ORAL HISTORY TRANSCRIPT

OWEN E. MAYNARD
INTERVIEWED BY CAROL BUTLER
WATERLOO, ONTARIO, CANADA – 21 APRIL 1999

BUTLER: Today is April 21, 1999. This oral history is with Owen Maynard, in Waterloo, Ontario, Canada. The oral history is being done for the Johnson Space Center Oral History Project, and it's being conducted by Carol Butler.

I want to thank you for joining us today. The first question I have, to begin with, is how you first learned about the opportunity at NASA and if you could tell us about your interview and the process there.

MAYNARD: All right. I was working at AVRO, Canada, Ltd., based at Malton [Ontario], near the International Airport, or actually on the same airport as the International Airport is that you flew in to come to Toronto. It's called the Pearson Airport, named after one of our prime ministers, who became prime minister after I left Canada.

I was working there, and had been working there for some years, actually from about 1946 until '59. It was in '59 when I learned that people from NASA were interested in interviewing me and several others with respect to working on the Man-in-Space Program, is the way they referred to it.

That's where I was, and I had been working on the AVRO Arrow airplane, very advanced long-range interceptor for NORAD [North American Aerospace Defense Command], the North American Regional Defense. Canada had the responsibility to design, develop, then operate the interceptor force, whereas the U.S. part had to do with the strategic defense force, the intercontinental ballistic missiles and the like, and the bombers. So this fighter was a reasonable percentage in terms of value or cost, Canada being 10 percent the

population and gross national product of the U.S. It was a reasonable piece of the total defense of NORAD.

So that's where I was working at the time when I heard about this, and the AVRO Arrow had just been canceled for several reasons, most of which I understand and some of which I would tend to agree with, and some I have some difficulties with. I'm not as emotionally torn up about it as some people are, but I do recognize it was quite a catastrophe to quite a lot of people and, I think, to Canada as a whole and to Canadian high-tech industry, not as complete a catastrophe as we who worked on it might like to think, because there were many other things that were going on in space and did go on in space without us after we got recruited and sent to the U.S. People talked about it as being a big brain drain, but there were very significant brains that were left here, let me tell you, and they did some pretty great things.

So that's where I heard about it, and the circumstances somewhat behind it. Apparently Sputnik I had gone into orbit, and as several other things that happened that showed that the Soviet Union was a way farther advanced in their technology than we dreamed of. We thought that they were back in the dark ages in this kind of stuff, but when they put Sputnik I into orbit, it really woke us up. [They] did that on the exact day we rolled our AVRO Arrow out the hangar door for the press to see, and hardly anybody showed up at the stands we put up for the press to see, and our wonderful airplane rolled out the hangar door in the absence of great media attention. Couldn't figure it out. We had no idea. At least I couldn't at my level.

So I think that answers part of your question, and I think the next part was—

BUTLER: If you could tell me about the interview process itself, if you remember.

MAYNARD: I remember some parts of it. How I got selected personally to be one of the people that got interviewed is a bit of a mystery to me, but I think it might have had to do with Jim [James A.] Chamberlin, who was also an employee and a very senior, tremendous technical leader on the AVRO Arrow. He was very familiar with what I had done. He and I got along quite well and everything else. So I think he was one of the people that was responsible for NASA being interested in us in the first place. Another fellow, named Fred Mitchell, who I worked more directly for. People never knew that they worked for Jim Chamberlin. You never knew that. You just didn't appreciate that. He was a very unusual, tremendous guy. A recent movie was made that included him as a character in it. They portrayed him—he was strange, but he wasn't the kind of strange they portrayed in the movie. He was a great guy to know and work with.

I think that he's the guy, and maybe Fred Mitchell, and maybe even John [D.] Hodge, might have—because I think they were the ones that were dealing with NASA on the subject in the first place, and I think that they might have thought that I would be a good guy for them to interview, not necessarily thinking that—I think that the company, AVRO, really wanted certain people to go and to get insight about certain things and then bring it back to the company, because the agreement was that we could go for two or maybe three years, I can't remember, and come back again without any sort of hard feelings.

I know this isn't part of the question, but I, indeed, came back after two years and represented some of the other people, that I was coming back anyway, so they said, "Why don't you come back and find out what's going on back there and see whether or not we want to come back." So I was coming back anyway.

So I came back and talked to Fred Mitchell, and I said, "What have you got going that would gainfully employ us? He said, "Nothing." And I said, "Well, I guess we won't come back then." But he's deceased now, just recently, as a matter of fact, but he indicated at that

time that, "You know, guys, the reason we would want you back would be to help create the sorts of things that we ought to be doing in the first place."

So I felt a bit bad about being sort of brash in my response to them, because what he was asking for was for us to think about coming back to help begin new things again beyond the AVRO Arrow and so forth. I was young and didn't sort of appreciate that that was sort of a thoughtful, maybe a right thing to do. But there wasn't the dedication and resource, and it's hard to get something going if you're just a technical person, without having the right policy set above you in the first place. And that continues to be the problem. As we talk on some other subjects, we'll find that without the right policies above you, you can't do anything.

The nature of the interview was, [Space task Group Director] Bob [Robert R.] Gilruth conducted it with Paul [E.] Purser, I believe, was there, and Charlie [Charles J.] Donlan, both from NASA, great, great people. I think it was Bob that was asking the questions. That's the way I remember it. The first question was, "Are you interested in the Man-in-Space Program?" And if there was one, we were barely aware of it. We knew it was possible to put people in space, or we thought it was. We, in fact, had little meetings and discussed these things in sort of a private way within the company. So I had an idea what putting a man in space would be about and how difficult and complex it was.

I just recently had left the Air Force in a permanent way, the Royal Canadian Air Force. I had been in it during the war, as a pilot, and I had flown as a pilot for the City of Toronto Squadron, but this was a reserve squadron, and I flew for the permanent Air Force that supported that reserve. I would flight-test the airplanes that we maintained and modified and whatnot, among other things.

So my response to "Are you interested in the Man-in-Space Program?" was, "Yes, I'm interested in everything from the flying in it to the engineering of it," and I put them in that order, indicating that flying would have been more interesting.

I had previously made a commitment to myself and to my family, without actually verbalizing it to them, that now that I had children, I would not fly operationally anymore. I figured that that was for younger people and unmarried people, because the risks that you took were such that there's a fair chance of you leaving a mother with some children. When I used to do the flying and see other guys doing it when they were in that kind of a status, it used to bother me that I was flying with people, that if that guy gets hurt or killed or whatever, not only does he get hurt or killed, but there is a widow back there and children without a dad. My having a tremendous family relationship and so forth, that was very important to me. In spite of that position that I had taken, at least internally to myself, I said, yes, I would be interested in flying in it.

Well, he came back instantly with, "Well, we aren't here to recruit flight crew. We're here to recruit engineers."

So I am the first, I think, Canadian—I know I'm the first Canadian to volunteer as an astronaut and the first to be rejected. I might even be the first person ever, because I don't think that the opportunity had been given yet to the—this is very early in the program, so I'm not sure that the opportunities had ever been given in the States for the Alan [B.] Shepards [Jr.] and John [H.] Glenns [Jr.] and so forth to volunteer, even. So anyway, I'm claiming that. That's a claim to fame that I have, the first person to volunteer as an astronaut, certainly in Canada, and the first to be rejected.

BUTLER: Quite a piece of history.

MAYNARD: I don't remember much else in the interview. They seemed to have known what my background was. I don't ever remember having a resume, but I do remember being interviewed when I went to AVRO in the first place. They must have had some kind of record about what they found out in that interview and what my supervisors had said about

me since. I hadn't done anything to embarrass anybody, so I think that primarily the work that I had done was viewed as being quite satisfactory.

He seemed to have insight about what I did in the Royal Canadian Air Force as a pilot and what kind of airplanes I flew and so forth, and he sort of disbelieved the fact that I had flown the … [DeHavilland DH-98] Mosquito at as young an age as I was. The fact that I had, he had a great deal of knowledge and interest about that particular airplane. There's kind of a long story about that, but it was a tremendously good airplane in the United States Army Air Corps, now the United States Air Force. When it was the Army Air Corps, they were looking at it from the point of view of using it as a reconnaissance airplane. That was one of its functions that it did for the Royal Air Force, the Royal Canadian Air Force, and Royal Australian Air Force.

So he was familiar with it and had actually flown in it as an engineering observer, with a very experienced test pilot from Langley Field, Virginia. They were super impressed with it, not only with its abilities in terms of bomb-load carrying capability in the bomber and fighter, fighter-bomber versions and also as a night fighter, photographic reconnaissance pathfinder, and actually could carry a passenger or two, and did so from England to Sweden and back, and they carried them in the bomb bay. So there actually was a commercial version of it, as well as the Air Force versions.

So I think that that Mosquito had a significant part in my being—maybe not my being recommended by the company, but in their accepting me as a potential NASA person. Throughout the years that I worked for NASA, I think that that was a significant part. Bob Gilruth, later Dr. Gilruth, in his confidence that he had in me, when he would give me different assignments, sometimes directly from him, even though he was very high above me, he'd either make them directly to me or he would do it through my supervisors, through the supervisory chain. But in NASA, particularly at the Space Task Group and at the Manned

Spacecraft Center, there wasn't much need to stand on formality of that sort. If he wanted you to do something, it was perfectly okay for him to go ask you to do it, and you did it.

I think that I told them that I would take the job, but he told me to go home and think about it for a while, for a day or something like that. I came back within the day and confirmed that, yes, I would do it. My wife agreed. I wasn't out of a job. I had been hired back after the cancellation of the Arrow and the firing of everybody. I think that was a Friday, and I was hired back on a Saturday, so I never lost a day's pay, whereas a lot of people did.

So I think I've answered more than your basic question, but the sort of answer that you'd accept.

BUTLER: Good answer. Good answer. You did accept, and you did move down to the Space Task Group, which was based in Virginia at the time. How was the move? How was your reception with the Space Task Group and even your reception with the locals in Virginia?

MAYNARD: How was the move? My brother's father-in-law, Charlie Miller, who had lost a son, he was a Hawker Typhoon pilot in the time of the Normandy invasion and subsequent time periods. He was a Typhoon pilot and he was shot down by friendly fire, it turned out. So Charlie Miller didn't have any sons of his own anymore. He had a son-in-law, my brother, named Glen. I arrived on the scene and visited with them and stayed at their home for a little while, and became very friendly and accepted into the family like the boy that they lost. I was more like his age, I think. Charlie Miller helped me an awful lot in getting the job even at AVRO when I first went there. He drove me up there voluntarily. There was no way for me to get from where I was to Malton. There were no buses. I don't know, there might have been something. But it was a big mystery to me how I was going to get up there to do

an interview, and he drove me up in his new Packard right after the war, and he waited for me while I went in for the interview.

This is something that should happen to ever young veteran that comes back from the service, to have a Charlie Miller to sort of help them along like that. Charlie is now deceased, but I am very grateful to him. He was American. I had originally some kind of bad feelings about Americans, because I lived on the border, with Michigan on the other side, and the American boys would come across and steal my girlfriends and things like that, so I didn't like them. I learned to like them as time went on, but it was a learning process. Charlie was one of these people that was a very good guy and was very, very helpful.

Now I'm not sure that I answered the question or not.

BUTLER: About moving down to Virginia.

MAYNARD: Yes, I haven't even got to that yet. The move on this side was very quick. We went through all kinds of processes with the Canadian Government to get passports and all that kind of stuff, and with the U.S. Government, all conducted in a very mutually agreeable kind of a way. Charlie Miller—the reason for me bringing him up in the first place, he was then in the real estate business, and he sold our house for us and got a good price for it and everything, within forty-eight hours. So we were effectively free and clear to go in about forty-eight hours. It took us a while longer to get through all the routines with getting fingerprints and all that kind of stuff, and for all the kids, and birth certificates and all that stuff.

Actually, we met some of the people that came from AVRO and went there with us. I didn't know everybody that went. It was thirty-some. I didn't know. As a matter of fact, I knew only three or four. We met most of them in the process of getting our fingerprints taken and all that.

So when we went there, we had a family, my wife and I and three kids, but we didn't already have a social kind of relationship with the other people that went down there. This business of designing and building military airplanes, in particular, isn't the kind of business where you have a lot of socializing. We worked tremendously long hours and we were completely unfair to ourselves and to our wives and our kids, but we were dedicated to getting the job done properly. I have a story about fairness that kind of personifies all this, but I think it is a little long, unless we tack it on later.

So when we went to Virginia, we knew very few people, and we stayed in a hotel called—what was it called? The [Chaimberlin] Hotel? Now I can't remember the name of that place. But I remembered it just the other day, thinking about it. We stayed in that hotel, and Rod [Rodney G.] Rose and Lela Rose and their two boys stayed in the same hotel, and a lot of the rest of the Canadians did until we found houses.

So how were we treated by the people began with the people we went there with, that you would think we would already go with a community of people that we had our support group and all that. People didn't know about support groups in those days because they didn't go charging off and doing things like that.

Very quickly, though, when we got to the Space Task Group offices and found ourselves homes, we very quickly were accepted royally into the community at the Space Task Group. I think that probably [H.] Kurt Strass, one of the guys that I immediately started working with, and Bob [Robert O.] Piland. I think that I wasn't probably there certainly no more than two or three days when I found out that I was invited to dinner at Kurt's place, we were, and accepted into their social group, which was centered on ballroom dancing lessons. They were taking ballroom dancing lessons, so we took ballroom dancing lessons with them. Helen had been a good ballet dancer, student. I have a daughter now that's world-class ballet dancer, retired. She wasn't that good a dancer, but she was certainly the best dancer in this whole group, and Bob Piland was probably the worst. I was sort of somewhere in the

middle. But we had a great time socializing with these people in a very healthy kind of way, and accepted into the community of work, quickly and deeply.

When we finally bought a house—and it wasn't very long before we bought the house—one of the neighbors was a NASA person, Perkins, and he had kids that were my kids' age, and they played together. So the local community was very readily accepted, or they accepted us.

Later on, when Bob [Robert E.] Vale and Marge Vale brought their kids down from Canada, they weren't in the original recruitment, but I thought it would be a good idea if Bob came down. I phoned him and asked if he was interested. Then I went and talked to some other people and they said, "Oh, yeah." So he and Marge came down with their kids. I'm not sure that that was a right thing for me to do, because they ended up being torn from roots that were much different from my roots, but they're [now] living in [Louisianna]. Bob is deceased now, but Marge and her kids are living in—I think they're in the New Orleans area now.

So we were accepted at both the community level and the social level. One or two evenings a week we would go to these ballroom dancing lessons with "Wally" teaching us, and then we'd go back to our homes … (different places [each] time). We would continue with playing records and doing this different kind of ballroom dancing, including the Twist. It was the latest step. We learned that from Wally pretty quickly.

So I think that we were accepted extraordinarily well, and we got to know [most of] the rest of the Canadians and English people. Some of them don't like to be referred to as NASA Canadians. I do, but they don't. Some of them don't, because they came from England and some of them feel they got kind of a raw deal coming here all the way from England to work at AVRO and then to be fired or laid off with no work. So it leaves a bad taste in their mouth, so their feelings for Canada aren't quite as warm as mine, and I would

like them to be. But that's their problem. Now that you've been in Canada for, what, a whole day, you can appreciate that.

That acceptance continued throughout, as far as I'm concerned, throughout my entire career at NASA. There was never indication one that we were viewed as "northern wetbacks" or anything like that. I used to refer to myself as a "northern wetback," but that's the only way that ever happened. Americans have great taste in appreciating Canadians, and I think they've had primarily very, very good relations with Canadians, as most other countries have. Canadians have sort of a way of getting along with essentially everybody, in very large part due to the role that our soldiers and airmen played in World War I. For no apparent gain to Canada, we went and helped people in their hours of need, and it just seemed that this was a good opportunity to go help Americans in their hour of need. That was a lot of motivation.

I actually went there with about the same salary that I had at AVRO, and the exchange rate on the dollar, the Canadian dollar, you could buy an American dollar for 90 cents Canadian. It was the other way from what it is now, only by 10 percent, but anyway, it was very nice to take the few little scheckles that we had from selling our house and so forth, and go to the States and have more American dollars than we had Canadian dollars when we left. So that's very unusual circumstance. We sort of wish that were here again on occasion.

BUTLER: Understandably. As you did come down and were settling in, what were your initial roles and responsibilities with the Space Task Group?

MAYNARD: I went to a meeting, after I sort of signed in, I went to meetings with Kurt Strass and Bob Piland, and I don't recall who else, and what they were doing was, they were looking at drawings that showed the configuration of the Mercury space capsule. We called them capsules in those days, rather than spacecraft. So we were looking at this design. It

was a pretty small piece of what I normally looked at. I normally looked at sort of a whole airplane or I would look at the crew station.

Sometimes I had assignments that worked on crew stations in the AVRO Arrow and the jetliner, and a little bit in the CF-100 interceptor. But I was kind of familiar with crew stations, and I was very familiar with the escape systems, ejection seats, and the like, and had looked at designing escape modules instead of just an ejection seat, a whole encompassing thing that would let you survive an explosion, a fire, and some other things like that, and then parachute you to the ground and land the whole capsule, rather than you just suspended from a parachute.

So the Mercury spacecraft, to a pilot and a crew station design kind of person, was like an escape capsule. We hadn't actually designed and built any for our airplanes, but we had considered them as approaches, and we did trade off studies to decide whether we wanted to do that. In the case of the high Mach number AVRO Arrow and the barely supersonic CF-100, but mostly for the AVRO Arrow, we looked at the escape capsules. So the Mercury capsule, with a single person in it, was sort of the same thing as we would [create as an] escape capsule for an airplane like the AVRO Arrow.

We ended up using ejection seats on the AVRO Arrow, and later on we used ejection seats in the Gemini spacecraft, but in the Mercury spacecraft we used an escape tower. I can explain to you why it is that you use escape towers or when do you use them and when do you use ejection seats and so forth.

BUTLER: Sure.

MAYNARD: But the Mercury capsule was like—it wasn't that unfamiliar to me, in view of the fact that I had studied and done some layouts and whatnot on escape systems before, that would actually be operating at very high altitudes and low pressures and everything.

So the first assignment was just to sit down with the guys and look at these drawings and chat back and forth. I was given an assignment to—one of the questions that I brought up when I was looking at these designs was how are you going to dissipate the loads and what will be your acceleration and acceleration rates on the flight crew and the different organs of their body when you have land impact.

Spacecraft was designed and the mission was designed so that if you have to abort off the pad or shortly after liftoff, that if the winds are not right, and a few other things, that you might end up landing on land. It was primarily designed to land in the water, but there was a possibility and a probability to land on land. And if you did, what would the nature of the land be, the soils mechanics and so forth? If it was hard stuff like concrete curb on the side of a highway or something, I believed that this would cause a great deal of difficulty with respect to the ability of the human body organs to take the impact, not because of acceleration, but because of acceleration rate. This was not a well-known thing to the rest of the people that I was meeting with, but it was well known to me because of the ejection seat system that we had in the AVRO Arrow, and the fact that I had dealt directly with the guy that invented it in the first place. He's the guy that knew all about what the real critical parameters were, not just acceleration, but also acceleration rate. [Once again, or more to the point,] acceleration is length over time-squared, and acceleration rate is length over time-cubed. That's what [is sometimes known as] a suddenly applied load, very high stress and potential fracture, [sheering, and crushing] problems.

So I brought that subject up and they said, "Well, what would you suggest doing about it?" And I said, well, you have to get the equivalent of a tire in between your structure that's going to deform and so forth, which is like the shock absorbers on an airplane landing gear. I'd worked on airplane landing gear in both the CF-100 and the AVRO Arrow, and I'd done the overall airplane dynamics differential equations, very complex kind of stuff, without a computer. So this was very laborious stuff to me, and I sort of got it embedded in my blood

how you deal with those things. I discovered what a tire is really for, why do you have a tire on the landing gear of an airplane.

Even though the pressure was very, very high in the AVRO Arrow's tires, for instance, if you didn't have a tire, you really did an awful lot of damage to things. Small as it seems to be as a contributor, when you look at the physics and the structures and dynamics associated with landing something with a finite vertical velocity and so forth, you need something that behaves like a pneumatic tire rather than something that behaves like a shock absorber, an Oleo shock absorber.

So I said, "Well, you need something like the equivalent of a tire." "Well, what would that be?" Tires on this thing. So I'm fumbling around, and finally said, "Well, have you looked at lowering the heat shield and putting a fabric or nonmetallic or even metallic, that's crushable, kind of a skirt around it before touchdown, before impact, and have that compress the air in that bag? That would behave as the tire to reduce the rate of rise of G."

They said, "Well, we think that somebody has looked at that and has written a report on it, actually, here at Langley Research Center." And they figured that that would [not] work.

I said, "Oh, I'd like to see that report." So some way or other I couldn't get hold of the report. I don't know why that was. But I got authorized to go ahead and study, investigate that more, and I did analyses to kind of convince myself that this was a right thing to do. I used a [modeling approach from a] book called *Eshbach* [phonetic], an engineering book that tells you how to scale things and model things and extrapolate from subscale to higher scale and all that. We subsequently will find that *Eshbach* along with that book over there on physics and chemistry, that they were sort of the bibles that I and my people used for many years in the space program.

I ran the analyses and I did drop tests of the models that I made, small subscale models, and I figured that it really was going to work. I did some of the final drop tests down

at a tank that they used to do tests on at Langley Research Center. They built scale models of airplanes, and they crashed them into the water in different wave configurations to see how they would survive a ditching. So that was a place that was all properly instrumented to do such things.

So I took my little model down there, and I did the tests down there, and I got the results. I wrote something up. By that time I had found the other guy's report, but I hadn't read it yet. I had just had it for about four or five hours. So I had my report and I gave it to them before they gave me their report. I said, "Where did I go wrong? I'm finding that this is a perfectly acceptable thing to do, and here's the way it would scale up," and all this kind of thing. "Here's what the G levels would be and the rates of rise of G would be, and so forth."

I said, "Where did I go wrong?" Now, I asked that in all innocence, because we believed, we in the aircraft industry—I don't know if everybody believed this, but I certainly did, and most of the people around me—that in NACA [National Advisory Committee for Aeronautics], that is, the people in the organization that preceded NASA, an NACA document was the gospel. It was the truth. There was no point in arguing about it, because it was right. It had been through the right reviews, and they never got released unless they were 100 percent, 110 percent, maybe, confirmed.

So here was this document they handed me. Here it was an NACA document, and I handed them one that didn't have any nomenclature on it. I think it had the Space Task Group working paper number on it or something like that. They read my document before I read theirs, and I said, "Where did I go wrong?" because I knew I was wrong, because NACA said I was wrong. They said, "No, you're right." [Laughter] My faith! It was like losing your religion or something like that, or finding out that your mother really wasn't your mother, or something like that, you know. It was terribly shocking to me to find that I was right and they were wrong. The shock was to find that they were wrong. The fact that I was

right, I got no elation from that. The shock of them being wrong was a greater thing to me than the fact that I was right. I fully expected that. I was supposed to be right. But they said I wasn't, and I would be very willing to stand there and believe them.

This led to—I think that that might be known in the community, technical community at NACA and the Space Task Group, is known as one of the early milestones in the Space Task Group, doing things somewhat independently in terms of confirming what they were told by other organizations and so forth. At least to the people that immediately surrounded me, it gave us reason to look into things in depth ourselves, to the maximum extent that we could, and not simply rely on what somebody else said. In fact, that was incorporated in the design of the Mercury spacecraft. Rod Rose actually picked up on it and had the actual system designed and developed, the full-scale system that was put on the manned Mercury spacecraft.

You noticed I said "manned," because I had to do with the first unmanned Mercury[/Atlas] spacecraft. We didn't do that on it, because it didn't have an escape system. It didn't have a man in it, and it was not expected to be landing on the land anyway. So the problem there was an expeditious getting of a flight-weight system into flight test on top of an Atlas. So the first spacecraft I worked on, there was no need to put this thing in it. But Rod went through the terribly difficult process of actually mechanizing that, so the concept was there. But how do you mechanize it? How do you make it happen is something that I would normally do at AVRO, and I was capable of doing it, but some way the job got split so I think Rod got the short end of the stick, if you will. It was a very difficult thing.

