stage after it had gotten into orbit, vent down everything and then to carry certain hardware with you up in the Apollo Command Module. Then a module behind you that you could, then, dock and go in and outfit this module in a very crude fashion, almost naive fashion, if you look at now. Very primitive now, that we would go into that stage and make it a habitable quarters.

13. WARING: While you were making plans for the wet workshop, were the plans always from the very beginning, that this would culminate in a dry workshop?

14. REINARTZ: No. So what happened is, sort of two things. As we had these series of flights, I remember things that were going on, and as the money was crunching down, we had talked about having one of the flights that we were going to fly and why you see the name ATM, was called the Apollo Telescope Mount. Well, originally, that was going to fit in one of the six service bays of the service module. It would ride up in that. They would design a new panel for that. The lid would come off, this thing would come out. They would conduct astronomy experiments with just the service module and the command module, just by itself. So that is where Apollo and the Telescope Mount and all that came from. So we had different flights, a workshop flight, etc. Well, as the program condensed down, we had these pieces of ideas.

15. WARING: Wasn't there talk also of using a lunar excursion module?

16. REINARTZ: Yes. Then we started switching over and said, "Well, what would happen if we cut the lunar excursion module, the portion that took off, and in liew of the lander, we attached this Apollo Telescope Mount to it and could somehow and that would be the thing." If you looked at any of our books that shows the beginning of the workshop, of the dry workshop and what became Skylab, was in, I guess this was still, I am not sure I can remember the date, about 1968. There is date on the chart that is reproduced in the book, where George Mueller came down to Marshall one day, one afternoon, and being an old professor that he was, he got up and with a flip-board easel gave his little bit of tutorial and talked about, "well, here looks like something that we can do. We can take these various elements and lets just put them together and hang them off each other." At that time what he showed was a lunar vehicle with the Apollo Telescope Mount tied to it, tethered down,

handing down on a tether. He showed some other devices around. Nobody could figure out what it was, so it got the name of "The Kluge." Nobody could describe it, so it was "the Kluge." In more polite terms it was called the "cluster."

17. WARING: So the cluster idea was with the tether and the LM and all this was somehow connected together?

18. REINARTZ: Right. That was the initial thing. As the picture just, to give you a little history, because you will see the picture as you go through the material. His Deputy at that time was an Air Force General, Davy Jones. Davy was quite a character. My son was more impressed, he was then about 12 or 13, the fact that he had met some astronauts, the fact that Davy Jones was one of the participants on General Doolittle's Tokyo raid. He had just gotten finished reading Thirty Seconds Over Tokyo. So he was more impressed with the fact that I knew somebody that flew over Tokyo, than meeting astronauts at that particular point. Anywhere, Davy was his Deputy, so George sketched out his ideas on this sheet of white paper with a ink pencil and talked, just like a lecture. Dr. von Braun and all his associates around the table, some of the rest of us back in the next row and so forth. This went on until about seven o'clock in the evening. He said, "Okay, those are some ideas and look at that." So we up and one of my friends, Jack Swearington, who had been with me when I set the little project office and was the head of the money, the Project Control Office. We went up to Davy and said, "Well, Davy, if you are going to give us some instruction, lets make it official." So Davy was the one that dated the chart. George had just sketched it up. You will see a date on it, 1905 for the date and signed Davy Jones for JEM. He ripped it off, handed it to us and said, "Here it is. Go do it." That was our headquarters direction for what eventually became the Skylab.

19. WARING: Do you know where the original chart is?

20. REINARTZ: As far as I know, Lee Belew has the original.

21. WARING: In his office, perhaps, or at home?

22. REINARTZ: I am not sure, but he still, at one point we lost it for several years and then rediscovered it. As far as I know he has that. Whether he has donated that to the museum or not. The last I knew, he had it. As a matter of fact, I think that someone framed it up for him when he retired.

23. WARING: It might have been in his office and I just didn't see it.

24. REINARTZ: Yes. Lee's involvement, Lee came over then in about the summer of 1966. We formally set up an Apollo Applications Office in a more and formal and complete sense, for all intents and purposes I had run the smaller group and then Lee came over and moved out of the engine office and we set up that. We gleaned up the nucleus of the people that I had had on the CENTAUR, and we had just moved those people into work those early phases.

25. WARING: When Belew came over, it was more formalized.

26. REINARTZ: It was still a wet workshop, but...

27. WARING: Right. The office still had the same title?

28. REINARTZ: As far as I remember, we kept the same title, it was still Apollo Applications. We did not...then we went along and through the wet workshop and it looked

like the program was less and less. We were saying, "Hey, it looked like Saturn, this was getting into late 1968, and it looked like things really just weren't going to go after the Apollo Program." People were optimistic then assuming that we were successful and launched in 1969 to the moon. This was about the time that we were recovering from the fire. This happened in early 1967, I believe, the Apollo ground fire. On the one hand, people were fairly confident and we had a lot of confidence in those days that it was just a matter of doing it. [We] envisioned that we were not going to end up utilizing all the shuttle Saturn hardware that was in the pipeline. So, the thought came, "Hey, if I were to put this on a Saturn V, then I don't have to worry, I can outfit a workshop completely on the ground and launch it up. Saturn V is so powerful, that I can take everything else I want in terms of supplies and terms of what became the multiple docking adapter, any of those things, I can just stack the whole thing up on front and send the crew up on flights and get it together."

