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**INTERVIEW WITH J. R. THOMPSON**
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1. Dunar If we could ask you first then how you initially became involved with NASA and in the space program?

2. Thompson First of all I got out of the Navy in '61, no in 1960. In March, [I] went down to work for Pratt-Whitney aircraft in West Palm Beach, Florida. I happened to get involved just as a young engineer in analyzing some of the performance of the RL-10 which was the world's first lox-hydrogen small engine, developed about 10,000 pounds of thrust as I recall. I got interested in rocket propulsion. That was the first exposure of my professional career although I had studied it and been intrigued with it when I was over at Georgia Tech in aeronautical engineering. It was during that time that Sputnik was launched, and I was like a lot of young engineers at that time - was attracted to what was happening in space. Having been involved to a limited degree down at Pratt-Whitney, I had some good friends up here, who also went to school with me, that were involved in the early hoopla in the space race and talked me into coming up to Marshall. This was back, I was a low GS number I forget what it was, but this was when I was a real new one. I came here in 1963. As a matter for fact I left down there the day Kennedy was assassinated. They were

having a little brunch for me leaving, and it came down over the loud speakers is the reason I remember. So I came up here because of my limited experience on lox-hydrogen engines down there at Pratt-Whitney on the RL-10. Then the J-2 which was the second-third stage power plan on the Saturn V. Well the Saturn V was not well along at that time well at all, but the J-2 engine was starting development out at Rocketdyne so I became involved from this end in working with them on that development. Later on, [I] got involved in the F-1. which was the power plan for the first stage of the Saturn V and being in the old PNVE, Propulsion and Vehicle Engineering lab out at the Center. [I] Got involved in most of the engine development programs that came along. So from 1963 until 1970, I was working on the Saturn program in various propulsion capacities and started to work my way up through the ranks, first as a unit chief, then a section chief, then a branch chief. It was all down in the bowels of the organization and working on the test stands, and I was traveling a lot back and forth to Rocketdyne in California. [I] Was involved in the development and later on with the qualification testing of the engines. Then after the Apollo program, I worked for a brief period of time on Skylab, our version of today's space station. That was a very exciting program because it got off to a shaky start, but it went on to become a fantastic mission. Then I was asked in 1974 to lead the shuttle managed project. It had been going several years, and it got off to a rocky

start, and I was asked to come in an mange that which I did. I stayed manager of that until about the third or fourth shuttle launch in the spring of '83. I managed the shuttle main engines, so it took it through the development program, qualifications, and early flights. Then I got a call from Princeton University. This was back trough some NASA contact. I really wasn't looking for anything. They asked me to come up and work with them on their fusion reactor program. They've got a large DOE laboratory up there. So at the time, I really didn't have any reason for leaving, but it was a really attractive opportunity at Princeton. So I did that for three and a half years and then Challenger. Then Jim Fletcher asked me to come back and head up the NASA investigation of the Challenger accident down at the Cape. I took a brief leave of absence from Princeton. Neil Armstrong was my kind of part on the Commission. He and I co-chaired a task team. He for the Commission and me for in terms of looking for data and trying to figure out what happened.

3. Waring Were you in effect a consultant for NASA or were you really working for . . . ?

4. Thompson No. I had to come back. Princeton was very helpful. They liked that kind of thing when someone in the University is asked, but I had to be a NASA employee because I had the NASA team working for me. So I had to come back

as an employee. It was a fast hand off of my full expectations as well as Princeton's. In fact what happened was after the investigation was completed in about two or three months after the accident, I returned to Princeton. I resigned from NASA and went back to Princeton. Then later in the fall, Jim called me again and asked me to head up the Marshall Center. They were thinking through all of that in what they wanted to do. It was a very tough time. Marshall was taking a lot of heat as you well know. I knew a lot of people personally, and I think it was that connection that probably, that Fletcher and then Dick Truly also who was back there, felt that because of my background in propulsion, had been at the Center, had been away from the Center that maybe there was a good match to lead the Center. I left Princeton. I really enjoyed that. I really thought I'd never leave. But I had been with the Agency long enough, and it was hard and I knew the people, and plus it was a very challenging assignment. A lot of people said the shuttle would never fly again. That in itself did half of it to come back and get involved in activities. From there, I spent about three years in Washington as Deputy Administrator and for other reasons left and returned to Huntsville. That's a quick snapshot.

