NASA JOHNSON SPACE CENTER ORAL HISTORY PROJECT
ORAL HISTORY TRANSCRIPT

HUBERT P. DAVIS
INTERVIEWED BY REBECCA WRIGHT
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[This oral history interview was conducted on July 28, 2009, with Hubert Davis in San Antonio, Texas, for the NASA Johnson Space Center Oral History Project. The interviewer is Rebecca Wright, assisted by Sandra Johnson.]

DAVIS: Some years ago I did a little study of what I think ought to be our first priority. It's an extensive and ambitious robotic exploration of the Moon. Continue to support the [International] Space Station, but don't concern yourself with sending humans beyond low-Earth orbit until we've prepared the infrastructure on the Moon to properly receive them and guard their lives. If that's silly, I'm sorry, but I think that's what should be done. I have the study that I'll be happy to share with you, if you want to have it.

WRIGHT: Was the study done while you were at the [Johnson Space] Center, or was this independent?

DAVIS: It was done after I left the Center. But we went with Buzz Aldrin to brief the NASA space architect at that time, which is a term that I never really approved of, because I think of an architect in terms of doors and windows and not the space program—but I had a fair amount to do with the detailed planning on the Apollo Program, and I know what needs to be done there, and it's a far cry from architecture.

WRIGHT: If you don't mind, can we talk a little bit about how you were able to build those details into the Apollo Program, and then how that information and that experience you're using and have used through the years to do your studies?

DAVIS: I'll have to back up to my time in the Air Force to properly address that, because I have been blessed with a series of assignments that built one upon the other, and it was I think more accidental than purposeful. I went to flight training right out of Texas A&M [University, College Station] and washed out. The reason I washed out is they didn't make left-handed airplanes. I did such things as have 14 rudder control stalls in a row with no semblance of rudder control, so they properly got me out of the flight training program and put me into the aircraft maintenance business, which is what I studied in the Air Force ROTC [Reserve Officers' Training Corps] program at A&M.

After a brief tour with the Strategic Air Command working on B-50 [Superfortress] airplanes, which were then our leading strategic deterrent, I was given an assignment to Chanute Air Force Base Maintenance Officer School [Rantoul, Illinois], where they taught me all the ins and outs of how to take care of airplanes. I was sent directly from there to Korea. On the ship going to Korea, they had a personnel guy that came in to see where people were going to be sent once they got there. He asked the question, "Which of you guys has jet experience?" A captain friend of mine held up his hand and said, "I do, and so does my buddy Davis." Yes, we'd had six hours of instruction in jets at Chanute, and that was our jet experience, but that was enough. Ironically enough, he was assigned to fly T-6 [Texan] airplanes as artillery spotters rather than maintenance, and I was sent to the premier fighter group on the peninsula, the 4th Fighter-

Interceptor Group. About midway through my tour there as an aircraft maintenance officer they had a big reduction in force, and I was promoted to be the group maintenance officer of the premier fighter group on the peninsula, at age 23.

A new group commander came in, and he called his squadron commanders together and said, "I want you guys to spend all your time on operations and leave maintenance up to this guy Davis." I was in de facto command of 900 men and 85 combat airplanes at age 23, which was a fair burden. By working 14-16-hour days seven days a week, I was able to learn a great deal, so I felt like I got about three years' experience in the rest of that tour. It was a wonderful experience, too, not only technically in terms of dealing with the aircraft problems, but in leadership of dealing with men. I had a lot of good times doing that and felt very close to these people and did all that I could to help them, which is I think the primary role of the leader—help your people.

After Korea, I had applied for and was sent to the Air Force Institute of Technology [Wright-Patterson Air Force Base, Ohio] to get master's level work in aerospace engineering for 18 months. It was a particularly good time to be there, although I did not get a degree because the school was not accredited. They were in the process of being accredited while I was there, so you can imagine the rigor that the professors put on the classes when they had all the accreditation officials sitting in the classes with them. I got, I thought, an excellent education in aerospace engineering, courtesy of the Air Force. I had three different offers to stay at Wright-Patterson and work in their labs, but I had toured those labs, and I'd seen entirely too many civil service technicians sitting around on the floor reading comic books, and I wanted no part of that.

I took a three-day leave and hopped on a military airplane and went to [Air Force] Headquarters in Baltimore [Maryland] and pounded on the desk and asked to be assigned to

Edwards Air Force Base [California], and they granted my wish. I took Mary [my wife] and our baby boy out to the desert, and we bought our first home in the little town of Lancaster, which is now a pretty good size metropolis. I drove the 30 miles every day in a carpool up to Edwards and worked in what was a real malassignment to me. I was an engineer and they assigned me to what they called the Technical Operations branch, where my job was to oversee the flight test programs of 20 some-odd contractor programs then underway in the so-called Century Series airplanes. It was a very intense period of activity for Edwards. It's only been matched, I think, once in the years since.

WRIGHT: What timeframe were you at Edwards?

DAVIS: I went there in 1955, and I resigned from the Air Force and returned to Texas because Mary was concerned about her folks getting old in 1958. It was mid-October 1958. I went to work for Chance Vought Aircraft in Dallas, where I ended up in preliminary design working on advanced systems. About two and a half years into that [President John F.] Kennedy said, "We're going to the Moon." I said, "That's interesting." Then [Vice President Lyndon B.] Johnson said, "We're doing it from Houston." I said, "I'm gone." So I called up and got an appointment and went down to Houston and interviewed with first Joe [Joseph N.] Kotanchik and then with Max [Maxime A.] Faget himself, which apparently he didn't do that often. But I was recommended by Walt [Walter C.] Williams, who I knew at Edwards when he was running the NASA flight test center there at Edwards Air Force Base.

My acquaintance with Walt came about because one of my first assignments in Center Operations was to find out how we could get the F-105 [Thunderchief] airplanes up from South

Base to North Base where they had a new hangar for them. To get there we had to either cross the lakebed or go on a taxiway that went through the parking lot of Walt Williams's flight test center, located was midway between Main Base and North Base. The lakebed got wet most winters.

I had to go up and deal with this crusty character, who had a very strong reputation, to talk him into letting us put in two gates and to open the gates and move his aircraft to where we could get through on the occasions we needed to move the airplanes. Much to everybody's surprise, Walt agreed. He was very nice during my visit with him. I was quaking in my boots the whole time because of the man's reputation, which I think you know.

Apparently Max called him and said, "What do you think of this guy Davis?" He must have given me a good report, because they hired me as a [Government Service (GS)]-14 when I was expecting a 13, and they put me in charge of the power and propulsion office under Caldwell [C.] Johnson in the Program Office.

There was a great flurry of activity in those days. I got there, on a Thursday in late March of 1962, and I reported to my boss Caldwell Johnson. One of the first things I asked him was, "Okay, Mr. Johnson, I'm here, now please tell me how we're going to do this thing, because it seems to me that going to the Moon and back is a pretty difficult task." His answer was crude, but that was Caldwell. He said, "How the hell should I know? That's why we hired a bunch of bright guys like you." Which took me aback big time, because at that time we hadn't decided on the mode of going to the Moon.

