ORAL HISTORY TRANSCRIPT

DENNIS E. FIELDER
INTERVIEWED BY CAROL BUTLER
HOUSTON, TEXAS – 6 JULY 2000

BUTLER: Today is July 6, 2000. This oral history with Dennis Fielder is being conducted for the Johnson Space Center Oral History Project at the offices of the SIGNAL Corporation. Carol Butler is the interviewer and is assisted by Kevin Rusnak and Sandra Johnson.

Thank you very much for joining us today.

FIELDER: My pleasure.

BUTLER: To begin with, if you could just tell us a little bit about how you became interested in aviation and engineering when you were growing up, and a little bit about your early career.

FIELDER: It was started at school. You know, model airplanes, that kind of good stuff. After school, it was probably just general stuff, but I eventually wound up being apprenticed at the Royal Aircraft Establishment [RAE] in Farnborough [England], which was in those days the centerpiece of the R&D [Research and Development] in the aviation world in those days, and it was eventually the space center, too, though not at that time. This was in 1947 through ’52. I was apprenticed and I stayed on there for another couple of years.

As an apprentice, you learn all the usual things and how to make stuff and be a clever artisan. But in the latter two years of that program, we spent—well, college time in college, but the other time was spent in the labs in the establishment rather than the workshops. Some of the labs did romantic things like guided weapons, and that's where I got started. I was in guided weapons labs as an assistant. I was assigned an apprentice who did all the dirty work in the place.

But after we graduated, we had the opportunity to back into the RAE as—what was I? An assistant experimental officer, AEO, lowest of the low, but into the guided weapons department.

I wound up working on the recovery of vehicles from water after they had been launched. We launched from the South Wales Aberporth area across Cardigan Bay, not very far in this day and age. It's just a tiny jump, but it was pretty good in those days. The rockets' launch vehicles reentered into the water and dropped into seventeen fathoms of water and were lost, essentially. But then they thought it would be neat to be able to recover them, so I wound up working on a series of parachutes and floatation equipments that were incorporated in the launch vehicle.

After the launch vehicle had done its flight and the experimental data was achieved, acquired, this sequence of events took place. Much to my amazement, it all worked, although we did develop each part separately. The vehicle was a cylindrical thing about twelve inches in diameter, twenty feet long, something like that. We stowed the parachutes up forward and some other parachutes in what we called the boat tail. It's the tapered section right at the back where the high-speed drag parachutes were deployed from. You essentially cut the back off the vehicle and the back took the parachute assembly with it. The chutes were inside that boat tail, and the boat tail separated and the chutes would deploy, slowed the vehicle down some.

Then some time after that we deployed a large parachute from the forward section of the vehicle, explosively separated skin. The thing flew out, the parachute came out, cable peeled off the side to the back, lowered it into the drink at a fairly good speed. Then we had salt water-activated batteries that fired another explosive charge that deployed another panel with a big buoy, floatation bag, which was inflated by a CO_2 bottle. It inflated after the vehicle theoretically had gone down to the bottom. It was attached near the front so if the thing worked, this whole vehicle came popping to the surface with the nose cone sticking out of the water.

So that was my world for a couple of years at the Royal Aircraft Establishment. But I knew all of the Royal Aircraft Establishment, because as an apprentice you get assigned everywhere, three months here, three months there. It was a big government R&D organization. Anything that you could think of was going on there somewhere.

When I first went there, 1947, two years after the end of World War II, all the German aircraft that Germany ever produced, including all the research stuff that was done….all those airplanes were brought over and they were all on the field. For the first two or three years, they flew them all at their air show, the annual air show. It was mostly flying these old German airplanes. I didn't fly them, but they were flown.

So part of the game they used to play was investigating other people's airplanes. They developed the Whittle turbine, was developed there very early on in the game. Lots of good things that I can only vaguely remember at this point in time. But the point to be made is that you got to know all of the types of R&D that were going on.

Apprentices actually became great people to escort visitors. It became a second duty, is to escort VIPs around, because we could get all in the back doors of all the buildings and things. So that's was where I played my game.

Then a group of prior apprentices had gone out to Canada and were working at AVRO, or A.V. Roe, as it was in those days, A.V. Roe to start with and then it became AVRO, AVRO Canada. So I thought that was a good thing to do, so I followed them out there. I didn't start with them; I started with G.E. [General Electric Company]. They were developing a radar, airborne radar system, fire control system for the CF-100, which was an in-production Canadian airplane at AVRO. I didn't stay in too long, because I was still trying to get into AVRO, and they weren't hiring a lot at that time. But I was six months working that kind of program. Then the opportunity to get into AVRO came along.

I see you've mentioned Condean [Ltd.]. I'd forgotten all about Condean.