It turned out to also serve as a sea anchor, which was highly desirable, but it had an awful fatigue problem. Maybe the term "fatigue" isn't right. It took an awful beating in the water, splashing about in the waves. But it served to stabilize the Mercury capsule, and it's a very, very, very poor boat. To be in that little tiny thing like that and be bobbing in the waves would lead you almost instantly to sea sickness, as far as I can tell. We did a lot of

tests to find that out. I think there would be very few people that wouldn't get sea sick in that thing all by itself.

BUTLER: I can imagine.

MAYNARD: Maybe even with the heat shield lowered and serving as a sea anchor. It helped a little bit, but I'm not sure it was still all that good.

I have a little document here that I wrote October 7, 1959, and it was called "Prepared by O. Maynard, NASA STG [Space Task Group] ECAD [Engineering and Contract Administration Division] Engineering Branch," and I don't remember what "ECAD" stood for. The "D" is for "division," but I can't remember what that division's name was now.

It says, "The following problems have been selected as specific starting points in the optimization of the Mercury capsule." So they took all of these things. I had actually written down assignments of who it is that would take them, and sometimes it was myself. All of these things got considered in the design at both NASA Space Task Group and at McDonnell [Aircraft Corporation], who was the producer of the Mercury capsule. So we could—[interruption]

That was Roy and Clara Snyder, and they are Mennonites from the community here in Waterloo and neighboring farms. There's a lot of Mennonites around here, one of the reasons it's a nice place to live. One of my neighbors was a long-time, long-life, full-life friends of Roy and the rest of them. My neighbor's name was Moses Martin. I've got some anecdote that has to do with everybody's name. But anyway, Moses Martin and Hannah were everything that you would expect in people that would come from this community, everything that you would expect them to be.

Well, Roy Snyder here asked me one time if I would talk to people from his church about the space program or what it is that I had been involved in. This is kind of a rarity for

somebody to be in the community that had something to do with it or even knew Alan Shepard and John Glenn and people like that, you know. They may be Mennonites, but they weren't blind, you know. So they wanted to hear about it. They had heard about that letter that I gave you from Joe Hoban, because he lives here, too, in this community now. He used to live in Sarnia, but he lives here now.

So they asked me to go talk to their congregation, and several congregations came to one church. This is quite an interesting thing. You'll probably find this in quite a few places in the States as well. The people in Friendswood, Texas, asked me to do the same thing. They accepted us into their church. We weren't Quakers; we were Protestants. United Church of Canada is what we belonged to, but there wasn't such a thing there. They invited us to join them in their church, and our kids were at the right age where this was really good for them and everything else.

So they just opened their arms to us. I mean, they kind of overdid it. They had me be the president of the adult Sunday school class, and I had never done anything like this before, so I couldn't figure out why that was, but I did it. One of my jobs was to get some kind of a speaker every Sunday to talk to the adults while the children were off getting Sunday school. Whenever I couldn't find one, then I would have to do it, or I'd have to make some excuse. It was easier to give a talk than it was to make an excuse, so I'd have to do that.

So this was something that NASA never gave us guidelines, "You should work in the community and become friends with the people," and so forth, but it was a good thing to do, for NASA to be accepted into the community. So one Sunday we had studied King Solomon's building of the temple. So in a few, two or three weeks after that, I couldn't find somebody else to give a talk, so I gave one that says—they kept asking me, "Tell us what the Apollo Program is about. What is it and why is it now important?" I didn't really hardly know, myself. It turns out that a lot of other guys had been asked similar things by their people in their churches. But I decided that, well, now I know about King Solomon's

building of the temple, I'll draw an analogy between King Solomon's building of the temple and people of the United States of America, since the United States of America doesn't have a king, it's really the people of America building the Apollo Program. So I drew parallels, quite a few. It's pretty interesting to look at things from that perspective.

One of the things I said was, the result of King Solomon building his temple was that it was such a magnificent undertaking and a magnificent accomplishment in the end, that people came from far and wide with golden treasures and whatnot for him. The Queen of Sheba and all kinds of people said, "I don't want any trouble with this guy. If he has a god that he can build a temple to of this nature, completely cedar-lined and all this stuff, I don't want to be in any conflict with this guy. He'll have no war with me."

So they would come and see this temple and bring him presents, rather than fight with him. Well, turns out I didn't notice at the time, but turns out that his father, David, was the guy that beat everybody up and did all the warring and everything, so when it came time for Solomon, there wasn't anybody to fight anyway. But I didn't know that when I was talking to the people in Friendswood. I hadn't studied it that deeply.

Anyway, when I came to talk to these people here, I researched it a lot more, and I had met some missionary pilots, jungle pilots, they're called, that would do missionary work in Africa for twenty, thirty years, raise their kids there. I learned a lot about the way people are in Second and Third World countries from these guys and their wives and their kids. So I invited quite a few people that I had met in the world of flying and in space and in power from space, young dynamic people that I had met from the local universities and so forth. I invited them to come to this church and hear what I was saying and then hear what the response would be from people that thought like people do in the Second and Third World countries. These people aren't backward at all, but they understand the Third World countries, because of their missionary work, much better than the rest of us do.

So I'm being very careful about getting prepared for this thing, and I get shown—Roy showed me the church where we would do this. I said, "I'd like to meet your minister or whatever you call him, because I'm going to be occupying his premises," sort of thing. I said, "Can we put a screen up so I can show some overhead projections and things?" So I looked where the screen would be, and here's this cross, gold cross up there, right behind where the minister would be when he's speaking and everything, and I thought, "This is where they want me to put this screen." I thought, "This isn't going to work." [Laughter]

So Roy took me in to meet the minister. Well, the minister turned out to be a young woman about your age. I'm not going to guess what you're age is, because I didn't know what hers was and I don't know what yours is either. But she had been educated [to be and] she was the preacher. I had pictured "this man with a black hat and beard" as being the head, the minister, but this was a young woman, sophisticated, highly educated, like my daughter. My oldest daughter went to Wheaton College in Illinois, same place that Billy Graham went. She was educated in Christian education and in piano, music other than piano, and physical education. So Merrill, my daughter, was both the same age as this Mennonite preacher, and it sort of blew my mind that I was all set to face up to this guy with a big beard and a black hat and everything, you know. The image was all wrong.

I told her the gist of what I had in mind, and that I had gotten myself updated on King Solomon and all that stuff. So I told her what the update was, and she agreed, yes, that's a reasonable interpretation. So she allowed me to use her pulpit, effectively, to give this talk from. They took down that cross off the wall and put up a screen. They don't stand on ceremony to the degree that you would think, that I had thought, anyway, so they're very down to earth, very practical kind of people.

But preceding my talk—and you know my talks are liable to get kind of long—preceding my talk, she gave a very long sermon to the assembly, the people assembled, and the theme of her talk was "Be satisfied." Or "Be content." Yes, that's the word, "Be

content." Contentment is a big theme of these people. And that doesn't mean to be content with whatever is laid upon you. If you don't like what's laid upon you, go get that fixed. But having done that, be content from then on. Don't continually be rebellious and all this kind of stuff. Don't be continually influenced by a person with the newer, higher performance, prettier-looking car. Be content with the wife you've got; don't go looking for another one. Things like this. It was sort of, be content with the earth, as opposed to going to the moon, sort of thing, which was very good, but it was sort of eating into my time. She had it typed up for me and asked me just to not publish it, but I could give it to my daughter and some other things like that.

But that was a very interesting experience, to go through that with those people and to go through with the Mennonites here. It would have been about 1965 or so, '64 or '65, that I did the thing in Friendswood, Texas, in 1995 or '96, probably about 1995, so thirty years later with the Mennonites here. The analogy was quite well accepted by them.

So I asked Moses Martin, I said, "You know, I said in that, when I was talking about the analogy, about how King Solomon's temple was very impressive to the people who came from far and wide to see it, and they were sort of super impressed with that thing. I understand that you and Hannah went to NASA, Kennedy Space Center [Cape Canaveral, Florida], on a tour one time. You were telling me about having been there. Were you impressed with the vehicle assembly building?" That very large building. Have you ever seen it, yourself?

BUTLER: Yes.

MAYNARD: "Were you impressed with that? I don't want to have any conflict with a country that has these kinds of magnificent facilities and has these kinds of resources to build these kind of facilities and rockets and all these kind of things. It's just magnificent." I asked

Moses, I said, "Were you impressed with that vehicle assembly building?" Because maybe it's the largest building in the world or the largest internal volume of the building in the world or something like that. I know when you look at it and you're miles away and you keep driving towards it, it never changes size; it's always big.

So he said, "Well, I don't remember being impressed myself so much, but there was a lady on the bus with us that, when we were getting back on the bus after having looked at the building from the outside, then went in and had an inside tour, we come back and we're getting on the bus, and the lady said, 'You know, this is the first building I've ever seen that was bigger on the inside than on the outside.'" And that sort of said it all. Moses understood what she was saying, had a funny look on his face. I thought, "Okay." [Laughter]

This community here is very good and it's very much like Friendswood was. Friendswood wasn't completely integrated yet at that time, and the first black family came to the high school at the time that we were there, and we watched that enterprise get initiated, and watched with great interest as to how the people handled that. I don't think we ought to get into it. It was favorable.

It was kind of a large family, five or six kids, and they were super athletes, boys, and the girl was a little bit older, about two years older than my oldest girl. My oldest girl was a very good athlete, Merrill. I can't remember this girl's name. I think that was their only daughter. But when she graduated from high school, in the yearbook it said that she willed her shoes, basketball shoes that she played basketball in, she willed them to Merrill Maynard because Merrill was a very good basketball player. Merrill was thrilled. I mean, I get choked up when I think of how Merrill accepted that and thought how wonderful that was. That was a great piece of help in that community's integration thing.

Then my son played football, a little tiny guy. He's even shorter than I am. But he put his heart and soul into football, and he did extraordinarily well for his size. Not even for his size; he just did it extraordinarily well, period.

So my children all behaved as they should have behaved, not because I made them do that, but because their mother was a good mother and because they were just good kids. Chris [Christopher C.] Kraft lived in the same community, and his kids were friends of my kids. His daughter was a friend of my daughter, and his son was a friend of my son. Chuck [Charles W.] Mathews lived there, and he had a boy and a girl, and they knew each other at school. So if you talk to Chris Kraft or Chuck Mathews, you might say that I told my kids that you were coming here to talk to me, and that they asked me if I would pass their fond regards on to them and their children.

BUTLER: I can certainly do that. Certainly do that. I'll be glad to.

MAYNARD: That's worth making a note about. Your basic question about "How were you treated?" I guess I would say that we were treated extraordinarily well, but we expected to be treated extraordinarily well. We had no reason to doubt that we wouldn't be. We had no "I wonder how they're going to treat us?" kind of thing. There wasn't any feeling of that. We just walked into the community and they just opened their arms. It wasn't because we brought big money to them or anything like that, I don't think. We spent quite a long time there.

Leaving NASA was a very difficult thing for me to do, but I had committed to it at a certain critical phase in the program. I said that I would do something and then after I had done it, I would resign. I did do that, and I did resign. I did it for a series of reasons that we could go into if we've got a week or something.

But both our acceptance into NASA and into the communities of both Virginia and Texas were ordinary to Canadians, but because we sort of expected to be treated decently and properly and everything. I think that we were treated a little bit better than ordinary. I think that we left with very warm feelings and very fond feelings about the people, and we still

write back and forth to people, some of the very first people we met in Friendswood. Frances Brown. You might look up Frances Brown. She still lives in Texas. She had the same number of kids as we had, that were opposite gender, and she was certain that they were going to marry each other back and forth and all this. We're trying to get Frances to come up here sometime, but I don't know that she ever will. We're still working that problem.

So that's a very important question that you asked, and I think that we had a great relationship with all those people. The difficulty about leaving was because we had established very significant roots there. I think in Friendswood, though, that our kids, coming from, of course, first Canada, then from Virginia, a lot of moving around, they were in the lower grades of school. Our son had just graduated from high school when we left Texas and moved up to Massachusetts.

Children, I think, have a lot more difficulty moving from A to B—boys, when they're in their lower teens, and girls when they're a little bit—girls don't have the same difficulties that boys do, I think. Girls' difficulties occur a little bit later than the boys do, I think. I don't know how that all works, but my kids do and my wife does. But when you hear about things like the shootings in Colorado two days ago now—

BUTLER: I think just yesterday.

MAYNARD: Just yesterday. Is that possible for that to happen here? And you don't even ask those questions anymore, because you don't like the answers that you're liable to get. But it's pretty sad. I tell you, I wouldn't have thought that anything like that would happen in either the Virginia community that we were in, or in the Texas community that we were in.

BUTLER: That's good.

MAYNARD: Or in the Kitchener-Waterloo community that we're currently in. I think we're terribly blessed that our young people are sort of as under control as they are, and it's a difficult thing.

I was telling you about the kids, the new province or new territory that's being partitioned off north of Ontario, in the Northwest Territories. They've just started as effectively a new province. It's not quite the same thing. But they had an awful lot of difficulty because of the kind of television shows that they watched. I think I was mentioning to you "All in the Family" was a big, big problem to them, where this sort of indicated that sons-in-law could be disrespectful to their fathers-in-laws and things like that, and this was just terrible for the people who actually rely so much on that to simply live in extreme environments like they do, to the point where they now have their own television system and their own culture and everything else. That's one of the reasons that Canada did this. Canada didn't stand up and do it; they did. They worked very hard to set things up so that Canada would do this.

The people in the Canadian Government that worked with them on this subject are to be very highly commended for it. I don't know how it's all going to work out, because it's only happened on April the first, and it's sort of like an April Fool's thing.

BUTLER: Hopefully it will all work out.

MAYNARD: Hopefully it will all work out. They have the equivalent of a new premier for this part of the territory, and he's a very young guy, just having gotten a law degree. We ought to wish him well. And he ought to set a lot of patterns for things like other countries that have got different cultures. Canada's got a lot of different cultures, and they almost, as

far back as you can think, they've encouraged them to keep their cultures. It's sort of a mosaic rather than a melting pot.

So in Canada they have this mosaic way of things, of looking, that these people live here and do what they want to do culturally and everything else, and let these people do this thing here, and work that out so that it works as a mosaic and … there [are many] conflicts between them. I'm sure there [are], some, because it's a very difficult problem, but hopefully Canada will set an example for some other people and other countries that have this unfortunate situation where they kind of can't get along with each other.

BUTLER: Hopefully so. I'm going to pause here and change the tape.

BUTLER: Would you tell me about some of the people that you worked with or actually interacted with socially and technically?

MAYNARD: Well, there was Bob and Marge Vale, worked at AVRO. He was sort of the same level as my boss was, as my supervisor was. My boss was a fellow named Hank Shoji [phonetic]. He and Bob and I would have lunch together frequently. Bob wasn't one of the people that was interviewed to go down and work there. I think maybe he had indicated that he wasn't that interested in it. When we got to the Space Task Group, it became evident that we needed certain expertise. I was asked if I would call Bob and see if he would be interested in coming down and joining us, and I did do that. He and Marge and their kids came down, and they actually lived in Friendswood as well. He ended up being a division chief, the same level as I was, in the Engineering Directorate.

Jim and Ella Chamberlin. Jim Chamberlin was sort of our leader. He sort of led everybody, but it was always really good to be on his side. You just pitied people that didn't cooperate with him. It wasn't that he was mean or anything; I wouldn't like to deal with Jim

Chamberlin if I was on the other side of the fence. I think I mentioned some time ago that there was a movie recently written about that AVRO Arrow thing, and he was sort of our chief technical guy on that airplane. He was just relentless about certain things.

I have some more things on that. I think I have to say, we were talking earlier about fairness, and I said that we weren't very fair. Well, there's a short anecdote. Maybe it's short. I was working on a set of problems, hydraulic plumbing in the Arrow, structurally analyzing it, designing the plumbing, the shape of the ends and the pipes and a whole bunch of things, selecting the pipes and actually bending them. I was sort of allowed to do that, even though I was an engineer. I was allowed to go into the shops, because I had been a technician and all that, and they loved me and all that.

But we had to redesign these pipes because of the very high pressures that we were operating at, high temperatures and high flexing and all that. I got the assignment to go do that. Each one is a whole new piece of science in itself, so there's a lot of different pipes. So one day Jim came to my boss, Hank Shoji, and he said, "We've got three pipes yet to go, and if Owen would just do this with this pipe, and this with this pipe, and this with this pipe, and put this extra loop in this one and bend this one the other way, and do the analysis and all that kind of stuff that certifies that it's ready to go, I could take that to Ottawa and get a clean bill of health on Thursday. If you could do it by Thursday, I could take it and get the clean bill of health on Saturday." Because we were really advancing at a very rapid rate in this airplane, you know.

I had been working day and night on trying to fix this problem that came unknown to us, at least [until we] started to get malfunctions in these pipes. … I didn't have anything to do with it before, but frequently I would get the assignment to go fix up some critical problem. I'm sure that other people got these kind of assignments, too, but I seemed to always have one or more of these.

So I would work until two or three, four o'clock in the morning sometimes on these things, and I'd have to build the pipe and put it in the test rig and put different loads on it, and figure out this and that and the other thing, and make a complex matrix, then invert it, and a big analysis as well as testing to get basic data. So it took quite a while to do this for each pipe. Sometimes I wouldn't do it right, and I would go get bad numbers. So I'd have to redesign it again, so it might take a couple of iterations. I never could be sure [that] I got it right [until I got it right and proved it].

Jim says, "Well, if you do all these things, then I could get this clean bill of health." And Hank looked at me, and I'm exhausted. I can't remember what time of year it was, but there was no air-conditioning in this room. It was a loft. It was a big, big monstrous room. I don't remember being cold in the winter, but I remember being awful hot in the summertime.

Anyway, I'm exhausted mostly because I didn't get much sleep. So Hank looked at me, and I'm sort of like this, you know. He says to Jim, "But Jim, you aren't being fair."

And Jim says, "Well, I have no requirement to be fair." He had a requirement to get this thing up and running and certified and ready to go. That's what mattered, and fairness has got nothing to do with it.

Today you'd probably get slapped about the ears for that, but we actually loved the guy for this, for this kind of a driving leadership that he provided and that just motivated the hell out of you. [I'd] go home, my wife used to say to me, "Why is it that you spend so much time at work when you've got these three wonderful kids and you love your kids so much?" And I did, you know. My kids are just tremendously important to me, and always have been. "Why is it that you dedicate so much of your time to work [so] much above and beyond the call of duty?" And I never could answer her that.

So we weren't fair. Jim wasn't fair to his wife and kids and to us, and we weren't fair to each other or to our wives and kids. We were maybe more fair to each other than we were

to our wives and kids, but we would set examples and standards that would end up treating other people unfairly.

I don't know that I would want it any [different] now, because it was very elating to have that kind of a pressure, I think. I think that might have ended up with maybe being why I've got some health problems now. But I sort of wouldn't change that for anything, nor would I change the tremendous stress sort of thing that you're under when you're a military pilot in the Air Force during a war. It's such great fun, you know, sort of thing. The worse it is, the better it is, or something like that. I don't know what it is. It's very confusing, and it's not very helpful to humanity, to maybe have that kind of a characteristic.

If wolves had that kind of a characteristic, they would go eat each other up overnight and the whole wolf population would be destroyed, but they're smarter than that. They know about territorial imperatives and things like that, and they know how important it is to leave that pack over there to its territory, and you stay in your territory. Humanity's only beginning to learn about that.

That business of fairness, Jim was the personification of the opposite, but we loved him for it. He just terrorized the civil servants at NASA when they were first exposed to him, about his way of—and usually almost all the time being right and putting all kinds of pressures on all kinds of people so that they couldn't behave in their very sort of relaxed way that they had gotten used to. Particularly when you're a civil servant, you kind of can't get fired. And to have a tiger like that come along and sort of almost bully you into doing things is difficult to deal with. I was always very happy that I was on his side.

Rod and Lela Rose went down there with us, so they're part of the Canadian contingent. We met, actually, in the Chamberlin Hotel. Sounds like it's named after Jim Chamberlin. Chamberlin Hotel in Newport News is where that was. They had a couple of boys that were our kids' age. Christopher was one of them, and my middle daughter called him "Criffer." She had some things that made a creaking sound, and he took them away

from her, and she complained that "Criffer's got my creaks." So she still goes around, every time we talk to Rod and Lela, we always remember that Criffer had her creaks.

A fellow named Tom [Thomas V.] Chambers and his wife Doreen. I didn't know him at AVRO, but I knew them and got to know them very well in Texas. Didn't know them in Virginia, either. I discovered one day that Tom had been on the *Arc Royal* aircraft carrier in its battle with the *Bismarck*, and if you remember that story about the sinking of the *Bismarck*, the *Bismarck* sunk the *Hood* on the 24th of May, Queen's birthday, a pretty bad thing to do.

BUTLER: Very.

MAYNARD: And then the entire Royal Navy had to go after the *Bismarck*, and if they didn't sink it, the morale of the country was already terribly damaged by the sinking of the *Hood*, and the *Hood*, the *Arc Royal*, and the *Spitfire* were the big morale things of Britain during the war. "As long as we've got those, we're okay." And the first thing to go was the great battle cruiser *Hood*, with one or two rounds out of the *Bismarck*.

Well, it turns out that I didn't know this before, but Tom Chambers was on the *Arc Royal* that sent up the Swordfish airplane, biplanes, funny-looking things, that dropped the torpedoes that hit the rudder of the *Bismarck*, that slowed it down and made it turn only one way, and allowed the rest of the Royal Navy to catch it and sink it. I immediately would put Tom Chambers on a pedestal, and I said, "Doreen, [it] must be great to have a husband that's sort of a hero like this," and Tom says, "Let me interrupt that. I was an electronics technician, communications equipment, on the *Hood*, ordinary seaman kind of a guy." I said, "Well, yeah, but you still are very highly recognized in the Navy." He said, "Well, actually, Doreen was an officer. She outranked me." [Laughter]

BUTLER: Great.

MAYNARD: John [D.] Hodge, I knew him in Canada, knew him and his wife and kids in the States. He was in the Flight Operations Directorate, and he wasn't involved with the same people that I was. I was more in the engineering side. They were engineers. They would operate the stuff that the engineers would conceive and design and get built. They'd participate in design reviews and that kind of thing.

John and I, actually, it was agreed that he and I ought to not necessarily write, but sign off on the mission rules for the Apollo Program. Each mission we made a set of rules for. I can't remember, his division prepared some and my division prepared some, and we put them all together, and both the Program Office that I worked for and the flight operations director, Chris Kraft, that he worked for, agreed that if Owen Maynard and John Hodge agreed on these rules, then they were the rules.

So that's the way it was, except after we did that, then Chris Kraft came along and said, "Well, that's okay, but during a mission, the flight director doesn't have to go along with those rules. If he needs to change those rules or make a new rule, it's his problem. He can't lean on those rules saying, 'I only did what the rules said.'" He's actually putting big pressure on his flight directors. When you shift from the Program Office responsibility to the operations responsibility, it can be a very sharp shift.

I was able to accept that okay, but a lot of people in Program Offices and engineering people, non-operations people, have a lot of difficulty with this. But I recognized that there had to be a transition point that's very sharp, between the engineering people, subsystem managers, systems engineers and whatnot, Program Office people versus [Flight] Operations Directorate people, and Flight Crew Operations Directorate people. So if it's got the word "operations" in it, I know what that is, and I've dealt with it and been in those kinds of organizations myself before.

But you kind of can't have the engineering world on the operation world's back during the operation. That's why you'll see the flight controllers, flight directors, and all those guys are sort of isolated in the MOCR, Mission Operations Control Room, and the other people are sort of outside that room behind locked doors. They actually interface through flight operations people who come outside to [them]. They have to know that they've got a problem. When they're in training and simulation, then it's a little different, but not much because you're training and simulating to know how to behave under the real operations situations.

So John Hodge and I were able to operate in that situation where I effectively handed over whatever my people and organization and my parts of the contractor world could hand over to him. We did that in simulation training kinds of enterprises and in the writing of rules and so forth. But we both knew where the line was drawn and who was responsible on each side.

I don't know where John got the capability, the insight to be able to do that. That might be a good question for you to ask him. I know he was a flight controller in England as well. He was involved in that kind of thing at AVRO, but we didn't really have that kind of a thing at AVRO except in flight test, and that was a different organization again. I don't know where John got the talent to do that.

I remember one of the things he did was, he could stand outside of a room, a room like this, with a window like that, and he could write on that window a message that said, "Everything is okay," and he'd write it in mirror image, as far as he looked at it, so that the people on the other side could read it ordinary. I could do that, too, but I know how come I can do that, but I don't know how come he could do that. It's something that's sort of difficult to learn to do. The younger you are, the easier it is to learn.