I got there in March, and it wasn't until July that John [C.] Houbolt won the fuss about going with Lunar Orbit Rendezvous. We had a lot of decisions that were held up during that interval. In the meantime, we were proceeding to try to develop the engine that had to fire on the

back side of the Moon, the Service Propulsion Engine; and the Pratt & Whitney fuel cells, which we had to have for drinking water and electricity; develop the reaction control jets that held the attitude of the vehicle; the launch escape system, which had the two motors: the launch escape motor and the tower jettison motor by different contractors. All those contracts had been let when I arrived, but they were in the very early formative stages for all of them.

The job I had in the power systems branch was to oversee on the part of the government, the conduct of these subcontractors and North American [Aviation, Inc.], the prime contractor, in carrying out those developments.

WRIGHT: That's quite a heavy load, walking in the door, because each one of those is such a vital system.

DAVIS: I asked Caldwell, "Okay, how many people am I authorized?" He said, "How the hell should I know? That's up to you." A lot of my fellow branch heads, as I put it, went out to the Gulf Freeway [Interstate 45] and stopped cars. It wasn't quite that bad. I was very selective in picking only the people that I thought would really make a contribution. That turned out to be a bad career move, because these other guys made division chief and I never did. They would hire 30 or 40 people, and I hired six or eight. I didn't want to get people that were more of a drag than a contributor.

WRIGHT: Did you go out and recruit, or did you have people seeking employment and you were able to pick from that pool?

DAVIS: It was a combination of those things. I called on friends. One of the people I brought in was Don [L.] Teegarden that you may have spoken with. He still lives in El Lago [Texas]. Don and I had worked together at Edwards and gotten along very well. He was working on the X-15 [airplane] program at Edwards as a propulsion engineer. The propulsion engineer at Edwards had total complete control of what was done to those engines, and they had only a tech rep [technical representative] from the contractor. They did all the work in house; so he got some really wonderful rocket engine experience. So I called up my friend Don. I said, "Don, come join me, I need you." He came in as my deputy, which was a great blessing to me. So you might want to talk with Don sometime. He's still there. That was an exciting 18-month or so interval.

WRIGHT: Guess that experience in Korea working those 16-, 18-hour days paid off for here.

DAVIS: Well, I repeated that. I was still young enough to be able to do that then. I don't do that anymore.

WRIGHT: Were any one of those subsystems more challenging for you than the others to get up and running in that small timeframe?

DAVIS: They were all difficult. I guess the most difficult one was the service propulsion engine that Aerojet was building. Later an even more challenging situation arose on the Lunar Module ascent engine, which was among my responsibilities. There I got an unusual assignment from NASA. When we went to Bell [Aircraft] for a program review, it became apparent to those of us

that were reviewing the program, including some high level NASA management that went with me on that one, that Bell had essentially given up on solving the problems of combustion stability on the Lunar Module ascent engine.

They didn't know what to do next. We broke the procurement rules by deciding to give a sole source contract to Rocketdyne [Division of North American]. I was assigned to go out and talk with the boss at Rocketdyne, a crusty old gentleman named Sam Hoffman, and persuade him to take on the job of accepting the existing valve package and combustion chamber that Bell had designed that was successful, and mating it with a Rocketdyne injector that was where the combustion stability problem arose, and put the Rocketdyne good name and nameplate on it.

WRIGHT: That must have been a sales job.

DAVIS: They treated me to a nice lunch, and I talked to him at the lunch table. I said, "Sam, you've got to do this. If you don't, the Russians are going to beat us." Well, he did.

Another good friend that I'd worked with at Edwards named Bill Wilson was assigned as the NASA engineer. Bill is still out in Los Angeles [California]. Bill was assigned as the NASA engineer to work with the really bright young engineer that Rocketdyne assigned to do this job—Steve Domokos was his name. He drove hard on this thing, and they came up with an amazingly simple fix that solved the stability problem. They put what we called the tomato can in the propellant line, which changed the dynamics of the feed system and resolved the problem. They had an existing injector that worked very well and gave high efficiency. That became the Lunar Module ascent engine that worked to perfection every time it was tried. There were several near

miracles that occurred on my watch that were done by others, not by me. I had a part to play in causing them to happen, which was very satisfying to me.

Then we had a fellow named Jim [James C.] Elms came down as Deputy Director of the Center, and he observed that we'd had a group that came down under Max Faget from [NASA] Langley Research Center [Hampton, Virginia]; some 900 technical people that were given no responsibilities in the Apollo Program other than to develop new technologies that might be applied later. Those of us at the Program Office were still burdened with doing all the stuff, and we called it Max's Hobby Shop. Jim Elms observed that it was indeed Max's Hobby Shop. He decided to fix that, and he did so by setting up what became the subsystem manager system that they assigned the technical people to direct technical responsibility.

Once again I had a crossroads in my career, because I thought I was going to be working for Guy [Joseph G.] Thibodaux in the power and propulsion division that he was going to head up, having the subsystem management work that I'd been doing for a year and a half or two years. I worked for a chap named Bob [Robert O.] Piland. Bob called me into his office and said, "No, you're not going to E&D [Engineering and Development], you're a Program Office guy, and you're going to stay with us." I said, "Well, okay, Bob, what do you got in mind for me to do?" He gave me another pretty challenging assignment. He said, "I want you to plan and manage the ground test program for the Apollo spacecraft, all of it." I said, "Okay, I'll do my best." It was again another one of these massive challenges that was handed to me.

WRIGHT: Did it help you, in developing this program, having all of those subsystems under your—

DAVIS: Yes. I knew what many of the problems were and many of the more important things. I knew very little, of course, about such things as guidance and navigation. There was always a little conflict between us, because part of our troubles in the propulsion group were caused by them insisting on using what they called the pulse mode of control for these reaction control engines. They sent them a series of signals, "rrr-rr" [imitates sound], and the valves had to open and close in that chattering thing. The reason they did that is because that was easier on the guidance people than sending proper commands to the engines.

But any damn fool knew that the most critical parts of operating a rocket engine are starting and stopping. That's when you're most likely to blow the thing up. I objected to the business, said we ought to use the pulse-duration modulation, which means that you turn the engine on and run it for a discrete interval of time to make it work, then turn it off. I was turned down because the guidance people held on to their "rrr" mode of controlling the bird, and we had to live with it. Now that was I thought stark insanity, but we did it, and we got by with it. But that was another difficulty we faced.

Planning the ground test program, with the background of having worked in that area for that length of time and that intensely, was a great help. I did triage on the ground test program, where I went through everything that people had suggested be done for a ground test and made a determination as best I could as to which ones were unnecessary, and there was a bunch of that—ones were done more frequently than they needed to be. The rule I used was that we wanted to do everything that's needed to be done once, but unless there's very good reason, only once in the test program. We applied that rule, and the subsystem people had to defend what they proposed to do to me and a group of people I gathered.

