INTERVIEW WITH DR. CHARLES R. CHAPPELL
INTERVIEWED BY STEPHEN WARING
23 AUGUST 1990
HUNTSVILLE, MSFC

1. WARING: . . . begin with you first so I can get a little better perspective. Why did you come to Marshall, and when did you come to Marshall?

2. CHAPPELL: Okay, I'm a, I'm sort of a, I'm a relatively new boy and probably maybe second generation type NASA person. I came in 1974, and that was after the Golden Age. The Golden Age sort of, Nixon ended the Golden Age with this, with his factor four decrease in the NASA budget over his tenure. I don't know when he left office, but it was early 70s essentially. I never saw Marshall at a time when it was just wild with seven thousand people and twice that many contractors. To a certain degree, it gives me a more comfortable perspective of the way NASA is today because I never saw it in the Golden Age, whereas a lot of people today, the people who have been here thirty years and who remember it the way it was, have more trouble living with it the way it is now. I never saw it the other way so I'm happy to make do with what I . . . .

3. WARING: This is normal for you?

4. CHAPPELL: This is normal, but I know that from the country's viewpoint, we ought to get back more toward the way it was, that that's the best thing for America. I spent a lot of my thoughts and time talking about that, because I think America is really missing something right now by not recognizing the significance of the space program. I came in '74, and the Center had reduced in size and was starting to work on the Shuttle. It was also realized that the shuttle was going to be the only launch vehicle for a while, and that once we, once NASA got the shuttle built that we'd need to fill it up with payloads. There might not be another business opportunity for Marshall and propulsion in the near future so that

Marshall had better get into some payload activities. The director then knew that in order to get into that business that you had to have some scientists who are, who would give the Center the scientific credibility so that the Center could argue for roles in science payloads. I was one of the people hired with the idea of developing another area of scientific work which could lead to payloads downstream, specifically in my case payloads that would fly on the space shuttle. In my, my expertise was in magnetospheric physics or space plasma physics or solar terrestrial physics all same, describe the same thing. There was interest at the Center in developing a shuttle payload that was called AMPS, which was Atmosphere Magnetosphere and Plasmas in Space. It would have been a shuttle payload to study, to remote sense the atmosphere, directly measure the ionosphere, remote sense the Magnetosphere, and then use the fact that when the shuttle flies, when it's in orbit, it's in the middle of a plasma, the ionosphere plasma. You could do active experiments by perturbing the plasma and measuring its, the way it responded. You can inject chemicals, or inject waves, electromagnetic waves, or inject electron beams or ion beams and watch the way they interacted with the plasma. That was the purpose of that payload, and I was hired to come here to start a research group in that area and to be the, essentially the project study scientist for that payload.

5. WARING: Were there, about that same time were there lots of other scientists being hired?

6. CHAPPELL: They were coming in, not lots, but they were coming in steadily. Bob O'Dell had been hired a few years before to do the Space Telescope. Tanberg .Hansen was hired about the same time frame I was to do some solar physics kinds of things. The Center under, I was hired under Petrone although Bill Lucas was the, I think he was the Deputy Center Director when I was hired, and he became the Center Director shortly after that. He was very very consistent in his support for hiring scientists to build up this area. It

was always a very measured powering. I think the center is very dominated by people with engineering backgrounds because of the history of what we've done. Most of the management, almost all the management, it comes from the engineering area. There's all, they're able, they are more aware of the needs within engineering than necessarily the needs within science. There's always, there was always a, it wasn't a, it was never a flood of hiring of scientists. The Center Director was aware that was important, and that would, so when science hires bubbled up through S&E, he was supportive of those. S&E is mostly E, and so there were a lot more, a lot of engineering hires too. The science expertise built up very steadily during the period of 70, early 70s through probably end of the 80s. It's, I would say it's been roughly level for the past few years. It hasn't built up much, but it developed to the point where there was good expertise in solar terrestrial physics and astrophysics, material sciences, earth sciences, and those are the areas that we push today.

7. WARING: Are most of these scientists being hired for developing scientific experiments and payloads, or they sort of adjuncts to engineering do you think? Is there a conscious effort to get out and get experimenters and astronomers and . . . .

8. CHAPPELL: Yeah, I think so. Now that's different from early Marshall. I think, the Space Science Lab has been there a long time, but I think the Space Science Lab was very dominantly in an engineering support role in its early, it's where you got out onto the edge of what was understood that the engineers could work with. You needed some scientists to try to push the frontier a little bit in materials or whatever, and it developed for those reasons. Then it was transitioned through this period of the 70s, and well I would say the transition took place in the late 70s to the very early 80s where it changed from engineering support to people who were doing their own thing in research and motivated by their own research interests, some of which led to building payloads.

9. WARING: In the process of Marshall building up its scientific strength in the 70s, did the organization of space science with in the Center change? Were there ways to make it more prominent?

10. CHAPPELL: Yeah, it evolved.

11. WARING: Could you describe that?

12. CHAPPELL: I remember particularly we, when I first came there my, I came as a branch chief and my branch was magnetospheric and plasma physics. It was in a division, I think the division was either called low temperature physics or astronomy and astrophysics or some, it was a, it was sort of a hodge-podge of science disciplines that king of clumped together. It was several years, maybe four or five, before it evolved so that solar physics and magnetospheric physics and atmospheric physics were all in the same division which they should be. If you look at the physical system you're studying the sun affects the magnetosphere and the atmosphere. To encourage that research interaction you ought to put those together organizationally, and it took several years for that to happen. So the way it evolved in ways that made a lot of sense, and I think that the way the lab is organized now is very good and recognizes or has responded to the most reasonable clumping of subdisciplines together. So like we have an astrophysics division that does gamma ray astronomy, cosmic ray astronomy, x-ray astronomy, infrared astronomy, and they should all be together.

13. WARING: Whereas scientists before were more dispersed throughout many of the other labs and were in that engineering support?

14. CHAPPELL: At least one of, most of the engineering support function was within the Space Science Lab although there was a large group with in the Materials Lab. They, one thing that happened again during this time period of the late 70s was that a number of the people who were very basic research scientists who were in the Materials Lab moved over into the Space Science Lab and joined people who were already there in materials and that materials, whatever it is now microgravity science division I guess is what is called now, became much stronger as a result, and I think that was a good thing to do too. Not all of them moved. Some of them liked the materials lab testing kind of environment, and they stayed there.