[R.] Bryan Erb was the subsystem manager for the heat shield on the command module, and he worked at AVRO, but I didn't have much to do with him at AVRO. He's one

of the guys that I said, after I left, or when I was leaving, retiring from Raytheon [Company], even, about this power from space thing, I knew he was interested in it, and he's one of the guys that I said, "To you, from flailing hands, I throw the torch. Be yours to hold it high." I did that with him and several other people in NASA. I told them what I thought were sort of gems of wisdom, sort of thing, but that's a whole different subject of what is wisdom. It is what the receiver thinks it is; it isn't what the transmitter thinks it is. So it's very difficult to sit down and say, "I'm only going to tell you what I think is wisdom" kind of stuff, because I can't tell that. It's up to you to decide what's wise about what I've said, it's not up to me to, before the fact, decide I'm only going to tell you these wise things, because I have no idea what you're going to accept as wisdom. Maybe nothing. That's the way with everybody.

Bob and Myra Piland. Bob Piland was in the same dance social thing that we were in. He also was the acting program manager and then the founding of the Apollo spacecraft program. He was a leader, very calm, calm kind of a guy, at least on the outside, and would get you involved. If [you] tended to be on the outside and not very interested, he would in some way encourage you to get in there and participate, because he was going to, at a certain point, give you an assignment, and he wanted to have you sort of in the middle of it before you actually got responsibility. Tremendous guy.

[The] program manager was Charlie [Charles W.] Frick, first one, and then later on Joe [Joseph P.] Shea, and Bob stayed on as assistant program manager for a while, but then he left and he took over another enterprise that had to do with Earth resources, i.e., … looking back at the Earth from space, rather than [just] looking out at [space]. This was long before … Frank Borman's crew went to the moon in Apollo 8. Already, certain people at NASA were thinking about "We ought to be looking back at the Earth from space," but most people had pie-in-the-sky kinds of ways of thinking or looking out at the moon. It turns out to be not as great a thing as looking back at the Earth from the moon.

So, already Bob and other people were off doing this Earth resources stuff and interacting with such people as my wife's cousin's husband, Jim Bruce. Jim came down. He'd come down to visit us, and he'd go over and talk to Bob. So we had some relationship with Bob and Myra after he left the Program Office.

Caldwell [C.] and Kitty Johnson. Caldwell wasn't a graduate engineer from a university, and he finally got in on the grandfather clause of engineering. I think Bob Gilruth had a lot to do with that, that put him in [this] kind of [category], a different pay scale kind of thing. He had won the Wakefield Trophy in model airplane designing and building, and this was an indication of real potential in somebody. So when he went to NASA, NACA back in those days, and said that he was Caldwell Johnson, they knew that he was the guy that won the Wakefield Trophy that year and so forth. They would then immediately want to hire him just based on that.

I was telling him a story one time about a guy I worked with in the loft at AVRO, when we were lofting the jetliner, [I] used to design boats [as well] with him [as a hobby]. We'd build boats and go and have a … long weekend [among] the 30,000 islands in Georgian Bay. [This is not the] 1,000 islands in the St. Lawrence River, but 30,000 in Georgian Bay. We'd go up there like Labor Day or something like that and we would run these boats. So Roy and I were into designing boats as well as lofting airplanes. So I mentioned Caldwell Johnson was also interested in boats, but more as something you use to go fishing with and duck hunting with. [With Caldwell], it wasn't sort of the designing of the boats [that was of interest]. It was Bob Gilruth that was more interested in designing boats.

But anyway, I was telling him about this guy, Roy Nelder [phonetic], an extraordinarily capable guy, and I said, "Yeah, he used to be in model airplane stuff. He won some kind of a trophy."

[Caldwell] said, "He won the Wakefield Trophy two years in a row and beat me out cold." That's who Roy Nelder is. This is a guy [in] Malton, where you landed. This is a guy

in Virginia, Tidewater, Virginia. They knew each other through this Wakefield Trophy thing. So if you're talking with Caldwell, you might ask him about his experience with Wakefield Trophies and did he know Roy Nelder and some things like that. Okay.

[Caldwell] took my son—he had a son, but my son was very much interested in what Caldwell was doing—that is, going … fishing. Caldwell taught him a lot about fishing. He took him fishing. Some boys are very responsive to men that do those things and others aren't. Where your son might not be interested in what you do, somebody else's son might be. And my son was very much interested, and he learned a lot from Caldwell Johnson. I think Caldwell will remember him and will have fond memories of him. Ross keeps reminding me, "Do you ever see Caldwell Johnson anymore?"

When Caldwell moved from Virginia to Texas, it was terrible, because he moved away from his beautiful Tidewater, Virginia, where he knew where all the flounders were and all the other kind of fish and the ducks and all that. He had this home on the water. He was completely disheveled when the decision was made, we were going to move to Texas.

We were going to talk a little bit later about relationships with the unmanned program, the [NASA] Jet Propulsion Lab [Pasadena, California]. When we get to that, I'll give you another insight into Caldwell's way of thinking.

Max and Nancy Faget. Of course, Max was the head of the Engineering Directorate, and he and Caldwell seemed to operate as if they were electronically interconnected. One would think certain aspects of the problem and one would think other aspects of the problem, and they could kind of overlap in ways that were different each time, but magic in the final output. Why they were able—I don't know that they knew each other for years and years and years, but they knew each other at the Pilotless [Aircraft] Research Division thing. Max would be thinking all the time, and his head would be going like that, you know, but he's thinking. You could sort of picture Caldwell just watching him and picking up on the waves and drawing a picture of what it is that Max was thinking about. It was sort of that magical.

Max was highly academically trained. He was a doctor, a Ph.D., I guess. But his dad was a medical doctor and he knew an awful lot about medicine, the human factors, as well as engineering. He was an executive officer, I guess is what they called them, in the submarine service, so he was what they call a submariner. A person that works and lives in submarines is a submariner, so he was a submariner. He wasn't the pilot. He wasn't an airplane kind of guy. He came from the other side of it.

He had experience during the war on submarines and probably in the Pacific, where you are submerged and away from humanity for long periods of time and have to sort of rely on your equipment for life support and all that kind of thing in a much more sophisticated way than you do if you're on top of the surface. So, being in a submarine and even being submerged for a short period of time is a big problem to start with. I've done scuba diving, skin diving. Scuba diving is self-contained. “Scuba” means self-contained underwater breathing apparatus, as opposed to holding your breath. So those are two different things and there's different rules and ways you treat them.

But being in a submarine is something I've never experienced, and I'm not sure I want to. But you are isolated and you are dependent, depending. You have to depend on your equipment. The cleanliness of the oxygen you breathe and of the air and getting the carbon dioxide out of it, making the thing simple, the business of coming back up to the surface again, you don't want anything to fail that stopped you from doing that or makes you do it at too high a rate prematurely.

Then to be in it in a wartime situation. In an airplane, you're shot at. Nobody ever actually shot at me or killed me or anything, or I never killed anybody else either. But when I tell Boy Scouts, when they ask me how many people did I kill, I didn't kill anybody and none of them killed me. They look at me and they think, "Well, okay. I guess since you worked for NASA, I'll listen to what you've got to say anyway." But they have a hard time getting over it. I think young boys are like that all the time.

But when you read stories about Max, [they usually have] to do with his sort of genius and his sort of way of thinking and relationship with Caldwell, very blunt in his behavior with certain people, not so blunt in behavior with other people, but when something happened that he didn't like, he could get very vocal about it. He could really put you down and really be very blunt. Joe Shea said one time, about Max—the command module in the Mercury capsule and the Gemini capsule were all what they called blunt bodies, and they had a certain virtue with respect to … reentry, being able to withstand the reentry head loads and all that kind of stuff. So Max was a big blunt-body person, and Joe Shea had a way of not exactly endearing himself to everybody, but he told Max one time, "Max, no matter what kind of a spacecraft you design, because of your personality I know it's going to be a blunt body right off the bat," which is kind of unkind. And Max did not take that as a personal insult or whatever.

He and Joe Shea were sort of [a] somewhat comparable intellect. They kind of tend to cross each other a little bit. I think the programs turned out okay that they were both involved in, but they certainly didn't see eye to eye on quite a few things. I appreciated both of their virtues. I don't think Joe appreciated the insight and the knowledge that Max had, simply because he was a mariner, a submariner. At the same time, Max would appreciate my perspective because I was a pilot. We never sort of talked about that, but it does matter where you came from and what your heritage is and what your personal experience is.

Kurt and Frances Strass were very good people that we met. I worked with Curt at work. It was they who got us involved in this social business of the ballroom dancing and stuff, and had us over to their place for dinner like two days after we crossed the border kind of thing, you know. Instant acceptance.

La Marr [D.] and Belle Beatty. I think that they're at the Cape now rather than Houston. They were in Virginia. He was a technician in the Mercury Program. That's

where I first met them, I think. Well, I guess I met them earlier than that. They invited us over for dinner one time, and she served lasagna like I've never tasted before or since.

In the Mercury Program, they continued to work on the Mercury capsule after I delivered it to the Cape and went back to Virginia to work on the Apollo Program, and they continued to do certain things with it. They had rented a cottage there on the beach or something. I was invited down to the launch of the Mercury Atlas number one, because I had done so much project engineering on it, putting it together in the first place, and then handed it over and went and started working on Apollo.

So I went down there for the launch, and I went around and visited with and met them. These people were all very unhappy. There [were] a lot of tears. This thing was getting ready to fly, and they'd put their lives and souls into this thing. Some people didn't really know what the problem was. They were so emotional about this thing. This thing was getting ready to fly, and it was like the baby that's grown up and he's going off to college, maybe going off to war or something. It was that kind of emotional. I had been away from it long enough that I probably felt that way at one point, but I didn't feel like that. Caldwell Johnson and I both were there as guests. We had no responsibility. We just had fun, because we were guests.

They got the thing, they launched it in overcast conditions, and it got up to 40,000 feet or so max—alpha q [αq] maximum angle of attack times dynamic pressure, and it blew up. Caldwell and I were in the room behind where the guys were that were controlling it, and we couldn't see or hear anything. We were there as guests, but we were bottled up. I guess we knew that something had happened because the noise stopped.

Bob Gilruth and Walt [Walter C.] Williams, another guy, was sort of the head of the operational community, operations community, at the Cape, he and I had a pretty good relationship. But I didn't have very much directly to do with him. He didn't have good relationships with some people like Joe Shea and some other people, but I think I had good

relationships with him. I don't remember too many people I didn't have good relationships with. Anyway, Walt Williams and Bob Gilruth come out of that room and put their hands on my shoulders and said, "Go find that thing. Find out what happened. Tell us what happened. Tell us what we need to do to fix what happened so we can get on with the program."

Took me off Apollo to do that, and I had been the project engineer, so I knew where all the bodies were buried. This guy Joe [Joseph M.] Bobik, who was the inspector that I had in Virginia when we built the thing, he had been the—I'm going to mention his name later, or we'll do it now. He came from Lewis Research Center [Cleveland, Ohio], another NASA Center, and first he came to Langley Research Center to be the inspector for the building of the Mercury Atlas number one spacecraft, and he had been the crew chief on Air Force One.

The first Air Force One was for [President Dwight E.] Eisenhower, and the airplane that preceded that, that was for good old Harry [S] Truman. It had a name like Rosie May or something. I can't remember what its name was. So this is the first military kind of an airplane, commercial/military high capability, full of all kinds of electronic equipment and everything else, but it's going to carry the President of the United States, the most responsible job in the whole wide world, around.

This guy was the crew chief for it. He had a crew, and he was the chief of the crew. If there was anything wrong with that airplane when it was being designed, even, and built, through to its actual initiation of its operational use, if something was wrong with that airplane, he would simply tell that guy to fix it in the following way. So as a crew chief and a master craftsman, so he had a background that was much more focused on airplanes than I had, that was more focused on boats and production machinery and then, later, airplanes. Relatively small experience with actual airplanes for me compared with him.

So we used him as the inspector, and the craftsman at Langley Research Center, NASA craftsman, that had grown up in the ancient times of biplanes and radial engines, before jet engines and everything else, and they were tremendously capable craftsmen. An

engineer or draftsman would give them a sketch of something to make, and they'd instantly make it. They didn't need a lot of information. Tremendously capable.

So we had to get this spacecraft built so that how we built it and how we changed it and everything could be documented so that ordinary technicians and craftsmen in manufacturing plants could build it, rather than it being the reason it's like this is because this craftsman actually knew something that nobody else knew how do this, how to tie this knot, even, how to sharpen this took in this particular way, and they knew this and they were very proud of it.

Well, they have their work critiqued by a guy from another Center, to start with, and a guy that had been in the Air Corps, rather than in NACA, an inferior being, you know, all the way around, a very quiet guy. He wouldn't put his hands on anything. He wouldn't fix it himself. He would get his people to fix it and then he would get the right people to document what the fix was, and then he would make sure that got handed over to the people that were going to make the following production units and all that kind of thing.

So this was a piece of capability and participation of a group of people, generally called inspectors, that you have to subject your craftsmen to, that they're normally their own inspectors. It's like you don't tell your mother that she's not cooking that roast right or baking that pie right, you know. If it turned out that because you had some kind of an epileptic condition or something, you had to teach your mother, "No, no, no, don't do it that way, you do it this way. Don't put so much pepper in it. You actually should measure the pepper," or whatever, the salt. The analogy with ordinary life is a little difficult to come up with, but for a craftsman, a man—and men are funny things compared with women. Women are funny things, too, but in different ways. But they sort of take offense at certain things, and there has to be a sort of relationship for people to accept criticism.

If you're a craftsman or a designer, a creative kind of a person, men have a big problem with the fact that they aren't creative like women are. Women create babies, you

know, and the [product] of their creation is a baby. Men don't really feel that they have created that same baby. They have no feeling for that creative accomplishment. What they do is, they expend their energies on creating things that turn out to be artifacts. They create boats and airplanes and other things that you then put up on display.

If you come along and critique, somebody from the outside world, outside community, comes along and says that what you've done isn't right or, "I don't even like what you did. I think you should do it this way rather than that way," when it comes to a piece of equipment, men don't—creative people, at least, those that are more straight craftsmen than technicians, they sort of handle this fairly well, but people that are creative and craftsmen at this level tend to be creative, too.

So it's like if you say, "I don't like the way you torqued up that lock nut. I want you to wire lock it instead," and that's the right terminology, but I won't explain what wire locking is… Joe Bobik was very into wire locking because on reciprocating engines, … there's a certain [band] of [oscillatory] vibration that, if you don't lock the nuts that you put on a bolt, [if] you don't lock them to the [shank] of the bolt, they will tend to [rotate] and … they will unwind, and the nut will fall off the bolt, the bolt will fall out, and the airplane will fall apart.

So on engines in particular, you wire lock everything… Joe had this religion that said you wire lock everything, period. The reasons on rockets, rocket-powered things, is a little different than it is on internal combustion engines, but it's still a good policy. These guys—Lewis Research Center is an engine center, and so Joe was more attuned to the really complex problem of an engine versus a piece of structure. So he brought that culture with him, and when he inspected the stuff, he would find fault with the lack of wire locking most frequently. He would give me a little chit that said, "This isn't wire locked, and it should be."

I appreciated what his job was, what we wanted him to do, not only to make the thing reliable and everything, but to begin to transition not just these guys in NACA or NASA to

being craftsmen for manned spacecraft, these guys that had mostly been talking about rocket, unmanned rocket things, if rockets at all and, prior to that, airplanes that were sort of experimental and not really operational.

So we had to get these—if these people were going to participate, we had to get it so that [their] work has to be inspected. When I used to design things at AVRO and somebody said, "We're going to have a design review," I'd say, "What do you want to review it for? I designed it and it's perfect." I wouldn't take these things well. I told you about [Avro Test Pilots] Jan [Janusz] Zurakowski and Spud Potocki in that regard. Okay. So I knew from where I spoke, because I was like that myself.

MAYNARD: Let's see. Did I get to—I can't remember the last question you asked now. We're still just going through this list of people.

BUTLER: Yes.

MAYNARD: We talked about La Marr Beatty. Tom [J. Thomas] and Mary Markley. Tom was sort of the money guy. He was the guy that controlled the funds that went from the big pot to the different contractors and the different divisions and so forth of the Program Office, so each Program Office had a Tom Markley. He headed up a division. I can't remember the name of the division now. But he was the guy that Gilruth sent down to Texas, down to Houston. We knew we were going to move from Virginia to Houston, so he sent him down to initiate the getting of the buildings that we'd move into temporarily while we prepared, while we built our own site buildings and so forth.

So he was on the forefront of quite a few things, and he was a Marine, short, stocky Marine kind of a guy. He was sort of bull-doggish and exactly the kind of a guy that you needed to do that kind of a job. So I had good relationship with him. He, in fact, was at

Raytheon when I moved from NASA to Raytheon as well. I had good relationships with him as well.

George [M.] and Mary Low. George Low had been at NASA headquarters. He's deceased now, as you likely know. When they moved to Houston for George to be the Assistant Center Director, they had a house built in the little community that we lived in, in Friendswood, down the road a little bit, a little closer to Clear Creek. My kids used to go and cut his lawn. He had kids of his own. I don't know why his kids didn't cut his lawn.

But my son Ross had a boat, a little aluminum rowboat, with a little tiny motor on it, and there are places he could put it into Clear Creek and run this little boat. Well, George was right on the creek, and George helped him build a little dock on George's property and let Ross keep his boat on that property. Ross was a very particular kind of a person, you know, and George saw something in him that he liked, and Ross in George, and they had a great relationship going because of this business that Ross could keep his boat on George's dock. I don't know why it is that George was like that, because he didn't have a lot of time for that kind of thing, and he had kids of his own, too. Anyway, Ross had a very close relationship with George Low, and Mary probably didn't participate in that. Would you interview her in lieu of him, do you think?

BUTLER: It's a possibility, if you think that would be a good plan for us to talk to her.

MAYNARD: Well, there's so much history to do with George Low.

BUTLER: Absolutely.

MAYNARD: Such a big deal. I think that to sort of put the burden on Mary is sort of overdoing it. George [W. S.] Abbey and everybody else knew George Low sort of inside

out, and sort of give the historical account of what he did and his accomplishments and all that kind of thing would be daunting to anybody.

BUTLER: Sure.

MAYNARD: He and I didn't see eye to eye as much as some people thought we maybe should, but I have to give him credit for an awful lot of things. I don't want to get involved in that any further.

BUTLER: Okay.

MAYNARD: But he's the guy that after the fire—he, being my neighbor, he was out jogging one morning in the fog, and he had terrible sinus problems. Boy, what he did in the presence of all of the health problems he had was just—what he did without the health problems would seem colossal, but in the presence of these health problems, it was super colossal. So he came by one day and asked me if I would take over the total engineering responsibility for the Apollo spacecraft program. He said, "We've got two kinds of problems, one set that is administrative and one set that's technical. We're probably in worse shape administratively than we are technically."

So Bob [Robert W.] Williams has resigned as the chief of Systems Engineering [Division], and I had previously been that. Bob Williams had been hired to be my deputy. When Bob got his arms around it enough and George Abbey came on board in configuration management enough, they then separated it off so that Bob Williams had Systems Engineering Division and I had Mission Operations Division. That was a division that somebody else was supposed to have had, Bill [Dr. William A.] Lee.

There was a time when they were two divisions, that Bill Lee had Mission Operations and I had Systems Engineering before Bob Williams arrived on the scene. Bill Lee came to Joe Shea one day as the program manager and said, "I can't do what needs to be done in this missions operation world, among other things, figure out where we are going to land on the moon, the site selection. When I try to figure it out, I say I can't land here because of this, I can't land there because of that, and I can't land there because of this other thing," he covered the whole moon up and he sort of concluded that he couldn't land on the moon. Now, he knew that we probably could, but he didn't have enough insight into how things were in the equipment and also in the orbital mechanics and piloting considerations and things.

So he figured that I could do that, and in previous presentations that I made, I appeared to know or at least talked about how you would figure out where you're going to land and so forth. I always picked the Sea of Tranquility because it always sounded to tranquil, just between you and me. That's not between you and me, because most people know that, you know. But it became a very sophisticated problem to figure out where to land. You had to know a lot more.

Bill was a psychologist. He ended up being the assistant manager for the lunar module, and he would be able to deal with all the subsystem managers in an extraordinarily good way, because there was more psychology involved than there was technical considerations. He learned the technical considerations pretty quickly, but he was like Joe [Joseph P.] Loftus [Jr.], they both had degrees in psychology and they shone like the lights in the night because of this.

But when Bill said that he couldn't do it and he thought that I could, I said, well, I sort of understand that, but I think that because I was a Canadian citizen, I hadn't taken out U.S. citizenship yet, I didn't do it at all at NASA. I did it long after when I got to Raytheon. But because of that, I had some difficulties with some security considerations and operational considerations that I could not be privy to because they couldn't tell—like there would be top

secret, no foreign, except Canadian. There's lots of things in NORAD that are like that, but if it didn't say "except Canadian," just said "top secret, no foreign," then I couldn't participate. I couldn't know the secrets and I couldn't know—if you knew the secrets, you often knew who it is that brought them the secrets. That was the big thing they wanted to always protect … the source of the secrets.

So because of the operational aspect, I didn't figure I could do that myself or even lead in it, and I didn't know how much of that there was. I knew there was some, but I didn't know how much it was. So I figured that the leader of the division ought to be the U.S. guy and me, a Canadian, okay, I can be his deputy, but I don't want to be the leader. And I explained that to them, that I didn't think I would be capable of doing that and taking the right responsibilities for things.

Well, they just ignored that and said, "Okay, you're the chief, totally." I said, "I would be happy to be the deputy and have Bill be the chief." Well, they had something in mind for Bill, besides, I guess, so they said, "No, we can't do that, so you're going to be the chief of both the Missions Operation Division and the Systems Engineering Division, but it's going to be one division called Systems Engineering Division still."

So I had to figure out—or my people and I had to figure out—I got all of his people, so we have to now go figure out what the sites are going to be, and a whole bunch of other things having to do with mission planning not from a detailed point of view but from sort of an architectural point of view. And Flight Operations Directorate under Chris Kraft and Rod Rose and those guys were the actual operations guys that had to put the numbers together in response to the sort of architectural structure that we defined and stated in that symposium that I've talked about before, that took us a year to put together.

I did that as the chief of Mission Operations Division for a whole year, effectively, and Bob Williams had taken over systems engineering of all of the equipment for both command module, service module, and lunar module. George Abbey was the configuration

management guy. So they got it to the point where we had established the baseline and also initiated the process of change, how do you control and manage change. It was in the latter part of that, that the fire occurred. I was the operations manager in the control room, in the Spacecraft Analysis Network room with the chief engineer or the program manager from each of the prime contractors in there with me and with my mission staff engineers in there with me. But we actually did it on a shift basis so that my mission staff engineers could operate as the operations manager or I on a three-shift-per-day basis. We did this during simulations as well as the real missions.

We did this actually at the time that the fire occurred. I was the operations manager, and I had just finished writing the catastrophe plan. Bill was supposed to have had that written, but he didn't. It's one of the things I had to pick up and do. I had actually just completed it. One of the things says, go lock all the safes with all the configuration in it, because you have to really nail down what the configuration is, or was, at the time of the fire, so you can initiate the investigations as to what happened. The only thing I had to do with the fire was issue that catastrophe plan that said who was responsible for doing this, that, and the other thing, and Bob Williams ended up being the guy that was primarily responsible in the Program Office for coming to understand all of this stuff.

I went about continuing with mission planning and the architecting and flight test part of things for essentially a year, quite a few months, anyway, while other people are off facing up to the fire issues. So I am not responsible for that stuff. If you want to find somebody who's responsible for the fire, they might have picked me as being responsible, but I think that they knew something that I knew and they knew, that they knew they'd better not do that, because they knew that requirements that I had laid on had been deleted by people outside my control that precluded the guys getting out and saving themselves. That's about all we ought to say. But you'd think that there would have been some people that would have

looked at me in kind of a funny way, at least, and said, "He's the guy we ought to put the finger on."