BUTLER: We came across that, I believe, in your bio from NASA.

FIELDER: Yes. Condean was a little spinoff. One of the guys who worked at G.E., General Electric Company, Canadian electric company, of Canadian General Electric, was a kind of an entrepreneur, and he wanted to become a business entrepreneur, own business. Part of the game we'd been working on the radar system was all the shop testing, the environmental shop testing, to see if it withstood all the required vibrations and impacts. We actually invented a couple of machines to do that with that were better than the machines that were commercially available at that time.

This lad presumably saw some opportunity to take a patent or two up on the side. So Condean was essentially a company that started up offering environmental test equipment, shop testing machines, and I just rode that piggy-back for two months or something like that. Then the opportunity came to go to AVRO, so we jumped ship and did that. I know he sold the equipment to Westinghouse Electric Corporation, and several other companies bought into some of this equipment. What the outcome in the long run term was, I really don't know.

But I wound up going to AVRO, and then at AVRO, because of all the test background, I wound up in the Flight Test Department as something called a flight test engineer. It was a kind of project management operation at a small level. Somebody might want a particular test done an airplane, so you worked with a test engineer to figure out what the instrumentation had to be on the airplane, what the recording requirements were, what the flight profile had to be. You worked with the test engineer and the test pilot to figure all the protocols. You wound up sometimes designing the test equipment. It wasn't all off the shelf back in those days; you had to design and build it. We did that for a couple of years.

When I was at AVRO? How long was I there? All the way through 1959. Five years. Most of that time was spent on the CF-100. The CF-100 was originally designed to carry, they were called FFAR [Folding-Fin Aircraft Rockets] rockets. They're wing tip pods, twenty-odd rockets in each wing tube, and the belly pack would drop out with another fifteen or so rockets in it. They were about three inches in diameter and about four feet long. That was just conventional armament.

Then they got romantic and they wanted to put some sophisticated weapons on it. These were sort of half oriented towards—the Arrow had been in its design phases for a long time. The armament selections were these two guided weapons, Falcon 2s and 3s and 4s and Sparrow 2Ds, I think is what they were called. The Falcon was a relatively short vehicle, and the Sparrow was a fairly long vehicle, maybe eight or nine feet. Sparrow 2D would just fit inside the belly armament packet of the CF-100, so the design office designed some kind of launch rail that folded back up into the armament bay. Then the protocol was that two doors would open, the rail would come down with the launch vehicle on it, the vehicle would launch off that rail, and the rail would snap back up into the airplane. That was the Falcon. So we worked on the ground mockups for that, trying to work out all the deployment mechanisms and whether the structure would survive the test environment and so forth. I don't think we ever flew one, to be quite honest, off that railway. I know we did quite a few off the ground in ground tests, but I don't think we ever flew one.

Then they decided that the Sparrow 2D was the thing to fly [on the CF-100]. Couldn't store them in the cargo bay, so they stored two under each wing. Each of these had its own little radar system in it. There was a central system in the airplane itself in the nose cone which would detect the target. Then the signal would go back to whichever vehicle you had selected internally, and its little radar would lock onto the same target and, in some cases, would use the mother radar as its source signal for a while till it could get its own signal locked on. It's a pretty good outfit. So they rigged two CF-100s with four of those, two on each wing.

Then they shipped a group of us off to Oxnard, California, to Point Magu. It's a [U.S.] naval research establishment where they had a range, test range out into the Pacific [Ocean], and they had target vehicles which were converted World War II piston-driven propeller airplanes as targets. There wasn't any explosive charge in the nose of theses things, but they had cameras rigged on them, and they could photograph the weapon as it came within reasonable distance.

Some of these airplanes actually flew home, and they were all done remote control by a guy flying another airplane off to one side. I think somebody on the ground actually got them off the ground, off the runway. Then a companion airplane took over, a pilot who was flying his airplane and the test airplane, target airplane, and then the same thing, more or less, coming back. The pilot would bring it back to the runway, or line it up with the runway, and then some ground guy would take it over to land the airplane.

Some of them came home with rockets stuck through the fuselage. Pretty impressive game, but we never managed to do that. [Laughter] Because we actually weren't firing that kind of rocket. But we were there for two years doing qualification testings of their systems, target acquisition, and precision on the weaponry.

In the meantime, they'd been developing Arrow back at Toronto. They'd actually got a production line. They didn't design any prototypes. There [weren't any] handmade models before they then went into production. The whole concept was that there would be a large order, a large production requirement. So the name of the game is rather than screw around putting prototypes together and then spend another five years putting a production line into going, start off with the production line and fix it as you went through the line.