15. WARING: What are the strengths of space science at Marshall relative to some of the other NASA Centers?

16. CHAPPELL: You mean their science confidence versus other NASA centers?

17. WARING: That's right.

18. CHAPPELL: I would say that the quality of science in the Space Science Lab is equal to the science done in any of the other NASA's centers. The quantity is different. The Space Science Lab has about a hundred and fifty people in it, and that's all of science at Marshall. Whereas at Goddard there are many times that numbers of scientists. Now the quality of scientific work that's done within the Space Science Lab, if you could sort of go one on one with either Goddard or JPL or Ames, but quantity wise Goddard is much larger in science, and JPL is much larger in science: JPL maybe not, maybe twice, I don't know the exact numbers but Goddard many times the number of scientists.

19. WARING: Are there scientific areas of specialization that Marshall is stronger than or more competent than other centers?

20. CHAPPELL: Yeah, I think if you break down into kind of into subdisciplines I would say in solar physics Marshall is about comparable to Goddard, and those would be the two best within NASA. In magnetospheric physics Marshall would be slightly less in numbers than Goddard, but the competence is the same. Atmospheric sciences, Marshall is modest in numbers of people, but it's excellent work. Goddard has many more people in atmospheric sciences, and JPL does too. In the microgravity area, Marshall is probably, in terms of quality and quantity, probably leads the agency. Lewis has some, and JPL has some materials that are . . . .

21. WARING: How much does Marshall have in the way of biomedicine?

22. CHAPPELL: Biomedicine is very limited. It's limited to protein crystal growth and cell separation and those kinds of things, whereas biomedicine as it applies to the human in space Johnson has huge amounts of that . . . .

23. WARING: Right.

24. CHAPPELL: . . . and would be dominate. Biomedicine as it applies to humans and to plants and animals, Ames has a very large activity there. Those two would be, in fact those two Centers sort of struggle for relative leadership in funding in life, what we call life sciences as opposed to biomedicine within NASA. Earth sciences we have, we have good people in earth sciences, far many times fewer than there are at Goddard. Goddard has a couple of major labs that just do oceanography and lower atmospheric sciences, and they do ground vegetation. They do oceans, land-ocean interactions. They do a lot in earth

science. We have, the people that we have although limited are doing some good things. Then the other one astrophysics, we've got good people in astrophysics across the board, but again much smaller numbers. So Goddard would be, Goddard, JPL would be, mostly Goddard would be more dominate in astrophysics than Marshall.

25. WARING: That's very interesting that in most cases other centers would have larger components in any of these subspecialities. Does that cause problems for Marshall scientists in competing for the research funding?

26. CHAPPELL: Yeah, but it, but it also, it's like the Hertz thing you know, or Avis I guess it is. It's when you're number two you try harder, and I think people do. The Marshall, Marshall scientists are more responsive to the science community outside of NASA because we're in a selling mode. We'd like to do more science projects and the other, particularly Goddard, would be dominate in so many areas that Headquarters would naturally look to them for many of these things. The way we, the way we went out on some of these is by being more, both more responsive to Headquarters and more responsive to the community that we represent. When a NASA center gets so many people in a given disciplinary that they dominate that discipline, then they tend to listen less and push more. So whereas our job really is to, at least I view our job as to being to respond to what the outside science community wants to a given discipline. So you don't go out and tell them what they want or tell them what they're going to have. You go out and listen to what they want, and we tend to do that more, and so we get a lot, we get an awful lot of support from the science community because we take that approach to it. So being the dominate one doesn't always make it the easiest for you.

27. WARING: So Marshall's relationship with the academic science community is different from that of the other centers?

28. CHAPPELL: Well it's similar in the general function, but it's, but in the spectrum of responsiveness I would say we were more responsive. We do the same function, that is we put together working groups of outside people. They decide what the next mission ought to be. We put the engineering talent on it to define the project more carefully and figure how much it would cost and then work with the scientist outside the Government Headquarters and work with the Headquarters and ultimately with the Congress to fund it. So that function, and then when it gets funded we build it. We have a working group of scientists that continue to interact as the thing is built. Then, we are now getting into operating the payloads too which we, I think is very very important which we didn't always do. Like we handed off Space Telescope which I don't think we should have done.

29. WARING: At what point did, do you think Marshall got into that operation? Is there a specific year where you think that changed?

30. CHAPPELL: Well, we started it, we got into it, let me delay that and finish talking about this other thing.

31. WARING: Okay.

32. CHAPPELL: The, so the function is the same. It's how you do the function, and I think we tend, we tend to approach the scientific community in a more responsive way. So what we end up doing as a Center, and there's shades of gray in this, but we tend to be more based on input from the outside scientists than from our own internal scientist saying "This is the way you do it and I'll go tell those guys outside that's what we're gonna do."

33. WARING: So, Marshall sort of plays the role of the middle man between Congress as the, providing the funding and the academic scientists who are doing the bulk of the research would you say that's sort of the way . . . .

34. CHAPPELL: Yeah, now our scientists do the research as well, but we are not, we don't try to dominate the field. That's where, when you're dominating the field you get so big on yourself that you stop listening to what other people are saying to you.

35. WARING: The federal, the funding is going directly into the Center. Say Goddard and they run the packages. They run things almost on their own?

36. CHAPPELL: Well, no. It all flows the same way. The money comes from Congress to Headquarters, is distributed to the Centers; the Centers implement; headquarters sort of has overview and keeps up with things and guides policy and guides themselves, the missions, and that sort of thing. Then the Centers actually build the stuff in conjunction with the contractor. So that works the same way both ways, it's just that it's the, really it's the communication. How much, how receptive is the Center to the input from outside. I know it's different because I've been, I was at one point in my career a mission scientist on a Marshall mission where I was the person at the Center talking to the outside community of scientists who had instruments on this shuttle mission. At the same time I was a PI on a mission that was being managed by Goddard. I was on the other side of the table, and it was very different. We were told each time by the project scientist what, the way it was gonna be in the Goddard mission. In the Marshall mission we were saying "Here's the challenge we've got, how do you guys think we ought to do it." There was a real different kind of a thing.

