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INTERVIEW WITH PETER BROUSSARD
INTERVIEWED BY STEPHEN WARING
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HUNTSVILLE, ALABAMA

1. Waring: Well let's begin at the beginning. Could you first describe how you got involved in space work in Huntsville?

2. Broussard: Well I can do that best by saying how I got involved period. I went back on active duty in the Army in 1952. My ROTC instructor's father was commanding General at White Sands. He asked me when we were driving up to Aberdeen, Maryland if I was interested in being posted at White Sands. I didn't think much about it, and it turned out I got orders to go to White Sands. I went to White Sands and was stationed there over a year. Then I got out and went back and got my masters degree. I went back out; we got married; and I worked at White Sands until 1960. I guess I just wanted a change so I came here in December 1959 and interviewed Dr. Haeussermann. He offered me a job, and I transferred here in July 1960. That's how I tied in with NASA. I came from the Army to NASA, and I worked there from July 5, 1960 until December 31, 1989. I retired last December.

3. Waring: What sort of work did you do during the 1960s?

4. Broussard: I started out in a systems and advanced research project. I did mostly projectory work and intercept audit work, mostly dynamics. Then Dr. Haeussermann asked me would I model mathematically the gas bearings that we used on the AD-5 and AD-3 stabilized platforms. I told him that I really didn't know anything about math, and he said well with a little conscientious study you can do it. I did. Really it's called lubrication, and I worked in lubrication from about 1962 until 1969. I was making mathematical models of the gas bearings, and then we branched off into more exotic thinks like [25?] bearings. I

won't go into how they work, but it doesn't require an external flow supply of air. We did things like grease bearings which was at the time pretty advanced. This was nearly all in-house work.

5. Waring: This was in which lab?

6. Broussard: That was in the old Astronautics Lab. I think they called it Guidance and Control Lab or something then. Now most of it is called EB lab. It's still EB lab. From there in about 1968 or 1969 we started on the Lunar Rover. I stayed with that until we finished it I guess in 1971 sometime. I was responsible for the navigation subsystem on it. Do you want me to just continue the sequence of what I did?

7. Waring: Sure why don't we do that.

8. Broussard: Until 1972 or there about, that work incidentally, all the prototype work on the navigation subsystem was done in-house. I would like to emphasize that because that was a change that came over the Center as time passed. We built all the equipment first, prototype navigation system together, and tested it here as well as at Flagstaff. On the basis of these tests we felt confident that the design would work, and it did work. It worked perfectly in fact. After that we had a contract with DOI to assist them in automating some of their underground coal mining machinery. I'm told this came about at a Christmas party, and unfortunately I won't remember the name of the DOI director. He challenged Dr. Fletcher with words to the effect that "If you fellows are so smart in automation and things like that why don't you help us in the coal mining business?" The challenge was accepted, and we stayed on that project from 1974 until 1982, first part of 1982. That's a little known endeavor that NASA. Very few people know it. The person in charge of that a fellow by the name of Gene Powell which Bureau of Mines or DOI were the same thing then . . .

9. Waring: What did DOI stand . . . ?

10. Broussard: Department of Interior.

11. Waring: Department of Interior, OK.

12. Broussard: He said that he wanted somebody to study this problem. There was one specific problem ought to make one specific system. He said "Either I want NASA to do it, or I'll go overseas and get somebody else to do it because the people here have played the same old tune over and over and over. I want some fresh eyes to look at this." We did, and we were very successful. For various reasons that we don't have to go into it was terminated in 1982 even though DOI wanted to continue it. They promised us a certain level of funding from now on. Some of the instruments we developed are in use in the coal mines. There was one coal company, Carbon County Coal Company in [67?] Wyoming, that used a depth measuring instrument that we made here. They saved an estimated $250,000 a month because they were able to use it. This was not written up or not briefed about it for what reasons I don't know. I can speculate, but sticking to the facts I don't know why. From there I went back to the Structures and Dynamics Lab in 1982. I stayed there until retirement. I was deputy division chief for the Control System Division.

13. Waring: Let's start going back through this. I have some questions for you. In working in the labs during the Saturn years, at first the labs were quite dominate within Marshall's organization. Then over time the program offices became more influential.

14. Broussard: That's right.

15. Waring: Could you talk about the relationships between the labs and the program offices?

16. Broussard: I'll do that by giving you an example, and it's one that I think about often. This was in about 1968. Another engineer, Billy Doran, suggested to me one day, "Why don't we make a study of the reliability of the Saturn gyros and accelerometers?" The split was he knew the instruments and records, and I had a background in mathematics and reliability. We did, and this has never been done before. We found that after about twelve hundred hours they started wearing out. These failures weren't attributable to anything else but wear out. They weren't random failures. They weren't early defects. They just wore out. This was important to us because these were lunar missions we were talking about. We went and gave a presentation to Herman Wiedner who was head of S & E at the time. It must have taken forty-five minutes. We had all the view graphs. We had the charts showing dramatically how the bottom fell out after about twelve hundred hours. He listened; we discussed it a little bit; and we went on back to the lab. About ten days later a memo came around from Wiedner saying that when a gyro and accelerometer has run a thousand hours, it is to be pulled off and not used again. I don't think the same thing would happen today. You would have tiger teams and this committee and that committee. Back then the labs and engineers would listen to you. That was good enough for him, why not listen to us? We did the work and we're presumably competent. Now days it would turn into a gigantic thing, but then one memo and that was all. That's what they called it from then on: a thousand hours, if you haven't launched by then take it off and put another one on.