29. WARING: So, by the time there was planning for a dry workshop...

30. REINARTZ: We hadn't launched the first one to the moon yet.

31. WARING: Right, and by that time you were thinking about launching at least a couple of [wet] workshops and then a dry workshop? Is that right?

32. REINARTZ: No. It never was both. It was that we were doing the wet and at that time, that was a portion of a program that included all these other lunar landers, circumlunar and various others. Then as that squeezed down into a smaller program, and the possibility and availability of the Saturn V. There were those who were really concerned, because it was typical like some programs have done, you kept improving it until it was finally cancelled. There were people that were concerned that said, "Hey this is

going to be more money, more uncertainties. Further down the road, we may never get there. Everybody agreed that technically and the results that you could get would be so much better, but there was trepidation that more money, back to Congress, having to continue out and so forth. But because it offered so much it received pretty good support from both the Center and Mueller. So we made a switch over then and I...

33. WARING: I think that was 1969.

34. REINARTZ: Yes, I think it was in early '69. It was shortly thereafter that Bill Snyder had become program manager. We had in Washington in early days, I think that Snyder was about the fourth manager we had in about four years. One died, one of the managers was there just a short time and died. But Bill Snyder came just about the time we were into that. Then that is when they had a contest for naming what it was and it came out that Skylab was selected. It sounds very familiar now, but at that time Skylab, ugh.

So we progressed into the program and once we got into that portion of it, we did pretty well in sticking to what we wanted to accomplish with it. A little after we started, we added in some more earth resources, we didn't have the Earth Resources in initially. Earth Resources were given to JSC. We integrated them in. George had in mind, which we could have done, it is discouraging now that I am working space station, seeing what is happening to it. We had multiple docking adaptor. We could have put more than one command module docking to it. We could have had an unmanned Logistics cargo carrier and resupply it as the Russians do, even automatically. We had a space station, we weren't permitted to call it a space station, as you may notice from the literature. We were never permitted, because at that time people had in mind, "Hey, this was just precursor to a space station." No one ever wanted to call it that because then you never could have a space station, because you already have one. So it was very carefully avoided being called a space station.

35. WARING: In effect then, Marshall and the Apollo Applications Office at Marshall, were sort of functioning as a planning office for George Mueller?

36. REINARTZ: Yes, there was very little in way of a headquarters or a contractor that they were using up there. Marshall basically supported the Headquarters' planning activities as well some of their own things and implementing their own things, but also did a planning function. In fact, if you ever talk to a fellow who if you want to more about our relationship with George Mueller, that's Dr. von Braun and of course Eberhard Rees was there, other than project people, a fellow by the name of Lewdy Richards. Lewdy at the time, I think he headed up a group, I don't know if it was called at that time Central Systems Engineering or exactly what the nomenclature. But he and George Mueller hit it all extremely well when George came in. I sometimes felt sorry for Lewdy, because George Mueller was the type of person who would work five days a week in Washington. Then he would go and tour the contractor's plants over the weekend. He would fly by Huntsville on Friday evening and pick up Lewdy, to make a tour of Rocketdyne and General Dynamics or whatever, collecting ideas, seeing what our current contractor was doing, listening to other people's ideas and so forth and bouncing ideas off of Lewdy. Lewdy was a bright fellow and knew a lot of different things and George used him as his sounding board. At one point during this clustering thing and after he outlined that initial cluster, one particular week, he had Lewdy Richards and I up in Washington and we sat in his office, it was sort of an L-shaped office, he put us over at a desk, and he said, "Now this is where you are going to be. Now you guys start working out the bugs on what I have outlined here and I will check with you from time to time." So we were sitting there captives in his office and we would be working and on the phone to Marshall and one thing or another. At least every morning, noon and the end of the day, he would, "Alright, how do things look like now, how about time. What would it do if we did such and such." We

would be back to the on the...for a week we did that.

37. WARING: Has there ever been another situation like that where a project office in a center and one person imported were working so closely together?

38. REINARTZ: It was probably had a degree of uniqueness, just in the nature of the program. It was an awful lot George Mueller's program, his brainchild and him pushing and pushing it through.

There was a period where we almost didn't end up in the Skylab, because for whatever reasons, and I don't want to ascribe the wrong reasons, but for whatever reasons, JSC was not in favor of this and the biggest announced reason was the concern of putting all the eggs in one basket. That we were putting six or seven years of work, putting crews, all the experiments, and suppose we had trouble with the one Saturn V. So that was one of the things that said, Okay, the program will buy a back-up launch vehicle. We will put that in the inventory. Not only that, but a back-up workshop, a back-up MDA [Multiple docking adapter] and a back-up airlock.

JSC wanted to conduct a series of small missions, whereby you launched a IB, you would put a small habitation experimentation device in the area where the service module, or the lunar excursion module lander would go on a IB and you go up and turn around and dock to it. It separates and you fly with this little small thing and when you get done you throw it away and re-enter. The idea being that we could have four shops of that instead of going up and visiting this vehicle in space station, you could have independent missions. George Mueller did not care for that at all and it got shot down.