5. Waring That's a good overview. That gives us a jumping off point for questions. Let's go back to the Saturn years here. We're getting a broad overview of the Center looking

at the technical and the managerial side. If you were writing a book for the general reader and were devoting a couple of chapters to the Saturn project, what would you say would be the three or four major technical challenges for the Saturn system, the three or four most important ones that should be covered?

6. Thompson Do you mean from the technical side?

7. Waring The technical side.

8. Thompson I think one attribute that I always thought the German team really brought to the Marshall Center combined with or be fortunate enough to be combined with the national commitment that was made. Budgets are always important, but the sense I had, that was a secondary consideration. The main consideration was to win, was to be able to do the job. So the robustness of the program in terms of testing to failure, there was never a discussion about if it blows up or if something happens, or if it cost too much. That wasn't the consideration. The primary consideration was you need to run the test, and what are you going to learn from it, and is it a necessary thing to do even if you fail it. You push it to the limit and that establishes an outer boundary. There was a lot of encouragement to do that. A lot and certainly Werner Von Braun and his leadership gets a lot of that credit, but Eberhard Rees was the muscle behind

the engineering in terms of building the integrity and the technical disciplines. He was a perfectionist in terms of wanting to make sure that everything that could be done had been done, and if hadn't been done, why hadn't it. Why did we not do it? It was that attribute of the culture of the center at that time that, at least in my own subsequent years after the Germans had phased out, I think help me and reinforced a lot of the need to do a lot of the same thing with shuttle main engines. As I recall, we blew up eleven, and they were very expensive and the funding environment had changed. It was not as easy to make a phone call up and down the chain after you had a significant engine failure as it was in the Saturn days because the ramifications were more - the oversight of Congress, the budget, but still people were committed to the shuttle. They knew they had to do it. That's something that you have to go through. You've got to find out what makes it not work and what makes it work, and you're never on a steeper learning curve than in the period of time right after a failure. That's when, you don't learn a lot about learning a good engine test. You learn a heck of a lot by pushing them to the limit. So certainly that would be one. It was a very aggressive engineering and ground test program, not only with the development of the propulsion power plants but once you get them integrated into the total system again on the ground. Again, [it was] very aggressive in terms of how far you push them, expose them to the extremes of the environment. So

that would be number one. You say a couple of chapters. I'm not sure . . . .

9. Waring In terms of engineering the rockets, the engineering of the engines themselves, were there special problems? We'll devote some attention obviously to the POGO problem which Marshall and NASA successfully met in a very rapid period of time, but were there any other . . .?

10. Thompson Well, in the Saturn program there were three propulsion related problems that really had to be tackled. The first, or the one that had by far the biggest ramifications, was the combustion and stability on the F-1. engine. This is an example of what I'm talking about. When you say Marshall and NASA, Marshall and NASA certainly led the activity, but the contractors were extremely talented and did a fine job. But Marshall took the brunt of, where there was heat, they took the heat and pushed the system to run these limit tests, and combustion and stability was a good one. If you look back today, I don't think we really ever understood that problem. We fixed it, and we ran enough tests to know that enough different things were changed so it worked, and we knew we had margins. Because we tried to trigger the instability. We actually plant little bombs in the injectors to try and to trigger the instability to go unstable. So we'd done enough of that to know that the injector itself, the basic design was unstable