17. Waring: Now there's more bureaucracy with the program offices so you'd have to go through a lot more layers to make decisions?

18. Broussard: Much more. If you are listened to at all. I don't see that. [106?] It's just a fact, and I've said that many times when I was working here the past few years. I would tell people, "There's a difference now. At one time, if the labs told you something that's what you did or you'd listen to them. Now, ..."

19. Waring: Can you pick a date in which you think there was a change or a program in which there was a real change?

20. Broussard: I think it was about the time of the Lunar Rover. We made the prototype of the navigation system. We took vehicles and altered them so we could do tests on them. We even made a vehicle except for the wheels. We didn't make that. We made everything else, suspension. It was a remote control vehicle, and we were doing that because they asked us to look into that possibility for a remotely controlled vehicle on the moon. This was all done in-house. We didn't contract anything out. Shortly after than it became apparent that when they started closing machines shops that we had probably the finest machine shops in the world. Seriously. The [120?] shop could do any precision machinery. I know when we were doing research in grease bearings one of the bearings was the hemisphere of about 1/8" diameter on to which had to be cut grooves. They were what is called [124?]. They crossed the meridians at the same angle. I had read a paper on this, and the man that had done research in this Dr. Midam in Holland said that it was very difficult to put grooves into a ball bearing curved surface. He recommended making a template and etching them in with acid. I went over to [128?] shop and talked to these fellows. There were four of five there. Abernathy and Snoody were two main ones I remember. They listened to me, and they said they could do it. In a few days they'd done it. I mean outstanding people, but they closed the [130?] shop. There were at least four good machine shops on the base at Marshall. One was in 1987; one was a building by the car pool; there was a [134?] shop which was across the street across from the fire station;

and there was a large one over, I forget what they called it, at the [135?]. That's closed. All that was closed.

21. Waring: What date was that? About 1970?

22. Broussard: It was in the early 70s. I can't tell you the exact date, but if I had to guess, it would be around 1972, 1973 something in there. I know that the [138?] shop did work for us in 1968 and 1969 and sometime after that, but in a few years they had closed it. The upshot is that you could have very little machine capability at one time.

23. Waring: During the Rover days you were still able to make prototypes for what you wanted to do the testing?

24. Broussard: That's right. We could make it all. In fact when we built a grease bearing at the time, it may still be for all I know that's been twenty years ago, it was the heaviest grease bearing that had ever been built. We built it right there. We had the materials. We had the bar stock, twelve inch bar stock of 41/40 steel. We cut that off, and gave them some drawings. When I say drawings I don't mean real high class drawings. Those guys were good. I still have that drawing somewhere. It's the one they went by. They just took it [148?]. The fly wheel and the bearings at the end completely out of the stock had weighed forty-five pounds. It was really a CMG type configuration control on the gyro. After that it is very difficult to handle on a machine. I think that machine shop over across the street from Astronautics too. They had a lot of machine shops. That all stopped, and most of us contracted out which is way more expensive, far more expensive and far less efficient. You can work hand in glove with the man that's doing it. He could call you and say, "I don't understand this; come over and talk to me." Contracting out is very slow, and you may not get what you contracted for. I'd say it started about then where more and

more stuff went out to the contractor. The people at Marshall were put into the role of overseeing, monitoring they call it, which is sort of an euphemism. It's not a very satisfactory way. Besides the young engineers don't have the experience of actually doing it. They don't know what it takes to make something. Consequently when a contractor proposes something, many of them now aren't in a position to say that's not that hard because we do it all the time. It just lost that experience. I think that has really changed for the worse too.

25. Waring: Do you think it's not just a loss of machine shops? It's the loss of the hands on experience that engineers get?

26. Broussard: Right. It's not a total loss. There's still some places. For example in EB lab and the ED lab, the only two I know well, there's still a pretty fair amount of hands on experience with electronic equipment; with the wind tunnel that belongs to the ED lab, some sophisticated simulation and computation of fluid dynamics. They do that. Also if you've ever looked across the street from the fire station, you probably know where that is, they have a wind tunnel facility, so we still have that. As far as making things in-house, that's been largely lost. Some of the things are made by constructors, but they still operate them there. It's not totally gone, but there's been a shift of the labs up to the project offices and things like that.

27. Waring: Now when you were working on the navigation system for the Rover, was all that equipment built in-house?

28. Broussard: Just about everything. When we started off, we thought we needed a more versatile vehicle than we really did for tests. We bought an [182?]. They're all terrain vehicles that cost us fifteen hundred dollars or something like that. We put the navigation

equipment on them and tested them near the airport by Anderson Road to convince ourselves that such an approach using the directional gyro and the odometers on the wheels was sufficient to navigate the vehicle. That was proven out. The next thing we did is we bought a new Jeep and a new travel [188?], a GMC, and put navigation equipment in it. We went out to Flagstaff and did [189?] similar to the ones what you would do on the Rover. Everything we tried indicated to us that it would work. What Boeing had did, I won't go into detail on this, in all that was to bring Sonny Morea into it. Incidentally, I think a lot of Sonny Morea. I think he ran a good program.