37. WARING: That's interesting, and that makes sense given that the structure you've told me about, but you know that sort of flies in the face of the perception many people have of Marshall. Marshall is secretive and a closed community and . . . .

38. CHAPPELL: And it's not. We weren't perfect in all these things, and there will be people in the Space Telescope community, the science, who will say Marshall didn't do this or didn't to that. A lot of that has to be looked in the context of how much money there was available. Like there was a big hassle in the Space Telescope of doing a second thermal vacuum test before they flew it, and it would have cost just an awful lot of money that just wasn't there. That could be, it wasn't done, that could be interpreted as Marshall as a institution wasn't responsive to the science community, but then you also look at that as the money just wasn't there for Marshall. There are cases where Marshall is probably heavy handed on projects, and because there's another interesting quirk in all of this. Prior to the time that Marshall started, before we had many of our own scientists, and the scientists who were here doing engineering support, Marshall dealt with some scientists from the management side and didn't feel particularly good about scientists as managers. They did that in the first, the first time that happened, I guess was in probably HEAO and Skylab. I know it happened in Skylab, and I forget which one came first. They interacted with some scientists who didn't do a very good job managing their investigation. Marshall was on one side giving the money to scientists for supposedly managing and getting it done. It left a bad taste in the mouth of many Marshall managers, and they just generalized and said well scientists just aren't good managers. That has shaped very much the way Marshall deals with its own scientists. The perception still is that scientists aren't very good managers even though they're ours, and so we better manage them pretty tightly. Marshall, and I don't know that I would want this in the book, but Marshall is the only place that I know of all NASA centers and of all universities, every place they're investigating, Marshall

is the only place where the Principal Investigator who is a scientist is not the leader of the investigation.

39. WARING: It's the chief engineer.

40. CHAPPELL: At Marshall, there's an engineer that's put on top of the Principal Investigator. It seems to work OK for all the rest of the world, but it doesn't happen here. I think it's because of this experience that Marshall has had being on the other side of the table, being the project, trying to get a project done and dealing with a flaky scientist at some other institution who didn't manage his or her investigation as tightly. That experience base has been translated into here.

41. WARING: Yeah. Do you think that's also perhaps just a natural prejudice of engineers? They feel their training designs them, their training prepares them to be more effective managers than the scientists could be?

42. CHAPPELL: I think there could be that feeling on the part of engineers, and I've done a lot of thinking about that because I don't think, my experience is that there is a spectrum of management ability in either scientists or engineers. Engineers can be very good managers or very poor managers, and scientists can be very good managers or very poor managers. It's not one versus the other, but it's where you happen to fit on either one of those spectra.

43. WARING: But the natural reaction at Marshall is that the, the engineer is the better manager for . . . .

44. CHAPPELL: That's right. Now there is a, recently I was talking to a guy named Richard Chapman who's done a study, he's doing some stuff on technology spin-offs, he's done a study of this. He brought in another point which I agree with, I think I agree with because I felt that I know within myself as I was converting from doing science full time to doing management and science. That is that engineers begin their careers with the idea that at some point they want to become managers, and so they make choices along the way to build up management skills because they see their career downstream as being a manager. So hence they're better prepared once they get there. Scientists on the other hand are very captivated by the research that they do, and many of them are not the least bit interested in being a manager. In fact there's still people on the Space Science Lab today who just are not the least bit interested in being a manager. Those, and many scientists who get into management get into it out of necessity and not out of choice, because they take on projects driven by the scientific appetite which is to learn something that nobody's ever know before. They have to build an instrument that's so complicated and costs 40 million dollars that they've got to have more than one person working on it, and they have to manage an organization. They have to get into that. They do it by sort of because they have to, and not because they thought that was where their career would go. In fact I remember feeling, and I guess it happened to me most recently in the past three years when I came up to this job knowing that I was going to be almost dedicated to management and would be away from this thing that I had been studying for twenty years and learning more and more and more. That was tough and it was a real, because I enjoyed management, but I was very dedicated to this learning in this area that I'd been doing since I was in school. It's not a, it was a choice I had to make, whereas I think maybe for an engineer, although many of them enjoy engineering, they enjoy doing things on the bench, there's probably less reluctancy to leave because basic research is something that's very personal. You're motivated by learning something in a given area, and you don't want

to leave it until you've figured it out. Work in engineering on the bench is, although there's some of that in there, it's not quite as much of being captivated by how it all really works.

45. WARING: And there are real affinities between engineering and management, in fact management as an academic discipline grew out of engineering in many respects, so there's a lot closer affinity than with science to management.

46. CHAPPELL: Now, there is a way that this all can work, and it does work wonderfully well, because I have friends all over the world that do it this way that are scientists. That is that you have, the scientist really needs the engineer if he's an experimentalist. He really needs the engineer, needs a good engineering talent. Scientists can understand the engineering, but they don't, they're not trained in it. The engineer needs the scientist in this area, because the scientist has the ideas of "God if we could measure this, then we can go measure this." That means that it's another instrument to build. So it's this wonderful combination, and that's the way it ought to be dealt with. It should be dealt with as a combination where they're just together all the time, and the scientist is thinking," God we could do this, and we could to that," and the engineer is thinking, "how are we going do this, how are we going do that?" So it really could work wonderfully, and that is the way it works at other places. The principal investigator because it was his idea and his basic research motivation which he wrote a proposal about and got funded, he's the main person. Almost inseparable from him or her is an engineer that's just a primo engineer manager, and they live together, and they know, and they're all the time talking to each other. The new technology the engineer finds out about the scientists learns about it, and then they think well now we could go do this, now we could do that. That's the way it really can work. It works wonderfully well, but Marshall has not been able to bring itself to have the engineer be even the least bit subordinate to the scientist.

47. WARING: What are some of the consequences of that? Is there a common pattern that results from that?

48. CHAPPELL: Yeah, one thing is that it is very, it is, as you might imagine, it is not completely comfortable for the scientist who sees his or her peers every place else in the world as the leader of the investigation and for some reason because they're at Marshall, they're not good enough to do that. You feel that.