with the changes, the multitude of the changes we put in, all the way from injector posts, the mixture ratios, to the angle that the injector post was impinging the oxidizing to the fuel, and the cavities to absorb the instability of the residences and the instability to try and change that. You're putting the bombs in was a way to establish margin and it being robust. The German team and the Marshall team had that instilled in it. We're going to prove that we've got plenty of margin before we go fly. POGO was another good example. We actually put pulsers on the feed lines to trigger POGO, and it's the same story all over again. The feed system can resinate. POGO can be there, but then we'd actually pulse to make sure that we had enough margin so it wouldn't happen. Then the condition, what we called the cool-down, of the J-2 the cryogenic lox-hydrogen engine. It was to make them start. It was very sensitive, and the J-2 had to restart. In orbit, it had to start for a second time. In order to get the proper quality hydrogen, not just a mixture of liquid and gas, but good liquid that the pumps can bite into and to pump was part of the start phenomena. So we had to somehow to figure out a way to get the good quality, the super cold hydrogen right to the inducer on the pump before we started. That was a process that took a lot of testing and again a lot of limit testing to make sure we had sufficient margin so it would restart. Those would be the three biggest technical challenges aside from all the structural consideration and material testing, but they were

three unique propulsion problems that had to be solved and had to be solved in a way and demonstrated that they wouldn't just work every now and then or ten times. They had to work hundred of times, and there had to be no evidence in the data that the residual problem was still there. Although I think that probably in all three the combustion and stability was really never understood.

11. Waring Theoretically.

12. Thompson Theoretically. It was solved by a very rigorous test program.

13. Waring Trial and error.

14. Thompson Trial and error and with good experience and heading on what we though would be conservative improvements and improving the testing. Every now and then, you go back. It was a long and expensive process, but it worked. POGO was more meanable to a lot of analysis and model, and that was very helpful but still it had to be proven by ground test, by experience. Developing the cool down procedure for the J-2 was extremely difficult to model, and it was primarily developed through experimental tests.

15. Waring Marshall had laboratory expertise and considerable depth obviously in the Saturn period. Could

you just talk about the advantages about having that sort of NASA laboratory system?

16. Thompson Well it was very, it gave you a good independent view. It gave you, of course you had the contractor. He's trying to do a good job. They did a good job, super job. But he gave you an independent view point. You had a separate team overlooking the data making sure they were in total agreement. Marshall perhaps, down in the bowels of the organization out in the laboratories didn't have any schedule pressures, didn't have any, they're pressure was to make sure it worked. They had pressures, but they were different. So that gave you a good check and balance in the integrity not only in the design but also in the test results. Between the combination, it was a very formidable team.

17. Dunar Could you comment a little bit, when you first arrived at Marshall, I think your experiences were a little unique in terms of some of the American engineers in a sense that you had some previous experience already. Could you comment a little about the relative strength that the young American engineers and the Germans brought to the Center?

18. Thompson I don't think there was much difference at least when I was coming up. When I came here there was probably a generation or a half generation gap in age, in

maturity, and in exposure to similar problems. Probably the, I think the analytical skills of the younger American team were sharper. The Germans brought the experience and particularly the know-how in this testing. That continues to stick in my mind in terms of you know you test it into the ground. You just keep beating on it until you know exactly where you are. That was the way they had been successful, and that was certainly what was needed on some of these problems that we just talked about that we encountered, and they made sure that it got done that way. They were very thorough. That was the leadership of the whole program at that time to me was Werner Von Braun, but the guy that executed it was Eberhard Rees and then others on down the line.

19. Waring Let's turn to Skylab then for a few minutes. Marshall had primarily been involved with propulsion work through the Saturn project, and then obviously with Skylab it turned to developing a manned space craft. Could you talk about that transition that Marshall went through? Were there some organizational changes that were needed?