29. Waring: I've interviewed him.

30. Broussard: Do you think he was booted out?

31. Waring: No.

32. Broussard: No?! After we had our first successful [195?], Apollo 15, they removed him. I won't go into that because it's politics, but it was a low blow. He ran a good program, and he did listen. I was going to say how this benefited us doing these tests and being able to do them in-house and quickly. I don't know the time, but from the time we started it was only three or four months, something like that, that we had enough results that we believed that we could do it that way. The contractor on the other hand, he wanted to build a sophisticated unnecessarily accurate unproven undesigned strapdown system. We don't need that. We didn't need a strapdown system. We needed one of the simplest inertial systems you could use. We argued with them, and Sonny was listening. Finally Sonny said well do it the way you think. We went ahead with the way we'd done it. We knew we couldn't be very far off. That's why I say he was a good manager.

33. Waring: This was an example to Marshall's conservative approach to engineering?

34. Broussard: Right, and realistic and efficient approach. It was "just try it." You have the stuff here, the people to put it together, and try it. Now you be hard pressed to do the same thing we did. Mostly in terms of making things.

35. Waring: When you were working on the navigational system, was there was any contact with people from Houston at the Johnson Center?

36. Broussard: There was some. I don't remember his name, but there was one young engineer that came here several times. That was most of the contact that we had with them on the navigation system. They made one contribution that I always said if I had of stolen an idea, I would have chosen this one. What the idea was we did on the navigation system. When you land on the moon, and they get into the Rover the question is how do you know which way is Lunar North? Lunar North is determined by its axis of rotation. We really hadn't addressed the problem. I guess we were so tied up in proving the main volume that nobody thought about it. Somebody in Houston came up with the idea, and I don't know how much it cost but if it cost over fifty dollars it was too much. What they put on the dashboard of the instrument panel of the Lunar Rover was a little straight line scale marked zero, one, two, three on each side. Above that on the hinge arm was a pin. You raised the arm up an there was a pin hanging down. If the astronaut drove the LRV around until the sun hit the pin and cast a shadow on the scale, he just maneuvered it until the shadow was on zero. It didn't matter. It could be on one or two or three degrees, but normally on zero. They know from the fibrous what his orientation is on the moon. From the fibrous you can tell. You pointed forty-eight degrees east of North so they targeted his gyro around till it read forty-eight degrees. Now he knows where Lunar North is. That was slick, but everything was nothing. It was just what I've said. I could make one here

probably, not as good.

37. Waring: It was essentially like a sun dial?

38. Broussard: Yes, a sun dial of course. Good thing for a sun dial. That's all it was.

39. Waring: Is that because of the way the moon is always oriented toward the sun?

40. Broussard: Yes. On a full moon ? you can see if he's looking that way the sun's over his back than he must be pointed so many degrees from Lunar North.

41. Waring: I see.

42. Broussard: That's an example of how, I think that was done at Houston. I don't know who did it, but it was a very good idea. We'll give him credit for that. I'm not sure he'd thank me.

43. Waring: Did you get any feeling of jealousy from . . .

44. Broussard: There's always been rivalry between Marshall and Houston?

45. Waring: Can you think of an example of that on the Rover project?

46. Broussard: No. I really can't because we took the ball and ran with it here. I don't think they had time to mount much of an offensive against us. We just took it and went. They did make that contribution.

47. Waring: Can you think of ways in which working on the Rover was alike of different working on some of the rocket technology with Saturn?

48. Broussard: Yes, the biggest thing was that you work with really a whole subsystem as opposed to say the work I was doing before that where I worked on just a component of say a gyro or a control gyro or relatively small part. At that time that we were working on the gyros and accelerometers, we did not make them anymore. We had previously but they were supplied by Bendex. We did some balancing but no making from scratch. As far as an engineer is concerned that's a lot of the fun just to make it from the very beginning. That's what we were able to do with the navigation subsystem. We could make, except for the gyro, we didn't make that, We started out with a terrible directing gyro. It was old, and it made a lot of racket. You could here it running all over the lab, but if it was accurate enough and that's all you needed. It did not have to be perfect. That's one of the differences.

49. Waring: Did your group working on navigation have to change your approach to testing when working on this system? Was that any different from the Saturn days?

50. Broussard: In a way it was. It was in a sense less precision. It was not nearly as exotic. We were being pragmatists.

51. Waring: If it got within a hundred yards of the LEM you could see it.

52. Broussard: That was close enough. I will say though, the difference I've noticed between twenty years ago and now. When you look at some of the programs they have now and I'll mention one by name, the ETEP Satellite, which I worked on three or four years, I think one of the reasons for the success of the LRV was that we had a schedule. I think we

had seventeen months from the time the contract was left until it was placed on Apollo 15. I do recall being in a meeting with Petrone about the Lunar Rover. One of the people there I don't recall, it wasn't Sonny Morea, told Petrone that it didn't look like that they'd be able to meet the Apollo 15 schedule. Petrone says well Apollo 15's going to leave on, and he named the date, July the twenty-something, the unit will be on it or not be on it. They found ways to be on it. It was that kind of thing, they had a schedule plus a man that was firm about it.

53. Waring: Do you think that firmness on schedule made engineering easier?

54. Broussard: Yes, a lot easier, because there were no insurmountable problems. If you do have one, that's understandable. But a lot of times you'd say well I'm not quite ready.