But when George Low asked me to be the chief engineer, he wanted to make sure that if something went wrong technically, that I indeed was responsible and I had no excuses, because when they would normally ask me what went wrong with something, I would know what went wrong. I might not personally, but I could find out pretty quickly through my people. I would know what went wrong and who messed up, if there was anybody messed up. Sometimes it would be me, and sometimes it would be my supervisor, and sometimes it would be somebody else, and sometimes it would be six people, you know. But some way I had a network that not so quickly would find out what had malfunctioned or something, you know. Where did the wire actually break or whatever? As to assignment-wise, who was responsible for that, that should have caught that or inspected for that, and so forth.

Bob Williams went through this terrible part of the fire recovery thing, and did some reorganization within that part, that division. I'm off talking to Gilruth about mission planning. Gilruth had assigned other people to do parts of the investigation, and he and I had lots of time to talk. We used to talk about sailboats and things, but very businesslike from now on, about how we're actually going to fly the mission.

BUTLER: How did you figure out how you would fly the mission?

MAYNARD: Well, Jack [John R.] Sevier had a great deal to do with that, and a great deal of it was actually initiated by Bill Lee, Dr. Lee, who was the psychologist kind of a guy. Some of it I used to talk about when I was in the Engineering Directorate, that said, "Well, here's what the configuration should be and here's what the architecture of the mission should be." I would talk about that, and that's why Bill Lee thought I knew everything there was to know about it, is that I did know enough that I could rationalize that the configuration ought to be

this because the mission is this, and the mission ought to be this because the configuration is this. I could play the two like the left hand and the right hand on the piano so that they were somewhat in sync.

But I had inherited Bill Lee's people. They were recruited by Bill or somebody else, that had a lot more insight into what kind of people do you need to work a problem like this, like Paul Purser did with getting Frank [Francis W.] Casey and all that. Somebody had the insight to get some tremendously capable people, and one of them was Jack Sevier. I can't remember the others that actually came from Bill Lee's organization. I'm kind of confused about where did they come from. Did they come from me or from Bill? If I went through the list of everybody, I could sort that out, but it's a little difficult for me to do right now.

It ends up that the best way to explain how we—not, I, but how we—figured that out, was we gave Grumman [Aircraft Engineering Corp.] a small contract to study the mission planning because it impacted on the lunar module so greatly, but for them to study it from the ground all the way up to the ground and back again, knowing that they didn't know everything about the command and service module, and that it was primarily focused on what the lunar module would be able to be doing.

The fact that I had worked with them so much in configuring the lunar module, the relationship with Grumman was just absolutely fabulous. When you told them to do something—I don't know if we've gotten into this—when you told them to do something, they wouldn't do it unless they convinced themselves that was something they should do, which was—we've talked about that. But that is a fabulous thing for a contractor to do. For a guy like me, in the customer side, for you to have the confidence that you can willy-nilly tell the contractor—and I never really did this, I never really told them what to do. I would sort of indicate what I thought the requirements were and the guidance and those kinds of things, and build on what we said in the statement of work in the first place, and things like that.

But I stayed away from telling them how to design it and what the configuration actually should be in any kind of detail, and only sort of monitor what they were doing. Then if, because of some insight I had, I would tell them what the problem was that I had because of this insight, then they would accept that, usually that or tell me how come I was messed up right there and then, or they'd go away and think about it. But it was always so rationally determined and so reasonable and everything, you know.

So we gave them a contract to actually tell us how we should fly the mission to make it the best for the lunar module, because the lunar module had to be very high performance and very light weight, so you had to get a lot out of every pound that you put into that thing. It was critical from that point of view, whereas the command module and the service module weren't nearly so critical. So we would modify the way we flew the mission in some part because it made life easier for the requirements of the lunar module and made it so it didn't have to be so heavy in certain areas, that kind of thing.

So how we did it was, we enlisted the aid of a very good contractor in Grumman and also in TRW [Inc.] and also very good people in NASA, in the Program Office. These were people that administratively worked for me, had worked for Bill Lee, and some that came from my old division and transferred to the Mission Operations Division. It's got the word "operations" in it, but it's not flight operations. It differentiates between what the architecture is and the commands that you give, and the intelligence. There's this thing called communications, command, control, and intelligence, C^3I, it's called.

Some of the intelligence I would—and it's sort of a security kind of a way of saying things. There's some intelligence about how things are in the world and whether or not the Soviet Union has got a spacecraft in orbit at the same time you are, and some things like that, some of which I wouldn't be privy to. We had to sort of rely on certain people to keep us straight in that world of sensitive stuff, and Grumman to keep us straight so that we didn't

overburden their spacecraft weight-wise and performance-wise, and some of it to keep us straight so we didn't overburden the crew.

We assigned a mission staff engineer to each of the missions to make sure that we didn't overburden the Flight Operations Directorate guys, Chris Kraft's guys, and we selected those people primarily from Chris Kraft's organization. Some of these people were what you call the "walking wounded." You can talk to John Hodge about that term. Ask John about the "walking wounded" and who were these people who got transferred, or temporarily assigned programmatically to work for Systems Engineering Division…

One of them was Manfred "Dutch" von Erinfreid III. Some of them were assistant flight controllers or would-be flight controllers that in a mission issues would occur, in the Mercury and Gemini and Apollo missions, but this was sort of preceding all the Apollo missions. If they were working the Gemini mission and something happened and they were the flight director and they did a perfectly good job directing the flight, directing the mission, but the other thing that these guys had to do was interface with the press, the media, after they changed shifts. You can kind of picture that. They still do this. You can kind of picture the problem. This guy has been stressed out, particularly if there's been some difficulty, like fifteen kids got shot at the local high school. Then you hand the problem over to somebody else. The press is going to want to be on your case right away.

BUTLER: Right.

MAYNARD: And little nitty-gritty kind of things that the press would pick up on, because it was a very open thing, you know. There wasn't any secrets. All Mercury, Gemini, and Apollo, but this would be the guys that were doing it back in the Gemini time period. They would have a difficult time sometimes because they would be so sort of stressed out that they would not be very tolerant of the media, because the media would be sort of there for their

own purposes, and the heroes in all these things are the media people, not the astronauts or the flight directors or the whatever.

So you had to interface with the media after having done your very stressful shift as flight director. It was the flight directors that did do that interface. So if you blew your cool at the time when you're being interviewed by the media, you didn't get to be a flight director anymore. That was one way to be a "walking wounded."

The term "walking wounded" comes from the infantry, where you'd send the troops in and they'd get wounded. The guys that were wounded out on the front line, and they were able to walk, and they walked back, they interfaced with the guys that are marching forward to take their place in the foxhole or whatever, if these guys going forward see these guys coming back, particularly if they talk to them, if this guy coming back says, "I did a stupid thing. I tripped over a wheelbarrow and fell and broke my neck, and that's how come I'm walking back," but if he tells the truth and he says, "It's hell up there," this poor guy that's going up there fresh, he's never been in battle before, he would be adversely affected by the "walking wounded" coming back. So it was a military thing. You keep the "walking wounded" away from talking to those that are entering into the conflict. It's counterproductive completely to have the "walking wounded" talk with the guys that are freshly entering into the conflict.

So the "walking wounded" can still walk, but they can't talk. They can't participate anymore. Once they're wounded to that extent that they are afraid, to the extent that they will adversely influence the performance of those that are going in to take their place, it's the "walking wounded" that get to that point that you have to be very cautious about. If John Wayne gets wounded and walks back, no problem, you know. He'll motivate the hell out of the guys that are going ahead anyway. So it isn't sort of all "walking wounded." Anyway, there's a general category that I'm referring to as the "walking wounded."

Well, they were good people for me to get, because they understood the operational world and they understood the operations people, and they didn't have wild ideas that they one day were going to get to be the number-one flight director or something like that. They had satisfied themselves that they were going to have to take a sort of lesser role until they worked off their penal thing, as they started to be nice to media people again or something like that, you know.

So some of these guys—and I won't mention, I won't attribute—I don't know why some of the guys were sent over to me, but I understand that some of them were in that category of "walking wounded," and I don't know if Manfred "Dutch" von Erinfreid was in that category or not, but he certainly was very vocal about certain things, and he could tell you what he thought without batting an eye.

The flight directors, the flight controllers, the operational people, flight operations people, had a camaraderie. I wasn't a part of it, except these guys that came to me from there. They were into the martial arts and they would get an awful lot of their frustrations worked out by working in this martial arts field. Manfred "Dutch" von Erinfreid III was the number-one guy in that world of martial arts. Gene [Eugene F.] Kranz was—I don't know, maybe he was number two or three or four, something like that, but he wasn't number one like Manfred "Dutch" von Erinfreid III was.

It was Manfred "Dutch" von Erinfreid III that was the mission staff engineer for Apollo 7, that is, Wally Schirra's mission. That was a very difficult mission to deal with. It was the first one after the fire, and you're dealing with Wally Schirra and his crew. Wally had some characteristics that were very different than most other people. Some way or other, the mission staff engineer had to convince the flight crew and the flight operations people that they had to do these certain things in the mission, called fulfilling the detail mission objectives.

So we had to have detailed mission objectives that were very rational, that these guys could arm themselves with and go to both the flight crew and the flight crew operations people, get both the people flying and the people on the ground, and sort of order, from the Program Office perspective, "Here's your requirements. Here's what you have to do." Not how you do it exactly, but you have to do it however you do it. You are certifying how it is to be done in the future. So you don't do it your way if you don't intend for your way to be imparted to the next crew and through your supervision ensure that you are disciplined and controlled enough that you're doing it as a flight director would do it or as a command module pilot would do it.

You are the forerunner of those, and you're setting the standard for those, and you're setting the details in terms of how do you actually throw the switches and in what order and all that kind of stuff. And how do you behave with respect to the capsule communicator and who is it in the crew, the command module pilot, the commander, the command module pilot or the lunar module pilot. You've got to kind of keep that straight, folks, that there are certain assignments that have to go here and here, and we have to know who it is that's doing this, because it's got to be handed off. You're really not just certifying the equipment in flight test, you're certifying the processes, of how do you fly the flight equipment.

That's very difficult to get people to definitize. It's difficult enough to write rules, but to get it to the point where you can actually get them to do things in certain ways or in certain orders, even, according to certain flight plans that are previously written and they have rehearsed in simulators and all that, and we, the Program Office, contracted for the simulators and had the simulators built for both the trainers that the flight crew operated and the simulators that we used for engineering simulation. The Program Office did not operate any of these. Either the flight crew did or the simulators that were used to simulate what goes on on the ground were done by the Flight Operations Directors, Chris Kraft's directorate.

So let me see. How come we got off on that guy?

BUTLER: Let's take a pause here a minute and I'll change the tape again, and we'll figure it out.

MAYNARD: All right.

BUTLER: Okay. You were talking about George Low.

MAYNARD: I was talking about George Low and Jack [A.] Kinzler.

BUTLER: Jack Kinzler.

MAYNARD: … Jack Kinzler, … had … craftsmen [who] worked for him, that … could create things sort of instantly out of whole cloth and didn't have to go through the engineering process. As long as they didn't interact with the way a subsystem worked or something like that, this was perfectly fine.

They did quite a few things that were sort of in line with the engineering development of things, but mostly they had a lot to do with mockups and experimental things, but not the actual flight hardware. On the [unmanned] Mercury capsule [for Atlas] number one, they did have something [a lot] to do with the actual flight hardware.

I mentioned Jack Kinzler and told you that he had to build that flag that they put up on the moon. George Low wanted me to do it, so he would come to me and he would say, "Now, we have to put a flag on the moon." I'd give him all this [counter] stuff, because [of] the weight and everything, it's got to be carried in the lunar module and occupy space and all that stuff, and here we are fighting tooth and nail to get an ounce out of the thing, you know.

He would come up with these frivolous things, as far as I was concerned, and I'd say, "Why do you want to put a flag on the moon? We are going there for mankind. We aren't going there for the United States of America. We're going there for mankind," and so forth. So I'd get [the response], "You don't understand. You're not an American," … is the way—I would think that's the way they were thinking, you know.

So then he would give up on me and he'd go to Jack Kinzler and he'd say, "We need a flag to put on the moon," so Jack Kinzler would make that flag.

So I would look at that flag and I would say, "What a pity," you know.

Well, he would ask me, … "What kind of a flag should we [use]—the Confederate flag or should it be the first flag that Betsy Ross did," or whoever did that first flag, with the numbers of stars on it. "Or should we put an extra star on it for the moon?" The design of the flag, you know. Who cares? As far as I'm concerned, that's not in the job, in the challenge that was given to us. Didn't have anything to do with a flag. It didn't say, "Land on the moon and claim it for the United States of America." It didn't say that. That wasn't the intent. If I argued with them, it would get them—we'd have to get to that kind of level of argument.

Then I said, "You know, that just looks so phoney. Everybody in their right mind knows there's no wind on the moon, and you're propping the thing up to look like it's blowing in the wind. We have a hard enough time convincing people that we're really landing on the moon as opposed to doing something out in the Mojave Desert taking movies of it, so as soon as you give them a thing like that, they're going to be all over it, the media and the kids three years old and everybody else. You must have an awful big national requirement or loyalty requirement to do that."

Anyway, Jack Kinzler made that flag. As far as I was concerned, they smuggled it on board, but it had to get weighed and we had to know how much it weighed and all that kind of stuff.

Alan Shepard, if you remember, we talked about using extra material from Alan Shepard's space suit for the space suits (for the models in the command module that we ended up giving to North American) that my mother had made. Well, when Alan Shepard came back from his mission in Mercury, the first American man in space, albeit suborbital, we had a picnic at the Morale Activities Building in Virginia, and my mom and dad were living with us at the time…

But my mother was infatuated with Alan Shepard, and Alan came to the picnic. I have a picture, which is one of the great pictures, that I took of Alan Shepard and my mother at that picnic, and my mother, believe me, is having a picnic.

BUTLER: I bet.

MAYNARD: You can shut it off. [Tape recorder turned off.] So here's the picture that I took with this cheap little camera, Polaroid camera, as a matter of fact, and there's my dad and there's my son and there's my mother and there's Alan Shepard. Look at the look of adoration in her eyes.

BUTLER: She's having the best time.

MAYNARD: Absolutely loved this guy, you know. And here's her soldier boy from World War I …, standing at attention, and her grandson just getting his picture taken. But her feeling about him was immense.

BUTLER: That's great.

MAYNARD: Well, anyway, after he landed on the moon in Apollo 14, he sent us a thing that was half the size of that, with a big "deal" on it, and the Canadian flag, which changed from that Union Jack to the maple leaf in 1965. So by this time it was the maple leaf thing. So he sent this piece of paper with this flag glued to it. "This flag was taken to the moon and brought back on Apollo 14 by Alan Shepard and crew," and all this, and gave it to my mother. [Actually] he gave it to me, and I gave it to my mother. I had a [conference where I displayed a lot of artifacts] one time that was a little bit like this, where I [had] stuff all spread out, and somebody stole it.

BUTLER: Oh, that's unbelievable.

MAYNARD: So I guess people would view that as being a pretty valuable thing.

BUTLER: I can't believe someone would do that.

MAYNARD: Yes. Well, I decided not to pursue it and sort of [close] the whole block down and all that, [lock] all the doors and everything. That would have been too disruptive to what was going on. It was kind of important, what was going on. But anyway, that's the Alan Shepard relationship.

Let me see. Okay. The Jack Kinzler thing, we talked about that. There was a fellow named Bob [Robert E.] Little and Clyde Thiele at Langley Research Center that were the supervisors, or the bosses, of the technicians, the craftsmen that worked there in putting the Mercury Atlas number one together, the Mercury spacecraft for that together.

I told them the story. I love working with these people because I am sort of able to communicate with them better than I am with the intellectuals of the world, you know. So I have a great time with these people. So I'm telling them a story that I heard when I was

working on the AVRO Arrow up in Canada, thousands of miles away… and years ago. I tell them the story about the guy that bragged about everything to all the other guys, and he would come in with something new, "This was the best there was in the whole wide world," or, "This thing that you've got, everybody else has got junk."

I get confused about which of these guys is which now, but the one guy that was the boss, he would hear that this guy was in bragging about this thing and upsetting the rest of the guys and occupying time and all that stuff. So he would try to stop the guy from doing all this bragging stuff. So this one occasion he come in with a watch and he says, "See this watch I got? This is the greatest watch in the world. See, it says 'unbreakable crystal' on it. It says 'unbreakable crystal, nonmagnetic, and shockproof.'" This is a tough watch. And waterproof to 200 feet, something like that.

So his boss, he takes a look at the watch. He says, "Let me see that watch."

"See, it says it right there, unbreakable crystal," and all that.

So the fellow took the watch and laid it on an anvil and a big sledge hammer in this hand, and he went CRUNCH! Smashed the watch all to hell, and said, "Hey, Bob, I think you were taken." [Laughter] That was the end of the conversation.

Well, I had heard that story up in the shops at Malton, at that airport, in about 1949 or '50, and I'm telling that story, and the other guys that worked for these guys, they looked at me and they looked at Bob and Clyde, and they started laughing. I said, "What are you laughing about? I think that's a pretty good story."

They said, "Well, you're talking about Clyde Thiele and Bob Little. That's who did that." They did, in fact, do that. I had heard that it was guys that worked in a government shop someplace. I'm convinced that was it. The guy that owned the watch, his name was Bob, because the story said, "Hey, Bob, you were taken." Small world like you wouldn't kind of believe.

BUTLER: Small world. What a small world.

MAYNARD: So that's the story of Bob. You might ask Caldwell Johnson of which of the two, who was the boss, and I think it was Bob Little, and Clyde Thiele was the braggart.

BUTLER: Okay.

MAYNARD: Caldwell knows that. I know he knows that.

John [B.] and Dottie [Dorothy B.] Lee. Dottie Lee was the only woman engineer at the time we went to the Space Task Group, and her husband was also an engineer. I dealt with them. Dealt with Dottie on the heat shield development and heat thermal protection on the Apollo Program. I remember meeting with her, talking with her about something that I thought was fairly straightforward, and she says, "You know, that's the most profound thing I've ever heard," and I remember, boy, what's profound about this? And I couldn't sort of figure it. It was something that was very ordinary to the airplane program…

It might have had something to do with what kind of material we'd used for the heat protection that everybody was fretting and fuming so much for. I simply stated what the material was that we used in a certain part of that AVRO Arrow [air conditioning exhaust duct which operated at] very, very high temperatures. I sort of spelled out specifications. I said, "You know, well, the worst problem that I had in thermal, trying to do proper thermal design, I ended up solving it by using this kind of material," and apparently I quoted to her something that she had an understanding was such a high classification that it was—and here was this "northern wetback" kind of brought it down from the North, said, "This is the right material." So, I don't know, she had some way been privy to the development of that, and here it was known by an ordinary guy like me.

Betsy [F.] Magin was Max Faget's secretary, a very interesting person. Had an awful lot of fun with her. She was a great fun person.

Carl and Julie. Julie [Julia R.] Watkins was Bob Piland's secretary, and she was a great girl, too, and her husband Carl was, as well.

Bob Williams. I've mentioned him before. I have such great admiration for Bob because of what he went through. I don't know exactly why he resigned and so forth, but I figured that he certainly saved the day in areas that I was weak in. I was an aeronautical engineer and he's electrical. He brought to bear electrical insight that I wasn't that capable of. He was such a pleasant guy. When you talk with him, he still lives in Wyoming someplace, and I'm sure that George [Abbey] would be very happy to have you go up and visit with Bob, because I think he felt very highly of him as well. I think that Bob got maybe not too good a treatment after he resigned. I think people let him carry a burden that he ought not to have carried, even if they had shifted more of it to me. My wife still writes to Bob and his wife, and we've seen them on a few occasions, not much.

A fellow named Jack [John W.] Small [Jr.] ended up being the guy at Grumman, that was our daily interface at Grumman. He represented NASA at the contractor's plant up at Grumman. We had a similar guy at North American. Jack Small, when I first met him, he was the communications expert. I asked him, "What do you think the communications system on the Apollo lunar module was going to be? Give me an estimate. You're a communications expert. Tell me how much that's going to weigh." And he told me a pound and a half. Even I, who didn't know much about those things, thought that that was pretty small weight, you know, a pound and a half. However, your cellular phone that you've got now, weighs less than that. He was thinking in the [real far] future. We aren't going to do this for 100 years yet, you know. So he was saying, what's the trend going to be? Well, we finally are going to get communications systems that on one end of it, you're going to have something that's just a few pounds in weight. So I'm trying to get the lightest weight because

this gives me the most capability to get to difficult places on the moon and all that kind of stuff. But his pound and a half, we've sort of retained that as a sort of joke thing. It weighed a lot more than a pound and a half, maybe two or three pounds. I don't remember what it weighs.

I remember Jack as being a good friend and a very good guy at Grumman, not just in the communications area, but sort of covered all areas. It was great to have him there and watching over things 100 percent of the time. So I would go up, and I had a great time when I'd go to Grumman. It was just plain fun for me to go there and deal with people that were terribly responsible people, but were sort of easy to deal with, in that you didn't have to be too careful about what you said to them, because you knew that they were only going to do the sensible thing anyway. You could be a little cavalier and get along.

Dick [Richard R.] Carley. You might have interviewed him.

BUTLER: Yes, just last month.

MAYNARD: Did I show you his picture in that AVRO Arrow thing?

BUTLER: You did.

MAYNARD: I didn't actually personally have a lot to do with Dick, but I did know him at AVRO and during the Apollo Program. He was off working the computers on the Gemini Program that I really wasn't involved with. He was sort of the world's leading expert in a lot of the features of digital computers and initiation of the use of a digital computer. He had an awful lot to do with that, a very responsible guy and worked very closely with Jim Chamberlin on that subject.

Chuck Mathews. Did we mention him before? Did you say you had interviewed him?

BUTLER: We have interviewed him, yes.

MAYNARD: Okay. I gave you a note about, if you're talking with him again, tell him my kids were asking about his kids.

BUTLER: Absolutely.

MAYNARD: Tell him my kids are all fine and they've all got kids except Ross. He doesn't have any kids, but he loves his nieces and nephews.

BUTLER: Oh, good. Good.

MAYNARD: Bob and Jean Gilruth. The Center director, the guy that came and recruited me, he is still living, but he has Alzheimer's in a very terminal kind of a way…

BUTLER: Excellent.

MAYNARD: And Alan Shepard. I didn't know Al's wife's name, but Al and I had an awful lot of very professional interactions in terms of engineering requirements. He was a guy that I would sort of—didn't have a lot of interaction with other astronauts, but he was the guy that was sort of assigned to interact most completely with detailed systems engineering and other kinds of engineering in the program. Of course, my mother loved him.

John and Annie, I guess it is, Glenn. I knew John a little bit. I didn't know him really very well, but he certainly was "Mr. Clean." I remember somebody asked me—my daughter's father-in-law in Massachusetts asked me one time if I thought John Glenn would make a good President. He ran for the presidency some time ago. I said, "Well, if you want an Eagle Scout for President, okay, John would make you a good President. But if you don't want an Eagle Scout, I don't think you want an Eagle Scout for President, then you don't want John Glenn. You're going to get an Eagle Scout out of John Glenn."

Absolutely straightforward guy, tremendously capable and responsible and brave and everything else. A great husband, I know that. His relationship with his wife was—just on occasion, if somebody went to mess her up when she was stressed out when he was flying and all that, including the Vice President. He wanted to come and comfort her or something. John was all over him about this. He didn't want him to walk on his property. Maybe he was a different political party, because John ended up being a politician, anyway.

Deke [Donald K.] Slayton. Very tough story about Deke, you know, the whole [deal] he had with his heart problems. I've had some of them myself, and I wasn't in a position that it hampered me as much as his did, because they occurred much later and I really wasn't an astronaut anyway. But I used to go—sometimes I would go on trips with him after he was sort of sidelined, and sometimes before he was sort of sidelined because of his heart problems.

I remember going to Boeing [Airplane Company] to participate in a review of the Dyna-Soar Program that was the Air Force's equivalent of like Space Shuttle. It looked more like the Shuttle than it did like the Mercury or Apollo or any of those. Had wings on it and everything. Because NASA had the responsibility for man in space, there was no charter for the Air Force to have that kind of a vehicle. So Deke and I went to Boeing to participate in a review, and I think it was a mockup review, representing all of NASA. You're supposed to

go to a mockup review and you see something that's sort of strange, you write a little chit and either ask about it or suggest a change in some regard, or something like that.

So [we] went and tried to play it low key, both of us, but it was right after we were there that the program got cancelled. The way we got treated by Boeing and people after that wasn't very good. We didn't get shot or anything, but some of the people got the sense that Deke and I deep-sixed that program, the Dyna-Soar Program.