We made the determination of what ground tests would be done. That included what we called the combined systems tests, where you had more than one subsystem involved in the test program. Such things as LTA-8 [Lunar Excursion Module Test Article], which was the thermal vacuum test article, was the first time we had the occasion to put all the subsystems in the Lunar Module. It was tested in Chamber B at Building 32 [Space Environment Simulation Laboratory] with John [S.] Bull and Jim [James B.] Irwin aboard. That was a manned test in a vacuum chamber, which was not quite as critical as the lunar program, but it was critical enough.

WRIGHT: How long did that test last? Were you there for the testing itself?

DAVIS: When I got through with the planning, it was time for my next assignment. They said, "Okay, we want you to run the combined systems test program for the Apollo Program." I was put in charge of actually executing the tests that I'd planned for the LTA-8 and what was called Airframe 1, which was tested at White Sands [Test Facility, Las Cruces, New Mexico]. As a little additional duty, they gave me the job of planning and executing the design and construction of the White Sands Test Facility. As additional duty, mind you. That was something I had to do in my spare time. That was great fun, very satisfying, and it's still there, as you know.

WRIGHT: So were you out in New Mexico quite a bit? That was that spare time, you filled it by going out there.

DAVIS: Yes, I was out there. They had two retired colonels that were the NASA and North American managers, respectively. These two guys were fighting like cats and dogs, and I had to

go out there and get them together. I said, "Look, you guys are officers and gentlemen by act of Congress, now behave yourselves that way." It got their attention, and they learned how to get along, which I thought was great.

I got out of the Air Force as a captain, and these guys were retired colonels, but they listened to me. That was good. I still have a lot of friends that retired from White Sands that were some of the leading lights in running that program. They did a really good job.

When the ground test program was coming to a close and we'd finished our tests, we then had the flight vehicles coming down the line. They set up the flight test group I was put into then. There were five lead guys, all of us GS-15s. We had a terrible time trying to figure out who was responsible for what. I went to the boss, who was then Owen [G.] Morris, and I said, "Owen, I want to draw on my Air Force experience and make a suggestion on how to deal with this. Let's assign each of us a tail number where there's a specific vehicle that we're responsible for, and then there's no confusion as to who does what amongst the five of us, and we rotate to the next five when these five are finished." He said, "Okay." That's where the vehicle management concept came from.

We didn't call it crew chief, because crew chiefs are sergeants, and we were all the equivalent of colonels. If we wanted to keep our pay scale, we had to have some title other than crew chief, but that's really what it amounted to, being crew chief on one of the vehicles.

Now it was arguably more important, because of the mission and the cost and the size of a Lunar Module as opposed to an airplane. It was the same task at hand of keeping very close track of a specific piece of hardware to be sure that it met all its requirements and had been handled properly and was built and assembled as it should have been. In that capacity, I spent most of my time at Bethpage [New York, headquarters of Grumman Aircraft Engineering

Corporation]. I was in the Lunar Module part, and there was a similar group that was assigned on the Command and Service Module under another guy besides Owen [Morris]. I think maybe it was [Rolf Lanscron], but I'm not sure.

That went on through the LTA-8 program; that was my first one. That was a challenge because the LTA-8 was the first time we had the occasion to design and execute the factory tests and then the tests at the field Center, in our case JSC rather than the Cape [Canaveral, Kennedy Space Center (KSC), Florida] on a vehicle with all of its subsystems installed. We had to define what these tests would be, what the limits on all the parameters would be, and how we went about doing it, in great detail, and to document the procedures to be used in conducting the tests. That involved a lot of work.

WRIGHT: How many people did you have helping you do the things that you just described? Did you have a big team or was it very limited in scope?

DAVIS: I had at most three people.

WRIGHT: Did you have authority to make changes at Bethpage as the NASA representative? Or did you have to go back and have someone tell Grumman?

DAVIS: If it was procedural changes and that sort of thing, I had the authority. If it was hardware changes, it had to go to the Configuration Change Board. I attended those, but the sponsor of the change was the guy that made the presentation to primarily George [M.] Low, the program manager. I'd sit close by and be there to object if something came up that I thought was

going to hinder our schedule or reliability or whatever. I was in an advisory role for that rather than a deputy role.

WRIGHT: Did you exchange information with the other vehicle managers and share information between you all?

DAVIS: We shared information and tried to stay close together. One of the things I was proudest of on Lunar Module 5 was I made it my practice, when I was up at Bethpage checking everything out preparatory to shipping to the Cape, to make a daily telecon to the Mission Control [Center] guy that was in charge of the Lunar Module and brief him on what was taking place and the anomalies we'd had and what we'd done to resolve them. He was so appreciative of it that he made me a member of the Mission Control team and gave me one of their cups, which I have somewhere in a box. Apparently I was the first guy that had troubled himself to call them up and tell them what was going on, but I just thought that was part of the task that I had before me, and it didn't occur to me not to do so.

WRIGHT: It certainly seems like that would help the Mission Control team to understand if you were sharing information on a daily basis.

DAVIS: Yes. They needed to know these things, because they were apt to experience the same problems that we had in flight. If it occurred once, it was apt to happen again, so they needed to know what happened and what was done to correct it. I let them know those things because I

thought that was part of what I was assigned to do. Never occurred to me to do otherwise, but apparently that was unique.

WRIGHT: I understand one of your LTAs was the Eagle [Apollo 11 Lunar Module (LM)] that landed on the Moon. Can you share with us what that was like knowing that your assignment actually went to the Moon?

DAVIS: It was scary, that's what it was. There was a million things that could have gone wrong and didn't. It's been my contention for all these years that the good Lord was with us or it would not have happened. That may sound hokey to you, but I mean it quite sincerely that there was some power greater than those group of humans behind that succeeding.

WRIGHT: I think at this recent 40th anniversary celebration, lots of people talked about so many things that went right that could have gone wrong.

DAVIS: That's right, yes. So it wasn't just skill and integrity and hard work. It was something beyond that that worked for us.

WRIGHT: Do you have any insight you can share with us on how many people that had your skills and integrity? The group of engineers and the group of managers that were there worked so well together and brought this technological feat to success. But yet, as you mentioned already, so many of you had strong opinions on how things should be done. How was it able that you all came together at the end and supported each other's decisions to create the success?

DAVIS: That goes back to my time at Texas A&M. I was marching in the Texas Aggie Band for four years. And if you can get 300 people marching in the same direction, each playing their part as best they can, you can do anything. Another A&M statement was in any group of people there's always two percent that are the "badniks," and you have got to at least isolate them, and if you can, get rid of them. So, in my opinion, the Apollo workforce was 98 percent pure, and we didn't suffer the two percent very long. I think most everyone that worked on the Program had the mindset that we were engaged in fierce warfare with the Soviet Union as to which society was a superior way of organizing human beings. The arguments that we had were secondary to the common cause that we had. It really was, to my way of thinking, warfare that we were engaged in, as much so as when I was in Korea. That drove nearly everybody, but you had the inevitable two percent. Does that answer your question?