55. Waring: You'd try to make things very perfect when you have lots of time?

56. Broussard: Right. We just had to be on there. Like he said it was going with or without us. Dr. Rees was another good example. I thought he was very good. He had a sense of humor but he was practical. I know we had to get [208?] to review each person and stand up and say was his subsystem ready. Reider like to talk about his problems but he was hard to put to the touch. We'd had such good success with our navigation system that Dr. Rees asked me, I'd given my presentation of tests we'd done, and he said "Is it ready?" I said "Yes Sir. It's ready. The only thing that we would error on this was the amount of slip between the wheels of the Lunar Rover and the Lunar surface. We have no way of really determining that it's a vacuum. We'd tested on sand who's composition is very similar to the moon, but we hadn't, it's not under vacuum conditions. Even then, if we are wrong, we'll be wrong in distance, how far we went. But as far as being able to come back to the LEM we'll be able to do it."

57. Waring: The direction . . .

58. Broussard: It clarifies direction but distance would be off. It turned out the distance was right on. In fact they used the navigation system to determine precisely where the Lunar Module landed. We knew we were on [326?] but how close? What they did was they set out and found their first two landmarks. By using the navigation system, they could triangulate back to where it was. It turned out that they were about four hundred yards off something like that. I thought that was pretty slick. I didn't think of that either. I don't know who thought of that. Houston might have thought of it. Anyway this engineer got up, but somebody made the comment about the motors to the wheels on the Lunar Rover. The director of the lab that was responsible turned to the engineer that was responsible and said "Do you have anything to say about this?" The engineer said, "I could but I'd rather not." Of course that tore Dr. Rees up. He turned around. His exact words were, I remembered them. He says "What do we have here? An engineer that doesn't have confidence?" The guy shut up. Actually the motors worked pretty well. They had a little trouble I think on the drive, but it disappeared. I might add that if you talk to people who worked on the Lunar Rover, nearly all them will say that's the best project I ever worked on. I've talked to many who have said "Man that's a good project."

59. Waring: It was a small project. Weren't there fewer people working on it?

60. Broussard: They didn't have that many people working on it. It wasn't that expensive. Well the contract, I'll give you rough figures, was for around twenty million, and it ended up around thirty to forty million. The latter figure what the government estimate was to begin with. It would be about thirty-eight or forty-eight. I think that's how Sonny got crosswised with records. They held that against him. Saying as how it turned out to be the same as the

government estimate wasn't a good defense.

61. Waring: Right. I should have asked him about that. He didn't mention it in that way, and I didn't think of it in that way. Although we did discuss the budget in quite detail.

62. Broussard: Yes, he's not the type that would really say too much. I told him, "Sonny when you have time, I want you to tell me the circumstances surrounding your leaving." As I recall that's basically what he told me.

63. Waring: That makes sense.

64. Broussard: It wasn't for lack of success, it was a howling success. Have you ever heard of a manager being taken off after a success like that?

65. Waring: Why don't we turn to the mining business? What expertise did Marshall have that caused the Department of Interior to come to Marshall?

66. Broussard: We had such a good reputation, and it followed on the heels of the Lunar Rover and the other Apollo shocks. That was it. I guess the head of DOI knew Fletcher, and I think it was half the challenge anyway. It was accepted, and we didn't have many people really working on it.

67. Waring: How many would you estimate?

68. Broussard: I'd estimate fifteen or twenty. Like Palowitch said, he wanted somebody who didn't know anything about it which at the time I though that might be a cute thing to say. Since then I've realized that it's probably a smart way to go.

69. Waring: What was the man's name?

70. Broussard: Palowitch, Eugene. It turned out that you had to learn a certain amount but not that much. You didn't have to know that much about finding your way around in a mine because people [384?]. You had to know a little bit about how the machinery worked; how they operated it then; and what they'd like to be able to do. But that didn't take too long, and from then on it was just mostly do you have any ideas. What ideas do we have on how to do these things?

71. Waring: Can you outline the specific sorts of technologies they wanted help with?

72. Broussard: They didn't say technology. They left it up to us. If you could use a ouija board or chicken guts that would be good too. They didn't care. If you just think of this room being filled with coal and the ceiling being rock, coal is surrounded by rock on each side. Frequently they had a catering to want to cut say to within six inches or a foot within the ceiling and leave that coal either for roof support or sometimes because the of quality of the coal. The question is how do you know you're six inches or a foot from the ceiling? There are two ways, only one that's really feasible. I'll just go into the way we use, and we did not invent this idea. I understand it came from geology, but I don't know. Rock has a residual radioactivity in it, gamma radiation. We built a counter. What the counter did was you put it on a machine, and it looks up. It counts the number of gamma rays it's getting from the roof. You can calculate the foot print on the roof. The more coal you have between the roof and the ceiling the fewer the counts because the coal scatters the gamma rays. So you just [411?]. Like I told you we made several of those and they are still being made. A man that was in that office retired and went into business making, and I don't know the details. I know he's still in the business because it's a very effective way of

doing it.