I would, on occasion, room with Deke. That is, NASA was kind of penny-pinching at the time. I don't know why we were rooming together, because I don't remember doing this with hardly anybody else, but I remember us being in the same room together. In the morning he would get up and do his exercises. I would do pushups and he had this little rubber thing that he'd do this with, you know. It was a little tiny thing he kept in his briefcase. Every morning he would do exactly the same routine, very, very organized in his routines.

I was reading in this book about him, this book I just got recently, my daughter got it for me, and he's deceased now, so I think somebody else might have finished off the back part of it. But there's a part in there where somebody was—"other voices in the night" or something. They have these little things every once in a while. I think it must have been his wife, I think it was—I don't know if it was his first wife or his second wife—sort of complained about when he was a little boy, he never had his adenoids and tonsils removed, and therefore he snored a lot. I don't remember him snoring. I would have remembered something like that. If I remembered the elastic thing, I would have remembered him snoring. I was reading it and I thought, "Gee, I don't remember Deke snored." I remember some of the other [characteristics], but I never remembered that Deke snored.

So when I read all of these books, I find—and I've got most of them there—when I read them, I find that the person that wrote it sort of some way misunderstood the nature of

the equipment that they're actually operating with. That kind of shocks me continuously as I read them. I keep running into that.

I read one recently in this *Reader's Digest* about Gene [Eugene A.] Cernan.

BUTLER: Yes, he just wrote his book.

MAYNARD: Yes, so the *Reader's Digest* has got maybe a compressed version of that book in it. I think we can sort of kill three birds with one stone here if we do it right. [Looking at book.] There's Gene, the last guy to walk on the moon. This is probably Buzz Aldrin. Yes, it is Buzz Aldrin with Jack Kinzler's flag. Here's Gene with—I had an awful time stomaching that. Where does it say, "Go land on the moon, return safely to the Earth, and, incidentally, while you're there, go run around in a Jeep and put yourself in jeopardy" and all this kind of stuff? I had a hard time with those things. I was amazed that they actually found room to put the thing on there.

Well, what he was talking about in here was the docking of the lunar module, the command module, and how complex that was. I remember conceiving it and talking—Caldwell Johnson said, you know, any young buck knows how to rendezvous, but docking's the problem. So I said, well, I'm going to take a look at that docking problem very carefully and make the assignment to Larry [Laurence G.] Williams to make sure that that docking system never created a problem, and if ever it did, he was to be there in that Spacecraft Analysis Network room to say how to get out of that problem. And he was, up until I left. Then as soon as I left, he never showed up again, and they had one of these problems after I left. [Laughter]

BUTLER: Of course.

MAYNARD: And he doesn't show up. I was there as a guest in the viewing room, so I'm sitting there with another guy, and he's saying, "What do you think is going on there?" I said, "Well, they've had a problem with the docking mechanism there, but don't you worry, because they'll call the SPAN room and Larry Williams will be in the SPAN room and he will come out and talk to the flight director and the capsule communicator and tell them what to do." It's all been written down and everything, but some of the nuances bear explaining again periodically.

I guess that picture isn't in here. So we are recording this, are we?

BUTLER: Yes.

MAYNARD: Let me say something about that docking system we used.

BUTLER: Okay.

MAYNARD: It's called the probe and drogue. So when I sat down with Larry Williams—and this is typically the way I would sit down and talk to a designer about things—I would say, "What are the requirements?"

"Well, it's to some way dock the lunar module to the command module, and vice versa."

I'd say, "Well, no, I mean in really elementary detail things."

So it went something like this. After thinking about it, I would have a problem on my mind, and about two or three o'clock in the morning my brain would work out what the answer to the problem was, and then in the morning I would wake up and I would have a different perspective on the problem than I had when I went to bed.

Caldwell Johnson would do a similar thing, except his mind did its working while he was out fishing in the wee hours of the morning, or duck hunting or something. Then he would come into work and he'd write little notes and leave them on your desk. He was into work before everybody else was. The notes would sometimes say, "Okay, about that problem we had the other day. Do this and this and this and this. Charlie, you do that, and Art, you do that," and so forth. Sometimes you'd see notes that said, "Owen, there's two flounders and three ducks in the freezer in the cafeteria for you," so you'd go down and there would be two flounders and three ducks with a little note on it to that effect. [Laughter] This guy just spoke his mind. He lived there at the Langley Field, and this was his home. He had sufficiently good relationships with everybody, that they would let him put his stuff in their freezer. Now people come along and want him to move to Texas, you know. This is bad news for a guy that's really got his beachhead established there.

So, within two or three days of us really realizing we're going to have to face up to this docking problem, I came into work and I had the following things on my mind to use, to tell Larry Williams how we should approach this. And it went something like this, that, I don't know, but I think that these two spacecraft, no matter whether they've been together in the last few minutes or they've been separated for a long period of time, they might have built up different charges on them, where one was highly positive or one was highly negative, or slightly different anyway. When you bring them both together, there might be sort of a big lightning bolt. Not saying that there really will be, but I've got to face up to what would happen if that situation occurred.

So the first thing I want to do is, I want to have one touch the other one and discharge that thing, and I know that you get voltage gradients. The voltage gradient is the problem. The voltage difference between the two things, divided by the distance between the two, and when that gets high enough, there will be a little arcing and a little pitting. That occurs in your light switches and everything else. That's why the light switch has to sort of go quickly

so that that pitting doesn't occur too deeply. So that when you make that dock, when the one thing touches the other thing, it has to be done at a fairly—it should be done at a significant rate of closure. So I'm just touching. That's all I want to do, is I want to touch, but I want to keep on closing. I don't want to bounce off. So that was one of the requirements, to touch.

Next requirement is to tie together so that if there's a tendency to pull away, it won't pull away. That's one degree of freedom. If you think of things as having three axes, an X, Y, and a Z axes, you get forces in three directions, and no matter what the force is, you can resolve them into three directions. No matter what the moments are, you can resolve them into three directions. No matter what the angular displacements are, you can solve them in three directions.

So, first thing, so there's three forces in both directions. So there's really six forces altogether, like three tension and three compression, so there's six of those. And there's three moments in both directions, so there's six of those. So I've got these twelve things that I have to deal with when the thing is [separate]—two things are [separate], they're completely free with respect to one another, and they have the ability to move in all of these twelve directions.

So I want to take one at a time. So I want to take the X direction, we'll say, along the centerline of the axes of the two spacecraft, or one of the spacecraft, and I want to tie that down, all of a sudden tie the two together in that particular direction. And having tied them together with a sort of a string that's in tension, you pull them together so that it will come apart against a compression thing, so that it can take both tension and compression. So there's two of the things.

Now, that makes one spacecraft able to sort of wobble a lot with respect to the other in … pitch and yaw and roll, all three directions. You don't worry about that. You just let them wobble in angular motions. You've got to nail down in sort of the X and Y direction and Z direction just by this one contact, that at the same time took out the electrostatic

discharge. So first thing is to tie them together and then to get rid of the angular motions in the yaw and pitch and roll. They might have violent motions because might have large velocities at the time when they touch. So you want some shock absorbers to dissipate that energy in those directions and also along the axis.

So it was very definitive about the way we stated the problem, and having stated the problem in sort of geometric axis kind of degrees of freedom, then degrees of constraint kind of terms, then that lets the designer think about how [he] can mechanize this now. So then we said—or I said, the business of tying it together in the first place is no different from an airplane with a probe on the end of it that hooks into the drogue on a refueling airplane. So when the airplane pilot flies up to the pipe tube that comes out of the back of the tanker, he puts this thing in the hole of that thing, and then he touches. There's an electrostatic problem there, too.

So the mechanization of it is, you follow—"Larry, you do what they do on refueling systems that the Air Force has got fabulous numbers of hours on." They didn't have so many hours as they've got now. Like these guys these days, they refuel two or three times in a mission. But the people did know how to do that refueling business. So tying the probe and the drogue together, the drogue is on the tanker and the probe is on the airplane that needs the refueling. So once you tie that together and the mechanization that you use to do that, the little probes or devices you use to latch them together and so forth, just copy it straight from highly developed refueling equipment.

Then having done that, having got them tied together, now pull them together by having that probe compressed with hydraulics or pneumatics, and just pull them together so that you force shock absorbers, that are like elbows, to hit up against the side of the drogue, which is already on the refueling thing. It's very much like that same thing. So the elbow of the three shock absorbers on the lunar module thing or the command module thing. It was on

the command module where this stuff was basically—the probe part was mounted on the command module.

It will then dissipate the yaw and pitching momentums, momenta, and then you retract the center actuator and just pull them right together until the two faces, the sort of round faces, they maybe come together like this or that, instead of flush. But whenever they come together like that, you keep compressing them until they come together flat. As soon as they're together flat all the way around, you then activate the latches around here that tie them together permanently. Then when you want to separate, you undo those latches and reverse, take that thing that you retracted and now you extend it. Then you are in the same problem as the probe and drogue and the refueling thing.

So the problems that they always had in this thing [were] exactly the kind of problems that you'd have in a refueling thing. You never had problems once they got the things tied together. It was never any problem occurred in the things that didn't have to do with the equipment of the refueling thing. So I never could understand why they didn't understand this.

There were some problems with who is it that trained the astronauts. We built simulators that trained them with respect to an awful lot of things, but we didn't build devices where they could go practice this thing, because in this case—you're a test pilot, you must have done a refueling thing at some point in time in your career. So this is not different from that. This is a pretty simple thing, and we'll just tell them that this won't be any different than your refueling thing, to speak of. But we'd have Larry Williams there in case some nuance came up because of the magic of deep space or something.

Anyway, that's the latest of one of these things that came up. I'm reading a book about somebody. "This thing is so complicated, you know, very tricky and all this kind of thing." You never heard them complaining about probe and drogue system in-flight refueling thing. I couldn't understand why they would think that this thing was complicated

compared with this refueling concept, except maybe they didn't have any experience in the refueling. I never did, because when I was flying, we never did refueling. They hadn't matured it to the point where it was a viable thing.

Now, I've mentioned Joe Loftus and Jack Sevier. You haven't talked to either one of those guys.

BUTLER: Not yet.

MAYNARD: Tremendously important people in the scheme of things, of crew stations and all that kind of thing for Joe, and the human factors, how do you fly the thing and how do you train. Now, I met these guys after Caldwell Johnson had been transferred from the program office back to the Engineering Directorate, and Dave [David M.] Hammock came to the Program Office from Engineering Directorate to take Caldwell's place. Because of some conflict that Joe Shea had, a constraint that Joe had with respect to—he wanted somebody different from Caldwell Johnson. Maybe they didn't get along or something. I don't know what it was.

So anyway, some way he got Dave Hammock, and Dave was the head of another department. Mine was Spacecraft Integration Department and his was Launch Vehicle Integration Department. He was a propulsion guy, primarily, that we used to interface with Marshall Space Flight Center and their propulsion stuff. Perfectly capable guy that grew up in a comparable kind of culture and background, what-not, to me, and he had a lot to do with boats, steam engines on boats, and pistons going back and forth. We had quite a bit in common that we could kind of talk easily, yet separate very easily what it is that we were involved in.

So Dave came on board as the command module engineering guy, and I was the lunar module engineering guy. Charlie Frick left, just like Caldwell Johnson did. Joe Shea came

on board as the program manager. He sort of required this to be the situation when he arrived. Some way he—enough said. Joe immediately said, "Okay, these aren't going to be two separate organizations. They're going to be systems engineering, and you're going to think total system rather than two different spacecraft or two different or many, many subsystems. Think of it as a total system. So that's the way you're going to have to think now, guys."

MAYNARD: And people didn't usually do that. There weren't many people who did that, but Joe did in previous things that he had worked on, and so did General [Samuel C.] Phillips, who hadn't come to the program yet, but he was, in the future, to be the program director from NASA headquarters.

So now things are right. We have an American guy that's head of systems engineering, Dave Hammock, and Joe Shea is an American guy, and they've got this Canadian guy that has some insight about how things work from having been involved in their conception in the first place, and bringing them up to speed to where they are now. A perfectly willing guy to not be the number-one guy and all that, you know. Things looked like they might work out.

Well, it wasn't very long before—well, I became aware that there was going to be a briefing in NASA headquarters about the—I knew quite a bit about the command module and service module and also more about the lunar module, but a lot of water went under the bridge on the command module and service module during Caldwell being the guy that, after contract award to North Americans, and the only thing that I really knew was they got my model. If they make it like the model, they'll have a good pencil sharpener on the guy's head.

There was to be a briefing at NASA headquarters, at a very high level. The people who were to be there [included] the administrator, Jim Webb. I thought of these people as being above God sort of thing, you know. There was to be a guy named General Sam

Phillips, that Webb and others were trying to entice to let himself be loaned from the Air Force to come work on Apollo. I guess at the time, to people that knew about how do organizations work, it would sound like that's a good thing to do. I was indifferent. I didn't sort of care who the hell was at NASA headquarters. They were so far away from what I did, that I didn't care, sort of thing.

But anyway, there was to be this big briefing, and it was to be done by the Systems Engineering Division at the Manned Spacecraft Center. So I put together the part for the lunar module, the status of it and everything, and Dave put together the part about the command and service module and the rest of the program. There was a lot more to be said about the command and service module than there was about the lunar module, and I knew about the lunar module. I would be [on a re-learning] curve about the command and service module.

Well, Dave resigned sort of the day before that presentation was to be made, and so I was the Assistant Division Chief, so it was abundantly clear that I would have to go make this presentation. So I got the visual aids, and I think they were like slides, glass slides, three-inch or something like that, that we used in those days. Sometimes we used flip charts and sometimes we used overhead projectors, and sometimes we used 35 millimeter, but the common thing was these glass things. They're very difficult to make time-wise and everything. So I had to essentially take the artwork that's been produced for my own presentation. I wasn't to [actually] make a presentation. I just prepared it and then I gave it to him, [Dave]. He understood everything about the lunar module, but I didn't understanding [everything] about the command module.

So I get handed all of his charts, and I have to go to Washington and brief God and everybody about this, where the program is. I went and I took all this stuff, and I stayed up all night thinking about how I'm going to use—it wasn't clear as to how you use these charts and what order you put them in or what you're going to say or anything. There was no (what

I call) facing-page text so that anybody could have made the presentation. So I have to figure out what the facing-page text—what I would say when that visual aid is up there on the screen. It isn't that it took me all night. I simply took all night to think through this thing. I'd had no sleep.

I go in the next morning and here is God and everybody, Jim Webb and General Phillips, and Max Faget is there and Joe Shea is there. A lot of us are learning how to get along together, like Joe and Max had a problem in this regard. Some people would say they didn't, and maybe you just wouldn't categorize it as a problem, but one thought one way and one thought another way.

Anyway, I went through and did the presentation, and I was amazed that I was sort of not uptight about it in any kind of a way. I remember I got to the point where I'm talking about the command module and what the lift-to-drag ratio was going to be so that you'd know how much cross range and up range and down range maneuvering capability you would have. Some people were of the school of thought that, well, we don't want it to have any lift-to-drag ratio so that it won't get off the ballistic track. That is, … it doesn't have any lift at right angles [to the] free air stream. If you put the center of gravity right on the center of the cone, then it won't have [any "LIFT"].

If you offset the center of gravity a little bit, it will start to create an angle of attack and the thing will move off in a particular direction. So your guidance system has to know about all that. If it's straight ballistic, you just have to know where it was when it reentered and how fast it was going in three directions. Then you could predict where it was going to land. But if you had this lifting capability, Lord knows, because you could roll it so that you had it at a certain attitude and the lift vector was over here and you rolled it, then the lift vector was over there, it would cancel out.

So just by spinning on the way in, just like a bullet does when it comes out of a rifle barrel, the reason it's spinning is so that any eccentricities in the center of gravity doesn't

create an angle of attack and a lift vector and cause it to come off its proper ballistic trajectory. So that's why you spin them up. So you could spin up the command module. It doesn't have to be spun up very fast to do this and to null it all out, so if you want to come in on a straight ballistic trajectory, you should spin the thing up. That's a fairly easy thing to do.

If you want to actually fly it steady so the lift vector is in one direction, that's a little harder to do in some ways, or in some other direction. So you can correct both up range, down range, and cross range, both ways, by simply rolling the thing up [to] the right angles and all that, which ends up being something that you have to do in the computer to help the astronaut to do this.

So there were those, including Max, of the school of thought that you don't want any eccentricity. You want a straight come-in ballistically. Then there's nothing to fail. So there was an argument from that one school of thought versus the other school that wants the maximum maneuverability capability. The astronauts would be in favor of that so that I can have the greatest ability to fly the thing, you know. Bigger, more of a jock kind of a thing.

So this argument had been going on in my absence under Caldwell Johnson, and North American's [involvement] and the flight operations people are involved and the flight crew people are all involved. So I came to this point and the document didn't say what the current requirement was in this regard, and I simply asked Max, in the middle of the presentation, I said, "Max, what's the L-over-D these days?" If you're in the airplane business and you're a pilot, you know that fundamental to the airplane is what the lift-to-drag ratio is, what the L-over-D is. So I realized that—I said this to Max, so, you know, "What's the L-over-D requirement like today?" You know, inferring that it wasn't like this yesterday or the week before or something, which is true. But to a guy that's coming in from the outside, here we have the chief of systems engineering [who] doesn't even know what the hell the L-over-D is, you know, sort of thing.

But Max came back and told me what it was and showed that we had a good relationship, and I guess Phillips knew that I was sort of new to that part of the job and so forth. So I skated over. That was the biggest boo-boo that I made all day. It was a completely forgivable thing, apparently.

[We had apparently] convinced General Phillips that he should, in fact, come to the program, but he said, on accepting the job, he said, "First thing I want to do is talk to Owen Maynard," because he knew that I had a lot of problems systems engineering-wise, and he was very, very much an expert in that field. And he's going to be the boss of the total program, command service module, lunar module, and the launch vehicle all come under his jurisdiction now. He's figuring that I've got more problems than anybody else's got and that he'd better kind of get in and help me solve my problems or at least understand whether or not I understand them.

So I don't know where we got into that. Some of the other astronauts that I've interacted with were, of course, Deke and Wally. And [L.] Gordon Cooper [Jr.], not much. I wasn't involved on Mercury by the time they started flying in it, or [M.] Scott Carpenter. Jim [James A.] McDivitt came along later. He wasn't in the first batch of seven. He came along later. Had a lot of interaction with Jim, and he actually became the program manager after George Low left, so he ended up being my boss. He was a colonel at the time, and I used to tell my guys, when they're dealing with other astronauts and everybody else, "I want you to take command of the situation, guys, and you view yourselves as colonels, because some of the flight crew are colonels. But don't give yourself a rank below that. You assume command and you assume that you're going to tell them what they're going to do."

I learned this from a guy named Squadron Leader CLV Leit Gervais [now deceased], in the Canadian Air Force, and he could jump into a place, a position that required you to take command of something, and he would take command in a way that you just dream about, you never would picture anybody doing this. He could command the situation where

the people that he's commanding outranked him by a lot, and he would, "I am in charge here." Didn't say, "I don't care what your rank is," or anything, but, "I'm in charge." As a matter of fact, when I heard him say this, he said, "This is the camp." We had a summer camp where the squadron was doing its training, to upgrade themselves to a certain level. I had received a little bit of training as his adjutant. I didn't know why I was receiving this, but I got trained as his adjutant.

We arrive in this out-of-the-way place, in an old building that had been run down, and we renovated it instantly—I did—for the reserve squadron that only flew on weekends normally, to come to this place. We meet in the mess, and Squadron Leader Gerve all of a sudden appears in the middle of the floor with all the other guys, with their beer steins and everything, having a good time. Peacetime. And he says, "I am Squadron Leader CLV Leit Gerve. I am the Camp Commandant here. The program for your "Camp" operations is as follows, and it is displayed over there." This is something that he and I had prepared before the fact. I didn't know it was going to be put out there for people to shoot at.

But anyway, there it is. "I will be the commandant." This is a fancy way of saying, "I am the boss of this thing. I don't care what your rank is or anything else, and I'm permanent Air Force and you guys are all reserve Air Force and so forth." And he says, "In my absence, Flying Officer Maynard will take my place."

All of a sudden I didn't sort of volunteer to have command of the situation, but he did disappear a few times. These guys all accepted this, you know. It was no problem, which kind of flabbergasted me. So I had to sort of play that role a little bit.

Turned out when I was talking to George Abbey about—I was interviewing him to see if I wanted him to come to NASA to work as the configuration management guy on Apollo, but I'm not sure that he viewed it that way. I think he came to figure out whether he wanted to come to NASA to be the configuration management guy. So we had two slightly different perspectives, but George probably knew that I had a different perspective than he

had, but I didn't know it. And he was actually thinking of being an astronaut at the same time, and Joe Shea talked him into being configuration management guy. And he was, and he did a tremendous job on it.

He is a tremendously capable guy and terribly insightful, has tremendous insights about certain things. His capabilities of understanding what's going on in people's minds mysteriously, I don't know how he did it, how he does a lot of that. But I'm sure he still does that, still has that capability, but it took that kind of a thing to take on the [job of] secretary of the Configuration Change Control Board, who defines what it is that's going to be brought up at the board meeting, and [whether] other people are prepared or [not is their problem]. You can't bring that up because you aren't prepared and so forth.

So the secretary of the Configuration Change Control Board has an awful lot of power, and I've discovered that the secretary of anything has got an awful lot of power. He can simply tell the chairman, before the fact, "Well, this isn't ready for review yet by the board, but this one is." So what gets reviewed and when it gets reviewed is dictated by this guy.

Now, did I talk about Joe Bobik? Did I mention that name? He was the inspector guy.

BUTLER: Yes.

MAYNARD: And I talked about La Marr Beatty?

BUTLER: Yes.

MAYNARD: Okay. When Caldwell and I went to the Cape for the launch of the Mercury Atlas number one, Joe Bobik—we were guests, and we'd had a few drinks and were having a

really good time and went around and visited La Marr and the wife and kids and all that kind of stuff, and everybody was so depressed. "Our baby is going to go flying." Joe Bobik corners me and he says, "Owen, oh, you can't believe how bad it is."

I said, "What are you talking about, Joe?"

And he says, "The problems with that capsule, mating it with the Atlas launch vehicle at the interface where the adapter mates to the Atlas launch vehicle is so messed up that you wouldn't believe it."

And I said, "Oh, Joe, you're just an old worry wart," you know.

He says, "I would say what's wrong but they won't fix it." When he said what was wrong with building the capsule, I would see to it that it got fixed to his satisfaction. Well, these people just didn't have that attitude.

What the problem was, is we had two contractors, that is, McDonnell and General Dynamics [Corporation] were the two. McDonnell built the spacecraft and the adapter, and General Dynamics built the launch vehicle. So you have two different contractors at these interfaces … [where Joe's "terrible things" had been observed]. Two different Centers. Kennedy Space Center is responsible to get them tied together, to tie these two contractors together. Kennedy Space Center is responsible to do that. The Manned Spacecraft Center is the Center that sort of owns it. The Lewis Research Center, which is way off north someplace in Cleveland, their guy, Joe Bobik, the inspector, has been following it all the way through, and he's responsible to find out if everything is perfect.

Back in the days of the Air Force One, he used to have a crew as the crew chief. He was the chief. He'd tell this Indian to this and this Indian to do that, and whatever was wrong, he fixed it. He got it fixed. Well, now this same guy identifies what's wrong, but these Indians that have to fix it are all from different tribes and they don't get along. They have been vying against each other, the government guys, for budgets, and the contractor

guys for, "I am the launch vehicle contractor and you're only the spacecraft contractor. Who's the superior and who's the chief?" and all this.

So that interface thing is a big problem. Joe told me about all these sort of mechanical—I thought, well, what are they're talking about? They haven't wire locked the way Joe wants it or something like that. But he said, "No, no, it's worse than that. It's so bad." He said it was so bad that he couldn't explain it to me, and I thought, well, he's just gone over the hill. "I'm here to have fun, Joe. It's not my problem. I'm not the project engineer in this thing. I'm just here as a guest." Caldwell was, too.

The thing gets to 40,000 feet and it blows up. Gilruth comes out, as I said, I think, earlier, with Walt Williams, and they put their hands on my shoulders and say, "Okay, go find it and fix it." The guy they'd assigned to take my place, they didn't talk to him at all; they just came straight to me. They said, "You can have any resource that this country has to find out what's wrong with it, and we'll talk about what we have to do to fix it."