49. WARING: Does it lead to turnover problems amongst scientists you think?

50. CHAPPELL: I think to a certain extent. I think we've probably lost some people who, who couldn't be comfortable, because we're bringing in this period where we're increasing, we're bringing in superb people. They were coming from places where they were running their whole show, and they get here and all of a sudden somebody says, "Wait a minute, you can't build that instrument. You're going to have to work for this person to do that even though you wrote the proposal and got all the money." I think it's led to some of that, and the feeling's not quite as comfortable. It leads to very strange organizational things, because the scientist really is the one that knows what they're trying to accomplish, and is the one that's in the best position to make the trade-offs if you don't have enough money, which science are you going to sacrifice. They're really, if they're very aggressive, they are the leader. They are the reason that the whole thing happened in the first place. To then put them in some sort of strange structure, and we try to, the way we manage our place it has a lot of strangeness to it because it's trying to work around this abnormality. The strange structure is felt by people too, and it's not run as, I think it probably doesn't end up being as closely nit and efficient as it could be if it were done the way it's done at most other places. That's something that's significant to scientists at Marshall. I don't know in the context of what y'all are doing . . . .

51. WARING: Yeah well, it would be interesting to see how that fits in, but that's, that's something unique to Marshall. Perhaps that, when we get into some of these individual projects, it'll, it could play a role. So what you're saying then is that in many ways there are a lot of similarities between the way Marshall manages a technology project like the shuttle and the way it manages a science project?

52. CHAPPELL: Yeah, and the difference in those two is that there is a science community out there for the science project who needs, which needs to be heard because that's why you're doing the thing. Whereas in the case of the shuttle, there is no science community out there. They are, it's a technological capability and the engineers within Marshall and the contract to design it and build it meets requirements that somebody has put down, and you have to do trade-offs. But there's not another ? which is the science community giving you advice.

53. WARING: Yeah, so there's a different set of negotiations . . . ?

54. CHAPPELL: There's a different set of negotiations. For the shuttle, you know somebody lays out how much you got to launch and how much it can cost and how long you have to built it and here's the money. The engineering manager then at Marshall gets his contractors, and they set it out to build the thing. In the case of the Space Telescope, the science community decided kind of what they wanted to do, and it ends up in specifications. Somebody gives them money, there's an engineering manager, but then there's a group of scientists who are building instruments for it, and they needed to be responsive to them. So you get this additional role of the project scientists which is the person who is supposedly in the same organizational block as the project manager, but is the project manager's link to the science community for which this thing is being done. Then there's the other contract

organization that's building the thing. So the role of the project scientists at Marshall is important, and is, I would judge although I haven't worked at the other Centers, I would judge though that the role of the project scientist at Marshall is not quite understood as well as it would be at a center like Goddard which does almost all science things. Just about every project that Goddard builds is for a group of scientists. You know there's one kind of satellite or another that they're gonna measure the oceans or the sun or the stars or whatever. There's a group of scientists, and they're used to doing it that way, whereas we're not because all our heritage up until HEAO or Skylab is non-science. So we today have not yet worked out fully in my estimation as responsively as we need to the role of the project scientist and how that all fits in.

55. WARING: Could you say that because Marshall, in a sense you can see how this would work, well let me put it this way. Marshall has gotten a lot of the big science projects: HEAO and Space Telescope.

56. CHAPPELL: . . . and AXAF.

57. WARING: That's right, and Goddard didn't get those. Is it because that special combination of engineering and management and science that Marshall can bring that allows them to win those projects, whereas the science dominated centers like Goddard tend to be passed over? Do you think that's, it's a sort of a strength in a way of Marshall's science capability that they . . . .

58. CHAPPELL: I would say in the case of HEAO and Space Telescope those, the assignment of those to us was before I was here, so this is hearsay. I would say that was done, they were assigned here more because of the engineering strength of the Center in doing big things than our science strength. In the case of HEAO, High Energy Astronomy,

we did not have much. We did some, but we did not have much in the way of astrophysics here, not anywhere near compared to what Goddard had, and with the Space Telescope we had almost no visible astronomy. We still have very little visible astronomy. They hired Bob O'Dell to come which filled a square, but again I think it was Marshall's ability to manage big space systems that was the attractiveness for the Space Telescope. That, as we built up our science capabilities in the 70s then we were in a stronger position to lobby for science praise, and what, the Center management consciously did that I mentioned that a while ago. It works, so that you, we are in a better position today to lobby for getting given science projects because of our, our science expertise in addition to our engineering abiiities. So they both work together today whereas in 1970, we didn't have much science strength. We got science projects probably based on the fact that they were viewed as very significant big engineering jobs which Marshall was better equipped to do having built the Saturn than somebody like Goddard who had been building much smaller satellites. I imagine the decision was made on the engineering and engineering management relative abilities for those early ones. It's different now.

59. WARING: Yeah, well, that makes sense. Do you think there is a common life cycle to science projects? Do they all sort of begin and proceed and follow a certain pattern? Could you describe that?

60. CHAPPELL: That brings us back to the operations thing again which, which I didn't get back to. The life cycle, the way it works is that every science project is the foundation for the next one, the way research works. You get a certain, you get so far off the mountain with one development and then you can see even farther and then you know what you need to do and technology comes along and you know what you need, where you need to get next. So every time you do a science project you realize what you could really do next time, the next time you try it. It's a self-perpetuating thing which advances knowledge as you go

along. The cycle begins with results from a given mission that you're flying. People come to understand things that they've never even thought of before you did the mission. It's just the nature of science. Then you think, OK now I've got to understand this so what is it that we need to build next? Typically the it works then there is a group of scientists with a common interest. They form, they talk to the headquarters people in those disciplines, and they form some sort of planning group, study group, science study group. They define a mission and then there's a period of time where that mission is compared to all the other things that people are bringing forward that ought to be done, and if it is good enough then, and you begin to get an idea how much it would cost, then it begins to be sold by NASA headquarters to Congress. At some point in there, we now tend to go ahead and put out an announcement of opportunity for people to propose on a mission even before there's money to build it. We do it in the, when it's in phase B as opposed to record the money's not there. You haven't gotten a new start, and so people write the final proposals. They're selected, peer reviewed, selected, and then you have a group of instruments for the thing. Then that group becomes the basis of sort of a support group lobbying group that hopefully pushes it along, makes all the final arguments to get Congress to agree to fund, to build the whole thing. Then you get a new start, and then that working group which in the, which is now the science working group as opposed to the science study group because they've actually been selected in response to an announcement, competitively selected. That group then becomes the science working group for the project. There's project manager, a project scientist, this group of scientists, and then a contractor is selected to build the space craft. The scientists tend to build their own instruments, although sometimes they have contractors help them build their instruments. Then, so then you go through the budget struggles. There's not enough money, and you usually descope something or you cut back on your aspirations for what it can do. The scientists build the instruments; the contractors build the space craft; it gets integrated, and then you go into the operations phase. Marshall's, we participated in the operation of HEAO. We participated in the operation of