We proceeded to add earth experiments.

39. WARING: Let me talk some more about all of this. In talking to people at JSC last summer, they tended to take a lot of credit for the shift from the wet workshop to the dry

workshop.

40. REINARTZ: They tried to kill it. At a point in time, they tried to kill it by having these small sub-things.

41. WARING: Right. Could you talk about their role in that decision to go to the dry workshop? By the time that...

42. REINARTZ: Who all did you talk to?

43. WARING: Like Chris Craft and Max Faget, Joe Loftus.

44. REINARTZ: You see Max was going to be the one who was going to a little can on the back, that you might now here called "Habitat" that Max Faget has a private company? It is just another version of what was going to fly twenty-five years ago. Only now he is with private industry instead of with the government. He still is working on a little "can."

No I think for you to get a somewhat more neutral person, you would have to get somebody like George Mueller or people, Bill Snyder, or one of the other fellows that were in it right from the beginning, ended up dying a couple of years ago, John Disher. John was the very earliest person that started the leading activities related to Apollo Applications. John ended up developing cancer. He made it down to our 15th Skylab reunion we had here in 1988. Within about three years after that John had died. But Bill Snyder could see from the headquarters view. A certain amount of this was just before Bill. The guy that I think was just preceding Bill was Chuck Matthews, who was in history the GEMINI manager at headquarters and then Chuck picked up the Apollo Applications for a period of time. I don't know where he is now.

There was...a fellow that I don't know whether you have talked to, he is now with

McDonell-Douglas, Robert Thompson. He was the Program Manager just before Kleinknecht. Bob was pushing the small individual flights. I am not sure whether Chris' memory has become a little cloudy in that area, but they were not initial supporters of the Skylab.

45. WARING: Was it pressure from Houston that helped Marshall see the flaws in the wet workshop, or were people involved in planning here always aware that there were problems in the wet workshop.

46. REINARTZ: Yes, JSC certainly did point out the problems with it and they were certainly recognized. The question was: is doing a little bit as crude as it may be, still worth the effort?

47. WARING: Marshall said yes?

48. REINARTZ: That maybe where they came from. But instead of what was the dry workshop. Their alternative would be small cans.

49. WARING: In talking more about the division of labor between Houston and Marshall, it was a lot more complicated than it had been for the lunar mission. How did that division of labor work out? Were you at the Lake Logan management council meeting?

50. REINARTZ: No, I wasn't at that session. During the early phases of the program we had an airlock. The airlock probably only because of one thing, there was a hatch for the crew to get out of and that hatch came from the GEMINI Program. So, aha, that ought to be JSC's. So, you build everything else around this hatch and all that logic follows. So they had the airlock contract. I think initially the airlock contract was about a 10 million dollar

contract just for this airlock. Well as it evolved, it became clear that this airlock was going to serve as the heart of this integrated cluster. That you were going to put all of your life support, that you were going to put everything there. Your distribution of power, solar. So it became obvious that it was very much tied to all of the rest of the things. George Mueller, and I can't remember if this was just before or about the same time that we added the MDA to the program, rather than just docking in, we said, let's put something up there that we can dock. I think we added it when we added the earth resources experiments. Then he said, "Hey we will put multiple ports on it." Just before the tail-end we took some of the ports off, because we saw that we weren't going to be able to extend the life that we might have been. So I think that MDA got added when we added the earth...we had to have some place to put them. Now we have this device up here, this airlock in the middle and then this workshop down here. We have an ATM sitting out there. He came to the conclusion, and I don't know what all drove the thing. But he came to us and said that is too messy as far as technical interface and so forth. He knew that Marshall fully supported the program and would give it the command power and people on it. So, probably for several reasons, which one might have been the most important, I am not sure. But he said, "I am going to transfer the airlock from JSC to Marshall." In those days, even with the fact that the space thing was going down, there was a little bit of rumbling in the Congressional thing. But George worked very well with that and was able to do in total dollars, it was a very small thing. When the program was over that contract was worth 230 million dollars. So it didn't turn out to be such a small thing. At the time that got transferred, that left a very relatively clean organization thing for the Skylab. It left Marshall in charge of all the motorized vehicles. It left Marshall in charge of the integration and the furnishing of all the systems or sub-systems that made it up. It lead Marshall in charge of integrating experiments into that vehicle. It left JSC with the job of coming up with a command and service module that could survive a long stay in orbit, which it had not done. The training and supply of the crew. The supplying of bio-medical experiments. Which they chose to

sub-contract a portion of back to Marshall. Bob Schwinghamer did that. JSC then did the earth resources experiments that now is MDA. They also performed, of course all the EVA operations. We provided the hand-rails and the extending poles and the clothesline for retrieving film. The aides to that we supplied, they supplied the suits and all of that. It was at that point that we got into the big fuss about the neutral buoyancy because they had to come up here to do the training. JSC then, post-Skylab, started pushing for their own neutral buoyancy. Ronnie Flippo kept it locked up for three consecutive years and finally gave in. Their whole argument was the training part. Marshall needs one for developing, we need one for training. The irony was, they built it and it collapsed because they had not done the foundation work right and they had to start all over again. So we paid for two neutral buoyancy facilities. There is a very low water table in Houston and they weren't ready for that. Somehow the architectural engineers didn't do their homework right.