20. Thompson Marshall at the time was of the, what they were good at was a large development programs. That's what Saturn was. Of course I was still down in the organization at this point, but in subsequent years looking back on it, at that time the program was coming off a very expensive

endeavor with Apollo. Politically, it was my sense that, and I think the fact that the country wasn't going to go through that again, the justification wasn't there. In a space station was a good, a good quick space station, was a good follow up do be done with a lot less people. It was probably too hard to get a new start. You know, let's go board on a space station. Nobody's going to do that. Again, I think this was some Von Braun, but others, I think George Mueller I think was instrumental initially just on the back of an envelope on the cartoon level showing just what could be done with the third stage of the Saturn V. Let's don't go out and design it from scratch. Let's take the third stage of the Saturn V. As a matter of fact the way it started was, what we're going to do is launch a Saturn V. Then after we've depleted all the fuel out of the S-IVB stage, then we'll bring in, we'll dock to it and make some provisions before we launch but it will still have fuel in it. Then we'll burn the fuel out, and then we'll go in and make some very simple modifications and let it in an order.

21. Waring Wet workshop idea.

22. Thompson It was the wet workshop idea. That's how NASA started on the space station. After a little bit more work, it was envisioned that although you could do that, you're not going to really have as good a space station as you

could. Let's still use the third stage hardware but let's not put propellant in the third stage. Let's lift it with a Saturn V, and then we'll load it up with some experiments and several floors and some lockers. So that's what they did, and that became the dry workshop. Dry workshop then became Skylab. The name changed. The organization changes at Marshall, although Marshall was the lead center, Houston had a very important supporting role just because of the interchange of the astronauts and all the equipment had to work, so there was a lot of liaison. They did have to do some restructuring. As a matter of fact at that time, I was picked to head up a group that would interface with the Houston people in the astronaut core to make sure that what we were building was useable. That it worked and . . . .

23. Waring Do you remember the name of that organization?

24. Thompson Manned Systems Integration Branch.

25. Waring Under what lab?

26. Thompson Under . . . .

27. Waring PNVE still?

28. Thompson No, they had just changed it. It was . . . .

29. Waring Structures?

30. Thompson It was the Systems and Analysis Laboratory. This was all under Karl Hiemburg. It was all under Karl and Tom Isabell was the systems analysis laboratory chief, and I was the branch-head of this manned systems integration. Karl was the . . . they change the name of these labs so much.

31. Waring Right. Well, I can check the organization charts for that. Was this in this organization . . . ?

32. Thompson Astronomics laboratory. Karl headed that up. Tom Isabell had the divisions of Systems and Analysis or Integration or something like that and I had the Manned Systems Integration branch. Skylab, the working, the interface with the astronauts with Houston was in that branch.

33. Waring About how many people were in that sort of work?

34. Thompson We had about 25 civil service at that time. Some support contractors went along, and then there were a lot of other branches and divisions that were working on Skylab but out focus was on providing the outward interface into Houston to make sure that they understood how it was designed to work, how it did work, how the procedure were to

be written. Anywhere we had problems with them or they had different view then we would [?332] it.

35. Waring In effect, part of this was sort of human factors.

36. Thompson There was the human factors. We changed the name. It was a small human factors group at that time and then it became this manned systems integration branch.

37. Waring Could you describe some of the primary technical challenges that were facing that group or that you were trying to solve in Skylab? You were working well on the space toilet for one thing.

38. Thompson Yeah, that was new, but Skylab had this waste collection system [?343]. As an example in the development program that we'd made the flights in the KC135 so you'd get 0-gravity time for a short period of time, 25 or 30 seconds as I recall. The big lox tank became a trash dummy. We pulled trash airlock on the top of it and get access. We a food table. You've probably seen the mockups at the Space Center.

39. Waring Right.

40. Thompson We built that mockup in that. We did that in-house. McDonnell Douglas provided some, but back in 4619 the building I was in, we outfitted it, and built it. That was used as a trainer. Eventually, all the equipment, we sent it down to Houston and resurrected it down there so they could do training, and we had another one up here for engineering purposes. So we added all the biomedical experiments that Bob Schwinghamer made out here and all the locker space and we really stuffed it full of experiments. There were no technical challenges in Skylab like combustion and stability on the F-1. With Grumman, trying to get the right, there were more people challenges. You know when you design a waste collection system, aside from how it works in terms of the airflow retraining the waste products, everybody is an expert in that. So you get 10 people in a room and hell, everybody's a damn expert. Handling some of the people problems were the bigger . . . Skylab was a bigger problem. It was a bigger challenge in that dimension as opposed to combustion and stability and cool down or POGO, those were tough engineering problems. These others were, the eating table, there were 10 different ways to design that. There were some principles you have to adhere to because the food system, and how you keep it down, and the trash airlock, how you use it, how you operate it. For example, we had a big fireman's pole coming from the top to the bottom. The Marshall engineers felt we needed a fireman's pole. The astronauts said hell we don't need a