Skylab which was in fact we, we went down to the Johnson Space Center, we didn't do it from here. We gave away, we were not able to do, whatever the political environment was in the Space Telescope, we were not able to, we didn't feel we could prevail in both building the telescope and the building the instruments and operating the telescope. So we built the telescope; Goddard built the instruments; and we transitioned Goddard to operate it. I don't think that's good. The Space Telescope experience doesn't think that's good, but it's not good in my mind for a very fundamental reason. The, you should have people operate the space craft who have really lived with it through the development and who are devoted to it. The scientists stay with it all the way through, but you really should, in my mind, the science project is not done until the operations are done and the data have been analyzed and you have the next set of knowledge. That is something that was new to Marshall, because the projects that we had built before were projects that once, once the engines burned out the project was over, and we went on to the next thing. So it was new for us to think about the fact that we were going to have all this data coming back. I can remember comments that various people made in the early years I was here. I was saying what the hell are these guys going to do with this data! It was just different. It was just really different. The idea of taking or operating something for fifteen years to get data, fifteen years after the real job had been done which was the engineering job was new. For Goddard it wasn't new because that's all they'd ever built was scientific things and for JPL planetary missions go on for years and years. They're used to that. I think that was different for Marshall, and then this transitional period of HEAO, Skylab, Space Telescope we weren't, we said to ourselves and the people here still say we don't want to waste our good engineering talent doing operations. Let's go build something else. We're development, that's what, we're a development center. We're not an operations center. Well and we are a development center, and we're not a dominant operations center, but the difference is the scientific project is not really done until you've done the operations and the date analysis. It was important for the Center to come to want to do operations,

and we did. We did a little in Skylab. We handed off Space Telescope. We sort of supported HEAO although the Smithsonian ran a lot of that day to day things. We really got into operations with Spacelab, and we did a very good job with that because we're very responsible. There was a more and more operational capability that was built up and then more and more scientists came here with the scientists knowing that the Center ought to be doing the operating, the Center ought to operate the science missions we build. It just doesn't make sense to hand it so somebody that hadn't lived with it for ten years and who's not necessarily devoted to it. In the, in the Space Telescope transition it was difficult to get Goddard to really grab hold of it because it wasn't theirs. They didn't have this commitment. Now we're adjusting. There's still people in Center management who worry about 'we shouldn't move to much; we don't want to get to be like JSC; we need to be a development center.' My response to that is that we need to do both. We do need to be, we are dominantly a development center, but for those things that are science missions we ought to do the operations too because you don't finish the job until you do that. It's not fair to the scientists for the Center to just sort of bow out of the job right when you get to, what for them is, the fun part as the new knowledge.

61. WARING: Well that's interesting that many people at Marshall would resist that operations role, because speaking as an outsider, one would think that that would be where a lot of exciting work would be, that would be where . . . .

62. CHAPPELL: That's where the limelight is.

63. WARING: . . . that's where the limelight is, and that's, do you think that the lack of operations at Marshall has hurt its ability to attract support and prestige and that sort of thing?

64. CHAPPELL: I would say that it's, that it very clearly is limited, the recognition that the Center's gotten for what it has done. We built all of the propulsion for the Shuttle, and yet the Shuttle is very dominantly associated with JSC. We built the whole Saturn except for the last few feet, and the, but the moon missions are associated with JSC. We built the Space Telescope, but the major discoveries are going to come out of the Space Telescope Institute at Goddard. It goes on and on, and it shouldn't be like that. Now we're adjusting, so we've got our own operations center for Spacelab, and for the first time, in two weeks when we do Astro, the world is gonna be looking at Marshall Space Flight Center, which [is as] it should because we built the whole thing.

65. WARING: So you'd say it more affects the Center in terms of not getting recognition, but the funding and that would not be affected?

66. CHAPPELL: Funding is affected a little bit, but a lot of the decisions put things here are based on the engineering expertise the people know is here, and the ability to manage very large complex things. So within NASA . . .

67. WARING: . . . there is prestige . . .

68. CHAPPELL: . . . within the family you know, but go out to somebody on the street and they don't know. NASA is NASA, and all they know is what the television's looking and where the press releases, does the press release say Huntsville, Alabama or does it say Greendale, Maryland or does it say Pasadena. That's what people see, and I, that was another very strong, it's the right thing to do scientifically to operate the missions, and I think its the right thing to give credit to the engineers here who put so many years into building these things. It's the right thing that their center get clear credit for having done it. In a science payload that comes through the operations, and the discovery comes [end of

side of tape] . . . He would say be careful about this operation, because we don't want to get eaten up by it. I think we don't want to get eaten up by it, but I don't think we have to.

69. WARING: Well for an engineer building something is just creating a tool, and then they pass on the tool to somebody else, and it's done for them. For a scientists the tool, it's not a tool, it's a research device and what comes out of the tool, what you can use the research device is what's important. It's that different outlooks of science as an engineer again.

70. CHAPPELL: Exactly right. Now there are engineers who do operations. Their operations . . . .

71. WARING: Right. Right.

72. CHAPPELL: . . . so they're, they can carry on through. Even within NASA it's not always clear that the projects are set up right. At Goddard, they have a project scientist, a project manager, and then they have deputy project managers who worry about resources and technical. Really what they should do, and then once they launch things they operate them from Goddard, but they hand off the operations into another general organization that just operates satellites. I think that's not good because it, even though it is within the same center but again it breaks away, breaks this chain. It breaks it away from the people who have given ten years of their life to get it built and hands it to somebody who's had nothing to do with it.

73. WARING: Well you can see how that's irrational because you have the, there's a distinction between builders and users that probably does not make much sense in the scientific project because the builders know more about it than the users would.