So at the time I came back from California, the production line was long enough that I think it had twenty aircraft in it, start to finish, one just putting the keel down, so to speak, and the other one just rolling off fully assembled. And there were twenty in the series like that. They ran off five or six flight [models]. You can look all this up in the books. It's much more accurate than I am.

Most of the work that I had been doing down in California was oriented towards the weapons bay that was one of the features of the Arrow. It would either have four, eight, or maybe even—I can't remember—a battery of Falcons, the shorter vehicles, or a smaller number of the larger vehicles, of the conventional guided weapons. And there were a few romantic things, like, I think it was called a Genie, a nuclear air-to-air weapon, or maybe an air-to-ground. I don't know.

But we got involved in all the test planning for that. The aircraft, pretty remarkable aircraft, I think, anyway. Despite all the negative stuff you find in some of the columns about, oh, [that] it would never have done what it was claimed to do, it had already done it! It got caught up in some historical anomalies, and even then I'm not sure who keeps rewriting history.

It was an excellent airplane. It did Mach 1.6 on the third or fourth flight. When you looked at that thing when it was down on the ground, you couldn't believe the undercarriage would actually support such an aircraft, because it was long, spindly-looking, especially the front. So there were some minor, maybe major at one point, aircraft undercarriage failures. But they fixed that.

I always remember because in the flight test department, the results of the flight tests are always in the hangar somewhere, good or bad, and they would bring any aircraft that ran into trouble, they would bring into the hangar to fix. On one of the occasions they landed an Arrow, and the brakes seized up on one of the main undercarriage legs. The guy managed to keep it more or less….on the runway with a lot of steerage, whatever. They brought it into the hangar, and it was a sort of exhibit. Everybody had to go walk by, because it had ground that leg right off to the middle of the axles and there were just half-wheels off on the bottom of this leg. It's amazing. So that must have been a pretty good leg.

I never got to fly in any of these airplanes as a flight test engineer. I flew at Farnborough a lot as an apprentice flight test guy, but I never got to fly in Canada.

BUTLER: I guess they wanted to show you all the fun stuff as an apprentice.

FIELDER: Oh, yes. To go back to that era, they were developing radar systems then. They were pretty large systems. I flew in the target airplane to make sure that—they had a radar system fixed up in a Mosquito, in the nose of a Mosquito, which is a twin-engine fighter airplane from World War II, and the radar was in the nose. It was a fairly big radar. It occupied almost the entire fuselage back in those days. The instrumentation was a camera, bore-sighted on the axis of the dish. Theoretically, if the thing worked and it sent out its radar signal and the signal came back and the dish would align with it, it would be zeroed in on the target.

So to identify the target, they flew a Lancaster, which is an old World War II four-engine, piston-engine bomber, and it had a machine gun turret in the back. That was my position, and I had this great big ALDIS light, which is actually a signaling light that the Navy used to use between ships, flashing light for Morse code. My job was to sit in the back of that and keep that thing pointed at that Mosquito airplane while it was performing sweeps behind the target. So if the radar system was working, then it would be pointing right at that light, and the bore-sight camera would be recording this black dot [on the negative], the bright white light shining down the bore-sight. So I wound up flying in the tail end of the

Lancaster, too many times. [Laughter] Then [we] had to go back and do the film analysis on it, looking for [alignment between the] black dot and the cross lines of the bore-sight camera. But that's my flying experience, flight test-wise.

BUTLER: That's certainly an interesting experience.

FIELDER: We spent lots of time—the Empire Test Pilot School, where the pilots came from [all over the world] for all the test flying at Farnborough in those days. [The] Empire Test Pilot School is…what it was called. Pretty sure. It was an international test pilot school. Farnborough had so many different types of aircraft that ranged from all these military airplanes to all the high-speed test airplanes and everything in between. So all the pilots wanted to do their tour of duty at the Empire Test Pilot School because they got all this cross experience across all the different airplanes. There were literally hundreds of different airplanes parked out on the apron at Farnborough. So we always used to get a lot of American guys would show up amongst all the others.

The British guys flew the Lancaster, and it was always boring, boring flying Lancasters. [Laughter] So after they'd finished the test flight, they always took it down to some altitude where they could see what was going on down there. We reported several fires in areas that were in rural, whatever. It was kind of fun. I liked that back in that day.

Arrow experience was primarily the instrumentation on the Arrow and nurturing different instrumentation for different tests. As I was saying, there was no off-the-shelf standard instrumentation, and you had to literally design it. But because there was so much and there were so many airplanes coming down the line, that we started to standardized it ourselves, so that you could, off the rack, take a few different pieces and put it together. AVRO probably might have had a commercial venture, a spinoff, among so many other things, but it all came to a bitter end.