WRIGHT: Yes, it does. It's just the more that we review what we know about history, and then the more what we learn from people's personal experiences, it still is one of the aspects that seems to be so amazing, that people come together, even though they may have strong opinions, to work toward a common goal.

DAVIS: You need to have first and foremost a common goal. Our goal was we were going to beat the hell out of the Russians. And it wasn't at all clear that we were going to do so until we did it. Along those lines, one of my proudest accomplishments in the Apollo Program, I may have mentioned to you before, was when they were setting up the program, they set it up with missions with letter designation to them. LM-5 was not intended to be the first to land. It was

intended to be the last to *not* land. It was to be flown in July of '69. LM-6 was in October, as I recall. The program manager decided that they'd make very sure that LM-6 and beyond had the minimum possible weight. They had what they called SWIP, Super Weight Improvement Program, with Grumman, where Grumman was not only on a cost plus fee basis, but in addition they were given a bonus of $10,000 for each pound of weight they could shave off the Lunar Module, beginning with Lunar Module 6. My bird, LM-5, did not get the benefit of that, so it was a bit heavier.

When we got some new notice about the progress the Russians were making, it was a little scary. I told my assistant Roger [D.] Hicks that we needed to do something to reexamine whether or not we had the ability to land LM-5 on the Moon. He did an analysis that I participated in, and we concluded that if the guys would throw the backpacks out the door before they closed the hatch, if they'd take the big heavy notebooks with flight plans that were for descent only and throw them out of the hatch before they closed it and prepared to get off the Moon, and most importantly, if the Configuration Change Board chaired by George Low would hold the line exactly in weight for 18 long months between then and when we flew, that LM-5 could make it.

So I went to George with this story when we got it put together. I said, "George, I have a Sicilian offer for you. How would you like to have LM-5 be able to land in July rather than waiting for LM-6 in October? It might make the difference between winning and losing." Well, what could he say?

So he did, and he was able to hold the line on the weight. Now we have Buzz Aldrin talking to people saying, "This is the guy that gave me a heavyweight LM, and we damn near crashed." I'll stand up and say, "No, Buzz, it was pilot error." That breaks up the crowd, of

course, but getting Lunar Module 5 to land was one of my proudest achievements. I want to show you a letter that George Low sent to me after the mission. [Retrieves letter] It's been eaten by the bugs, so you'll have to pardon me, but the thing you need to look at is the handwritten note at the bottom.

WRIGHT: It says, "Congratulations, Hu, you must be pleased that LM-5 was the—"

DAVIS: "First to land on the Moon."

WRIGHT: "First to land on the Moon."

DAVIS: That was a wry note, and the reason it was wry was because achieving that meant that many of the Grumman people got laid off three months earlier than they'd all anticipated. It was a mixed blessing, so far as many people were concerned. I've since been told that the Russians had a vehicle in orbit with us for Apollo 11, and it turned out in recent years they found out it was an unmanned landing probe that failed. We didn't know at the time but what it was a manned spacecraft that Russia was preparing to land while we were in orbit around the Moon before we landed.

WRIGHT: How much information were you given about the Russians? I know that upper management was in meetings.

DAVIS: Very little. Very little. All I knew was that there was something in orbit with us, and they suspected it was a Russian spacecraft. They didn't have any knowledge of whether it was manned or unmanned. They didn't even know for sure who it belonged to.

WRIGHT: Was this after the launch that you learned this?

DAVIS: It was after we were in orbit around the Moon when I first heard about it. But people weren't talking very much, because it was, I guess, considered a deep dark secret that they knew how to detect such things. We thought it was a very nip and tuck situation up until the time that Neil [A. Armstrong] put his foot on the Moon.

WRIGHT: I find it interesting that you have worked so closely with Buzz Aldrin since then. I'm sure you've had a chance to talk to him about his perspective on your bird.

DAVIS: Not in any serious way. He's always just made that joke about, "This is the guy that gave me an overweight Lunar Module."

WRIGHT: What an interesting, almost simple way to lessen that burden, by leaving the backpacks and the flight plans. That's still weight, certainly nothing that they needed to return home with.

DAVIS: That's right. When we got to thinking about it, it was an obvious thing to do, but apparently people hadn't thought about it before. That was a lot cheaper than paying $10,000 to

cut a few thousandths of an inch off corner fittings on the descent stage. We had a lot of adventures getting the vehicle ready to go.

One of the most frightening ones was after we shipped the Lunar Module to the Cape, somebody came up with the idea that we were subject to stress corrosion where the joints in the descent stage were put together because they had not used a zinc chromate finish on the aluminum part. The high strength aluminum alloy 7075 was found to be vulnerable to stress corrosion, which meant that the corner fittings might fail. After we had the descent module all thoroughly checked out in Bethpage and shipped it to the Cape, the order came out that they had to disassemble the thing, take it apart to the piece parts, use the zinc chromate material on it, and then use shims to be sure that there wasn't any eccentricity in the joints, and then put it back together and check it out again.

It was really a terrible situation for me to go out and look in the hangar and see my nice descent stage laid out in piece parts on kraft paper on the hangar floor. But we did it, and we got by with it. That was another occasion where something greater than us was at work, because it all went back together well. And I never will forget the fact that one of the tubing fittings leaked. The leak occurred at an elbow joint that was just an inch or two out from where it disappeared behind structure, and we had to replace that joint. They had the best welder that Grumman had, go out there and unbraze this fitting, take it out, and put a new one in and braze it back again, and just pray that it didn't leak again. He did, and it did not leak. We must have had 20 people gathered around watching him while he was doing that.

WRIGHT: I guess you were checking off your list of all the things that went right as it landed.

DAVIS: Yes, that was another thing that went right. We got it done, and that was I think an important thing, because it's been my contention ever since that that lunar landing was at least as important as the fall of the Berlin Wall in getting us out of the situation of being in a far worse situation than we're in today with regard to the Russians.

WRIGHT: Do you feel like the momentum at the Space Center changed at all after you had the first lunar landing?

DAVIS: Of course it did. It was almost entirely lost; it carried on just through inertia. Later, I was a party to LM-15 as my last such assignment. Because there were five of us, I went from LM-5 to LM-10 or Apollo 15. LM-10 was another interesting assignment, because the decision had been made before I was given that assignment to have Apollo 15 be the first to stay three days and to carry the [Lunar] Rover, which was a very significant modification to the vehicle. I had to look after getting those things done, which was another interesting drill. There again it worked well.

WRIGHT: Did you spend a lot of time at [NASA] Marshall [Space Flight Center, Huntsville, Alabama], or at all?

DAVIS: No, I didn't worry about the Rover itself. I worried only about getting it stowed in the Lunar Module, which was not easy, having it where the flight crew could get it out and get it to work on the Moon. But the Lunar Module itself was what I was concerned with. The Lunar

Rover I just steered completely away from that because it was Marshall's responsibility, and I wasn't about to touch it because I didn't want any hint of my being responsible for it.