74. CHAPPELL: What I've always advocated, maybe if I ever run NASA I'll get to make this happen, I've always advocated that there should be within the project organization, there's a project manager and project scientist. Then there should be deputy project manager for technical things, a deputy for resources, and a deputy for operations. All the operations deputy does is to plan for the operation of the space craft once it's launched. Then when it's launched, that person becomes the project manager. In other words, the technical and the original project manager who is dominantly worried about building the space craft, he goes on to build another space craft. The technical guy goes on to worry about building on another space craft, and this person now who's been with the project for a long long time and he's only worried about operations. He's lived through all the trials and tribulations of getting it built, and he becomes the leader and carries on.

75. WARING: So there's continuity.

76. CHAPPELL: There's continuity. The scientists are still seeing persons they've worked with for years and years, and they've all been through it together. It's not like somebody just said, "well we got the damn thing built so I'm going on to something that's more fun." That would never happen, but anyway I haven't prevailed over that yet. I think it would work. I think it would work if we did it that way. One other thing I might mention Stephen is that in terms of the, we've talked about science being a small, being a fairly modest part of what Marshall does, but I should reiterate and we've talked about this before, but I should reiterate that I view Marshall very unique among the NASA centers because we do both science and manned space flight. We're the only people that really does the two of those things comfortably. JSC does some life sciences, and they do dominate manned space flight, and Goddard does dominate science and a little bit, occasionally they get hooked into a shuttle payload for something. Marshall really bridges that and does both.

That is very important because in order, manned space flight can be very domineering. Those who do it, they want to fly people in space. That's their deal, and they're very dedicated to it, can be overwhelming. They don't view, they view the science as kind of a tag-a-long thing to get people into space. Their responsiveness to what the scientist wants is at a much lower level than it should be. Then there are the science people like Goddard who could care less about manned space flight, don't like it, attribute all sorts of negative things to it that aren't really true, some of which are, but just want to stay away from it. Then there's Marshall that does both, and so we're able to serve a very important function for NASA. We're unique in NASA. We've had deep history in manned space flight, and now we have good scientific work in a limited number of areas. We're able to bring those two together in the same center and have people who work for the same guy talk to each other and make it work better. That's why we were successful with SpaceLab, and we'll be successful with Space Station because of that unique experience that we had.

77. WARING: That's an important thing to bring out, and that's something that was new to Marshall beginning in the 70s, beginning with Skylab. It was not true of the first twelve years of the Center's history. The center was sort of born again. It was unique before, but it became unique in a different way. Why do you think, I have sort of some related questions, why does technological achievement in manned space activities tend to take precedence in NASA over other forms of science? Is it . . . ?

78. CHAPPELL: I guess I can think of two reasons. One is that a dominate part of our job is to put humans in space and to push back the frontier and to ultimately colonize space and live there and move the human species. Our charter says now that we can explore the solar system, permanently live in space, and ultimately populate the solar system. That's a big job to do that, but it's part of the job. The scientists who say, "we don't need all this manned space flight; we can do our scientific work with automated space craft," there

probably is a lot of the scientific work that can be done and should be done with automated space craft, but some of it requires human beings. A certain percentage of it, but that's not, NASA's job is not just to do science with automated space science, our job is to have a permanent presence in space and populate the solar system. If you are going to do that, you are going to have to fly people in space. As a scientist, it's sort of a self-serving thing, you know the Van Allen kind of stuff. He likes, and he's a good friend of mine, he likes studying energetic particles around planets. So the more money NASA put into that the happier he'd be. He doesn't, he's not interested in having people live in space. However NASA's job it to do that also. That's one answer.

The second answer that as wonderful as science is, and I'm a scientist and I'm captivated by the things that I've been fortunate enough to study and learn. As wonderful and all that is and as important as all that is ultimately to the public it doesn't get their attention. What is thrilling to the man on the street is somebody just like he or she is sitting on top of a rocket and is going to get shot into space and is going to live on a, and that's this, the relationship and the association and real linkage between the man out on the street and the space program is humans flying in space. Again I say that as a scientist. I believe that even though my science for years and years was more important to me than thinking about people flying in space. For the general public who pays for this they're captivated by the human element, and we have to, we should reflect that. NASA should reflect that. My response to the Van Allens is that the space science program has always benefitted from a healthy space project. It's not that the percentage, you can look at a chart and a percentage of money on the NASA budget spent of science has always been about twenty percent, and it never changes. When NASA's budget goes up it goes up; when NASA suffers, it suffers. It's always been at twenty percent.

79. WARING: That's a very interesting observation.

80. CHAPPELL: It's in their best interests, unless they just cannot come in touch with the reality, it's in their best interests to encourage a very strong space program, very aggressive space program both manned and unmanned, and they'll benefit substantially from it.

81. WARING: A related question is why in the wide perspectum of sciences has astronomy, astrophysics tended to be a greater beneficiary of the space program than perhaps some other experiments?

82. CHAPPELL: Well, it's varied. It is today. It is that way today, but it hasn't always been that way. There have been time periods where the planetary program was very dominate. The Viking mission to Mars, the Viking cost a billion dollars. Viking was flown in the mid-70s, fifteen years before the Space Telescope at a billion and a half. You back the dollars up or equalize the dollars from the early 70s to the Space Telescope. There was a lot of money to be spent on Viking, and we had Voyager going at the same time. The planetary has been dominate, and there was a time even I think when solar terrestrial was dominate. That was earlier on when we couldn't get space craft very far away from the earth. So we did an awful lot of things in the earth sciences. Astrophysics has been very successfully lately. I would attribute that to both the effectiveness of the astronomy community in getting its act together and pulling together. The number of astronomers in the world is large, and if they can stop bickering with each other and pull together then they're pretty strong, and they've been doing that. They've had excellent leadership. The past two guys who managed the astrophysics division have been very strong. Charles Delwin is in now. He's very strong, and Frank Martin before him was very strong. Before Frank, I think it was Bland Morris who did a good job too. Within the wars up at Headquarters over within OSSA struggling for the piece of the pie, the effectiveness of the division chief was very important, and those two guys were good. They knew how to work their, they're very adept at dealing in that environment.

83. WARING: And the fact that they have strong lobbying groups among scientists is very important.

84. CHAPPELL: That's very important Yeah. With planetary has weakened a little bit recently over the past five to seven years and their a leader up there was not that strong. When they had strong leaders they were ? . That makes, there's a lot of, there are a lot of decisions made in the smoke-filled rooms, and the guy who can make his case the best and work the system the best comes out.