Somewhere near that bitter end, that was February of [19]'59, when finally it was terminated. That history's well documented, too, right? Everybody was laid off, with a few exceptions. Most of us were married at that time, so our wives were working. So it was like an extended vacation. As long as there was a little money coming in, that was okay, because surely it would start up again. They couldn't possibly shut it all down forever!

After about three or four weeks, it became evident that we should all start looking around for a new job. Some of the organizations at AVRO were trying to lease off whole departments to other [aero] industries. I can't really confirm the details anymore, but I believe they leased off significant organized divisions, whole structured divisions of people from the drawing office and the design office to somewhere in California, North American [Aviation, Inc.], Boeing [Airplane Company] maybe, whatever, on a lease basis, on the premise that AVRO would still get back into business one day and they could just terminate that lease agreement and all those people would come back as an organized unit. Of course, that never happened.

In the meantime, there were other ventures, like job shops, where you could go there once a week or so, of course, and look at the bulletin board to see who was offering jobs. The only other aircraft industries in Canada [were DeHaviland and] Canadair at that time. [Canadair] was based in Montreal. I can't remember what they were making now. It was a civilian airplane, I believe. But, anyway, [James A. Chamberlin], was doing a tour of the

Southern United States, looking for general opportunities for employment and somehow ran into NASA.

This was in the time of—NASA had been organized in 1958. Very few people knew what the hell it was all about. Nobody in Canada knew what it was all about. Yet this lad had come through Washington [DC] and gone to Langley [Research Center; Hampton, Virginia] and got a feel for the nature of the beast, somewhere close to Sputnik, I think it was, or whatever the first satellite was that the Russians put up, which generated a great deal of heat. Congress got very excited about it all, and they decided that they were going to do this man-in-space thing. It was their solution to their lack of technical prowess.

At the same time, the U.S. was heavily invested in weapons development—intercontinental ballistic missile programs. [The] Atlas, whatever. Most of the aircraft industry that was not in the aircraft business was in the rocket business and in the ballistic weapons business. They were building them on the West Coast, shipping them to the East Coast, and launching them at the Cape [Canaveral; Florida]. Ninety-nine percent of the American industry, aerospace industry-type engineer, was working on that problem, either that or in the aerospace business. They couldn't recruit enough engineers to join NASA at what was then low-income civil service salaries, to provide any momentum to the space program….

BUTLER: [James A.] Chamberlin?

FIELDER: Jim Chamberlin. Well done. Jim Chamberlin held a couple of meetings at AVRO, introducing the concept of the American space program, [Laughter] and that these guys were desperate for people, and they were going to come up and interview.

BUTLER: What did you guys think of that idea?

FIELDER: At that time? Well, you know, anything was worthwhile giving it a try. It was a job, right? Couldn't get a job anywhere else. I think we all had in the back of our minds the fact that there was an opportunity to go south of the border into the U.S. at some point in the future, but I don't think any of us was sort of seriously planning to do that at that time. Canada's a nice place once you get used to the winters up there. You have to be young to survive up there, but it's great country.

Anyway, I was trying today to remember who interviewed me up there, because a group of maybe four or five people came from the Space Task Group, which had been formed in '58 and was based at Langley. Dr. [Robert C.] Gilruth was its leader, and Chuck [Charles W.] Mathews was one of them. There was an administrative guy, whose name has completely escaped me, he was not a technical guy, but he was part of that group. I think it was Chuck Mathews that I talked with. It was just a one-on-one, and it probably lasted thirty minutes, something like that.

The interesting correlation was, Chris [Christopher C.] Kraft [Jr.] may have been there. I'm really not sure. I can't remember if he was part of that team. Max [Maxime A.] Faget, I believe, was there, and one or two others. But the correlation was, Dr. Gilruth and his merry men were essentially the Flight Test Department at Langley Research Center, and that's the world they knew and the world they talked to, and it was the world that quite a few of the AVRO guys had come from, like me.

Fred [C. Frederick] Matthews was one of the Canadians who came down, who was another flight test guy from AVRO. Fred Matthews…did a lot of the design work that related to the mission control system and the flight controller concept and how they interfaced and so forth.

But I think probably the reasons that some of us got chosen was that not that we knew anything about space programs, but that we were flight test people and we were part of the clan, so to speak. We had the right attitude and the right language. [Laughter]

Somehow or other, they all put their heads together a few days later and came up with this list of people they wanted to offer positions to. They came with salaries, which at that time were commensurate with the Canadian industry salary, only just, but it was an income. I can't remember how many people they actually interviewed or how many they offered positions to. Rod [Rodney G.] Rose was always the keeper of that secret list—not secret, but that type of information. But I think there were some forty involved in that final transition, in two sets, like a twenty-five and a fifteen, two groups. We all wound up coming down to romantic places like Buckroe Beach in Virginia.