73. Waring: This is a fellow from the Bureau of Mines?

74. Broussard: No, from out here. From Marshall. Bob Pease.

75. Waring: Was that the main sort of technology that Marshall developed?

76. Broussard: Yes, you sat and thought now how could I do that? We did more than that, but that was the one that I told you that saved so much money out there. They had a tremendously thick seam. It ranged anywhere from sixteen to twenty-five feet thick, and they couldn't cut all of that. You'd have drums in the front up and drums in the back cutting down. They just don't extend that far. They wanted to avoid in that case the last top two and a half feet of coal because it was high sulfur coal. They just put on that machine and looked at the readout. It tells them how many inches of coal they're leaving that's good. What they have to do before that was to drill bore holes. They'd drill and drill up which took an average eight minutes. You drill until you saw white putty coming down which meant that you'd hit the rock. They told us that $250,000 a month was saved using this. We went farther than that. We looked at other instruments too. One was a sensitized pick. The drums you'd cut with had picks in them. Sometimes you would like to take it up all the way up to the rock which is a different problem. How do you do that? We made a sensitized pick. As it strikes the rock the force on the pick is much larger. You can use any kind of strain measuring device in a resistance. It'll tell you it's much higher. You can back off from the rock.

77. Waring: Was there any sort of off-the-shelf space technology that was similar to that [449?]?

78. Broussard: No.

79. Waring: Marshall was being inventors.

80. Broussard: Oh Yes, that's what we did. We used a lot of available equipment, but frequently you just design it yourself. That was successful, but not quite as successful as the background camera. We took this automated system and used it we used it on a mine that the Bureau of Mines had in Bruceton, Pennsylvania. We automated the whole thing above ground. We started out with a large computer which was far, far larger than what we needed. One of the dangers of getting a contractor to build you something. The more expensive, the bigger it is, the more money they make. It worked. The response time on this drum, or the requirement on a command to the drum is so slow, we're talking about five and six seconds, that we finally took a Hewlett Packard hand held programmable computer and sent the signals to it. It calculated them. That cost us $200.00. You didn't [474?]. It was plenty fast enough for the rate in which the machine advances. Sometimes when you go in you see things that people that are exposed to don't see. Not because they're dumb, but because when you've always done something one way there's a tendency to keep on. You don't question it. We noticed that any records you wanted were recorded on the strip chart. Now strip charts are fine for a quick look, but if you want to do analysis you don't want them on a strip chart recorder. We got to thinking about it and said well why don't we take an explosion proof box; we had to learn all the rules and regulations about explosive prove containers because they are very careful about that in the mines. We said why don't we use that the same Hewlett Packard computer and a micro cassette recorder and have the input go into the recorder, program the computer, so that when you got your data you could go ahead and record it. The computer could be run for twenty-four, thirty-six, up to three days if you wanted to monitor methane, or wind current, strains,

vibrations, any of that. We had it rigged so you just rewind it, punch a few magic buttons on the computer, and analyze the whole thing for you -- standard deviations, give you a plot of it and also do statistical tests like trend. Is there a trend toward say more methane? It could do trend tests for you. It could print out at the end yes there is a trend toward more or no there isn't. They didn't have to do anything just install it. You would have to be trained in a computer. Just open the box, rewind it, and sit there a for a few minutes and it would give you the answer. We thought that was pretty clever. I notice that now it has been adopted by the Bureau of Mines and some mines. I saw a newsletter a year or two back. We thought that was pretty good. In that case it really involved no new technology just thinking about what you were doing.

81. Waring: What was that devise called?

82. Broussard: We called it a Data Log.

83. Waring: A Data Log?

84. Broussard: Yes. I don't know what it's called now, but it logged data and also analyzed it. The one they came out with however does not have a small programmable computer. It's mostly recorder. You do have to take it topside and have a larger computer analyze it which I think defeats the purpose. These you could give to anybody and say hook this to your methane detector and take the signals. It'll record it, and when it gets through you'll know what you have, requires no skill. Just open the box, rewind it, punch these buttons, let it go and after a while it'll spit out the answers which I think was far superior and much cheaper.

85. Waring: Who was your group working for? Were they working under a sort of contract

with the Bureau of Mines? Who paid for this?

86. Broussard: Bureau of Mines paid for it. At the time it was around two million a year. They paid for it. They paid our salaries, and they paid our travel. They paid for whatever equipment we used. I think it was a great set up.

87. Waring: Were you guys teased about this from your colleagues? You know aerospace people working underground?

88. Broussard: Those few who knew us did some teasing, but a lot of people didn't know and still don't know. It was a challenge. It was the kind of thing you could sit and think long hours about. How would I do this? What would I do? What made it doubly hard was it was such a hostile environment. Everything about it is hostile. There's dust, shock, vibration. Incidentally I found working with coal miners very pleasant. They were always cordial, nice people, but they live in a rough environment, and they're pretty on stuff. You have to prepare for that too. They have to go on about their business so you have to be able to make things so they will withstand the thousand natural shocks they're going to get either from the environment or the miners.

89. Waring: That was a sort of similarity with preparations for space work right? In working in space you're preparing for a hostile environment?

90. Broussard: Oh Yes, except in space it's really in a way more benign. I'm serious. In the natural environment of the miners, like I say they're fine people, but they are a lot of it is sledgehammer stuff. I saw one time in a mine the motor that drove the conveyer belt underground overheated. What do you do then? Get another motor? No. This minor disconnected a hydraulic hose that contained a solution of sort of mulch of water and oil.