So I thought to myself, first resource I want is Joe Bobik. Now I want to listen to what he had to say. And next resource I wanted was, I thought probably the Navy had some kind of an underwater thing that would go down there, diving bell, and you get into the bell and you find the thing, some secret way of finding it that I wasn't privy to, you know. This is the United States you're talking about here. They can do anything. So I figured that they had this kind of capability to find the thing, and I would only have to sit there and watch, sort of. But, no, it was out in about thirty-some feet of water. We predicted where it would land because [based on its ballistics from] when it shut off and all that.

Then we went out and looked. We rented a fishing boat, [i.e. it] looked like a fishing boat. It was really for this kind of a purpose, with four scuba divers and two sixteen-foot aluminum boats with Evinrude motors on them. We sent them out in a square search, where you tie a chain between the two boats. They would just go down the water, dragging the chain on the bottom, and whenever it would hang up on something, scuba divers would go

down and see what that was. If it was something like an old missile that had been there for a long time and had all kinds of growing stuff on it, then it wasn't new, so they'd lift the chain over it, and then they'd continue on and do what's called a square search. So you went like this and then went out like that until you found something.

I can't remember where we found it, but we started at a point where we predicted it would have landed if it went ballistically. Then we did this square search, and we found it rather quickly. I had Joe Bobik on board with me all the time when the guys are doing this. He's telling me about all the nitty-gritty problems. The first thing they did was—he's the safety guy, the inspection guy, and all that stuff. The first thing they did—he wasn't too seaworthy in this, didn't feel too good. The boat was a little bit rocky, I remember that.

But anyway, we got the thing together, recovered it. [There are] some pieces of it we had a difficult time finding, and the Air Force thought that some of this fiberglass that we had on the top, that replaced the launch escape system, they thought that that might have fallen off and punched a hole in the Atlas tanks, and that's how come it blew up.

So I couldn't find some of this stuff that they postulated that that might be the case, so I dove down. I had done some skin diving when I worked for [the MacCraft Boat Works in 1940]. We lost an anchor and I went down and found the anchor [without] scuba gear. So I didn't really know how to work the scuba gear thing, so I just dove down [about] thirty feet, I think [that] is not an unreasonable—yes, you can dive a lot further than that. Free diving. If you do it with scuba gear, you have to be careful about how fast you come back up again. You can [scuba dive] deep and you can [stay] down there for a long time, but if you're free diving (just take a breath on the surface and dive down and hold your breath) you can do that without sort of damaging yourself, but you can't stay very long.

So anyway, I drove down, skin diving, to see what it was like. They told me—I said, "This thing is sort of orange color," but they couldn't find it. Then when I got down there, I could see why they couldn't find it, because everything else was orange color, too, all the

little life forms and everything. They tend to be that color. So then I had to describe more specifically what kind of orange and what its shape was and things like that, and then they found it.

We put it together, and I discovered that Jim Chamberlin was the guy that was in charge of this recovery thing. I wasn't. I just was told to go find it, but Jim was still my boss. He always would show up as being your boss, you know. So he and I would go to different contractors and hear what they had to say about the thing—the Convair [Division of General Dynamics Corp.] people that built the launch vehicle, McDonnell, that built the adapter that I had put together, but they had done some super analyses with computers and everything more so than I did. And several other experts. Even Chuck [Charles E.] Yeager. We went and talked to Chuck Yeager about what happens at high speed and things. I did. Jim Chamberlin didn't do that.

But we finally figured out, in a very elementary way, what we believed had gone wrong, and the Air Force and everybody else had done it in a very sophisticated way, with the greatest of computer programs and systems engineering analysts and everything. Jim is chairing these meetings. They had made their presentations that were magnificent. We stopped for a coffee break and Jim sees me over in the corner, sitting beside him, sort of, on the stage off where people didn't really see me, and I'm using this [little old circular] slide rule right here. I'm doing calculations. Normally people use slipstick slide rules like this, but I used to use this "sissy" one … and get people torqued off. They start not making sense. So I'd pull this thing off. They didn't know how to work this, and they knew how to work that one.

So anyway, I'm working with this thing and it didn't bother Jim, but it would bother a lot of other people to see me doing this calculation and then see him asking me, you know, "What are you finding out? What's the answer you're getting?" He knew what the problems

were that I was analyzing. So he figured that I'd be getting the answer about now, and I had this envelope. Sure enough, I had this envelope. I was writing on the back of this envelope.

I said, "Oh, I have a negative margin of safety of 5 percent at the adapter launch vehicle skin interface on the launch vehicle side," to the point where he just heard me say that. He knew, when I said that, that that meant that the skins of the launch vehicle would be put in compression and they would buckle because the [compressive] stress in them [due to drag and bending loads] had exceeded the tensile stress due to internal pressure. As long as the thing was pressurized, you could put compressive—like the skin itself was pressurized. You could put a compressive load on it like this, as long as there was enough tension load on it that didn't let it go into total compression. One equaled the other out. So the local pounds-per-inch in compression, due to the bending moments and whatnot, was 5 percent greater than the tension loads in the skin due to the internal pressure.

I predicted that using the technology and approaches that you would use [for] designing an arrow. I don't mean the AVRO [Arrow]. I mean the kind you shot with a bow. I was a toxopholist, sort a nut about archery, and so I had certain ways of understanding how … you design an arrow for the purposes of making it stiff, yet light, and all this kind of stuff. The equations that you use are much the same as you—the same as I used, in any case, for this total stack of Atlas-Mercury thing. I don't know how these other guys formulated. They had the fancier equations of motion and everything, and mine was pretty elementary.

So I told them we had this negative margin of safety of 5 percent. So after coffee break, everybody comes back together, and Jim stands up and he says, "Well, gentlemen, I'd like to thank you for the really wonderful presentations that you've given us, and the understanding that you have for the program and the problems and everything is tremendous. We certainly appreciate it. However—" He was the master of that, too. "However, THE NASA has determined that there is a negative margin of safety at max-alpha-Q of about 5 percent, and that NASA will write the contract change notice to add doublers on the Atlas

skins so that we'll allow them to go into compression some before they buckle, and we'll also change the trajectory to decrease the bending moment [by] not [pitching] it over so fast. Thank you very much, gentlemen," and that was the end of it.

These guys were livid, the Air Force and General Dynamics and everything else. But Jim had said, "The NASA," like it wasn't just NASA that determined it, it was "the NASA," like "the Christ child," "the God almighty," and he said, "the NASA did something." I looked around to see where the rest of NASA was, and I was the only guy that was NASA. He had a funny way of doing that. We, in fact, did that change and they went on and continued to fly the thing with some doublers on it.

I spent quite a bit of time [with] Jim Chamberlin, but he was a key guy in so much of this, in [the Arrow], Mercury, Gemini, and Apollo. Well, not so much Apollo. I didn't realize that he was viewed as a leading expert on Apollo. I'd been off doing Apollo by myself, without the benefit of Jim Chamberlin being around, but when push came to shove and they had certain problems that they couldn't have me solve, they would go to Jim to solve them because he had the right security clearances, because he had gotten his U.S. citizenship and all that. He had told me, when I was required to—I had this thing that says, "Please sign this piece of paper that you intend to become a U.S. citizen," and I said, "I didn't know, when I left Canada, that I was supposed to become a U.S. citizen." And he says, "Well, don't worry about it. You can intend to be one today and sign the piece of paper, and you can intend to not be one tomorrow, you see, but you already signed the piece of paper." Another one of the "is is," you know, kind of a thing. But I think he must have become a U.S. citizen and he would get clearances and coming to understand certain data that I didn't get to know about.

BUTLER: If we could pause there for a minute, I'll change the tape again.

MAYNARD: Okay.

BUTLER: After you left NASA, I understand that you moved on into industry to work on Solar-Powered Satellites. Could you tell me about your work in that, and how it evolved, and the status that it's in now?

MAYNARD: All right. I didn't leave NASA to work on Solar-Powered Satellites; I left NASA to find out about such things as Solar-Powered Satellites. I didn't understand it. They had been conceived, but I was looking for something for NASA to use to pay back the taxpayers and everybody else that paid for us having the great opportunities to do the Mercury, Gemini, and Apollo Programs and to actually give them something that would begin to pay them back. I talked about that to Bob Gilruth, now Dr. Gilruth, and Chris Kraft, now Dr. Kraft. Everybody is a "doctor" these days. But I didn't know what I was looking for.

Joe Shea and [D.] Brainerd Holmes at Raytheon said, "That's consistent with what we at Raytheon would like to do as well, so we'd be happy to have you come here and spend 90 percent of your time figuring out what ought to be done in the U.S. [by] Raytheon … and [10 percent on] what ought to be done … in Canada, but from a Raytheon perspective, since Raytheon-Canada is in Waterloo," where we currently are. … I never did come to work for Raytheon-Canada, like I was supposed to, but I was to spend 10 percent of my time figuring out what would be appropriate for Canada to do, versus what would be appropriate for the United States Raytheon to do. Therefore, NASA would be our customers in the United States, and Canadian Space Agency would be our customers in Canada, but the Canadian Space Agency didn't exist yet. So I was plowing pretty unplowed ground.

I never did find out what Canada should do and get it compatible with what Canada wanted itself to do, and I never could do that. I never could get that 10 percent of my time spent on what Canada should do. So when I retired in '92, I tried to bring that back into

existence, because I feel very strongly that both the U.S. and Canada ought to be doing certain things, and I'm not in a position to actually tell them what to do. I don't work for either one of them, and they have no reason to—they have people that are doing that sort of thing for them.

Once you leave, you are an outsider, and it's very difficult to—as a matter of fact, when John Hodge started working on the Space Station, he had worked on it for quite a while, and he left NASA, I think, and he came back and he started working on it again. I heard that he was doing this, so I called him up to say congratulations, but I was sort of kidding, because it was a very tough problem. It was a problem that you sort of didn't want to have.

I said, "Congratulations, I think, John, in your new assignment." I said, "Incidentally, I wanted to tell you that as you start, that when I was in the Engineering Directorate in the Spacecraft Integration Branch and you were in the Flight Operations Directorate, in the Flight Control Division, and you were the head of that division, and you were worrying about Gemini and subsequently Apollo, while you were doing that, I was in the Engineering Directorate in Spacecraft Integration, I got the assignment to define the configuration for the Space Station that would sort of replace that configuration that everybody else was yammering about sometimes under contract and sometimes by internal studies and all that kind of thing."

And I had reviewed some of these studies and had expressed my unhappiness with them, so AIAA [American Institute of Aeronautics and Astronautics] decided that they would have a publication, one of their early journals, that would be dedicated to the Space Station and have Bob Gilruth—wasn't yet a doctor—to be the honorary editor of this. So I got the assignment to write the central paper on space stations. I probably had a big ego that got me into trouble, because it precipitated that, so it's all my own fault that I got this thing, among other things. I had to go figure out what a space station should do.

That resulted in a patent. Manned Spacecraft Center was new, and NASA was relatively new, and they had a bunch of legal patent attorneys. Those attorneys thought this was a good thing to patent after we wrote the article and it appeared in the magazine. I can't remember the dates, but I can get them, to find that article.

We finally conceived a Space Station that was based on the same sort of way of thinking that we had conceived the—not the Mercury, because other people really conceived that, and other people really conceived the Gemini, but the way we sort of conceived the Apollo Program under the overall leadership of Bob Gilruth.

In the first meeting that I had with Bob Gilruth on Apollo, I asked him what the guidelines should be, and he had said that, "Well, you're an aerospace technologist. We hired you," and these other three or four guys who were at this meeting. "You guys, [for the] government, have to figure out what the guidelines should be." We didn't even know what President Kennedy was going to say. We didn't know that he was going to decide that we really want to go to the moon and land before the decade is out and return them safely and all that. We didn't have that as a guideline. We had to sort of—what would we think ought to be done, or what are the options that we've got to tell NASA headquarters that they can tell the President that he can now use as a policy statement? And that was all kind of “loosey goosey,” the way that gets done.

But that's sort of what I was doing. I was fishing around in this field of things to see what would make some kind of sense. So we had defined a fair amount about what Apollo was, enough that we could get that contract with North American going, and enough that we could get the lunar module contract started, but not quite. We didn't get the right amount of money and all that kind of thing.

So this came at a time when I was in sort of transition of quite a few things, and so I all of a sudden had to invent—and I didn't think of it as an invention, but it ended up getting patented, and I didn't think it was patentable, but I'm not the one that decides those things.

So I ended up making some sketches and using my little circular slide rule and other things. I had studied quite a bit of issues about what I thought requirements might maybe could be or should be, so I wasn't starting exactly from ground zero.

I came home from a meeting where one of the contractors was presenting what they [thought the] Space Station should be, at one of the NASA Centers, the Langley Research Center had a study [by] North American, so I was sitting there observing that and appearing very negative, so that's when I really got the assignment to go, "Well, you figure it out yourself, then." And so I know that people that are sort of in charge of things or put themselves in charge of things deserve what they get, you know. "Go figure it out, you know, by yourself." So I'm going home on the airplane, and I'm making sketches of what I think this thing ought to be. Rather than writing requirements, I tended to draw pictures. That's maybe not the right thing to do, but anyway, that's the way I did it at that time.

I walked into my office in Virginia, and I gave these pictures to Will Taub [deceased]. I said, "We've got to write a paper to put in this AIAA document." I was working for Chuck Mathews at the time. "We're supposed to talk about space stations. Bob Gilruth will be the honorary editor."

So Will Taub took this terrible sketch thing that I made, and he's a great artistic guy as well, and he made that into a picture that looked kind of rational, and it kind of looked like this. It said that the thing is sitting on the pad, the Space Station sits on top of the lower stages of a Saturn launch vehicle, and [it appears to be] just a [big] cylindrical thing. There's nobody in it, but it's got a rocket motor that separates it from the launch vehicle. I'll give you copies of this [the patent].

BUTLER: Okay. Great.

MAYNARD: Then when it gets up into orbit, it either automatically or [a] crew might get aboard, but this could be done automatically. You simply take a shaped charge and cut this skin so that three things fold out from it that will actually create artificial gravity if you rotate it, and it would look like this when it's folded out, with three radial arms that are 120 degrees apart, and on them there would be—this is [unclear] that I put on there just to sort of finish the picture.

But the basic concept was to launch, or build the thing totally on the pad, and while it's on the pad, you sit or you can stand—there's different rooms on each of these three arms, and you can actually go into them and you're standing so that Earth's gravity is in the same direction as your artificial gravity is going to be, and you can actually learn how to do things on the thing before you launch it, including put the salt and pepper where you want it and everything in the refrigerator and all that stuff.

Then when you get into orbit, you then have cut these arms [along 3 longitudinal lines] so that they will now swing out horizontally, and start to rotate them, and that will create artificial gravity. The farther you get from the center of the axis, the more [artificial] gravity you'll have that's proportional to the radius out times the angular velocity-squared. So you can make this so that you can get—and I thought at the time, one-sixth of a G, the same that you're going to get on the moon.

If we're going to go explore space, we're going to have to at least learn how to walk on the moon. Then having done that and provided all that capability and medication and everything else that would let you live at one-sixth of a G, instead of at 1 G, then you would want to get a lot of experience about—then you could go explore the rest of the solar system or whatever you wanted to do with at least one-sixth of a G. If you had spun it up more, you could get more.

So you could have proportions of the radius. So if you had one-sixth of a G halfway out, you would have a third of a G all the way out. If you had half a G halfway out, you'd

have a whole G all the way out. So it would be more expensive and difficult to do, the higher the angular velocity would be, but I don't know, I didn't actually figure out the numbers on that.

But that would be the basic concept, so that when I talked to Bob Gilruth about it, he said, you know, what we want to do as a sort of guideline was make it so that people—the guideline he gave us for Apollo was, formulate the program so that it can be accomplished by ordinary people. I had a difficult time understanding what that meant, but I finally did, and we finally did, ordinary people being ordinary test pilots, ordinary astronauts, ordinary Center directors, ordinary chiefs of systems engineering, ordinary chief engineers. Not geniuses. Don't want to require a genius to do this.

There's all sorts of reasons why you don't want that. If you have somebody that's extraordinary, then you can kind of take advantage of that extraordinariness, but if you formulate the program so that ordinary people can do it, then when you get extraordinarily capable people, they'll be able to actually do it a little bit better or cheaper or something.

So if we're going to send people up into space, to Mars or someplace, we want to be able to send ordinary people out. We don't want to have [to have] super athletes that can take these low-gravity things and survive and recover, and we don't want to have to have them particularly within a particular age group. We want to be able to use ordinary-age people to go do it, even senators and—weren't any women who had flown yet, so even women sort of thing, you know.

So we thought that what we wanted to do was fix it up so that these people can treat being in space as being ordinary, like they could sit down and have a cup of coffee and smoke a cigarette [can you believe how "in-vogue" that was?]. Now, these are words we actually said, because in those days it was terribly common for people to sit and smoke a cigarette, and that was a part of living. I mean, you wouldn't use that line these days, because, "Gee, I'm against this whole program because they got people smoking cigarettes,"

but it was only like the personification of, you know, being in a very familiar kind of an environment, make it as familiar to them as you can. Therefore, have artificial gravity. So it was fundamental in this Space Station concept to have artificial gravity.

This was to be flown in Earth orbit for however many times you needed to fly it, and put as many of them up there as you needed to put. Then when you're ready to go to—[Brief interruption]

Okay. So that you would build several of these and fly them in Earth orbit, and then you would decide, we are now mature enough that we can do other things, experiments and a whole bunch of other things, and we'll put a hangar at the end of it, so that part of it rotates and part of it doesn't rotate. The part that doesn't rotate is at roughly zero gravity, like everything else is normally, and the part that rotates does so around it, and the central part, you can open up the hatch like this and you can fly a mating spacecraft in just like the command module. See, we knew all about the command module by then. So we have the Apollo command module kind of a thing, with a little short service module on it because it's not going to the moon, it's just going from Earth up to the Space Station.

So there's a whole bunch of legal documents, legalese, that got written about this, and one of the plastic model airplane people made a kit for it, which I bought and I have made that model. It's much more detailed than this. When you have built two or three or four of them—what was it, the Niña, the Pinta, and the Santa Maria? You say, okay, I've got my little fleet and my name is Christopher Columbus and I'm going to go to Mars instead of America, and I will take off from Earth orbit and I will use propulsion, high thrust kind of a propulsion thing, probably, to get me out of Earth orbit and on my way to Mars, and then I'll use ion propulsion almost continuously all the way there and all the way back.

I didn't get into the details of how do you actually make a trans-Mars spacecraft out of it, but it becomes the central living place where everybody is during the trans-Mars insertion and trans-Earth insertion once you get to Mars, on the way back. Inside the non-

rotating part, you could have the Martian landing vehicles like the lunar module that goes down and lands on the moon. You open up the hangar doors and away it goes. This is a big thing, but it ends up giving you this—it really was a trans-Mars spacecraft. It was designed so that you would progressively mature it by flying it in Earth orbit first, and use that as your basis for your Space Station. This is entirely different than what we've currently got.

So I told John Hodge that this paper had been written and that this patent had been [given]—NASA had decided to patent it, and it covered all the kinds of—lots of other kinds of space stations as well as this, so that when other people wanted to propose something, they wouldn't sort of patent it and then get the patent rights, rather than NASA getting them. That patent is so old, I don't even know what the date was now, but it's so old that the fact that they've got it patented wouldn't do anybody any good.

But here's what happens when you leave. See, when I left the Spacecraft Integration Branch and had conceived this in the presence of great people, great leadership like Bob Gilruth and so forth, this is what we sort of figured was the right thing to do after we did the stuff to do with going to the moon. Then as soon as you leave, the next guy that takes the job, he just throws that all away and he goes and does what he wants. John Hodge was off doing that, and I said, "I just want to alert you to the fact that this patent exists and that we thought through this thing with Bob Gilruth, and it may be perfectly reasonable to understand that what we might do in the future, the Space Station might not be consistent with this at all, but I want you to at least know that this exists, and it existed at a time when you were off doing something else and you wouldn't have been aware of it."

And he said—you haven't talked to John Hodge yet, right?

BUTLER: Actually, we just spoke with him a few days ago in Washington, D.C.

MAYNARD: Oh, did you? So you had your interview totally with him?

BUTLER: We've talked with him at least once and we'll see if we need to go back.

MAYNARD: Okay. Well, he said to me after all this, he said, "You know—" I was working at Raytheon at this time, and so was Joe Shea. He says, "You know, if you and Joe Shea wanted to continue to tell NASA what to do, you shouldn't have left," and hung up. So that told me a lot, that once you leave—when I first left NASA and went to Raytheon and would come back to NASA for Shuttle reasons, proposals on Shuttle and discussing of Shuttle and navigation guidance computers and stuff like that for Shuttle, in the early months of that transition, when I would come back I would get treated royally. Everybody was very nice to me, particularly the people that worked for me at one point.

But as time went on, it seemed to all of a sudden to occur very abruptly, like about three or four years, something like that, all of a sudden I was the bad guy because I was a contractor and I was out to spend the taxpayers' money irresponsibly, and it was NASA's responsibility to make sure that people didn't do stupid things with taxpayers' money. So contractors are only people that are money-grubbers and they don't do things that are for the greater good, like we NASA people do.

So I didn't believe that, but it appeared as though that's what they believed, and that's the way they behaved. It took about three or four years, something like that, for them to come to that kind of conclusion. So I know that I can't—once you leave, you can't go home again. When I came back to Canada in '92, I came back to Canada and I purposely—I really know that you can't come home again to some extent, and I found out to what extent that was in different areas, with respect to your relationships with your cousins and all that kind of thing versus your relationship with the different parts of the government or industry or whatever. Really pronounced. Not a shock, because I kind of knew that this would happen.

And I've run into that problem dealing with the Canadian Space Agency, even though I'm very good friends with the chief executive, the president, and with several of the astronauts that I met and know quite well, and they sort of [say] things [like], "You're one of the guys that I heard about when I was a little kid growing up," you know. "I really loved the AVRO Arrow and the Apollo Program and the Mercury" and all that kind of stuff, "and that's how come I'm an astronaut today."

So it is sort of impossible for somebody from the outside to come in and tell the government what it is they ought to do. However, I'm struggling to do this, still, and Raytheon is being … supportive [but they see no positive approaches permitted by either the U.S. or Canadian governments]. My job was called Manager of Space Systems at Raytheon, and that sort of was a big umbrella under which I could do anything and use [certain] marketing funds … to do this…

Well, [Dr.] Joe Shea came to me one day and he said, "There's a guy named Arthur Heron [phonetic] and Bill Brown, that you don't know, that have been sort of wasting the company's money [and time] on a thing that's called power from space," Solar-Powered Satellites and Microwave Power Beaming [to the Earth] and things like that. He said, "Go talk to them about it and put it to bed, and get them off the back of other people within [this Division and others that might be involved.]" It's a big company.

So I found them and talked to them, and I have the organization, or I have the charter, if you will, to do what they want to do within Raytheon. So I talked to them [for about] a week. I [went] back [to] Joe Shea and I said, "It won't go to bed, Joe. This thing is more potentially real than you've been led to believe."

And he says, "Well, you know—" He didn't say this in these kind of words, but sort of, "Well, you know, I hired you to do these kind of things, and I have to sort of follow through and let you go ahead and do these things."

So we organized a—or he organized a blue ribbon committee within Raytheon, chaired by [Dr.] Martin Schilling [phonetic], who was the top engineer, senior vice president for engineering. I don't remember what his exact title was. He was a very, very capable, highly responsible, [highly respected], good guy. So some way Joe Shea arranged for him to chair a blue ribbon committee, with several people, top-level people, from within Raytheon on the committee, and some consultants from the outside as well, and he me—it was primarily me—put together a briefing that briefed these people about the Power From Space, but I got Bill Brown [and Arthur Herron] to help. A tremendous amount of the work was done by Bill Brown [now deceased] in this first presentation, and Arthur Heron [also now deceased], the guy that was the marketing guy [and later on the Contracts Administator], that thought this was a good idea.

So the three of us go to this blue ribbon committee and we present [the] Solar-Powered Satellite [SPS] concept, and the microwave power beaming part of it would be the part that would be of most interest to Raytheon. After the presentation, [Dr. Schilling and others] asked all sorts of questions.