85. WARING: What do you think had been the most important scientific achievements of the Center? Is there a sort of a hit list of most innovative or most long-lasting achievements, new ideas?

86. CHAPPELL: Let's see. There would be two categories. There would be the projects we've done and there would be personal discoveries of scientists here which you'd here a lot less about. Of the projects I would have to put Space Telescope and Skylab as very comparable for different, very different reasons. I think, I believe that ultimately in its fifteen year lifetime that Space Telescope will accomplish a very high percentage of everything we ever wanted it to do. Certainly greater than ninety percent and maybe a hundred percent particularly if you fold in the fact that scientific discoveries tend to come in areas and in ways that nobody thought about through the whole planning and design and development of the whole thing. I had a personal experience on a mission that I had an instrument on ? where we put the concept for the investigation together, we designed the instrument, we wanted it to operated over just a certain part of the orbiter because we knew that's were the most important stuff was going to be. In compromising with everybody else we had to agree to let it operate over another part of the orbiter where we

didn't really care anything about it and that's where all the major discoveries came from. That's the nature of science. Science is discoveries of things. The definition of discovery is something that you didn't necessarily think was going to ever do, it just came out of left field. That's the way science is. If you fold in the discovery factor on the Space Telescope considering the incredible capability that it is even with its aberration, it's going to just blow people away in terms of the science return. A lot of that, the stars will fall on Goddard Space Flight Center and the Space Telescope Institute and not on Marshall which is the reason I wish we were operating it from here. It's going to be tremendous. I would also put Skylab up there just because that was the first real merger of science and manned space flight, and it was very successful. The solar measurements off Skylab and Apollo Telescope were really neat. Guys are still analyzing their data and getting great things from it. The Earth Observation's pretty good. The medical experiments very unique medical experiments and a little bit of microgravity materials, but this idea of successfully bringing together science and manned space flight I would put that as the primo thing. That set us up to do Space Lab, the Space Station, and whatever goes next after that. In terms of personal discoveries, I don't know, I think that's more subjective. It would be harder for me to say, but they've been, maybe the right way to put it is that there been very significant scientific achievements on an individual level in all the discipline areas that we do in the lab, all four of them. I would, if I start citing individuals I would go on and on, there are very significant things. The investment that the Center made in scientists, in hiring scientists and adding this new dimension is really opening up another wing of the building as far as adding this new dimension to work the Center. To do that investment was a very good investment.

87. WARING: There are many people who, particularly old-timers who were there in the Saturn years, here in the Saturn years, who argue that the history of NASA has been a story of decline. Could you comment on that? There was this heroic initial period, and there

was less bureaucracy. There was a lot of money, and then after Skylab NASA suffered on their, with a lot less public support. They had less funding, and this particular view holds that NASA became more bureaucratic and hence the agency has declined, lost competence. How do you react to that, to that view? It's a view that sometimes comes out in the media. People are talking about the Shuttle and the Space Telescope too.

88. CHAPPELL: I can't argue with that in a general sense. You can't, you can't, you can't do things when you don't have resources. Bear Bryant said you can't make chicken salad out of chicken shit, maybe that doesn't apply. You can't take an organization and cut its budget a factor of four. This is what we're doing today. You can't take an organization and cut its budget a factor four and then look at it and keep judging it on what it was able to do when it had four times the resources. That's completely unfair, and yet most people, most, I don't if the media knows, it's never referenced in these NASA bashing articles. I'm sure the public, not many of the public knows what the NASA budget is, but it's never shown. It's never referenced and NASA is compared, NASA is looked at as an organization today and criticized because we can't do things the way we did them in the Apollo era with four times the money. That's rankly unfair. It is, the organization has bound to have declined in it's ability by virtue of the fact that it only has a fourth of the money it used to have.

89. WARING: Has Space Science declined in NASA?

90. CHAPPELL: Yeah, it's always twenty percent.

91. WARING: I mean in terms of the achievements? Do you think . . . ?

92. CHAPPELL: Let me just say I don't think NASA's achievements have declined anywhere like the factor four. I'd say through a heroic, it was heroic in the beginning and

you had heroes and money. Then for the next twenty years you just had heroes. In many instances even more heroes because they didn't have any money. They were doing, they were living, they were doing what they could do based on just grit and guts and experience. They had good experience, and there's still a lot of, NASA still, NASA has lost a lot of people with wonderful experience but still has a heavy element of very experienced people.

93. WARING: I think a lot of people who make that, who have that stereotype of NASA are judging NASA and has you say using very hard standards because in many ways the achievements of Space Science and the Saturn/Apollo years, although they were important, they were first steps. There are many dull but very important achievements that come out of all these, these small science or even big things like the HEAO. The HEAO observatories were very important, and most people would not know that those things existed.

94. CHAPPELL: This is something we mentioned a while ago. The science comes out of the missions, is dealt with in the literature which the public doesn't read, and finds it's way in the textbooks which somebody's child studies in the third grade and the tenth grade and in college, but the public never, you don't see that. The product that comes from the science is most significant to everybody, and the general public, although they don't see it, so they don't know. When a science mission goes off a launch pad at the Kennedy Space Center, there may be three column inches way back in the back of the paper that says a Delta launched a magnetospheric satellite today, and that's the last anybody ever knows about it. It'll end up in their child's science book ten years down the stream, and they won't ever know about it. When a human being goes off the launch pad, everybody knows about it, and we follow them on television. We watch them on television. There's no TV camera watching a particulated moon except in the planetary and you get the images and people

are aware. So NASA is seen by the public as the planetary program and manned space flight because that's what everybody sees.

95. WARING: It's sort of like an iceberg. People see one part of NASA and one part of its achievements. Then like all big science projects it's a specialized agency that produce specialized knowledge, and people are just not aware that that exists.