51. WARING: Another thing that comes out when you talk to Houston people in regards to later stages of Skylab development was the habitability issue. The Houston people claim that Marshall was mainly concerned with workability, making sure that the engineering systems really functioned. But that it was really the Houston people who were concerned with habitability, making it a pleasant place to live.

52. REINARTZ: Yes, and that is correct. Our guys had been building rockets. We hadn't had people around them. In fact, you wanted to stay away from them. It was that and that is true. The Marshall people had built and certain of the things regarding habitability with a given amount of money in the program and so forth, were deemed nice to have, rather than a necessity. So there was a certain amount of, let's say, lack of appreciation, by the Marshall people of the concerns for being in these tin cans for up to 90 days or 84 days. So I think that that is legitimate. I don't if it is quoted in any of the books, but George Mueller, again in his thing, of course George was looking around to tap things that could

add to the program and help influence with Congress. So he secured as a consultant, Raymond Lowey.

[End of first side of tape]

53. REINARTZ: ...his first reaction was, he had looked at...I am trying to remember exactly when he brought him in. I think that it was after we had gotten Skylab in early 1969. He came down and looked at our mock-up of the workshop. At that point, this is one of the things that JSC helped us to change, it just had the chromatic paint on the inside. It was about the same color of your fern there, maybe a little more yellowish then that fern. Lowly took a look at that and said, "You know what color that is don't you?" And I said, "No." He said, "Sing-Sing Green." That was the color of the death cell at the Sing Sing Prison in New York. Don't ask me how he knew that, but that is what it was. After that, it had to go! So we got rid of the Sing Sing green and ended up with the beige kind of thing. But, from the engineering thing, don't add any more weight to the vehicle. Don't add something else that I now have to prove that it won't off-gas. You know, engineering type thing. It was aesthetics, ease of accessibility, there were a number of things. They were not given as much attention. They were not given as much funds. So there was a little pushing back and forth. But, I think it, again within the time-frame we had, and the funds that we had, got reacted to and most of the things got taken care of to a good degree. We had, for example, it was a different aspect, I don't know if it was really that much better, but the Apollo Telescope Mount was pretty well along in design and we had a crew representative, not necessarily the crew that was going to fly. Then they selected the crew that was going to fly on the Skylab mission including Owen Garrett, that is here in town. They did not like the way we had that ATM control display panel laid out at all. So we ended up basically redesigning the ATM control panel. Which was probably one of the single most expensive items on the thing. In fact, someone was kidding one time and said, this thing that was

about the size of the front of your desk and not that deep, maybe just 18 inches deep; it was costing about like...how many Cadillacs were represented by that control panel and now we are going to redesign it and add upteen more Cadillacs, because it was an expensive item. But it was the heart of the system to make it do. When it ended up, the science people were tremendously pleased. As a matter of fact, certain other things are still being studied with the sun. It turned out to be an instrument that could be used by the crew and it really worked out.

54. WARING: Related to that, one of the characteristics of Marshall through the sixties, was the arsenal system. There was some in-house work done on Skylab and its various components. Could we go through some of the things and talk whether those things were made in-house, starting with the multiple docking adapter. Was any of that done in-house?

55. REINARTZ: Yes, actually what was done, was we had proceeded to the point where we actually built the flight shell. Then we turned over, we in the program office, felt that one, because they were going to integrate the E-Rep experiments into it. Somehow we were already going down the track and then the E-Rep came in and then they selected Martin-Marietta to do the some of the work on the Earth Resource Experiment. We had them as a integration contractor, so Lee ended up deciding that it would probably be in the best interest of ourselves and Martin if they took that piece of hardware and as integrators had to work these real problems, not just sitting up in their ivory tower, but had to deal with real problems of hardware, and schedule and everything else, like the rest of the contractors that they were telling them, "hey, you ought to do this and do that!" So that put them with something solid for them to chew on. So we transferred, basically, the structure to them and they took it over and proceeded to do the final design integration and the physical integration and everything on that structure. In fact, as I recall, when we sent it out there, there wasn't anything drilled into it or anything. It was just the bare piece. In

fact, we kidded Martin-Marietta, cause they set it out on the floor and circled it for about two weeks before they decided to drill holes in it. To reassure themselves that they were really ready to start drilling the things, putting holes in this piece of flight hardware.

56. WARING: Did Marshall deliver it to them?

57. REINARTZ: Yes, we delivered two of them. The program at that point, had two of everything. I think at the time we actually had in the experiment world, the idea was that we had a qualification unit and a flight unit. The idea was that we would refurbish qualification units and use them for flight in the event of the second. But as far as everything else...