It was a pretty impressive transition. That interviewing process was sometime between February and April, and we were in the States in April. I was, along with the other engineers. Some of the wives came down two or three weeks later. If you'd been just emigrating into the States in those days, there was the usual long waiting list [years] to get visas and all the other good stuff. We came in very quickly under that umbrella, which at that point shows you how desperate they were for personnel. We probably increased the population of the Space Task Group by a third at that time.

They were hiring as fast and as furious as they could, and it was mostly graduate people. But the whole idea, the whole concept of—I'm sure there are some people who understood the way the government worked and what an enormous opportunity it was at that time to have joined that organization and stayed with it for ten years, or whatever. The career opportunities were absolutely unbelievable. Why there weren't 10,000 people lined up to get hired into that job, I do not know. But we just fell into it.

And of all the people that came down from Canada [and stayed]…wound up with fairly impressive positions as the program matured and it developed down here and so forth. John [D.] Hodge was a division chief. I wound up being a branch head. Several of the guys wound up being division chiefs, as a matter of fact. Enviable, enviable, and it was [unclear] we all were there. It was a great happening.

BUTLER: How was the reception from the NASA people that were already there?

FIELDER: Well, I don't think we ever had time to find out. There was so much to be done and so few people to do it, that as soon as somebody said, "We need to do this and you've got to figure it out. Here's the pass," you really hadn't time to sit down and shoot the breeze about who you are, where do you come from, what do you do, and why do you do it. That slowly came by association.

They assigned us to people. I got assigned to—see, that's gone away from me [Howard Kyle]. It'll come. And I never saw him. He was always traveling. [Laughter]

Nobody ever sort of told you exactly what to do or why to do it. They were just empty jobs. Most of us, I believe, understood what the missing ingredients were, because it was the whole flight test game. There was a fairly well structured set of protocols. You had to have this, that, and the other to make the things work. And here we had a spacecraft with presumably a man in it, and it was to be instrumented, and it had to come down to the ground.

[In] the Arrow, going back to that little spot again, the CF-100 flight test program, all the instrumentation was on board the aircraft. All the recording was done on the aircraft. When the aircraft landed, you took off the data cassettes or the film cassettes or whatever it was that the data had been stored on, took it, and then processed it, laboriously, mostly manually. The Arrow was the first plane that I had worked on that had a telemetry system, real-time telemetry data, and a mission control set up for the flight tests of the airplanes, so you could watch the flight tests in real time and close-loop it with the pilots. They also flew a test engineer in some of those, close-loop to complete the loop on the test program, and it's all done with active telemetry.

Obviously that was what was going to have to happen with the manned spacecraft. It was all telemetry down at the ground, and you're going to have a bunch of guys to interpret all that stuff, since there weren't any computers [available] to do that, which always amazes me. There were no satellites and no computers back in those days. No desktops, because we used the mainframes, the big guys, IBM 360s, which I got introduced to at AVRO, by the way. AVRO was one of the first corporations to use the big mainframes in their design office, which is why they were able to develop the Arrow, I think, because of all the mathematics that were involved in the aerodynamic design of that big—so, anyway, the

Mercury Program was rooted in telemetry with which Langley was familiar, because they had done some of that same work. I'm sure that's why they picked some of us from AVRO, because we were working that kind of problem, too.

BUTLER: What was your first project when you came down there to work? Was it the telemetry and helping—

FIELDER: Can't remember. First project.

BUTLER: I think you were in the communication control techniques area.

FIELDER: Yes.

BUTLER: It all involved with setting up the network?

FIELDER: We were romancing about no satellites and no computers. So the only way to interpret the information that came down in real time was to have it displayed and present it to people who were able to then make decisions and loop back to the astronaut.

Of course, in those days we had a few doctors in the program, flight physicians. The general theory was, they had no idea how this guy [the astronaut] would react to weightlessness; [that he] would pass out and be useless the entire mission, so you couldn't depend on them to do anything, which was, of course, the opposite position that the actual astronauts took. But that dictated a lot of the control technology that went into the game, like the ground [system] was able to manage all the controllable elements in the spacecraft. The reentry profiles…reentry ignition, and all the other parameters, were all ground-controllable.

As the astronauts came aboard and got into their control mode, the design control mode, they reversed all that, but there were still the options from the ground. There again…you were in orbit, and you could only communicate when you were in ground contact. Anyone placed on the Earth can only see that spacecraft horizon to horizon, which is somewhere in the order of five to seven minutes at [orbital] altitude. So we were going to fly this guy for three orbits, as it turned out, the first time.