WRIGHT: I imagine you had enough to do.

DAVIS: Yes, I had plenty to do without that.

WRIGHT: Were a lot of modifications made to the LM at that point?

DAVIS: Yes. We had to put in additional cryogenic storage for the fuel cells, for example. We had to be sure that the ascent propulsion system, which used supercritical helium as its pressurant, was sufficiently well insulated to last for the additional time on the Moon. That system, by the way, is the only one that caused a comment to be made by George Low directed my way during the countdown for the Apollo 11 launch. There was an issue that came up between a guy at the Cape and me as to whether or not we had the ability to turn around the next day if we had to stop for some reason. The KSC guy raised alarm that no, the supercritical helium will heat it up too much, and we'd be out of limits and couldn't go. My numbers said otherwise, so we had that discussion on the loop with George Low listening. He finally said, "You guys get off the loop and solve this offline." We did, and I won the fuss, but that was not even necessary, because we didn't have to wait. We launched the day we intended to. That's some of my adventures. I hope that helps.

WRIGHT: It does. It reminded me—again, with the recent 40th anniversary—it came up on a couple discussions about the lack of specific knowledge on how the Lunar Module would land on what was there. Some thought maybe it would go down 10 feet into the dust.

DAVIS: That was very early on. Ranger and Surveyor [Programs] put that issue to rest long before we made the landing attempt. We knew it was going to be okay well before we launched the vehicle. That was another case where—Tommy [Thomas] Gold was this notable scientist from Cornell [University, Ithaca, New York] that's caused all sorts of grief in years since with his various theories. He's a guy that in recent years has said, "We don't have any shortage of petroleum, all you have to do is dig deep enough, because it's near the core of the Earth in such huge quantities that we could never consume." He's the sort of guy that brings up those sorts of matters. He's the guy that said, "You land on the Moon, you're going to sink 10 or 20 meters deep into the soil, and you'll never hear from them again." So we had to go with the Ranger and Surveyor Programs to find out whether that was true or not. Obviously when LM-5 landed, the footprints were perhaps an inch or inch and a half deep, no more.

WRIGHT: Just like you said, it's quite astounding that all went as well as it did. You moved out of the Apollo Program after Apollo 15 into the futures area. Is that correct?

DAVIS: I was assigned to work on another Lunar Module that it turns out didn't fly because the Program was canceled before it was its turn, but Grumman didn't need me by then. I stopped going to Bethpage because they knew what they were doing well enough to where I wasn't going to be of any help, so I stayed home and talked to them on the phone. I was assigned to LM-15,

and that was dullsville compared to where I'd been. I did a little study on something, I forget what it was, and went to show it to Max Faget. He found out that I could even draw a picture, which amazed him, that a guy from the Program Office could draw something. He offered me a job to work in what he called his Special Projects Office.

He set me up sharing a little office adjacent to his own with Jack [John M.] Eggleston, who was a friend and neighbor. Jack was the head of the Special Projects Office, and I was his sole employee. Max said, "I want you to take a look at something for me." I said, "What's that?" He said, "I have a suspicion that this nuclear stage that they're working on in Huntsville makes no sense if the [Space] Shuttle can meet its goal. I want you to do a study and compare for me the effectiveness of the nuclear stage to a chemical stage or stages." They had been spending $100 million a year for 10 years on the engine, and they were about to give Marshall another $100 million a year for 10 years to build a nuclear stage.

I got with a friend in Mission Planning named Jack Funk. He was the trajectory analysis expert. He and I did such things as fly to Mars five times overnight with 10-inch slide rules. That was before we had pocket calculators, never mind computers. Well, there were computers, but they were operated behind glass doors by these people in white suits, and you'd go give them something to do and go back three days later to pick up the results. That was what we had to work with in Apollo and the years immediately after. So Jack and I got together and examined what people were saying at Huntsville and [NASA] Headquarters [Washington, D.C.] about this nuclear stage.

One of the first things I noted was they planned to bring it back and dock it with the [International] Space Station. Looking at that engine, once you pull the rods on the nuclear reactor, it's radioactive from then on for 10,000 years. They were going to use this thing to fly

from low-Earth orbit to the Moon and then come back and dock at the Space Station. The shield they had on it to protect people from nuclear radiation was good only for 15 degrees either side of the centerline. If you had the nuclear stage come back and dock and move 16 degrees, it'd kill everybody aboard the Space Station. If you failed to dock and it entered the biosphere, you might contaminate Paris [France] or New York or London [England] or whatever with radioactive material from the reactor.

So there was a very strong disadvantage, in my view, of using nuclear power, and still is—unless you're at what's called C_3 [characteristic energy]. That's called excess hyperbolic velocity. C_3 is reached when you're escaping from the Solar System. So unless you can use a chemical system to get you to where you're not going to be returning to the biosphere ever, you ought not to pull the rods on a reactor. But if you want to go way far off and you can get that velocity, okay, go ahead, use it. I still have that point of view, but the nuclear people keep coming back with what they call a nuclear safe altitude where if you put it at 5,000 miles, the chances of it coming back are sufficiently small that you ought to be able to tolerate it. Well, I don't buy that, thank you.

WRIGHT: Was this your first work in the Shuttle Program or Shuttle area?

DAVIS: First work for Max Faget and his so-called Special Projects Office. The next thing he had me take on was a thing called a Space Tug, which was another Marshall project that they'd been spending big money on, which was a hydrogen-oxygen propellant upper stage. The requirement that Marshall had set for it, and Headquarters, was to take 3,000 pounds of payload out of the Shuttle payload bay with this thing called the Tug, go to geostationary orbit, drop it

off, pick up another 3,000-pound item, and return it to the Shuttle. That's an exceedingly difficult mission, and it requires cryogenic propellants.

But the downside of that is that if you have an abort while you're carrying this thing, you're going to lose the whole thing. The reason being that hydrogen leaks out through metal walls. It's the world's smallest molecule, and hydrogen will leak out through anything. So you had to assume that you have a Shuttle payload bay filled with hydrogen gas, and if you enter the atmosphere with the [Shuttle] Orbiter, it has vents that allow atmospheric air with its oxygen to come back into the bay. All it would take would be one spark, and it would destroy the Orbiter and its contents and its crew.

I looked at that, and I said, "We ought not to do this thing. It's damn well dangerous." Max said, "I agree with you. What can we do?" Then he said, "I tell you what. Let's give them something that they can't get the propellant out of it unless they have a steam wand and a spoon." That is, a solid rocket upper stage.

By that time Special Projects Office was off somewhere else, Building 45 as I remember, and I had five or six people working for me then. That seemed to be my favorite number for subordinates, something between five and ten. I had this guy look at what we needed to have. By that time, the contractor reps [representatives] were coming by to see me frequently, because I kept a blackboard with my wish list of things I'd like to have studied written on it, and these would change from time to time as we'd decide not to do it or we got money to do it and it was no longer a wish list.