After the presentation, [Dr.] Schilling asked me to come and see him, so I did, and he said, "What you are suggesting has got all the earmarks of a very highly potential program that will solve some very key problems and, in fact, provide bases for an awful lot of advancement in the world of space and technology and [much] else. So the blue ribbon committee decided that you ought to be allowed to continue this, using certain company funds and going out and trying to get contracts, precipitate funds from the government and other people, and that you should form a consortium with the key members of industry that would provide some capabilities where Raytheon doesn't have them, and so forth.

"So you sort of passed the first test. But I, Martin Schilling, would alert you, because you’re [the] Program Manager and you're the chosen person to take this thing further, and you sort of invited yourself to be the chosen person, so you haven't got any real excuse, you

are the chosen person." He wasn't a mean guy. He didn't say, "Don't be surprised if you find yourself nailed to a cross sometime." But that's what that means.

So we went away and we talked to [Dr. Peter Glaser] Arthur D. Little [Inc.], [who] conceived the whole idea, and Grumman—you know how I felt about Grumman as an aerospace contractor. And Spectrolab [Inc., unit of Hughes Electronics Corp.], that [were one of] the photovoltaic solar cell [experts], one of the only two or three in the country that are really capable in this area. So we thought if we put these three contractor industrial complexes together, we could have a critical mass that would help us come to understand this thing.

We formed a consortium with those three [sets of] people, with us three: Raytheon, Arthur D. Little, Grumman, and Spectrolab, with Arthur D. Little as the lead, because they had the patent. They had patented the idea. These patents don't last forever, so I think it's probably all gone now. The government had a tough time dealing with us, because Arthur D. Little had it patented. They didn't like that, NASA or anybody else.

But we went to NASA and we told them about it. I thought this is what NASA needs to focus on and develop a capability to make this thing happen, including space stations …, and manufacturing in space, and [assembling], and remote manipulators and … Canada went off and built a thing called the Canadarm [Shuttle Remote Manipulator System, manufactured by Spar Aerospace (Canada)]. You know that [big arm] that's on the Shuttle, reaches and [handles] things?

BUTLER: Yes.

MAYNARD: Well, that came about because of the work package or the work breakdown structure that I made, that said the program should be broken down into these areas, and one of them was Remote Manipulation, which meant what you would do without a man in direct

contact with it, but man would control it remotely… One of the first guys we contacted in NASA headquarters, that got him all fired up, he said, "Gee, this is something that Canada could do based on the STEM [phonetic] program that they did, that we used as an antenna on the Gemini Program," a communications guy who knew about this. He said, "Those people think right." So they ended up getting Canada to actually pay a lot of that [expense] to build that arm, and Canada benefited greatly from having done that. Now for the current Space Station they're building an even bigger one with artificial hands on them, rather than just an arm.

So that piece grew into some 10 percent for Canada or more, but it wasn't a piece that I had anticipated for that at all. So I kind of can't claim any sort of piece of the action or anything there, which I don't want to do anyway, because I don't like [it when people focus so hard on the first niche that comes along rather than gaining a broaden perspective].

So the Solar-Powered Satellite had in its work breakdown, it had a requirement really for a Shuttle, a Remote Manipulator, a whole Microwave System, a whole Space Transportation System to get the stuff up there, to bring it back for repair, a whole Communications Network, a whole big deal. This was really a big deal.

We got Sam Fordice from NASA headquarters [to] some way [precipitate] enough money for us to go do a contracted study for NASA, and he [arranged for] Lewis Research Center be the contracting agency. We did a study that was a little bit more extensive than the Blue Ribbon [Investigation] that Raytheon had done all by itself, quite a bit more extensive. I was looking for a copy of the book, of the report that says it's authored by the lead guys from each of those four companies, Peter [E.] Glaser, Arthur D. Little, Owen Maynard from Raytheon, [J. J. R.] Mackoviak from Grumman, and I can't remember the guy's name from Spectrolab.

So when people say is it feasible to do this, to have a system that would get you power from space for use on Earth, that study said, yes, it's feasible. It doesn't say how much

it's going to cost and a whole bunch of other things. But there wasn't much question about the feasibility except in the power beaming area. A lot of skeptics figured we couldn't get the efficiency in power beaming that we said, and they said, "We love Bill Brown, great guy in the electrical community," but I think he just made some mistakes and he sort of claimed to be like [the guy who later] invented "Cold Fusion" as opposed to "Hot Fusion."

So then Sam gave us another contract to do an investigation with Jet Propulsion Lab being our customer, and it was called the Reception Conversion Subsystem, RCV, for [the] microwave power transmission system. This is the final report, a big thick thing. I was the Program Manager for it, and Bill Brown was the Technical Director. So we demonstrated the issue that was bothering the chief engineers of all the companies that says this is not feasible, namely they said, "You can't get the kind of efficiency that Bill Brown claims you can." So Jet Propulsion Lab put out a request for proposal, competitive procurement, but a lot of the insight as to what should be done, we … had to do [the work as a "TURN KEY" operation], but they were very capable of doing a lot of this themselves.

So they sent out a Request For Proposal [RFP] and got multiple bids, and we won, which wouldn't be terribly surprising. Then we went and did the contract. We demonstrated much better than we contracted for. We were to transmit a beam of power from a transmitter at Goldstone, an existing transmitter dish and all that, semi-horizontally, a little bit above the horizon, to a tower up on the hill, which they already had built, put a rectifying antenna up there as we had demonstrated to our own satisfaction in the lab. Put this thing up on the hill, transmit and demonstrate an efficiency of conversion from radio frequency power to direct current coming out of this rectifying antenna with an efficiency of greater than such and so a percent [55%].

What they put in the request for proposal was much less percent than we had demonstrated to our own satisfaction in the lab, so we were perfectly confident that we could do this. But it was above the threshold that the chief engineers of other people in industry

thought was doable, so we did that test and exceeded all of the requirements by a lot, did it within [the] estimated and agreed-upon cost and schedule, and with the right instrumentation and did a turnkey operation where we handed it all over to JPL so that they could sit and run it and make the demonstrations themselves. We did some demonstrations ourselves and got convinced that it was performing properly. But it was the thing that demonstrated feasibility technically, even in the areas where the critics were dominant.

Then after that, and then the Jet Propulsion Lab wrote papers, sometimes [jointly] with Bill Brown, but not me, because I would bias it because I was the Program Manager, but with Bill Brown, would write technical papers that talked about these demonstrations and what we did. People would then read those, and because they were JPL, they were authentic, accepted widely, da-da da-da, da-da. And it's the same as I used to think of NACA papers, you know.

So at the time of this report, which is September of 1975, about the time you were being born or something like that, we had demonstrated feasibility, technical feasibility, sort of—not sort of, but without fundamental question from the experts in the field, that you really could take the existing technology of the microwave oven, magnetron, that there's millions of them built, and you could just build more millions of them and use those in the transmitter in space, and this rectifying antenna on the ground where the big skepticism was that we demonstrated to have much more efficiency, the same efficiency as we claimed, but much more than people had previously thought to be possible. That made the thing actually feasible in the sense sort of different from the guy that invented cold fusion and tried to convince people that that was feasible, and it turned out that other people discovered that it wasn't feasible and he had made some mistakes.

Well, what we did by that time in 1975 was convince the world, through JPL [and NASA], that this thing was technically feasible. Whether or not it was economically attractive and some other phrases like that, some subsequent investigations got done, with

Bill [William B.] Lenoir as the guy from NASA Manned Spacecraft Center, an astronaut that had flown on a mission, but I can't remember what it was, but he ended up having motion sickness problems and he sort of ended up not being an astronaut anymore, but he was a very technical guy. He's the guy that NASA focused on to present this stuff within NASA and outside NASA and so forth, and we fed him insight that we had. We sort of turned over the marketing of it to NASA at that point.

So we had it made, and NASA was convinced that this was the right thing to do. George Low was now the acting administrator at NASA headquarters, Chris Kraft was the Center director in Houston, and we did this all [through] Lewis Research Center [and other NASA Centers]. The people that normally are concerned about power and energy and things, they support it because they had been involved in it, and they understood it, the Jet Propulsion Lab, the very key technology arm of NASA that is run by California Institute of Technology (CalTech). So we had the academic community with the industrial community, the government community, all sort of believing that this is a feasible thing. And it was going wonderfully well.

A change of administration, [James E.] Carter comes in as the President. Carter was a submariner, like Max Faget, in the nuclear era, and had a lot of faith in nuclear energy. He, through the Office of Management and Budget, told NASA that providing power from space for use on Earth is not within NASA's charter. That's Department of Energy's charter, [so they told NASA to "stop work on it"].

MAYNARD: So one day they had a congressional hearing on the subject, and Barry Goldwater, Jr., was chairing this particular piece of the hearing. They had Bill Lenoir explain—I think that Goldwater didn't know what Carter's pronouncement had been, but you know that the Congress doesn't necessarily follow the White House. So anyway, Bill Lenoir made this presentation, and Goldwater, Jr., is listening along with several other people, and I

and Bill Brown and Peter Glaser from Arthur D. Little, and somebody from Grumman and somebody from Spectrolab, I don't remember who they were now, we were there, but … just in the audience sort of thing.

So after Lenoir's presentation with George Low, the acting administrator, and Chris Kraft, the very highly regarded Center director, and Bill Lenoir having done this wonderful presentation, Goldwater couldn't help but be impressed. So he said, "Well, that's very impressive. So when are we going to have it up and running?" and all that kind of thing. …I think it was Chris Kraft [who then] said—or maybe it was George Low, but one of them said, "Well, we've just received a directive from the Office of Management and Budgets [OMB] that says this isn't within our charter and we aren't to work on it anymore, and it would be within the Department of Energy's charter."

So Goldwater said (we anticipated this) …, "Well, is there a representative from the Department of Energy here? This sounds like something that really ought to be done." So Bill Lenoir said, "Yes, there is." So he said, "Who are they?" They stood up, and he said, "What are you guys doing about this? Are you going to pick this thing up and run with it?"

And they said, "Well, we just heard a week ago that this is within our charter and we're supposed to look at it."

"Well, what have you done?"

"We haven't done anything. We didn't know that we were responsible for this," like a little kid, "I didn't hear you, Mommy, when you said put the dog out."

Now, they were against it because this would take money that would normally be spent on fusion. So it was a group of people that were fusion oriented in all of the Department of Energy, but they didn't have much of an alternative but to take direction from this committee and begin to come to understand it. So something like what Joe Shea did to me, they picked a guy out, named Kuminov [phonetic], Dr. Fred Kuminov, and they said, "Go put this thing to bed," just like Joe Shea told me to go put it to bed. Kuminov was a very

capable, responsible guy. He started to investigate it. We told him—we, Raytheon, told him everything that we knew, whether he wanted it or not. We laid ten hundred times as much stuff at their doorstep and would tell them about it without them paying us for it, and really dumping the whole thing on them, including the program plans at great lengths and detail, more than we'd shown anybody. We sort of did all their work for them.

Then they had no alternative but to go pick it up and investigate it, so they did, but they sort of said, "Well, we'll have to investigate it independently of Raytheon, because they're so powerful and so persuasive about things, you know. So we'll have to go look at it independently." It would be like Kenneth Starr and independent counsel, you know. You can't be confused by somebody on the other side being friends or something, you know.

So we weren't sort of allowed or required to participate. As a matter of fact, we were required to not participate in this big investigation they were going to make, but they did, and Kuminov himself got religion about it, and he spent millions and millions of dollars on it.

Then they concluded that, "Yes, it's economically attractive, but we aren't ready for it yet, so let's wait for another ten years and look back and look at it again." But Kuminov and his people got so space-cadet oriented on it that they loved it, and if they couldn't do it as part of their work, they would do it as part of their hobby, so they would have annual meetings on it still and everybody would get invited and so forth. But it was not in the mainstream at all of either NASA or the Department of Energy after Kuminov put out his very, very large volumes of reports.

George Abbey and everybody else in NASA knows all about what I've just told you, but at the time in that meeting with the congressional hearings, after Lenoir finished his thing, Goldwater said, "Well, what does industry think about this? Do they think this is something that's possible to do?" And George Low or somebody said, "Well, there are some people from industry that understand this, that are here as observers, and you might ask

them." So they did. Like this is congressional testimony, like, you know, "Did you ever sleep with this person?" kind of testimony and all.

I was representing Raytheon, and Peter Glaser was representing Arthur D. Little, and somebody was representing Grumman, I don't remember, and somebody else was representing Spectrolab. So the other three guys said, "Yeah, it's feasible and we're ready to go."

And I said, "Well, I'd like to give you an analogy, a comparison of where we are in this program [with] where Apollo was when President Kennedy [challenged us] to land [man] on the moon, return [him safely] before the decade is out, where we were in that program and our understanding of things. I'd like to give you a comparative analogy."

At the time when Kennedy said that …, what he did is he gave us a challenge. He didn't order us to do it. He just challenged the country. That means he's challenging the Congress and so forth to put up the funds and everything.

At the time when he issued that challenge, we had fifteen minutes of [sub-orbital space]flight with Al Shepard in space. John Glenn hadn't been up yet. There were several areas of technology that effectively Frank Casey's book on physics, reading it, you didn't get the idea that you really knew what the issues were. There were several areas and they were, we didn't know what the full-scale scaling factors would be for a heat shield as big as would be [needed] to bring the guys back from the moon.

This was in Bryan Erb's subsystem area. But at the time I don't know that Bryan was even the subsystem manager. There's no contact yet, so he wouldn't be at the time when JFK made that statement. I guess there might have been. Yeah, I guess we did have a sort of premature contract with North American, but there hadn't been any reentry vehicle of that size. All the military nuclear weapon reentry vehicles were a lot smaller and they come in at a lot lower velocity. We had a very large-scale thing and also in a velocity range that was much higher than normal reentry vehicles had.

So there was some physics to do with the scaling of thermodynamics parameters of ablation that was the cooling technique that we thought would be required, and we wouldn't understand that totally by arc testing or anything until we actually had something that size entering the atmosphere at roughly that velocity. That didn't occur until the Saturn V actually put a boilerplate heat shield on it and forced it back into the Earth's atmosphere at the right heating rate and [another at the right] heating load, two different launches that figured out what those things were. Then we could now decide really how thick the heat shield had to be and things like that. So that was one area of uncertainty [at the time of JFK's challenge].

At the time when he said, "Do it," we didn't know how thick the heat shield would have to be, and that gets translated into technical terms, as we didn't know what the thermodynamic scaling factors were from arc jets and all that.

We didn't know what the lunar surface was like. The scientists were telling us that the lunar surface was like a fairy castle structure, electrostatically suspended particles that when you landed on it, you'd just sink many meters into the moon surface, like very light snow for hundreds of meters, maybe. And the leading scientists that had spent their money looking [through] telescopes and radio telescopes and everything else, when they tried to formulate what that would be like from normal scientific data and research perspective, they concluded that it's what is called soils mechanics, was something that you couldn't actually land in. So here Kennedy has challenged us to go land on the moon, and we didn't know whether, if we did, we would sink out of sight.

So when we studied it and talked about it, when I'm presenting the story on the thing, I would talk about, "Well, I'm not going to tell you that we can actually make a landing," and that's what the man said, "Land man on the moon, return [him] safely to the Earth." I said, "I can't tell you, as the designer, that we know how to land, because the physics that comes to us from the leading scientists in the country says that we would just disappear, and we aren't

about to send anybody up to do that, especially when you tack on the end of the challenge and return them safely to Earth. We could land them in this dustbin and left them there, you know, but, no, we would want to bring them back safely. But when the President actually puts that one in his challenge, then for certain you can't leave them in the dustbin.

So we said, "What we can do is we can put a configuration together that will go down and do an excursion down to the lunar surface and attempt a landing, all the way to attempt a landing, and if you sink out of sight, we can abort off it and bring the guys back again." So that's where the "E" in lunar excursion module comes from. That's where the "E" is. We can do an Excursion down and back.

Now, understanding this history of that, Grumman and my organization at NASA continues to this day to refer to it as the LEM, the lunar excursion module, but NASA headquarters didn't like that. Once they understood why we put the "E" in, they didn't like that. "You've got to be more positive about your way of thinking." But I had to be more honest, you know.

But anyway, I'm back at the congressional hearings, and so what did we have so far? Two things. One was the heat shield factors, the soils mechanics at the moon. We were arguing about what … [mode] we should use, lunar orbit rendezvous or Earth orbit rendezvous, different techniques like that, but in any case we needed a very light lunar module to go from the lunar orbit down to the lunar surface.

We needed the weight, projected weight problem, weight-growth problem that most people said, "This really caught you guys by surprise," but we knew the weight was going to grow so much [of a percentage] per month, effectively. You have to be able to continually come up with ways of improving the weight situation, which Grumman was very good at with the weight improvement program and then the super weight improvement program. Weight was always a big problem. They knew it and we knew it. [At least] my organization, part of NASA, knew it.

So when Grumman proposed to change the pressurization system from nitrogen, which everybody else used, to helium, which is a lot lighter way of doing it, you have to store the helium in a supercritical state, which is at a terribly, terribly low temperature [and] nobody had ever gotten helium cooled down to that point before.

They'd never gotten anything cooled down to that point before. But if you could get it cooled down to this theoretically predictable thing that we hadn't demonstrated and actually determined the thermodynamic numbers and the heat leaks and all that kind of thing that would be associated with it, unless we could [and] we weren't certain about whether or not we'd be able to do that, so that we ran [the required Research at Grumman to determine the previously unknown thermodynamic parameters and scaling factor]. If we said, yes, we could do it, we ran a big risk, a very high risk, of not being able to do it because of the weight growth. The LEM finally got down to absolute skin and bones, you know. It was the lightest thing you could conceive [and we in the end really needed that supercritical Helium].

We actually used supercritical helium in the … descent stage, but not on the ascent stage, and that created a lot of problems with [and for] Max Faget, his practical business of, "You mean I'm going to have to stake my life on supercritical helium? You mean I'm going to have to stake my life in this submarine that's submerged for a week and a day on this piece of garbage that I don't know anything about? I've got to know about it."

So we had great difficulties with Max on that score, but we convinced Max that this weight problem was so potential and it really did turn out to exist, that we had to develop this technology if not [for primary use], but to use it to save us when we got to this big weight problem, and at the same time to use as an indicator to the rest of the community that, "If you guys let your weight grow too much, we're going to have to go to supercritical helium," including Max and all the subsystem managers. So it had two prongs to it. One was real in terms of getting weight down, and the other one was a threat to the rest of the subsystem managers to keep their weight under control so that we wouldn't have to use this thing. Well,

they did to a large extent, and we did use it, but we did use it in the descent stage, and it worked fine.

But at the time of the commitment, we didn't know about that. So now we've got soils mechanics, the scaling factors, the thermodynamic characteristics of the supercritical helium. How many is that?

BUTLER: I lost count.

MAYNARD: Soils mechanics, scaling factors for the heat shield, supercritical helium performance thermodynamically. Did I say soils mechanics?

BUTLER: Yes.

MAYNARD: I don't know. Is that four or five? It's really getting late. I can't think. Anyway, I said what the number was, and then I said, for the power from space part, we have a comparable lack of understanding in one or two more areas, so we're close to having the same lack of confidence, if you will, but admittedly worth the try that we had in Apollo at the time when Kennedy—well, we did have heavy lift launch vehicles to get the whole package off. We knew that that was possible to do, but we weren't anything near having that kind of a capability for the power from space thing.

I listed some issues in the microwave power-beaming thing and in the remote manipulators and some other areas. I can't remember what they all were now, but there's one or two more than there was in Apollo, which simply said that, yes, this is a lot bigger deal and more to the point of giving people power, useful good power on Earth, without polluting the world. And to be that close to the same kind of criticality that we were in Apollo, the first thing we ought to do is what I was trying to say, first thing we ought to do is improve

our understanding of the technologies in these areas and get them down to only one or two, maybe less than Apollo had before we go actually committing to it or asking the President to give us a challenge in this area.

The Grumman guys and Arthur D. Little and Spectrolab guys, they didn't like me saying that because they sort of advertised that this was a 100 percent feasible thing, "Give us the tools and we'll finish the job tomorrow." And I was saying, "I don't want to shut off advanced research and development, because I [didn't] think we would get there if we go just totally alone on what we currently know and have told people. There's still some skepticism that we have, and we really must do this advanced technology work."

By and large, that work never got done, because whether the Department of Energy spending the millions of dollars they did and so forth, and then saying, "We should put it on the shelf and let industry develop the technology for other reasons and then we'll use it," well, you know, you couldn't let industry develop the heat shield, scaling, understanding of the supercritical helium, or the soils mechanics on the moon. There's no reason to expect that industry would naturally develop and fill in the gaps in the technology for power from space. It would just be too risky, in my mind, so that's why I said this.

But the Grumman guy and Arthur D. Little guys and Spectrolab guys, they view me as having sold the farm or, you know, let them down or something like that, and, in fact, haven't developed hardly any of that technology. Then Bill Brown [now deceased but in most recent years questioned the tubes as] the basis for doing it at the time ([he] was using tubes for the transmitters)… Somebody in NASA asked me, begged me, and begged Raytheon to do an investigation of how would you approach the job if you were to do it solid state rather than the tubes, because solid state technology was coming on strong and all that. They begged me to do a study and got Raytheon to commit to the resources to do it, and they paid a little bit to do it.

I ended up doing it, and I couldn't get Bill Brown to participate, because he was [then so strongly] a "tube man" and he wouldn't even read the final report. Here's the final report, these two green books. I'm not an electrical engineer and I'm not a physicist. I didn't have Frank Casey [now deceased] around and I didn't have a Bill Brown kind of a guy around, but I got to do this all by myself pretty much. I had some minor help, but people at Raytheon would find more interesting things to do because I couldn't pay them for only but a few hours. So the report, I think I mentioned before, that report is written badly because it simply is a collection of the stuff that I put together that presented to the people that I was contracted to do it with.

There was no requirement to write the full-blown neat and fancy report, but that tells an awful lot of how you'd go about doing it solid state. There's a concept in there that's called the sandwich concept, where photovoltaic arrays on the back of the transmitting aperture … [collect] power that's sent down to it by a collection of reflectors and separators and filters and so forth, so that only that part of the solar spectrum that is highly efficiently convertible to direct current to drive the amplifiers on the microwave side of the sandwich, that's sort of fundamental to that solid state thing.

As you think about it more and more, thermal control ends up being the limitation for how big things can be and how much power you can get out of them. There's only really one way to dissipate waste heat, and that's by radiating it to something that's at a colder temperature than you are. Deep space has got this nice cold temperature. So using the most efficient waste heat dissipation coating, thermal control coating, to do this effectively, I put the numbers together, assuming that now the critical issue gets to be how good can you make thermal control coatings and how long will they last, and will you have to go and repaint them, resurface them with something. That ends up being the issue, rather than can you [otherwise] technically do it.

This should have an awful lot more investigation than what I was able to do and several other areas should, that are pointed out in that and in all the other investigations we did. We'd say, "Here's additional investigations that should be done." We didn't say that Raytheon ought to do them, but it would probably be best if Raytheon didn't do them, had to get somebody else to do them.

None of those things got done, so the government took taxpayers' money and paid us to tell them what to do, as we viewed it, very responsibly, but there are those in the government that [view]—Raytheon says to do these things just in order for Raytheon to rake in some more money, and, trust me, I don't work for Raytheon anymore, but, trust me, that was never Raytheon's attitude. And it's not industry's attitude, to a very large extent.

So the right technology developments weren't done in the area that I had mentioned to you earlier, with that chart over there, the log chart that talks about the power beaming from having multiple beams transmitted from the same aperture, with the bottom line being something like—I have to get the ground receiving aperture down to about 1,000 acres. That means I have to have about 1,000 transmitting beams coming out of the transmitting aperture, with pilot beams on the receiving end that command the power to come to them.

This hasn't been demonstrated, but this is theoretically conceivable as much more so than the notion of landing men on the moon when the scientific community is saying they're going to get lost in the dust or what the thermodynamic performance of the supercritical helium is, or the scaling factors for the heat shield. So the very key thing is that we have to—and Bill Brown, just before he died, he died not too many months ago, and just before he died, a series of telephone conversations I had with him, he told me that he really thought that we were going to have to go solid state rather than tubes, which was contrary to the messages that he was giving before.