96. CHAPPELL: Getting back to your other question, I can't, I can't make myself agree with the general, today's new media's understanding of NASA as an organization who just shot and crippled and nobody's any good anymore and they can't do anything. I think that is rankly, rankly unfair characterization. I think that you have to say that NASA's overall ability to do things in a quantity sense is less today than it was at the peak of Apollo because we're dealing with one-fourth the resources. As I said to a group that I spoke to the other day, if you're running a business and somebody tells you that next year you're only going to have a quarter of the money you had this year to operate, you're not going to be able to do all of the things you thought you were going to be able to do. You probably won't be able to do the things that you do as thoroughly as you would have if you'd had four times the money. That's a real, that's there and people should, the public should, people should understand that and they don't, that the budget is very different. The second thing is that bureaucracies do mature unfortunately, and NASA's a thirty year old bureaucracy and it matures. The strange thing is I guess in my experience that declining budgets make the bureaucracy much worse because then you have to watch how you spend every dollar more carefully and that means more overhead of people and red tape. More people have to decide you can spend this ten dollars when five years ago it didn't make any difference because you had a hundred. This declining, bureaucracy's mature anyway even if their budget stayed constant because somebody will trip up once in a while, and the government's response to that is right a new law that applies to everything. In time the

bureaucracy gets less flexible, but if you combine that with declining budgets, it's even worse. That's probably endemic to organizations. It's not specific to NASA. I think it's very general. In those two things, the budget's very different and the bureaucracy is older would say that NASA cannot accomplish the magnitude of things it used to be able to accomplish in Apollo. However in terms of heroes, I think there's just as many heroes today or maybe more because they are trying to do more with less, and they're getting criticized for trying to do more with less. I'm not sure that's fair. NASA can't do the quantity things that they used to do although the public still expects that we can because they don't know. It still has the best people in government. It still has the most motivated people in government. I can't imagine, it's not even like a government agency, because people, people are just, it's the eyes on the stars kind of thing. People are just driven to accomplish things that have never been done before, and there are not many government organizations that have that kind of motivation level. So the knock, for the Congress and for the public to knock the best that it has is not prudent.

97. WARING: Is there, we've covered a lot of things here today. Is there anything else we haven't talked about that you think the historian of Marshall should be aware of?

98. CHAPPELL: There's a, I think there's a spirit of von Braun still around, and people are very driven to accomplish the things that they all dreamed with him. They're still going about doing it despite all the flack, despite the lack of adequate support, despite the setbacks. People are still going for it, and I'm just so anxious for the portrayal of this activity to be, to reflect this magic moment in human evolution. It's just got to capture that because that's so, it is what has been done here in conjunction with the rest of NASA, but so dominantly here because of von Braun's leadership and his dreaming and his abilities to, particularly his abilities. It's just very magic in the history of mankind, and I just hope the book's going to reflect that.

99. WARING: You might expect too much from an academic book, but we'll try.

100. CHAPPELL: I know it's academic, but still in an historian is a person that can see the big picture and can find the significance of trends of period of time.

101. WARING: That's right. There's no question that space exploration is something new. This is something new, and it's created in Huntsville, and in Marshall. Looking out the window here, it's created a new culture, new ways of thinking, new ways of organizing society, new achievements.

102. CHAPPELL: So much out of this place has permitted human kind to escape the earth. Think of the earth as a whole and here's the, the things developed here allowed human kind to punch up out of the, to get out of the rocks, to escape as von Braun says to escape the bounds of gravity. So many people have said it so many different ways. Here's this tiny place of a couple hundred thousand people that have made this thing happen. That is significant on the scale of the evolution of human kind and if you look at it in terms of human achievement and expansion of the human environment as a function of time over the millions of years since the first human walked on the earth, this is a huge jump up in a just miniscule amount of time. We're thinking several million years and thirty years have just gone like this to a new plateau. That needs and I hope that gets reflected.

103. WARING: Yeah, I understand that perspective and that's an important thing for us to develop. Another way of looking at that is yes there is, there are unique achievements that have come from NASA, but the way the historian views these things is what had done in space is a product of historical social trends on the earth. Obviously for our book to be a success, we have to show both that new dimension and show that it had a definite context in

a particular time in a particular sort of society, and this society had to do certain things in order to make that new achievement.

104. CHAPPELL: I don't know if I disagree with that. You're saying that an analogy might be that there are converging tides? There are converging trends in society which come together to cause something to happen?

105. WARING: Right.

106. CHAPPELL: I agree with that. and I think I would just modify that by saying that these converging tides or converging trends led to a huge spike in what society was able, and not in a significant little ripple on the water but a tremendous water spout of an accomplishment and achievement.

107. WARING: I suspect historians, you know that's obviously an important issue. Is space achievement an evolutionary process, or and in the short term say of fifty years maybe it is sort of an evolutionary perspective. From what you're saying, obviously in terms of all human history it's something brand new.

108. CHAPPELL: It created such a thrust upwards that human kind actually became able to escape the environment we had been trapped in or had lived in or evolved in since we became human. All of a sudden we got a new playground, and I'm convinced that hundreds of thousands of years from now that there will be species of human beings that are very different that will look kind of like us but will have very different kinds of characteristics because they've been living in low gravity all their life. They won't need all the muscular strength, and their heart won't need to be as big, and they'll be able, their head will be pretty big. That will all happen. It's happened over the past million years, and it will

happen over the next period of thousands of years as the species goes and lives in other places. That would be really significant, and then one day we'll find other creatures on planets or on other stars. We'll figure out how to get there. There's going to be a really neat exhibit in the Smithsonian called "What Next Columbus." It'll be, I'm on an advisory panel for it. Valorie Neal is designing the thing. It tries to conceive where human kind could be in exploration in the next 500 years. It's going to be really neat. If you think about it, we say today that we don't know how, we don't think you can travel at the speed of light. We don't know how to do that. We don't think that's physically possible. What did people think we could do five hundred years ago? Your top speed was twenty mile an hour on a horse, and so if you say based on where we are today and what we didn't know we could do five hundred years ago where might we be? What it does is it's okay maybe we'll figure out how to travel at the speed of light, and so how far could you get in five hundred years when you could get five hundred light years away? Within five hundred light years of the earth, there, the order of a thousand stars that we can get to, and probably a very high percentage of those have planets probably at the right distance to support some kind of life form. So five hundred years from now it may be really different. Anyway I just think this is the dawning of that. The things that happen here throughout NASA in this thirty year period was a dawn that opened this whole thing. People dreamed about it for a long time beginning with ? I guess, but this is where it happens.

109. WARING: Yeah, that's a theme we need to introduce, to not only show the origins but emphasize the significance and the consequences of firsts in space. Well very good.