These guys that worked for Boeing [Airplane Company] and North American [Rockwell Corporation] and Thiokol [Chemical Company] and others would come around and ask if they could copy what's on my board. I said, "Of course you can." So they did. About two thirds of

the time, in a few weeks I'd get a call and somebody had a briefing they wanted to give me where they'd gone off and done the study on their own time, and I didn't have to get money out of Headquarters to do it because they'd offered it without that. I became known as a "thief in the night" by the contractor guys in a good-natured way. They didn't object to doing that, they were glad to do it. We were able to get a lot of work done without having to deal with Headquarters and all the bureaucracy they put in the way.

WRIGHT: Did a lot of those items on your wish list move forward?

DAVIS: Yes. The dominant one was done by the Air Force. They called it the Interim Upper Stage, IUS. Later on when it was obvious it wasn't going to be interim, it's permanent, it became the Inertial Upper Stage. I don't recall whether the number of times it flew was closer to 25 or 50 missions with the Shuttle. George Low indicated some concerns when he was Deputy Administrator about whether the Shuttle could compete with the Delta launch vehicle or not. So he said, "Let's see what we can do with a Delta class of payloads, and how would you propose to do that." I went off and did a study I called the "Delta Killer." They later changed its name from that ugly term to being the PAM-D, Payload Assist Module-Delta. It was a simple platform. You'd raise up the payload with a solid rocket motor attached to it in the payload bay and use an electric motor to spin it up to stabilize it, and then let it go and get a safe distance away and fire the solid rocket motor, and it did the same thing the Delta did.

A larger version was called PAM-A, which was a larger motor designed to replicate what the Atlas/Centaur [rocket] could do. It flew a few times, but not as many. The PAM-D is used

to this day as an upper stage on a Delta launch vehicle. Those three items were brought to fruition from work done in my little office. I had a lot of help from Thiokol on the IUS.

The Air Force in their wisdom saw fit to give the motor job to Chemical Systems Division, their competitor, which had a lot of trouble with it. Boeing had done the study and said it was going to cost something like $20 million a copy. By the time the Air Force and Chemical Systems Division and Boeing got through with it, the IUS cost $50 million a copy, which was not necessary. But you can't win them all.

WRIGHT: No, but like you said, that certainly did leave a mark in the program, didn't it? How long did you have your little office of five to six people for Max?

DAVIS: I have to think about that—several years—I don't recall. Just a few months before I took early retirement, Max reassigned me from that job to be his representative to the Shuttle Program Office. My job was to sit in these Configuration Change Boards and handle those problems I felt I could handle and run up three flights of stairs to get him for those that needed his attendance. I sat in those dull six-hour-long meetings talking about such things as, "Should we remove the lights from the centerline of the runway at the Cape?" They spent five hours on that subject when it was immediately obvious that, one: the computer landed the machine and didn't need the lights, number two: they were only used at night and we didn't plan any night landings, and number three: it was a lead-pipe cinch—if you hit the thing with the nosewheel tire when it's heavily loaded it was going to blow. So it became obvious in the first 20 minutes of that discussion what ought to be done: take the damn lights out, but they talked about it for five hours.

I put up with that for three or four months and never had occasion to run upstairs. Then the early out opportunity came along. One of my friends came by and said, "What are you going to do about early out, Hu?" I said, "Well, I don't know, I don't know what job I'll get, but I understand a lot of the old-timers are going to retire." He said, "No, dummy, I mean you. I came in about the same time you did, and I had about the same military time you did, and I'm eligible, and I think you are." I said, "Do you still have a copy of the memo? I threw mine in the wastebasket because I knew it didn't apply to me." He gave it to me, and sure enough including counting my two-week active duty tour after I left active duty in the Air Force, I barely qualified for the early out at age 48. So I took it because I was bored with the job that Max had given to me, and I didn't want to hang around anymore.

WRIGHT: Were you part of that group that he pulled together to develop the first planning of the Shuttle? The first set of designs that they pulled together?

DAVIS: No. I was disappointed not being selected for that group. But he put me in charge of the payload accommodations branch, where I was supposed to deal with the science community and the other users and determine what we needed to provide for payloads inside the payload bay. This was a terrible battle with the subsystem managers, because I had to go persuade the guy in charge of the telemetry to give us a certain number of channels to be radioed back to Earth from the Orbiter system, from the electrical system guy to give us so many kilowatt-hours, and then to the thermal guy to get rid of the heat that was generated by the electric power, and the mechanical systems guy to put in the necessary support structure to where we could hang the

payloads in place. I had to deal with all these kooky scientists that had their own ideas of what ought to be done. There were 30, 40 of them, and they were all different.

I remember very well one meeting that I chaired where we had these guys in there, and we were talking about the electrical supply, and they were all complaining because I was planning to give them 28-volt unregulated DC [direct current] power, and let them do with it what they will. They were really upset about that because they wanted precise power. Some wanted AC [alternating current], some wanted DC, some wanted one voltage, and others wanted other voltages. I said, "Okay, you guys, tell you what. I'm going to go get a cup of coffee. I'll be back in 20 minutes. You agree on what you want, and I guarantee you I'll give it to you." Well, you know what happened? I came back in the room, and they had a bunch of sheepish looks, and they said, "We'll go with your 28 volts."

WRIGHT: Was the size of the payload bay determined when you were working there?

DAVIS: It was determined, but not by me. It was determined by the Air Force, probably dictated by the National Reconnaissance Office, which wanted to put their huge—what amounts to the Hubble Space Telescope—in the bay; and by Marshall, who wanted to put their space tug in there, because the payload bay was sized before I did my study that resulted in it getting canceled.

The space tug had the heavy oxygen tank, which was most of the weight of the thing, way out back. So one day a fellow named Bass Redd that worked in the Orbiter design shop came by and said, "Tell me where the payload CG [Center of Gravity] is, Hu, we got to put the wing on this thing." I ran the numbers with the mirror of the telescope in the aft end and the

LOX [Liquid Oxygen] tank of the tug in the aft end, and biased the payload CG aft to account for those matters. As a consequence, to this day we must carry all the weight in the rear end that we can as ballast. And we still have an overload problem on the nose gear because the CG of the Orbiter with its payload today for every flight except to place Hubble has been much forward of where you'd like it to be. That's my fault, but you have to act on the information you have.

WRIGHT: It had to be a different time than it was with Apollo. Can you share some of the differences of how things were done when all of you were planning for the Apollo certification processes and the testing, compared to what was happening during the Shuttle planning and the design era?

DAVIS: [Christopher C.] Kraft, who beat Max Faget out for the job of Center Director, had a friend named John [D.] Hodge that he assigned to head up what he called the Advanced Systems Directorate, which was a parallel organization on the same level as Max's. Their job was to look into the future project stuff. They ended up being a bureaucratically hidebound group that primarily worked in supporting studies, these Marshall projects of the nuclear stage and the Space Tug and things of that sort. They were also working on Space Station. Max didn't like it. The real task of the Special Projects Office that he formed was to destroy that organization, which we succeeded in doing. John Hodge left and went to work for the Transportation Research Center in Cambridge, Mass [Massachusetts], which NASA had briefly. Max won that one because of the work that Jack Eggleston and I had done that essentially refuted all the stuff those guys were promoting.