He was an absolute, tremendously competent guy and very, very highly regarded. I'd give him copies of that report and he had sent them back to me because he didn't believe in

them, you see. But all of a sudden he asked me to send copies of that to Dick Dickinson at JPL, who was the guy that managed the contracts for these demonstrations we did at Goldstone on that RSCV program. He's been involved with a lot of studies that NASA has done since then.

So I have gone to the trouble of putting all that stuff together, sending it to Dick and telling him about all this stuff and everything else. He's not paying me, but I feel like I sort of must do this, because that Martin Schilling guy, when he said, "This thing's got all the earmarks," and all that kind of thing, but he says, "My guidance to you as the program manager is, make sure it gets well on its way before Bill Brown retires."

What he was saying is, you've told us this story based on tube technology. The world's leading expert on tube technology is Bill Brown, and you'd better make this thing happen while Bill Brown is still up and functioning working-wise." He was quite a ways from retirement age at the time when he said this, and we thought it was funny, you know, a little bit of humor, but he was dead serious, "You don't have a tiger. This is not in the category of formulate the program so it can be done by ordinary people." At the time when we thought it was feasible, it would have required extraordinary people like Bill Brown, extraordinarily dedicated, capable, responsible, and greatest human being that you could know, you know.

So he died when he was eighty-four or something like that, so he would have retired at sixty-five, so that's like twenty years ago he would have been retiring. Twenty years ago from 1999, twenty is 1979. So we would have had to have it well on its way, not completely done, but certainly we really had to know, be under contract with a whole bunch of people and so forth. By 1980, in order to fulfill that kind of a strange requirement programmatically, to make sure you're well along before Bill Brown retires, now Bill continued. He retired late and he continued to work, and he worked after he retired, so it took his death, actually, to convince me that we had gotten to the point where Martin

Schilling [told] me, "Make sure you get it well on its way before Bill Brown dies instead of retires," and we have passed both of those milestones.

My health isn't good enough to go have a visit with you sort of out of town. You've kind of got to come here. And I'm not nearly as smart or as technologically capable as Bill Brown was. Nobody is that I know of. In the solid state area, I did indeed get Raytheon to do certain investigations that brings the solid state devices along. So does Space Defense Initiative and some other activities that have gone on.

But now I understand that Dick Dickinson has discovered that there's some other ways of doing it without even using solid state, with using some kind of a gaseous or bunch of crystals in an ellipsoidal kind of shape, monstrous, big transmitting antenna that conceivably could do multiple beam-forming and everything else and be self-healing and a whole bunch of wonderful things.

If you tried to do it, say, with tubes and somebody else, … the Russians or the Chinese came up with solid state and beat your own economically and everything else, you'd be dead in the water. If you tried to do it with solid state and somebody else came up with these other concepts sometime in the not too distant future, and aced you out and beat you in a competition, you'd be dead in the water. So you have to do these advance researches to have the confidence not only that you can just do it, but you can do it before the competition comes and does it.

So that's sort of where I believe we are. Dick Dickinson and I both—but you sort of have to rely on Dick, because he's not retired yet and all this kind of stuff. But there are a great number of things that should be done in the world of advanced research and development by industry and by academia, and we can sort of spell out what those things are. And by country. Like Raytheon-Canada has a great capability to come to understand some of the issues simply because we're very close to the radiation belts and know how the beam is going to be affected in going through the ionosphere. They claim that, you know, we've

already studied the ionosphere, but it's not for that purpose. It was for some other purposes. The phenomena that we're concerned about here is different.

I could be a little bit more specific in what I think should be done and what I've been trying to encourage the Canadian Space Agency to do, but I haven't been doing it directly to them. [I've been completely unsuccessful in] telling this to Bryan Erb, who still works for them. I would be willing to, and somebody else, highly technical people that would pick up on the concept and make those kind of charts so that they understood them and they believed in them. They [would have to rewrite] that green book so that they understood [it]. They [would have to believe] in it, in a few key areas that Canada would have some advantage in doing. We can talk about things that other people [have], that the U.S. would have some advantage in doing.

So I guess we probably ought to leave it at that, unless you've got another question.

BUTLER: I think this is a good place to close out for the evening. I want to thank you for the wealth of information you've shared with me today. It's been fantastic.

MAYNARD: Well, it's been a pleasure, because I don't view the history of Apollo and of my career as being all that sort of valuable to the degree that it's available. I don't think I've ever told anybody as much in one session as I've told you, and sort of bared my heart quite so much in some of the areas as I have with you.

But if we can make something worthwhile come out of it that will help NASA and the Canadian Space Agency, I am a dual citizen and I believe in NORAD and I believe in NATO [North Atlantic Treaty Organization], and I believe that the U.S. and Canada, we need to work together. We don't need to be one country, but we need to have such things as NORAD and NATO, and we need to be together on this power-beaming thing. We are north and

south of each other. We are in the family of time zones. We are concerned about the same piece of geostationary orbit. Our neighbors are north and south, not east and west.

This goes along with the North American Free Trade Agreement, except just extend it into South America, whereas the European community has banded itself together and actually gone quite a bit north and south. Probably if it's advantageous to have a North American Free Trade Agreement that involves the U.S. and Canada and now Mexico, I think that there are those that think that it should involve South America as well. It could involve South America and go all the way to Antarctica, and Antarctica goes all the way around in azimuth, in longitude.

You actually could beam power to outpost islands out in the Arctic and also to Antarctica. A lot of people will say you can't do that, but I think you can. But it needs to be investigated, what you really can do and work out the teaming, whose expertise you're going to use, who are going to be the leading experts, not as individuals, but as agencies, MIT, Caltech, Raytheon. I don't want to say Raytheon too much because I don't want people to think that I'm out promoting Raytheon, but I happen to have a very, very high opinion of Raytheon, so high that [those are] the people I went to work [with] when I left NASA. I would have gone to Grumman, but I didn't see my going to Grumman was going to help Grumman. I could see my going to Raytheon might help Raytheon and Raytheon-Canada, but Grumman didn't have a sort of equivalent counterpart in Canada.

So if I can convince you of nothing else, that I really am sincere in trying to pass on to people things that they may not be happy to receive, and they may tell me, "If you wanted to do all these things, you should have stayed with NASA," or something like this, and try to tell NASA what to do, don't do that if you're going to leave, so whatever we can not so much salvage—it sounds like too negative a thing, but there still is a tremendous opportunity and there is a need [(more and more imperative and sustained is the need and it must be shown to be fulfillable before committing to its fulfillment)].

I have these … long charts that I was going to show you. To engineer an enterprise like this, I have [documented] what systems engineering [(the methodology) would have to be like]. When I left NASA, they were still trying to figure out what it is that [I and my Divisions had] been doing all those years. I put together what I call a circular slide rule, and some people call it the "last shot" slide rule. I had that circular slide rule here. [It depicts the process rather completely.]

Most engineers don't know about circular slide rules. But what is on this circular slide rule, on the outer tire is the different phases of a program that go from BASICS, Phase Zero, because people normally don't take the trouble to pull together all of their basics before they start spending a lot of money. First phase is BASICS and the next phase is PROPOSAL. Then START-UP after contract award. Define the concept definitively. Then lay the thing out, make all the drawings. This is the way it's going to look. Do the configuration, not at the start, but at this point. Release the drawings [for] manufacturing and all that, all these different phases.

Then if you don't establish the basics beforehand, you're going to just waste money all over the place, because the fact that you didn't understand what the heat shield thermodynamics scaling parameters would be, or the thermodynamics of the supercritical helium, or the soils mechanics, you start off without knowing those things. Then to insist, not including excursion in the acronym, Lunar Excursion Module, is just sort of lying to yourself [as well as others].

The actual way of explaining how do you do systems engineering in a very responsible way can be explained on this piece of paper. Then what's the program look like when you lay it out as a program plan that is much more definitive than that, if each of those dozen or more phases are expanded upon in this chart, all key definitions of all different markings are, there is Phase Zero basics right up at the top. You see "basics." Then the

Roman numeral O. You never saw that before, right? It's called "Basic Need Resolution and Advanced Development."

And there's a gate that you [must go through to] get from this phase to the next phase. [You must review the] design and [other specific kinds] of a thing, like me facing up to Jan Zurakowski and Spud Potocki, but at all technical [and other] levels… Unless I get a "yes" that I'm compliant with everything, I can't be allowed to proceed into the next phase. And if I get to this gate here that says "To the Competition," and I don't win the competition, whether it's competition in the same—someone else beats me out on the demonstration at Goldstone or I don't get the money for this because somebody else wants to go spend it on fusion, I just didn't win the competition and there's no excuses about what the rules were of the competition, because it's not fair [(fairness never enters into decisions)].

So this isn't an easy thing to do. That says "Advanced Development" at the top of that column. Over here it says—the whole thing starts off with "Need Sources." Who is defined for need? Who defines the requirements? When the man says 1,000 acres, I would take that. I would look at that as a potential need. You put that down as a need statement and it says, "Damn it, they can't be bigger than 1,000 acres." If you come in with 2,000 acres, I might continue to talk to you, but you're liable—but the guy that can do it within the 1,000 acres, he wins and I lose, and I go out the bottom there. It says other competitors get the money and you can just stop work right there.

BUTLER: Let me change the tape.

BUTLER: Go ahead.

MAYNARD: And here in the Phase I, called "Proposal," but I have different ways of naming the phases, the letter is one, Phase I, but remember it's preceded by Phase Zero. It's called

"Proposal" if you want one word, and it's called "Pre-Proposal through Proposal Review and Receipt of Contract" if you talk about the nature of the gate that got you into it and the gate that's going to get you out of it.

Then there's an objective statement for each one of these phases. In that lower typing it says "Ensure that high, but defined quality is," and that's what's written for each of the different phases, but in this case, the proposal phase, this "defined quality is proposed compliantly with alternates as insight dictates, and with required resources." It's kind of long, but objective statements sometimes are long and they sort of have to be a single sentence, complex sentence, and everything else. But they have to be a single objective and single objective statement.

Like when we decide we're going to go bomb the hell out of Yugoslavia, we'd better have our objectives. People in the military understand what this objective statement is about. You know why you have to do this. You don't know what you're doing if you don't. So the objective statement for the next phase, this is actually "start-up after contract award," where the customer tells the contractor all kinds of things that they weren't able to tell … because of competitive procurement limitations on what you can tell and what other contractors had proposed, the ideas they had and all that kind of thing.

This happened on Apollo after we had competed Command and Service Module to several people, making different proposals. They allowed us to have North American consider some of the approaches that they had come in with, that you might have thought might have been proprietary or otherwise, intellectually protected. So there's start-up.

Then concept. Really, under contract you definitize the concept so that when you're talking about the concept in your proposal, in your pre-proposal activities, you can be a little bit more vague than you have to be at this point. This is simply cutting down the vagaries. Then preliminary layout and it goes on and on and on for quite a few others, consistent with that tire that's around the "last shot" slide rule.

So you need to focus. A lot of people will say, "I want to do something rather than nothing," and the something's got to be something like some big piece of hardware that you put in orbit and you demonstrate something. If it isn't in line with what you're actually going to do subsequently under contract to make the production item, you will lose out to your competition. Competition might be competition of what people want to do with the tax dollars in terms of the allocations that Congress might make and so forth. If you haven't proposed something that's rational and stable and well understood and has got a big payback and really is fulfilling in [terms of] need and all those things, you will lose the competition for that money, and it will go someplace else.

So this sort of is based on the lessons learned, that I learned from both—well, from the AVRO Arrow program, which was designed for production [from the outset]. The first Mark 1 Arrow was built [with] production tooling, which I think I indicated before. It's very rare. People used to build prototypes, and then when it came to, "Okay, now you want to buy a bunch. Now I have to redesign and you'll have to pay for all that development and tooling and everything."

This is based on—shows you what you have to do and where you have to do it, to develop the program, the enterprise based on design for production from the [outset], but not have to repeat the design and development over and over and over again. There are very few things that are done that way, but I'm a solid believer in it. A lot of things that Raytheon has done while I was there, and since, have been based on that.

So I think this is the kind of a thing that could be shared if the government decided this was a good thing to do. To a large extent, the government does, because we had contracts with the Air Force and the Army and the Navy, that all of this sort of evolves from. It's the basis for Raytheon's methodologies. They don't follow it verbatim, letter to letter, because different kinds of contracts and investigations might require a different, much simpler approach. But this is the whole thing. If they're going to do—if you want to—if

they say the whole nine yards, this is the whole nine years of the enterprise, a major enterprise. Power from space would require—it just couldn't happen if it didn't face up to doing the whole nine yards right from time zero.

So the "whole nine yards" term comes from—you've heard it, right?

BUTLER: Yes.

MAYNARD: You think it might have something to do with football? Well, [in my version] it doesn't. It has to do with back in the old days when I lived on the farm. Frances Shaw was a very entrepreneurial kind of a guy that went to grade two in school. These guys that go to grade two in school, you can't beat them. He started an enterprise where he leased some of the riverside area to make a dock to have gravel barges that got gravel from different places along the Great Lakes, and came and dumped it off on this place on the St. Clair River. Then he would go down with his trucks, gravel trucks, and he would load them up with this gravel. Then he would sell them to the—he sold things not at the county level, he sold them to people [and] at the township level.

See, this is a county. The whole thing's a county. But this is Sernia [phonetic] Township. This is Eniskilen [phonetic], and this is Brooke [phonetic], and this is Dawn [phonetic], and this is Moore [phonetic]. This is Sombra. So he would go to the township, head offices, and tell them, "You know, if we put some gravel on these very, very bad roads that you have—" Clay, Sombra clay is very bad stuff. Cars [wheels] just dig trenches. The old Model T Fords used to just—in the springtime, they'd just dig a trench like you were going to lay tile in it or something. Like dogs would get in it and they couldn't get out, and the little tires were about this wide.

So they had to fix those roads up so that [there're] reasonable beds there to get sort of year-round transportation, transportability. So he figured out that, "If I put gravel on these

things and … put enough of it on, I can stabilize these things." He would convince one of the townships to do this, and he would bring the gravel and dump it where they wanted it dumped, and then they would have a spreader, would spread it over the road, and all this kind of stuff.

But when they bought the gravel from him, the gravel came in trucks that held just about ten yards, but sort of guaranteed nine yards, nine cubic yards. So if you decided you wanted to do your driveway and you said, "Well, if I had about two inches of gravel on that driveway," and the driveway is this long and this wide and I now know how many cubic yards it is, so I think that I need seven yards, seven cubic yards. I don't want to buy nine cubic yards. I only want seven.

Well, he would deliver less than nine yards to you, and he would sort of be convincing that when he loaded it, that it was—yeah, it's seven-ninths of a truckload. But it's kind of hard to tell. Then he runs it over rough road and the gravel goes down and looks like a lot less. He dumps it on your driveway and [it] almost instantly sinks into the soft earth and sort of disappears, and you think that you maybe got half a cubic yard, you know, by this time. You end up thinking that you got cheated.

So he would say, "You know, just between us folks, you'd be an awful lot better off, or we would both be an awful lot better off if you'd go for the whole nine yards in the first place." Then you know that you didn't get cheated and I'll know that I won't have a customer that's lost faith in me. So that's where "the whole nine yards" comes from [(Owen Maynard's version)].

BUTLER: That's great.

MAYNARD: And trucks of that era were nine, ten yards. This time, these days, they are more like eighteen yards, multiples of nine, still. I don't know why the nine was there.

But that chart I showed you is about nine—the two of them put together [are] about nine yards long and it's about a yard high, and if you take each one of the blocks and you try to talk about what does [it] mean, even the objective statements, what do I mean by that objective statement, you can raise a thing that's at least a yard long. At least I can. So this multiplying length by height by depth is nine cubic yards.

BUTLER: The whole nine yards.

MAYNARD: So that is—if you look at the enterprise like this and say this is the way I want to do something, then you discipline yourself to go do it right, you're using the whole nine yards approach and you're not cheating yourself or anybody else.

So I would be happy to talk to anybody about that, and I'm going to be talking to people that are responsible for safety inspections and establishing criterion and whatnot in the province of Ontario. I'm going to be talking to them about safety.

At the same time on that circular—this slide rule thing, this guy here, there's a whole bunch of attributes down here. Says "Design for primary and detailed form, fit, and functionality. Design for comparability, interchangability, standardization." A whole bunch of "—ilities" that designers like to have things put in those terms.

Way out here, number thirty-two, I think it is, is "Design for safety." So these guys I'm going to be talking about in terms of attributes in the total enterprise is this one out of how many? One out of forty-two attributes that you can put together checklists associated with and conduct design reviews based on—let's see. How compliant we are with what we, before the fact, determined to be the need and the requirement, and both the customer and the contractor agreed that these were the needs and the requirements. This is how much the contractor is proposing to require in terms of dollars.

Funding rate is the important parameter, and Chris Kraft once told me that his biggest problem with his people was they didn't recognize funding rate as being a technical parameter when they were putting together technical things. I think money just rains down from the sky some kind of a way. It isn't the total money that counts; it's how much you get per month. If you put your program together so that you spend that per month, and may opt not to spend it and make it all consistent with your total organization and all that kind of stuff, it ends up being that you really don't need to monitor how much money you have spent; you need to monitor what your projections are for staffing up to be able to spend money at a certain rate and then cut down from that rate to a lower level at some point and build up at other points and so forth.

If you're manning plan doesn't match the funding rate that you're liable to get from the customer, the customer can't be magical and change his funding rate to you too frequently. So I've tried to put in these kind of documents not what the technical requirements are for power from space, of the marketing thoughts and so forth, but how do you go about running the enterprise. Not that I'm ever going to have anything to do with it or certainly never get paid for it or anything like that, but I've thought a lot about it.

I would be thrilled and happy if I could contribute to, in your case, going through George Abbey. I know that somebody in headquarters decides a lot of these things, but I know that George has an awful lot of respect. People respect him in high places all over the place. If I think George picks up on these things and he's got the kind of a mind that can do this much better than I do. We might be able to do something, you know, overall beneficial.

So [there're] so many dimensions to what we've been talking about, that it's scary. I just hate to see—I watch people go off in certain directions, like with the Space Station. I'm not going to ever stand up and tell people that the Space Station isn't properly conceived or anything like that. A lot of people do say things like that and do say that about the Space Station. But I don't know the nuances of how come it is like it is. It certainly doesn't look

like the one that I conceived. It isn't [compliant with] that patent, and it doesn't fulfill the requirements that I conceived at that time under the jurisdiction of the great Bob Gilruth and Chris Kraft and all those other guys, at a time when we had a certain way of thinking. But it's like two generations ago.

So, you know, none of us are sort of great nuts on the Internet or even the laptop computer. Some of them, you know, Chris and others might be, but I'm not, and I don't want to get involved in it. I'd be happy to use this bloody slide rule and so forth, because I sort of understand what's going on in that narrow field. If I could get into it, I don't really know how to type with any kind of speed. So you can't bring me into the present, and the present can't be brought back to me. We have a big problem in that regard.

BUTLER: I'm hoping that this project will help get the word out.

MAYNARD: Hopefully you can make modern history, as well as ancient history, out of this, even use the history to—what is it they say? If you don't understand the history, you're bound to repeat all the bad parts of it. Anyway.

BUTLER: Right.

MAYNARD: So this is what's in these two charts, the whole nine yards. It's actually past history because, indeed, Raytheon and, I think, other people do perform the activities somewhat consistent with this for certain parts of the federal government contracts. I don't know if NASA does or not. But I've been trying to impart this stuff to Canadian Space Agency and other parts of industry in Canada, and I haven't been very successful.

I don't know how I would do with NASA. The closest NASA Center to me is Lewis Research Center. But I'd be happy to entertain some way of communication, have them

come here or have them take me there or something. [I've been preparing to talk to Ontario's] Safety Guys, you know, [and I'll dive into] "Brave men shall not die because I faltered" [emphasize my old motto that my other gave me in 1940]. I've got a message for them, that they can't just pick that safety thing and say, "I'm an inspector and I'm going to make this whole thing safe." It's not that simple. It's the one area of expertise that is among thousands that have to be traded off and all that stuff. So if you don't understand that right at the start, you're doomed to failure, or you're doomed to really not ending up with something that's safe.

These guys—I'm going to tell these guys this little story. In that book there about all the heroes [of the distant past].

BUTLER: We have a little while.

MAYNARD: Back in World War I, the guys that were flying these kinds of airplanes that ended up being aces in the Royal Air Force—and … there wasn't such a thing as a Royal Canadian Air Force at that time, but a lot of Canadians flew for the Royal Flying Corps [and] in [its successor] (Royal Air Force) when it became the Royal Air Force. But on the Allied side, there was a belief on the part of the policy-makers on high that you shouldn't give pilots parachutes, because in the middle of the battle they're liable to panic and just bail out and leave this very expensive airplane and waste the taxpayers' money. So you don't provide him [with safety]. Their safety criteria [was] based on the safety of the investment in the airplane, not on the safety of the [pilot] flying it.

Like right now the U.S. is doing extraordinary things to make it safe for the flight crews, … these guys that are [operating over] Yugoslavia. Compared with other air wars or whatever that anybody's ever been in, there [hadn't] been the emphasis on that kind of safety [that we have now]. [If] they fly at lower levels, they could drop a lot more bombs, carry

bigger payloads and a whole bunch of other things, so safety in the U.S. military is an extraordinarily in-depth consideration.

But back in the World War I era, a good many people on the Allied side didn't give parachutes to their pilots. They gave them to the observers in balloons because the balloon could get shot down and then they kind of can't make the balloon sort of desert and run away, and the balloons don't cost that much anyway. So they allowed as how parachutes were okay for observers in balloons, but not in airplanes because they're liable to abandon this difficult thing to fly and all that.

World War II comes along and they give parachutes to everybody. I don't know what the policy was in the United States Army Air Corps in either World War I or World War II, but I think that they tried to make the flight crew as safe as they could in World War II. I don't know that most people realize that. Safety is not an absolute thing. It is who it is—he who has the gold gets to make the rules. So if the rule is, I want the airplane to be safe and brought back safely, versus I want the pilot to be safe and brought back safely, they're two different [things]—you might think they're the same thing, but they aren't. Unless the objective is pointed right where you want it, you don't get the benefit of it.

As a matter of fact, I got told once, when I was flying those Mosquitoes, after I got [to] England and I'm flying with the Royal Air Force out of Royal Air Force bases, I got called in one day and got told that, "From now on, if you find that you are in some kind of difficulty and you are going to run out of gas or something like that, don't ride the airplane down through the clouds and take your chances on landing in the North Sea or hitting a mountain or something like that. You bail out and save yourself. At this point in your career, you are worth more than the airplane. Yesterday, if you ran into a certain situation, you should [have protected] the airplane, because it's a very valuable thing. But after this point in time, you are worth more than the airplane is. Protect yourself. We can always get you another airplane."

And I was shocked to find that there came a point in time specifically where one side of the rules were this, and the other side of the rules were that, and I don't know if that applies in the United States. I doubt that it does apply in the United States, and I doubt that it applies in the Royal Air Force either, in this era.

But safety is—equipment safety, you don't want the equipment to malfunction, but when you draw the mark between making a management decision and am I going to protect the pilot or am I going to protect the airplane, am I going to protect the car or am I going to protect the baby, if you do all sorts of things to protect the driver, then you're kind of counting on the driver to keep the car under control, and it makes things safe for the rest of the passengers.

Like in my car, I've got an air bag for the driver. Everybody else kind of is on their own, sort of thing, you know. And I don't know, when I get to talk with these safety guys, ask them kind of embarrassing questions about safety, you know, "Have you really got your head together right on safety?"

BUTLER: That's important. It's certainly been a key factor in everything that you've shared with me today.

MAYNARD: So I guess that's about it. I don't know if you want to reserve coming back here tomorrow or—

BUTLER: I think probably I should take this back to Houston, get it all transcribed, let you review it.

MAYNARD: Are you actually going to get it typed?

BUTLER: Yes.

MAYNARD: Oh. That would be good.

BUTLER: And I think we've pretty much covered it. We've covered a great deal of information, and I'm honored that you shared so much with me.

MAYNARD: Well, it was my pleasure and actually my screaming desire to do that. I appreciate you coming all this way to do it.

BUTLER: My pleasure.

MAYNARD: So if you go and have a nice night's sleep at the Holiday Inn, then take the van in and turn your car in at the Holiday Inn, instead of making that long drive, then if you come another time, you take the van in the first place, it will make things a lot more pleasant. We always take the van from here every time we go to the airport…

BUTLER: Okay. Thank you.

[End of Interview]