58. WARING: How about the airlock module? Was anything done in-house on that?

59. REINARTZ: No, whoever did the airlock, it was originally a McDonald, not McDonell-Douglas, McDonald contract. We just took over the contract from JSC and managed the contract. So we did the MDA structure work. Then we did a lot of work, had done a lot of work on control moment gyros, but the actual build of the control movement gyros was done by Bendix.

60. WARING: This is on the workshop, itself?

61. REINARTZ: Well, it was mounted actually on the ATM. That stabilized the whole thing. We used the brains for that part of the control, were done out of the ATM. The control system brains and the computers for controlling that. The electrical system was controlled out of the airlock. But the attitude control, because we didn't have any propulsion then, we just maintained attitude and maneuvered attitude, was done out of the

ATM, the ATM computers. Marshall managed the contract. So the ATM as a total unit was done at Marshall. It was built at Marshall, tested at Marshall, tested at the vacuum chamber in JSC, delivered to the Cape, all done with a Civil Service lead team, supported by certain of the contracts that had the control moment gyros, that had the computers and so forth, made up part of the team. But it was entirely managed by Marshall. We bought components, assembled them together, built the structure in-house that the Apollo Telescope is mounted on, what became the internal frame that they were mounted on. All that hardware was basically built in-house and we bought components. We made up wire-bundles and all those things that go to make a piece of hardware that weighed over 25,000 pounds.

62. WARING: Did the ATM then, essentially first function as the command and control center of the workshop?

63. REINARTZ: As far as...Yes, I would say that it basically was the principle one with certain secondary functions signed off to the airlock, taking care of the distribution, especially of the life-support system was the principle thing out of there. It really included...we ended up from a power stand-point, we collected power from both the workshop and the ATM. [We] had it so that we had a central bus system such that if we lot some here, we could feed from there, nominally they sort of took care of themselves with certain surplus made available to the other one. But the ATM gave us an opportunity to put another set of solar arrays. [Then] with the problem that we then had without the ATM solar arrays, it would have really been bad. So we had the ATM, the brains for the power and the attitude control. The life-support things for the manned and those type things were out of the airlock.

64. WARING: How about on the workshop itself, aside from the experiments.

65. REINARTZ: Aside from the experiments it was done by us. We did the neutral buoyancy work from here. But the hardware experiments were done...I think that we may have done one experiment in-house that was not a life-support. It was a very minor one, it was basically a Douglass-Huntington Beach job. The ATM was the big thing that we did on the Skylab, in the fact that we were the prime contractor on the ATM and did all the testing, except for what we used the vacuum chamber at JSC.

66. WARING: Another thing that Marshall was known for through the sixties and early seventies, and perhaps still is, was said that Marshall was known for its conservative engineering. This was said to be a legacy from the Germans, a real concern with reliability and having those stringent requirements. How did that affect the construction of the system?

67. REINARTZ: First of all by putting the vehicle on the Saturn V, we had an advantage that would let you do the conservatism that many people that did enjoy the luxury. We had a tremendous lift capability, and solving many problems...sometimes you know if you could spend some more money and make it lighter or you can reduce the redundancy and take the risk, or go for newer technology solutions and so forth. Or, you can use an older system, a heavier system. You can add some weight. With practically everything we went with the weight as the way to solve the problem, using weight because it was not an issue. It was one of the few times in the space program where you didn't have an overriding thing, of just every time you had to go back and do some redesign because you were going over weight. So the conservatism expressed itself, I would say, primarily in that. Plus the fact of how many charger battery regulators we had on the ATM, you put enough you conservatively rated how they would be grade. The fact that we started out with three CMGs, I don't know that anybody knew that we really do basically a complete control with

two of them at the time we selected three. It turns out that we did and by the time the one CMG stopped, the guys had pretty well figured out how to do it with one CMG.

68. WARING: There were four solar arrays.

69. REINARTZ: Yes, we put out each that basically were independent from the ATM and the fact that we had two different sets of solar arrays. We had an ATM set and a set-up workshop.

70. WARING: Were there other redundant systems like that, that you can think of?

71. REINARTZ: We had...I can't...you know we had a single trash compactor. So trash started to accumulate if our trash compactor didn't work or our trash dumper, we carried along our own garbage can on the airlock tank...I would have to go back more of what exactly was redundant in the various systems.

72. WARING: Another part of the engineering tradition at Marshall was extensive testing.

73. REINARTZ: Well, the fact that on the ATM it was probably one of the last good size payloads that had, there haven't been many since then, we did a full qualification, or we built an item just like flight. Did the complete functional testing here. Ran it down to JSC. Did the complete vacuum testing. Ran it down to the Cape, ran it through all the preparations just like it was getting ready for the launching.

74. WARING: Were there vibration testing on the ATM?

75. REINARTZ: Yes, vibration testing done here at Marshall. Ran it through the whole

nine yards of testing, including running it through the Cape, which again, our people, per se, had never operated as a prime contractor. KSC was very concerned about that, because they knew that we didn't take orders too well. Down there KSC calls the shots. We said, "Hey, we are going to come down. We are going to use your paperwork. You call the shots, we do them. If you say "jump" we are going to say "how high."" So what we did, is we took the KSC paper and introduced it back up here at Marshall when we started. Took it to JSC, took it to the Cape with us. By the time we got down there, our guys were familiar with the paperwork system that KSC was using. Probably no more than any prime contractor would have had, but because we ran that ATM through there and then brought the flight along as a second article, people were used to it by then. We had less problems with the ATM through that process and particularly down at the Cape, then we had the workshop down at the Cape. The workshop came with missing items and problems, new people, now working with KSC. We had problems with the airlock, more so than we did the ATM. Primarily due to the fact that we carried more haul-away through the system.