fireman's pole, we'll just push off and go down. So we flew a fireman's pole, but we kept it stowed. I don't think they ever pulled it out. So there was a little bit of a culture difference between the good solid hard engineering at Marshall and then the operational experience at Houston. The fireman's pole is a good example. In other areas like the waste collection system, that waste collection system that Marshall designed and was responsible for, operated far better I think than the early one on the shuttle that came out of JSC. I'm talking about the relative mechanics of it, and not the people and the interplay. But the challenge was different in Skylab, but it turned out to be a super program. I've always thought Marshall was at it's best when there's a good technical challenge. One launch, our structures people had not properly dented this other shroud around the solar array so then when you get up to a certain pressure, it blew off and did some damage. It tore off one of the big solar wings. So we had one that was caught and was still retained and held out a couple of feet. It had not let loose. It was jagged metal and all that around it. So for about a week and a half, around the clock, out at Marshall, Marshall led it and Houston came down, they were very important, and came up with all the repairs for the system. I thought at that time, we had one in a hundred chance and that might have been high of pulling that off. But the damn thing really worked great. It still astounds me. We got enough power, saved the vehicle. It worked

great, and then went on and I think early on that each mission was a couple of weeks or something, then it ended up being 30 days. Wait, we were up there a total of a year with three visits. First one was 30 days and then 60 days, and then 90 days or something like that.

41. Waring Could you describe how Marshall organized its activities during the rescue operation, during the first what was it a week or so after the Skylab vehicle itself had been launched before the astronauts went up the first time.

42. Thompson After the launch, after . . .

43. Waring You knew there was a technical problem.

44. Thompson It was clear in moments or within half an hour after the launch, that we had a significant failure. Then, for any launch, Marshall has problems teams set up. After we had in our minds although we didn't have any pictures of what had happened, we pretty well psyched out what the condition of the thing was. We knew we had lost one solar array. We knew from some data that we had another one partially deployed but hung up. We surmised of all the jagged metal, and then we set up, Rocco Petrone was the director of the center at that time, and he set up several teams. George Hardy was a primary player, Jim Kingsbury, Bill Lucas, but Rocco drove it. He set up some teams to try

to figure out what to do and since whatever repair was going to involve sending up some astronauts trying to somehow cut loose the wing or something. The group that I had was heavily involved with it. We worked a couple of things. We knew we had to build some kind of shield to protect the side that was exposed, where the thing was torn away. There were a couple of concepts developed there. The one that you see here was the final one that was deployed was the two huge long poles and through a clothesline arrangement we wheeled it out. Houston had a little parasol that they deployed from the airlock. The advantage to the parasol, and this was a big meeting to decide this, was you could deploy it without ever going - this was after the vehicle was saved. I'm getting ahead of myself. First you had to get the solar array out. So their astronauts came down here, and we trained in the Neutral Buoyancy. Came up with just big off the shelf big pole cutters, you know wire cutters, and we had a lot of other gear and simulated the problem.

45. Waring What was the origins of those cutters. I've heard some design came from hardware store equipment, others came from technical utility companies?