The name of the game was to put as much coverage around the Earth, around the world, as you could in units of seven minutes. More or less continuous across the U.S., because you could put [stations] anywhere you wanted. Once you got off the U.S. territory, you had to look at [locations] like Bermuda, the down-range [islands] down through Antigua, and off to Africa coming up from Madagascar, Indian Ocean, Australia, Hawaii, mid-Pacific, and back on to the West Coast. [Time was 10 minutes.] The max, horizon to horizon, and the actual signal you could receive, five to seven minutes, something like that.

So the name of the game was, you'd put people [flight controllers] at each of these seven-minute locations, who were able to put flight control correspondence into the picture with the astronaut, exercise any decision-making that might have to be made for whatever reason, and in the meantime, communicate back to the Mission Control Center, wherever that happened to be, Florida [at] the Cape or whatever.

The issue became one of what kind of equipment did you put at all these stations, what kind of telemetry. Some of them had radar stations for the tracking of the orbit. What did you do with that? How did you get the information back from there, and if you couldn't get it back from there, could you make a decision there based on whatever you can compute at [that] location?

I wound up, for some reason, getting involved in defining the requirements for all those communication activities, from a mission control viewpoint. Before we came on board in 1959, they'd already got…the spacecraft contractor.

BUTLER: McDonnell [Aircraft Corporation]?

FIELDER: McDonnell. They'd already got McDonnell and a bunch of other contractors on board to develop the spacecraft and the related launch vehicles, whatever. The network, as it was generally referred to, was a sort of poor cousin and not well understood. But they had, nonetheless, issued a contract, two contracts, to Westinghouse and Bendix [Corporation]—they may have been tied together—for developing what was to be "the network." That contract was awarded to Langley Research Center Instrumentation Support Division, ISD. I can remember that [G.] Barry Graves was the division chief, and his deputy at the time [Paul Vavra], who subsequently joined JSC [Johnson Space Center; Houston, Texas].

I wound up being the guy who would sit down and try to figure out what all these communications points should be. Goddard [Space Flight Center; Greenbelt, Maryland] was also involved, because the computer complex was going to be located at Goddard, and the so-called communication switching complex was to be located at Goddard, because Goddard, up until that time, had been that center, that type of center, for all the unmanned satellite programs, all the research satellite programs. The control centers were all at Goddard. [Each] scientist who controlled their projects all had control room at Goddard. They thought that surely the manned spaceflight program would be controlled from Goddard also, especially since the computer complex was at Goddard. You'll have to get out and look at all the politicians' analyses for what happened after that.

At that time, the network was switched through Goddard. Goddard was the sort of center point, distribution center point. Then circuits were brought down to Langley for connections into that system. Langley researched that. They got the contract to develop this network of stations all around the world through the Bendix contractor and the communications between them with the Western Electric [Company] contractor. Western Electric was the [systems engineering] arm of AT&T [American Telephone and Telegraph Company], which was then the Ma Bell system. It was a wonderful place to work with, AT&T, an enormously powerful operation. But Western Electric was the engineering arm of AT&T for international communications.

So I wound up…in the Space Task [Group], being the one guy who was trying to figure out how much bandwidth you had to have here, how much bandwidth you had to have [there], what was the protocol, how did you connect all the stuff together. One school said you joined them all together as a circle, and they all talk to each other, and then some came down from here. The other protocol said the control center was in the middle and there was a line to each one of these [stations], not between, and if one [station] wanted to talk to the other, it came down to here and then back out to there, like a wagon wheel, [that] was my concept. The wheel was the orbit, and the spokes were the paths of communicating and to the spacecraft. [The center was the control center and switching center.]

I had to convey that little jewel across [organizational] lines, to the Instrumentation Support Division people, who were the contract managers, and they, in turn, conveyed it over to Bendix, who were implementing this thing.

You've probably done all this archival research, but there was some wonderful correspondence that came out of the Bendix [and other] people who went around the world siting these locations for the network. They sent out a batch of people who were probably worldwide correspondents of some kind, who were going out to all these perspective sites, which somebody, probably at Headquarters and through the State Department, had come up with a list of perspective locations, which again had some kind of operational acceptance as well, to go through final selection.

They sent these guys out into the boondocks, into the depths of the oceans, looking at uninhabited islands in the Pacific. I can remember, but I don't have any of the actual correspondence memorized, but some of the memos that these guys sent back about how they got involved with manta rays and fishing boats with guys who couldn't speak English, exploring these uninhabited locations, and then the groups who went down into Mexico, and the groups that went into Africa and got involved in civil wars. There's some interesting stuff in those days, and I just passed that stuff by as incidental to the purpose, but if [I'd] really had [my] thoughts connected, [I'd] have stashed all that stuff in a box somewhere.