Under high pressure he took it and sprayed the motor down. That's what you do. He cooled it. Of course things don't last as long there, but they've got to turn out coal. That's money.

91. Waring: That's right.

92. Broussard: Anyplace else you take the motor off and put another on. Do it that way. They were very nice people. I enjoyed working with them.

93. Waring: What was the relationship between the coal group at Marshall and private business in the mining industry?

94. Broussard: Do you mean the coal mines themselves?

95. Waring: The coal mines, or companies that were providing equipment for the coal mines. Could you talk about that?

96. Broussard: We didn't have really much to do with the companies that provided equipment because we weren't really competitors. They weren't really supplying anything we were doing. Now the coal mining companies themselves were always agreeable because it's money to them. Unless it's some hair brain scheme they were agreeable to us doing tests. We did most of the tests at Old Ben Coal Company up in Benton, Illinois. We did some out at Britain, New Mexico. I've forgotten the name of it. I'll think of it after a while. It's right outside of Britain, New Mexico. We did some sensitized pick tests there. They were generally agreeable to it. Anything to help them get more coal out they were in favor of it. You have to be careful to work on a non-interference basis which means that you have to be attentive and study sort of the lay of the land and determine what you could do

without really interrupting anything. Most of the time we could do it. They didn't have to stop for us very often.

97. Waring: When Marshall had constructed these devices who in effect did they belong to? Did they belong to the Bureau of Mines?

98. Broussard: Bureau of Mines. They did. I don't think we kept anything from them.

99. Waring: Who were some of the leading members of the coal mining group?

100. Broussard: I worked with Dick Stein who's retired. He's down in Birmingham now. I talked to him today incidentally.

101. Waring: Bob [620?]?

102. Broussard: Bob [621?] right. Dick Campbell. Dick Campbell runs Campbell Engineering now. He left shortly after that and started his own business.

103. Waring: Was their a name to your organization? Did you have a . . . ?

104. Broussard: I think it was called Mineral Extraction Office.

105. Waring: Mineral Extraction Office. Was there a lab you worked under?

106. Broussard: No. I was in that office, and we were located in 4200, 4201, and 4202. I was the technical manager for it. I guess Bob [636?] was the manager. I took care of the technical end. I worked directly with the people in the lab. We'd get together and talk

about what would be a good idea, what would be good to try.

107. Waring: What labs did you work with?

108. Broussard: With EB. Nearly all with EB lab.

109. Waring: Well, we went through a lot of stuff here. [turn tape over] Were there annual reports that came out of your Mineral Extraction Office? Were there progress reports of any kind?

110. Broussard: There were progress reports, monthly progress reports.

111. Waring: Do you know where those would be stored?

112. Broussard: They certainly should be in the documents out at Marshall.

113. Waring: In the Documentation Repository?

114. Broussard: They certainly should be. I don't think I have a copy of any one. I do have the final report somewhere. Dick Stein and I wrote it. Our names do not appear on it for some reason. This is probably the only document where there's no author's name where it says author. Don't ask me why it didn't. Somebody saw fit not to put any names on it. How's that. If you're looking for the author it won't be on there.

115. Waring: OK. I'll look for that. Were there annual reports? Do you remember making those?

116. Broussard: No. Monthly reports.

117. Waring: Monthly reports and then a final report?

118. Broussard: Yes, a final report. It was written in the first part of 1982 if that will give you a clue.

119. Waring: OK. It will. We'll look for that.

120. Broussard: Or the last part of 1981.

121. Waring: OK. Why was it discontinued? You said you didn't have direct knowledge . . .

122. Broussard: You want speculation . . . ?

123. Waring: Well speculation . . .

124. Broussard: You accept speculation?

125. Waring: I'll accept speculation since I don't know anything about it, and I haven't run into anyone else that knows anything about it.

126. Broussard: I think it was because, this is opinion, I think is was because the director and maybe some of those with him and specifically I will name a name because I can quote him, Kingsbury, announced at the onset that he was against us being in it. He said "I'm from coal mining country." He didn't want us to have it. He was from Pennsylvania. He

was against it so a project that starts out like that, it's really a wonder that it lasted eight years. I don't think Dr. Lucas was in favor of it. I think that's why we got out of there. I do have a memo here that I wrote for Lucas to send to NASA Headquarters stating what we had done and we were finished. My stuff is still out in the shed. I've been retired eight months, and I don't feel like digging out in it.

127. Waring: Well if we can't find it I might ask you to go digging for it. Do you think they were just sort of embarrassed to have personnel in this project?

128. Broussard: Yes. Even though it was minor number. I think one time something about this appeared in "Marshall Star" and that was the only time. It was a well kept secret. I can only speculate but I am accurate when I say what Kingsbury said. If the head of the S & E doesn't want you in a program, you can not expect a whole lot of support for [676?]. That hampered us.

129. Waring: We will ask him about that.

130. Broussard: Ask him and see what his [678?] and let me know what he says because I heard him say it.

131. Waring: Presuming they did not care to have their organization go into it, do you think they allowed the organization to go into it because they realized that Marshall faced a lot of budgetary problems?

132. Broussard: No. I don't think that was a part of it. That involved only fifteen or so people. That wouldn't have affected it much. Personally, if somebody says I'll give you two million dollars a year to work on these problems from now on that's what they offered.

They hated to see us go. Truthfully.