WRIGHT: But Max still was able to get the funding to keep your project office going. Was there any time during that time period you were there that you guys felt you were going to lose your funding to keep your office going?

DAVIS: We got very little funding. We had a fellow named John [H.] Disher that ran the advanced systems shop at NASA Headquarters, and he became a fan of what we did, and he saw to it that we got a dribble and drabble of funds, but we never got more than 20 percent of what this other group had received. I was able to get things like a little $50,000 award from Headquarters to study making use of lunar resources to build a power satellite. A guy that became a close friend at General Dynamics [Corporation] named Ed [Edward] Bock headed this little $50,000 study, which they put a lot more than that into it, I think. He found that if we built a base on the Moon and developed the resources of the Moon, we could get 90 percent of the mass needed for the power satellite construction from lunar materials, because of the one-sixth gravity field of the Moon was ever so much easier and cheaper to get from the Moon's surface to geostationary orbit than to get from the Earth's surface to geostationary orbit. And it might make the difference between power satellite being economical and not. That was done for $50,000, and that study to this day has held up as being an accurate representation of what we could do. It wasn't optimistic enough to suit the space colonization crowd. They did a study and said, "No, it's not 90 percent, it's 99 percent." Well, hooey, who cares? Nine percent isn't worth the additional problems, I don't think.

But another issue that came up somewhere in that period was how you ought to go about building a Space Station. I was asked by Frank Borman to join his group when he headed the first Space Station study out of Houston, to leave Max's group and go to work for him. I turned

it down. The reason I turned it down is they were concentrating on what was known then as the modular Space Station, which is the way we ended up building it. I said, "That's foolishness. You don't want to put up a Tinkertoy set. You want to build a heavy lift vehicle and put it up in no more than three or four pieces with a heavy lift bird rather than trying to put the thing together with all those EVAs and all that difficulty, because it's going to cost you a lot more and take a lot more time." They said, "Well, we need to look at both." I said, "Okay, thank you, but no thanks." So I turned down that job. I think I was proven correct in that, but the hard way, because they went ahead and did it. We spent far more money and time and effort to build that thing than was justified. We could have had both a heavy lift vehicle and the Space Station for far less money than we spent on the Space Station itself. That was another one of NASA's several missteps in recent years, in my view.

WRIGHT: You also worked on, I believe you told me, the solar power satellite. Did you want to talk about that at all?

DAVIS: I'll be happy to, that's my favorite subject yet today. When I was running the Future Programs shop for Max, I had a visitor from Arthur D. Little [Inc., management consulting firm] named Dr. Peter [E.] Glaser. Peter had come out with this story that was printed in the journal, *Physics Today,* where he said, "We can generate all of mankind's electrical power most efficiently if we put satellites the size of Manhattan Island [New York] in geostationary orbit and beam the power to Earth with a microwave, pick it up with a thing called a rectenna, and turn it into DC power for the high voltage transmission lines." Peter wanted to see me and talk to me about his concept. I, of course, accepted. He came down, and I heard him out. I said, "Well,

that's interesting, Peter, but I know there's got to be a fatal flaw. I tell you what, I'll see if I can find it, and if I do, I'll let you know what it is."

That cost me three days and four nights of a Thanksgiving weekend running numbers on an accounting pad with a pocket calculator. Yes, I had a pocket calculator by then. I did not find a fatal flaw. So I called Peter up and said, "I think you've got something." He said, "Okay, what are we going to do about it?" I said, "Well, I'll see what I can figure out." I talked to Max about it, and he wouldn't even broach the subject with me. He said, "No, that's too far out for me. I'm not going to listen to you, but if you can persuade Guy Thibodaux," who was his roommate at LSU [Louisiana State University, Baton Rouge] and headed his Power and Propulsion Division, "if you can persuade Guy, I'll listen to both of you." So I set to and took my analysis over, and Guy heard me out and came to agree with me.

We went to Max, and he listened, and he came to agree with us. Then Max took it to Chris Kraft and he became the world's foremost advocate of solar power satellites. At that particular moment, NASA had an Assistant Administrator for Energy. That was a very brief assignment, but they had an Assistant Administrator for Energy briefly headed up by Dr. Jack [Harrison] Schmitt. Chris took the thing to Jack. Jack took it to the Department of Energy. The two of them went to Congress, and they got the $19 million Boeing and North American studies funded.

I asked to head the one at JSC. Bob Piland, who had by then been put between Max and myself, instead gave the job to Clarke Covington. I was given the subordinate job of working on the space transportation part only of the solar power satellite, which turns out to be the impediment of why we're not doing it today. So it was I think a pretty important job. We did the study, and we came out with the conclusion from both the Department of Energy and NASA

that it's technically feasible, but that its costs were a factor of between five and ten higher than it needed to be to be competitive with coal-based power.

That was 35 years ago, but technology has advanced tremendously since then. It's my view that what we desperately need to do as a society is to go back and review the bidding on the power satellites' cost-effectiveness compared to the now-increased costs of clean coal power. Since we did the study 35 years ago, technology has advanced. We thought we might get 15 or 16 percent efficiency out of solar cells. Well, today they're routinely getting well above 30 percent. The satellite mass in those days for a 10-million-kilowatt station was 100,000 tons. Today, I think we could get that same satellite up for about 23,000 to 25,000 tons—roughly one fourth of what we had then. This is important, because it reduces the burden of transportation by a factor of four or more.

It is very likely that if the study was done honestly today that we would have a cost-effective solar power satellite at our disposal to solve, not just for a while, but for all time mankind's needs for energy. Generating the power in geostationary orbit rather than here on Earth, the waste heat, which 30 percent efficient cells put out 70 percent of the heat as waste heat. If you radiate it into space rather than putting it in the biosphere, you can use something like 40 percent more electrical energy here on Earth with no more thermal burden on our planet. So I think it's a vitally important thing for society at large to do this. We waited 35 years, and it's doubtful to me whether we still have the ability to do it, never mind the 35 years we ended up spending the nation's treasury on far Mid-East oil. I think we desperately need to go back and do the study again.

About two and a half years ago I was greatly encouraged when a small office in the Pentagon that has no money, but does have some very bright young officers, picked up and said,

"Hey, there's a niche market for the military here, because look what's going on in Iraq. We're spending huge sums of money to carry diesel oil from the ports in Kuwait to where the troops need it in Iraq. The enemy has roadside bombs, and we're losing a lot of people." It's their opinion that the cost of a kilowatt-hour in Iraq is somewhere between $1 and $10 rather than what we pay, which is, before you put it on the transmission system, maybe a nickel a kilowatt-hour. They have an incentive to have this thing for their purposes without regard for the kind of cost difference that might exist. I think if we used lunar materials for that 90 percent of the mass that we can beat the cost that we're paying today for electrical power by building power satellites from the Moon.