BUTLER: Maybe somebody's got them.

FIELDER: I'm sure it's archived somewhere. Maybe it's in Bendix's old archives. I don't know.

Anyway, we wound up with eighteen stations, three or four of which were ships, the only way to connect these things together, and we were going to use the star arrangement where all the parts, the circuits, came into Goddard, which was the sort of switching center. Each individual station went through the switching center, down to the control center, which was at the Cape to start with and then moved to Houston. So essentially everything was controlled from the Mission Control Center, but the actual physical switching at that time was done at Goddard, and it was physical. It was relays and mechanical things going "click, click, click, click." All of the circuits were either hard wire, cable, or radio frequency, HF radio.

If you're not familiar with HF radio, it's 3.1 to 31 megahertz, I believe, is the actual band. That's where all the ham radio work is done, and things like international time signals are in those signals somewhere. But they echo all the way around the world. The hams love it because they can talk to any country in the world. But it's very sensitive to the ionosphere, which is also very sensitive to being heated up by the sun, which changes the length of the path. Certain frequencies work better at certain path distances than others.

So one of the states of the art in HF radio is that you have one frequency that's working fine right now and you have three or four others that you're trying…at some level and they will come up as the others fade out. So to maintain an HF radio path with some reliability, you have to have several frequencies working, and you keep switching from one to the other as the ionosphere goes up or down. HF radio was the way that Europe spoke to the U.S., and it was all teletype and some telephone, mostly teletype.

Then coaxial cable was starting to come in, and there was a coax cable that had been laid from Europe to England to Land's End, and the cable disappeared off Land's End and [went across the Atlantic and] came up on Bermuda. The next loop was to go from Bermuda to New York and then hook into AT&T's network of hard-wired cable. But at that time, at the time of the space program, that Bermuda-to-New York cable was not in. So there [was] the HF radio.

I spent some time out in Bermuda monitoring the interconnections between the cables and the HF radio. …There was the station on Bermuda at the Air Force base there. So you've got to see that stuff to believe it. There were huge, monstrous antennas. But the HF radio was the only path from Bermuda to New York, and that carried the tracking signal information, too. So [the HF path] was quite an important parameter…

HF radio was also used from Madagascar to Spain, with all the idiosyncracies of that distance. There was no voice to Australia, as I recall, other than HF radio. For teletype purposes, there was AT&T, amongst all the other international carriers…looking around the world for old cables, old coax cables, that might serve [the] cause [and] reactivate them. One of the [old cables] they reactivated went from Hawaii to Australia, I believe. I'm not really sure about that, but it was something like that.

But teletype speeds, what was it? Thirty bauds, thirty bits a minute. It was keyed, hand-keyed stuff. Teletype keying speeds, one character per stroke, [seven bits per character]. [Laughter] Another story, right? I've told this to other people, too.

After we'd made the decision and everything was going to be teletype with voice over the top if we could get it, so all of the data that went from station to station, to the Cape, to the control center essentially was teletype. The information from the tracking stations from the radars was converted to teletype language, teletype pulses, and sent on a teletype system.

But part of the name of the game was that the guys who were sitting at the consoles would write down their little terse report on a piece of paper. One of the officers, one of the people at each site was a teletype operator. They would give this piece of paper to the teletype operator and he would teletype it, and that's how it got onto the network to go to Goddard.

The Goddard switching center was another world unto itself, because each one of these teletype terminals wound up in a big frame of equipment with relays banging away in the back. But the teletype operators could get backlogged, and especially if things got interesting, like, "The crewman said this," "The crewman said that."

So we wanted to know if the teletype operators, who were mostly military personnel whose life was dedicated to teletyping and they could do it in the dark, in their sleep, whether they would get distracted by getting involved in the mission activity itself, getting involved with the romance and all that good stuff. So we did some testing. We got a lot of teletype operators, and we drummed up a lot of standard text. Then we got an astronaut to sort of come into the environment and make his presence aware to these guys who were working away, as to whether these guys would be distracted. It was like a second nature to these guys to translate visual information to key strokes, and it was as if a separate part of their brain did that, because they could actually hold a correspondence, a voice correspondence, reading off this stuff, still going, and never make a mistake.

BUTLER: That's pretty good.

FIELDER: But that was because they had done it as a military career, and that's what their name tag was, teletype operator. Don't have any of those anymore. We had some in NASA who never graduated to NASA personnel, mostly girls who were secretaries who could teletype operate, but not with that kind of abandon on the system.