46. Thompson No, we ended up sending up some specially designed tools, but we also had some tools that were bought right down town. Not knowing exactly what we would encounter. We took up in the Apollo Command Module, which

is what they flew at that time, a collection of the different tools. We got through all of that. We did the training in the Neutral Buoyancy Simulator. Back in the laboratory we had big full-scale mockups. We had that thing pretty well psyched out - what the problem was, what it was going to take to do it. Again my guess was that the chances were one in a big number. But it worked. In retrospect it was reasonably well thought out and well prepared for, and we had an excellent crew to go implement it. They knew what to expect and probably took more risks than they should have, but it worked and that was what it was all about. That was one problem, to save the vehicle and get the power out and get the solar wing up. Then we had to protect the other side. That's when they deployed the parasol first because you could deploy that without going on another EVA so they pushed out through the airlock. It started lowering the temperatures. If you don't put the shield up then the temperatures inside the workshop were too hot. As I recall, they were in the 90s. The parasol brought it down some, but when we were starting to think up these long missions and then the solar panel knocked it down, but the thermal shield that we deployed on another subsequent EVA at the beginning of the second mission I think brought the temperatures down in the 70s or something like that. Started down in the high 90s and then to the 80s and then to the 70s, and it got comfortable then and a night it got cooler. So the program started kind of rocky, but it closed any gap that existed,

although there was really none, between us and Houston and made things very cohesive. Then we had an outstanding science program that was ongoing and we extended the mission and it worked great.

47. Waring Just to refer back to that relationship with Houston, there seems to have been quite a bit of controversy or conflict however you want to say it about some of these human factors problems and habitability concerns. Could you elaborate a little more on the nature of that controversy? In part you're arguing that it was just inherent in designing in the engineering problems that needed to be solved, that there would be different interpretations. Do you think there were some institutional differences between Marshall and Houston? Do you think Houston was defending their turf?

48. Thompson There might have been a little of that. For example, the parasol and the thermal shield were two examples, but I think it brought out the best of the two centers. Both were used. Both were needed. You know we split up in teams, so a lot of the astronauts were aligned with the thermal shield, the EVA guys or the astronauts that were going to go out and deploy that. The differences in opinion, I thought, were very honest, and this question may come up later in shuttle maybe. So long as the tensions are natural, and you need the tensions, you need the different

viewpoints to get the best technical solution. That's what happened in Skylab. Would it have been easier at the different levels of management to handle the people problems? The answer is yes, but you ended up with a much better solution wether it was from the fireman's pole that Marshall, we wanted, our team wanted, that ended up being we don't need that to some of the things that they were pushing and Marshall had a stronger engineering solution and Houston had a stronger operational solution. So you tried to find the best of both of those.

49. Waring A lot of it was sincere glaring technical differences rather than political ones.

50. Thompson Oh yeah. I never got the sense that it was nothing but a good honest difference of opinion. That was always my sense.

51. Dunar In general, do you think, in your experience, is it better to have a program directed out of headquarters or in the center?

52. Thompson I like the lead center. Apollo, they say it wasn't, but it was a mixed bag. Call it what you want. Marshall did the launch vehicle, and Houston did the upper systems and Headquarters pulled it together. Skylab was the lead center Marshall. Shuttle, lead center Johnson. I

found it to work very well when you get the right guys at the top, and they can make it work.

53. Dunar Does it become more difficult as interfaces become more difficult to run the lead center?

54. Thompson No. I like the lead center because the engineering, the details are down where they ought to be. In Washington, what they can bring are dealing with Congress, budgets, that kind of thing. If they get all meshed down, that's not what they do. The people up there don't need to spend time in the nuts and bolts stuff. They need to get good people at the centers and let them execute it. My experience with both Skylab and Shuttle and both were lead center programs and one headed by the Center I was in and another headed to another center that I reported to as a manager of the shuttle main engine. A lot of natural tension. A lot of differences of opinion, but never got the sense that it was political. I always enjoyed that. I always thought it was healthy and makes for a much stronger and I was on the losing of many arguments, but always felt that when we came out of it we had the best solution. [635 turn tape over]

55. Dunar Were you involved at all earlier before you became involved as the manager of the main engine, but were

you involved at all earlier in the discussions over wether solids or liquids should be used in the shuttle?

56. Thompson Only afterwards in shuttle reviews [812 stop] [rest of tape covered in static and not understandable]