That means that we got to get with it with regard to the Moon. Not with people, necessarily, but with an aggressive robotic program. My priorities for NASA today are twofold. Number one is people aren't going to believe you have low-cost launch services until you do it. We've got to go ahead and not have NASA manage such a program, because Marshall has had about six different tries and they've blown every one of them. It's time to stop that foolishness and find out what it would take in terms of incentives to have the private sector pick up developing this heavy lift launch vehicle that we need.

There's today a big competition going on, because the Shuttle program manager has funded a little bit of work at JSC to come up with what they call a Side-Mount Shuttle-derived vehicle. Well, the Shuttle-derived vehicle is something else that I did for Max in the Future Programs Office in the early '70s. He called me over one day and said, "I want you to look at something, Hu." I said, "What's that?" He said, "What can we put up with the Space Shuttle propulsive package if we don't have the Orbiter present?" I said, "When do you want it?" He said, "How about a week?" I said, "How about 10 days?" He said, "Oh. Okay."

So in 10 days I went back to him with some charts and said, "Yes we can do it, and it'll put up 150,000 to 160,000 pounds of payload, and we can recover the engines"—which at that time cost $50 million apiece—"by putting a heat shield on 1307." That's the bulkhead between the aft section and midsection of the Orbiter. "Quartz cloth down the sidewall." Put it down with three huge parachutes on the King Ranch [Kingsville, Texas]. If we hit a cow, we pay for a barbecue and invite all the cowboys. Then once we recover it with a big lumber carrier like Schlumberger [Limited, oilfield company] builds, we take it out to twin piers in Laguna Madre [Gulf of Mexico] and put it on a barge and carry it back to the Cape and use it again." And that we called the Shuttle-derived vehicle.

Headquarters said, "Hey, that's a really neat idea. Marshall, go off and design us a Shuttle-derived vehicle." Marshall did so. And they decided they had to add the Shuttle midbody to it, which is made out of boron-epoxy and is a terribly expensive piece of business. They put all the bells and whistles on it, and the thing collapsed under its own cost because they made it far more complicated than they needed to.

That subject has come up again. Mack [Edward M.] Henderson at JSC has done a study with my friend Jack [John] Frassanito who owns a graphic artist company under contract to the Johnson Space Center. Jack hired Ted [Dr. Theodore A.] Talay, who once ran the Vehicle Analysis Branch at Langley Research Center. Ted is one of the world's foremost authorities on space launch vehicles, deriving mass properties, costs and schedules, and running precision trajectories to see what they will do. The JSC team, including Mack, Jack and Ted, came up with the Side-Mount Shuttle-Derived Vehicle (SDV). The Shuttle Program Manager, John [P.] Shannon, has picked up on the Side-Mount and says he wants to do two things: continue to fly

the Space Shuttle for a while and build the heavy-lift Side-Mount SDV to share the facilities at Michoud [Assembly Facility, New Orleans, Louisiana] and Kennedy Space Center [Florida].

The Side-Mount Shuttle-Derived Vehicle was an awfully good idea 35 years ago. Today I think it's time for us to move on and incentivize the private sector with an equivalent amount of money, which they say is $6.5 billion, but perhaps not to develop this thing, but rather to incentivize the private sector to build a fully reusable two-stage to orbit heavy lift vehicle to do the same job at much lower cost per flight. If we do that, I'm convinced we can get the launch cost down to something like $300 a pound from something like $8,000 to $10,000 a pound. It will enable this power satellite thing to come into being.

That's my crusade I'm on currently. I'm working with this small group of people at the Air Force that want to do it. One of the guys that's in this group is right here in San Antonio. He's become a friend. His name is Bob Lancaster. He was promoted from major to lieutenant colonel fairly recently and was kind enough to invite me to his promotion ceremony. He's in charge of the Security Service Advance Planning Group. They're the people that are interested in getting this niche market filled with energy from space rather than from diesel oil.

WRIGHT: You've been on both sides of development. You grew up in the NASA era and learned those processes and procedures and saw it from the government side. Then you were off in consulting for a while, and of course now working with these groups. What are the pros and cons of doing what you're saying now, moving more to the incentive for the private enterprise? Why do you feel that will work out better than the government side?

DAVIS: The government side has dramatically changed in the short years I was there after Apollo before I left. They changed rather dramatically. And they've changed even further since. Today the Constellation Program is working on a system where they're going to add between four and six new O-rings on the solid motors, which is what cost us seven lives and an Orbiter [STS 51-L *Challenger* accident]. I think that's a dumb thing for us to do.

I think it time to do something different, and figure out what it takes in terms of loan guarantees and guaranteed purchase of flights from the private sector to motivate such companies as [The] Boeing Company to go ahead and invest their own funds to build these things and manage it in-house, and NASA end up being the purchaser of services rather than the provider of services.

WRIGHT: When you were working for Max [Faget] and in special projects, he would give you a project or you would come up with these ideas. Did you have a specific process that you put yourself through in order to meet, for instance, your 10-day deadline to get all those pieces done? How did you take this idea and turn it into a plan that someone could look at and want to know if they moved forward? What was your system?

DAVIS: Just ordinary common sense as best I can tell. I don't know that there's anything all that mystical about it. Because rocket science ain't rocket science. It's a matter of having a good education, good experience, good background, knowing what questions you need to ask yourself, and then doing the best you can to derive the answers for them. Nothing magical about that process. It's what each of us use every day in managing our lives. So I don't think there's anything really special about what I did. I just think it was doing the job I was asked to do.

Everybody needs to do their best to find out what's important, and address those matters first, and then put the story together as best you can, and then test that story, and then take it forward. I don't think there's any great mystique to it.

WRIGHT: You mentioned through our time together that this person was your neighbor or this one lived where they did. Was it a good environment that so many of you lived so close together in the community and worked so close together? Did you have times to share ideas and thoughts outside of the Center as well, because you all were such close neighbors?

DAVIS: Yes, there's something to that. You know what the vernier thrusters are on the Orbiter?

WRIGHT: Yes.

DAVIS: They have little tiny motors that help control it. Well, that came about from a conversation that my next door neighbor, Henry [O.] Pohl, and I had on his front yard one Sunday morning, because those 1,000-pound thrusters are just too big to give you the delicate control you need. So Henry stopped his lawn mower and he and I decided we needed to add the vernier thrusters in order to give people the finer mode of control. It would pay off greatly by conserving a lot of propellant we'd otherwise waste. There was some of that that went on. It wasn't as frequent as you might think, because we didn't have that much time for social life. But it did happen, and it was useful to have people living together in Nassau Bay and El Lago and Clear Lake City and the communities around there.

WRIGHT: Must have been nice at least with the commute. You didn't have to go very far to go home at night.

DAVIS: That's right. I only had to drive three miles to work, and I had the sun at my back going and coming.

WRIGHT: That sounds like a good deal. Were there some other areas that you wanted to talk about before we close today?

DAVIS: Like I say, the future is my dominant interest today.

[End of interview]