That was different then when you talked about organization management. That was a new thing where Marshall served as the prime contractor and took a piece of hardware down to the Cape as a prime contractor...

76. WARING: And in effect, Marshall was sort of a prime contractor to JSC, right?

77. REINARTZ: We were a sub to JSC as far as, you were talking about the experiments?

78. WARING: Well, experiments and in effect Marshall was building a spacecraft.

79. REINARTZ: As far as from operating the spacecraft, yes we were a sub to JSC for the operating. But as far as, if I try to compare it with space station, I think we were a level two. We integrated the vehicle and we served the role that Weston was trying to serve. We

were "the lead center role" which they are going back to on the space station and probably going to JSC. We did that before, twenty-five years ago, we were the lead center on the space station. We made what I feel was a much cleaner division of work than they have on the station. The political thing that we got into on the station is just an invitation to problems.

80. WARING: Could you describe some of the ways, the panels and boards, by which Marshall and JSC worked together?

81. REINARTZ: I am probably not the best one to talk about that because I did not participate directly in those. Getting some people, most of which are pretty much up in years now, that were more directly involved in those would be better. But we basically took off from the concept that we worked in the Saturn Apollo Program. We didn't invent anything new. In fact, if any or a criticism that someone might level is that we were not after having developed certain management tools for using in the Apollo Program, there was no great push by anybody to create something new or different. That was not ever a big thing, not that maybe it shouldn't have received attention, but it was not, there were just some minor things changed in the way the Program Manager got together with the prime contractors or we had periodic meetings with the all the prime contractors, the headquarters management, the program director and so on. But they basically worked in a very similar manner of Saturn with any of our boards. One of the things that we had a very active and very qualified group in our Project Office at Marshall, of systems engineers, headed up by George Hardy. George later became the SRB manager in the Shuttle days and was Deputy Director of Science and Engineering. The guy who one of his key people was Luther Powell, was at a later point, he was a space lab manager, then he was one of the earlier managers of the Space Station. Then he had John Thomas, who became the guy on the re-working of the Challenger and is now running Lockheed's launch opts down at the

Cape. He had a number of brilliant people that went on to take various small jobs. We did a very substantial system where we had about a fifty man system engineering, which was a little bit different from the programs before then and since then.

82. WARING: Why?

83. REINARTZ: Well, again, it was just a combination of circumstances of capable people in the right place. In effect, what it became, it became the Marshall's System Engineering for Skylab. They worked extremely closely with the laboratories and ended up with very direct access and worked in the thing. Jim Kingsbury, who at that time was director of one of the laboratories, I guess it was called the P&VE [Propulsion and Vehicle Engineering]. He sort of acted like a chief engineer, that if we ran into some things that we couldn't work...but there wasn't this thing, as much as a sense of the division of the projects and laboratories as there were in some earlier phases and then in some later phases. We sort of ran a period there where we were very close. Some of the mangers felt that they couldn't have as direct control of their people because they were off working and responding to this Systems Engineering group. But, it turned out to do a pretty effective job.

84. WARING: Now that is interesting, what you are telling me about the labs, because through the late sixties and into the early seventies, the labs were very dominant in the organization. They weren't as dominant as they were...

85. REINARTZ: We are talking primarily the 1969-1973 time period.

86. WARING: Right, but the labs still had...

87. REINARTZ: They still had the bulk of the people. They were still very strong. It just

turned out to be that the management up through the last Apollo flight through 1972 were very tied up with that. Skylab just sort of happened! While these big things were going on here as Skylab was almost like, until it finally blossomed forth, was like, I read "Historians write about the river and the mainstream. Meanwhile on the banks, people are having babies and growing up and living and doing..." Well, Skylab was on the banks, Apollo was the river and we were over here on the banks and nobody bothered us.

88. WARING: Bill Lucas has talked to me about the "Lead Lab" concept which was used early in Skylab. The Center was using the lead lab. Is that right?

89. REINARTZ: Because Kingsbury was from the lab, that the center of gravity kind of fell in that area, was done. But again, I don't think it was as much a lab as an individual and his role and perception of things and our organization and so forth, more so than a "laboratory" per se leading the activity. I think in reality our projects and in particularly our system engineering was the lead. The labs worked together and occasionally if we did have two labs and we were having some differences in inputs or getting things...we would call in Kingsbury and say, "Hey, help us."

90. WARING: So it helped to have a prominent laboratory director to help.

91. REINARTZ: Yes, then Lew Belew didn't have to go to the Director of Science and Engineering to go work the problem. The lab director was more accessible on a day to day basis than going to the front office. From that standpoint, it made his entry a little lower level to get somebody that had been given authority to work across the labs. I won't get into a debate with Dr. Lucas though!