133. Waring: The Department of Interior did?

134. Broussard: Yes, the Department of Interior. They were really disappointed that we didn't continue because we had made good gains.

135. Waring: Did the Program Development Office have anything to do with getting started?

136. Broussard: Yes, that's how it started, from Program Development. Then . . .

137. Waring: Do you know which person in Program Development? Can you recall?

138. Broussard: Program Development was under Murphy then, but I guess it really started with John Goodram. He retired before he really got into it. Pease was next. Pease and I made a lot of trips to talk to people and talk to Palowitch.

139. Waring: Pease was in Program Development?

140. Broussard: Yes. Later it became special projects office. It was transferred to that office, Special Projects.

141. Waring: OK.

142. Broussard: The man that headed Special Projects then was Jack Swaringer.

143. Waring: OK. Why don't I ask you a couple of general questions? What do you think have been the most important changes at Marshall?

144. Broussard: I think the shift from doing most of your work in-house to letting contractors do it. That's the most important and the worst change.

145. Waring: What do you think is the most positive change at the Center? Can you think of something . . . ?

146. Broussard: I'd have to think a little bit. I will say about NASA, I had a good career there. There are things at any job that you don't like. I do think that NASA tends to look out for their people better than other organizations I've seen. I think better than the Army even. They're very good. When I retired it was very efficient. Makes you think they want to get rid of you almost. It was done very efficiently and pleasantly. They gave me a nice watch for retiring. I though that was a nice touch. Jack Lee is very solicitous about the morale of the people. That's something positive. That's more than I can say for one or two of the other directors we've had.

147. Waring: Is there anything else you think a historian of Marshall should know? Anything we haven't talked about or anything I haven't asked you about?

148. Broussard: Except more of the same. I said the shift what I just mentioned going from in-house work to contractors it has several bad implications. I think it gives the civil service personnel after they either get out of it or if they never have been in real in-house work; I think the contractors kind of take on an aura of being better that civil servants. They are absolutely no smarter. I don't think they're as smart.

149. Waring: This makes it hard for NASA to manage their contractors?

150. Broussard: Yes it is. I can think of incidents. I know on the Tether Satellites I was sitting in a meeting with the contractors and we were talking about the Tether itself which is kevlar. Kelvar is sensitive to atomic hydrogen in space. It's conceivable that it could erode it enough to make it dangerous. It wouldn't support the satellite. We had flown some kelvar on one of the shuttle flights and painted the tether with several different paints. One of them was a silicon base paint. We found that it wasn't affected at all by atomic hydrogen. That's good. In the meeting I stated these results. The direction they were going and have gone is it's a very complicated tether now. We have a strength number which is the kelvar and it has a nomex coating over it. It's heavy and large. I told them "Why don't we just paint them with silicon base paint?" This guy goes into a rigamarole about difficulties and blab, blab, blab. I finally said, "Are you telling me that you can not paint a string?" That's putting it into some basic terms. That's what he's telling. He can't paint a string. I know a lot of people that can. I can dip them. I can spray them. It's that kind of thing. I think that contractors go unchecked sometime. Somebody ought to say, "No this man has a good point. Tell me why you can not do it." It wasn't done. It's because they have to call in experts from labs and say, "Can you paint a string?" As it was, they just let it go, and it cost us much more money. It has other results dynamically if you have a heavy tether. I think that's the worse thing that has happened.

151. Waring: That's something we are writing a lot about in our chapters.

152. Broussard: Is that right?

153. Waring: Yes, everybody says the same thing.

154. Broussard: Same thing?!

155. Waring: Why don't we turn it off then. [turns tape off] [turns tape back on] Tell me about the flat floor.

156. Broussard: I guess I started in that right at the end of the Lunar Rover. This is another example of how we did things. We didn't go out and get a contractor. We heard that you could use epoxy to pour one. We found a building. They were reluctant to give us this. It's the building now that's used for the Mars facility where they have handball and all of that, basketball. We were in the west end of that building. We talked to the epoxy people, and they recommended a certain type to use. We ordered I don't know how many gallons of it. Then another fellow and I went driving around the Center looking for fifty-five gallon drums which we found. At the time you could buy things simply from Sears. You had a fund in the division, and you'd say in this case we needed drill motors. I think 3/8" drive. We bought three, four, five, or six. Some machinist turned out a shaft and paddles on them. We took the epoxy and poured it in and took our drill motors and made mounts. We just tuned them on. Epoxy has to be mixed real well. We poured it just like you'd pour concrete. At the same time you also had to have something to ride on it. We designed, in-house, the mobility unit I think it's called now. We scrounged up some little thrusters that had been made back in the fifties just working on compressed air. We had used the telemetry system in the remote control vehicle that we had made for the Lunar Rover. We used that for our telemetry. We got some cameras together. We put the whole thing together. For the fun of it, there were about six or seven people working on this either pouring the floor or making the mobility unit, I asked them "I want you to tell me just for my own benefit how much time you think you've spent on this project?" That's when we had it working. Everybody gave me his estimate. What it turned out to be was five man months which is chicken feed. If you'd gone to a contractor it would have taken

five man years or maybe fifty man years. For the first one, we put the mobility unit on and it worked. We had some rough spots in it because we were kind of inexperienced. You had to pour things sort of quickly otherwise as epoxy sets up it starts heating up and you get thermal gradient and you get [782?] wrinkles. That was the first one. Some people thought it was a boondoggle. Some time after that I was transferred. I didn't get along with some people because I had a tendency frankly to go on and do projects. This was one of them. I don't know if I bothered to tell any people what I was doing. Managers don't like this. They have a point, and I can see they do have a point. They like to know what the people under them are doing. Sometimes we'd take off and do something. I wouldn't take long contrary to what people say. Anyway, five man months . . .

157. Waring: Why did you want to build this? Why did you make the decision to build this?

158. Broussard: What they needed, we'd sort of gotten into remote control with the Lunar Rover, and we decided to go on from there. It was apparent that we weren't going to build a remotely controlled vehicle for the moon. They'd turned that down. Let me digress just a moment. We also did with the Lunar Rover, practically nobody knows about this, we were asked by Washington that since we have over half the power left in the batteries when the astronauts leave the Lunar Rover, how much would it take to be able to put the necessary equipment on the Lunar Rover so that after the Astronauts leave we can guide it remotely from the ground. We did a rush job on that. We modified a sun sensor to track the Earth. We took the antenna staff, the directional antenna that the astronauts have to get out when they stop and aim it at the Earth, we took that staff and broke it. We put the sun sensor on it looking around the antenna, it was gimbaled, so that the antenna would track the Earth the whole time because you had a Earth tracker on it. We did remote driving tests on that. We did a lot of those out at Flagstaff. I would say that at that time, we knew more than

anybody in the country about it. We knew about reaction times -- how much time delay you could tolerate if you're steering a vehicle on the moon continuously considering you'd have maybe two to three seconds of delay. Conclusion, after two seconds the average person could not drive very well at the speeds we were driving at. We went from there and said since we're not going to use this for a remote control vehicle, we do know that sooner or later we'll be doing rendezvous in space. Let's try to have a flat floor to simulate being in space. No friction, virtually no friction. Television cameras and vehicles with which we will rendezvous all be put on the flat floor. You can check what age you need -- the distance between you and the target, the rate of change of the distance, the velocity of approach -- what age do you need. That's really what started the whole thing. I failed to say that when I started out. We just kind of left from the Lunar Rover remote control to this. It was after I left they moved it to the fabrication building. After that, you may have seen it, it's over . . .

159. Waring: No.

160. Broussard: It's over, I don't know the building number. Let me get my direction straight. It's south of the building the ED is in. I can't even remember which building that's in.

161. Waring: They kept building a series of flat floors using the same basic technique?

162. Broussard: Right. Really the same stuff. They didn't put I can not think of anything really different they did. My wife says I'm modest. Yes, I started the flat floor. There's a similarity between me and Sonny Morea. He had a success. I had several successes, and they wanted me elsewhere. I'm not bitter about it. It probably worked out just fine. We had great success on the Lunar Rover and on our bearing work and on the flat floor.

163. Waring: Is there a NASA equivalent of the flat floor in Houston?

164. Broussard: I don't think so, nothing this size. It's a good idea. It will not do everything, but we knew when we started that it would not do everything. One of the things it's good for it to test full size equipment. This is almost impossible to do anywhere else. You can do it there. Certainly other things you can not do. Nobody ever said that you could. It's one of the main attractions at Marshall.

165. Waring: I haven't been there, but I'll have to get somebody to take me and show it to me.

166. Broussard: Yes, it's flat as it can be. It's better than the first one we poured. We had a contractor pour this one. That's not why it's better.

167. Waring: Maybe they had lots of expertise to build on?

168. Broussard: No. I don't think they did. They poured it. They sanded it even. They made measurements with lasers. They went over it and it's fine honed. It's a good facility.

169. Waring: Very good.

170. Broussard: You can say you talked to the man that started it.

171. Waring: I will.

172. Broussard: I didn't share it with anybody.

173. Waring: [turns tape off] [turns tape **BACK** on] . . . and then I've got to go.

174. Broussard: OK. I was going to say the difference between now and the sixties is the Germans controlled it. There was some bitterness about the Germans especially how many of them had high paying jobs without being competent. I shared some of this bitterness myself, but the Germans by their very nature when they get their marching orders, they do it. That's one of the differences between then and now. The Germans if they tell them to do this, that's what they do. That was kind of nice. When we had a mission if that's what Dr. Haeussermann said do, that's what we did. The Germans underneath him told me that's what he wants you to do.

175. Waring: Now, do you think there's a lot of resistance from lower-level people to the directions they are given? Do people drag their feet more?

176. Broussard: I wouldn't say they drag their feet more, but I think there's a feeling of what I've alluded to earlier. The people in labs do not have confidence in people in the Projects Office. Of course the Project Offices have raided the labs for years, ten or fifteen years. Once you take an engineer from the lab, his confidence diminishes. He gets away from it, and pretty soon he will act like he was never in a lab. That's what hurting them. There's some of the bitterness in the lab about the project office for that reason. They take some of the best people, and they do it frequently by offering promotions. It probably benefits the Projects Offices for a while but the labs suffer on account of it. Of course there's some of us that wouldn't work for the Project Offices because we like lab work better. I had no choice when I went to the coal mine because they told me I would. They gave me no choice. There was a lot of politics involved.

177. Waring: Very good.

178. Broussard: I'll let you turn it off for good now.

179. Waring: Yes, I've . . . [turns tape off]