92. WARING: Let's talk about the meteoroid shield problem.

93. REINARTZ: That was a thing that has happened on other programs and it will continue to happen, it basically is any place where you interface between organizational hardware is the spot where you ought to look closest. You don't always learn that and remember that. Dynamic interfaces are even more so, where hardware moves relative to each other. We had as best can be reconstructed, a misunderstanding between our structural people and our aerodynamics people, in-house and basically in-house we had the responsibility for the aerodynamics.

94. WARING: The design of the meteoroid system was an in-house design?

95. REINARTZ: No, McDonell-Douglas designed it, but we gave them the parameters to go by. What happened was basically that we did not provide sufficient vent area from underneath the air that was trapped...which was not much because this thing was cinched up around the stage during the ascent phase. We did not provide sufficient vent because of this misunderstanding or this miscommunications in the documentation that described this situation. Consequently, when we launched it, the pressure behind the shield exceeded the capability of the material holding the shield onto the thing and let go. The minute it got slightly away from the thing, it gets this several thousand mile an hour air stream going behind it and wraps it around like tissue paper because it is very thin type of device. So it went out max Dynamic pressure, I guess 60-63 seconds. It was a dynamic interface that was going back and checking a lot of electric interfaces. We checked and rechecked. We did late in the program, what we call "sneak circuit analysis" which says, "Hey, can I possibility run a complete circuit around another way and cause some function?" We found one or two things that could be trouble. We did a lot of other testing. But, we didn't have the type of double check on that Dynamic interface that we should have had.

96. WARING: So the idea all along was that the air would flow underneath?

97. REINARTZ: No. It would be up so tight that your inside where the airstream, you end up with actually a little bit of practically dead air right at the very surface. Then you have this big airstream. You have some turbulence and then you have this airflow going back. The idea was to hug it and stay tight to it.

98. WARING: So there would be no air coming between. Was there a cap at the top or was it just cinched?

99. REINARTZ: I think that it was just cinched. It was so close that there might have been some lip, it wasn't closed itself. There might have been some slight...I think it came up from wherever it was, there was a flange that was out or something like that. At the end of a tank you have some kind of a flange. I just can't remember. There was probably something. It was cinched up tight. It wasn't the air flowing through it. It was the fact that there was air trapped behind and when you go up into the vacuum, very quickly, the pressure inside at 14.7 is substantially greater out there. If you take 14.7 for each square inch, it doesn't take too much of a pressure differential acting across 22 feet in diameter, 30 something feet long.

100. WARING: So it was the difference of the pressure of the air trapped inside and the outside? It wasn't the air going through?

101. REINARTZ: It wasn't the air going through, it was the differential between the ground air trapped on the inside trying to get out and outside air rapidly increasing and there should have been sufficient vent so that the pressure differential between what was on the inside and the outside stayed the same. That it went down on the same rate on the

inside as the pressure that was going down on the outside.

102. WARING: So as I understand what you are saying, there were evidently mistakes in the design and construction of the meteoroid shield, it wasn't a problem.....

103. REINARTZ: It was constructed like it was designed. It was a design problem. It was built right.

104. WARING: It wasn't a problem with the way the thing was cinched at the Cape for the final checkout, it was a design problem?

105. REINARTZ: No, it was an inherent design problem.

106. WARING: That clarifies that a bit for me. Maybe one more question here about the rescue efforts right after the launch.

107. REINARTZ: It was obvious very quickly that a solar array had been prematurely deployed. They didn't know right away whether it was because what happened or whether some circuit had been tripped, but a light came on that said, you have a deployment of your debris shield. After it got up into orbit and it we got the ATM out which was great, we got the solar arrays out because then we could get power. That crucial getting power to our upper system. Then it became very clear that a very large portion of it was missing because the temperature was going up. It not only served as a debris shield, but we used thermal paint between the outside of the shield and the inside so you would radiate on the outside. We had different combinations of paint, since we generally flew a center-oriented condition to get a heat balance...once you took it off, you began to absorb all this heat. So it was not only debris, but thermal in that it effected the thermal balance, which was more critical

than the debris part. The question became, How do we get something up there to thermally protect it? How hot will it get? All sorts of efforts were initiated by our all contractors and here to come up with schemes to do that, to protect it. The control people had to start learning how to control something that was different than what they were controlling. They had to start maneuvering it in ways that were not done. If you put in one attitude, you got to hot and you were going to spoil all the food and all the supplies that were up there. If you get too hot you are going to create some gassing that is going to make some gases that we can't live with. On the other hand, when we move it the other way we had a water-looped cooling, it was going to freeze up the water. So we proceeded to go from hot to cold, hot to cold, trying to find the optimum attitude that we could get in. Of course our people were learning. Rocco Petrone, who was our Center Director, both times we launched it, who was like a bull in a china shop normally, and at that point, Bill Lucas was his deputy. We were using large amounts we had a bunch of bottles that had gaseous nitrogen in them. You used your control on the gyros for maintaining attitude control. But when you wanted to roll over and do an earth maneuver, you used a certain amount of the gas for maneuvers. In these early maneuvers the guys were using all sorts of those. Rocco's expression was, "You are pouring out liquid gold you know!" He would just hit the ceiling. They were doing things they had never done before and they were learning. So that was an operational problem everybody was dealing with. They ended up with two designs; One that JSC did in-house and one that Marshall did in-house. The thought was, the JSC design had the advantage from the standpoint that it was a riskier thing. Perhaps in terms of functioning hardware, because it was this mechanical umbrella and there is always a chance of that having a malfunction. But it could be deployed from the inside of the spacecraft. Marshall came up with a sunshield that required a EVA, but had very little mechanical risk to it. I mean, you are going to get it up there, it is going to get deployed and you are going to put it exactly where you want it. This thing you had to put out and kind of guess where to turn it.

So they elected to go initially with the sun shield, with the umbrella. But at the time, we didn't know exactly where the solar array [was]. I saw at the confidential level of secrecy, some MIT radar shots that they were taking of that. One of our people by the name of Don Bowdon went off to an Air Force facility, where I never knew where he went, and they had cameras. I think what they were doing was looking down on our Skylab.

108. WARING: From a spy satellite?

109. REINARTZ: From a spy satellite. So they knew pretty well what we were going to see.

110. WARING: Well, I have never heard that story before.

111. REINARTZ: He went top secret.

112. WARING: Is that when they were building the "junk-pile" in the neutral buoyancy simulator, did they in effect use spy satellites?

113. REINARTZ: Right, to a degree. I never saw what he saw. What he saw was better than the radar thing. From the radar thing you could tell that we had one basically missing and one partially deployed.

114. WARING: Ground-based radar?

115. REINARTZ: Yes, Ground-based radar. He saw some photo-type things. They had a pretty good idea and we teamed up with some different tools that you have read about. It was a rather frantic time. Many people went with very small amounts of sleep. One of the

big guys that worked our manned systems and the neutral buoyancy tank, later he was the Center Director with Bob Thompson. At that time he was with the manned systems group. He was very instrumental. He went at least three days without any sleep. Many people were getting only a couple hours a day and went at least the first two days without sleep. So it was a very frantic time. On the other hand, it also showed that those types of things show that when we take all these years for doing things...we had the conceptual design, the preliminary design, the critical design review...it went through each step, but it was done. Morning was one, afternoon was the other. Then there was paperwork involved. It was built and tested and we went through all those steps.

The one amusing story...when we were building our shield here at Marshall, Rocco Petrone was out here most any time of the day and night and the place was working twenty-four hours a day. Everybody was working. We were building our sun shield, the cloth portion, (I forget exactly what it was made of) but equivalent to a cloth type thing. It was flexible material that had to be folded in and then out. So they had taken our airplane and flown up to International Latex Corporation and picked up a couple of seamstresses and brought them down here to Huntsville. They were over in the Clog Building sewing up this big thing. Rocco was around on one of his tours. Here were these little old ladies just grinding away on this thing. As they would run it off on this thing, they would take their foot as seamstresses have done since time immemorial and kick it out of the way. Rocco is saying to the lady, "Does she know that she is kicking flight hardware?" It was deadly serious, but there was still a sense of humor because Rocco turned away first thing, because everybody was out and everybody would be working together, but one place Rocco ran into something and he came up and asked somebody, "Who was in charge?" Nobody knew who was in charge. They were all working, getting the job done, but didn't know who was in charge. "Got to have somebody in charge of everything," [says Rocco]. So there were a lot of humorous things, or gallows humor of who was in charge and so forth. People would stick a sign out and say, "I am in charge!" or whatever!

It was a hectic time and people all over the country did a lot of good work. The scary part was that the first time that Pete went up and tried to dock, the stupid thing wouldn't dock. He had tried several times and everybody though this was the last straw. We had done all these things and now he couldn't dock. Just before he went out of radio communications, he said, "I am going to give it one last try." He came around. As soon as he came around, the guys could see on their board, before he said anything, the lights just light up that he has docked in and then he said, "I am docked." A very big cheer went up that time. But he hit that thing so hard, he hit it like a full-back going into the block. But he got there. He went beyond where you were suppose to hit it at. But he did it on the back side. Nobody could see how fast he was going about it.

We had vented it because of the concern for gas. He drew a gas sample and we completely vented the thing down and put whole new air supply in. We had some of the crew space adaptation sickness to a varying degree. They still don't know what causes that or they can't predict it on a person. It doesn't necessarily mean whether you are a jet pilot or not a jet pilot. Some people can adapt, some can't. It appears to be the general rule was if you take it slow, if you don't do sudden head movements. If adapt very slowly to the thing and take several days, then you do seem to reduce the incidence of it. But it is still one they are working with. It just means that on short missions you can't be fully effective for a lot of people in the first few days of the mission.

116. WARING: Just as a sort of overall retrospective impression, what are your thoughts and feelings about Skylab?

117. REINARTZ: I felt very good about it. We advanced what was being done at that time. We had extended durations. We showed that you could live and work. We showed that you could gather good scientific data. That we could gather both life science, that we gathered. We gathered solar science and earth science. They talk about Mission to Planet

Earth or with planetary.... [end of the tape.]