But that was all part of the game we played, the integrity of the network. One was getting this data into the network with the personal interface to the machinery. Open wire was the way most telephone and teletype circuits went when they were on the continent. So we got AT&T and the Western Electric people to walk the circuits. There was always the incident at the Cape where some tractor would dig up a cable at a critical moment. So as the missions became operable, they would shut down any operation they could conceive of that might present a hazard to the circuitry, anywhere in the world. They would padlock all the frame rooms and not let anybody, nobody working on either the cables or the frame rooms. Walked the circuits all over the country from one end to the other, just to make sure there was nothing going on that would jeopardize the communications.

It was like that for maybe the first half a dozen Mercury missions. After a while, it sort of got relaxed a little, but to my knowledge, there was never really an incident. I think as a result of that, the integrity was sort of pushed into the program. It was all electromechanical technology. I don't think there was a solid-state device in there, maybe a rectifier or two.

So I wound up working in that environment for a long time. One of the first things I did was learn the code, learn the teletype codes and a few other codes, to understand what the engineering technology was, very simple stuff.

Working with Barry Graves' division was not always easy, because their background was telemetry and instrumentation. They worked quite a lot with the Marshall Spaceflight Center, which was in the unmanned satellite business quite a lot before they became involved in the manned space program. So they had all worked together on satellite communications and transmitting telemetry data, whatever, whatever.

That one got by me, too.

BUTLER: Talking about working with the division and Barry Graves.

FIELDER: Yes.

BUTLER: Maybe it'll come back.

Obviously a manned space program hadn't been active before, and here you've been talking about setting up the network.

FIELDER: Oh, I just remembered.

BUTLER: Go ahead.

FIELDER: It all revolved the business of the crew, the astronaut, who in the original concepts, before there were any astronauts, before the original seven showed up, Marshall was dominantly involved in defining the spacecraft configuration, which McDonnell was developing. They regarded the crew as just another piece of instrumentation. There wasn't even a window in this spacecraft. I'm sure you've got all the background records on that.

But because of that general attitude, when the Instrumentation Support Division, along with Bendix, were getting involved in designing the general character of this thing, it was all based on the fact that there was no control characteristics on the spacecraft. Therefore I'm going over there now, armed with this requirement for the crew to talk to the ground, for the ground to talk to the crew, for the crew to be the dominant control element, and therefore we'd have to supply all the—and they always kept saying, "No, that's not the way it is. It's going to be this way." [Laughter] So it was not difficult, but just a bit stressful every now and again.

Barry Graves eventually, I believe he left NASA for a while. Certainly he left Langley. But he wound up back in the Johnson Spacecraft Center in the Engineering Directorate, responsible for Mission Control Center design and development here in Houston. We went through a whole other set of contradictory approaches to things, from a requirements viewpoint and from an implementation viewpoint, which is another whole world, because by that time the world of electronics had advanced enough for information management to be a generic term by then.

But that's where I came from, was pushing the communication system around the world, and I got to go to some of sites, more for just understanding what the systems were. Bermuda had a nice PS-16 radar added. I spent some time there trying to understand how that worked and what its data outputs were. It also had this Mission Control Center there for backup to the one at the Cape and at Houston. So there was a mission control environment there. So I spent most of my time either at Bermuda or at the Cape, and I had a bunch of guys who went out to the rest of the world.

BUTLER: What did you do during the missions themselves? Were you in the control room helping monitor some of this?

FIELDER: Early, when we were first firing this thing up and operating it and they were doing initial simulations, I would station myself somewhere where I could monitor it all, either at Goddard or at Bermuda, and just keep records and notes. Sometimes I jumped in and did some suggesting. But once the flight controllers got in there, they became very intolerant of a non-flight controller. And I was not a flight controller. [Laughter] Getting in there and telling them what to do and how to do it. They were receptive between missions or after the mission pressure, but while they were all under the mission director's jurisdiction, they weren't about to tolerate some systems engineer coming them and telling them which way was up. I understand that.

BUTLER: Were there any major challenges or events that occurred perhaps during a mission or during training that required your input that you can think of in particular?

FIELDER: A little incident does come up. After I sort of got out of that business, I went into the advanced missions business, so I was doing the AAP [Apollo Applications Program] program before it flew and so many others. I wound up on the staff of the Flight Control Division. By that time they'd built the Mission Control Center in Houston, and they were doing simulations on the system to shake it down. Who was the guy? Howard—can't remember his name now.

BUTLER: [Howard W.] Tindall [Jr.]?

FIELDER: No. Now, there's a guy, Howard Tindall. Yes, Howard Tindall is an interesting character. He's died, has he not?

BUTLER: Yes.

FIELDER: That's a shame.

The guy who was the master simulation manager for the Johnson Space Center setup designed all the test simulations and all the flight controls that were on board, and they'd run all the mission simulations, but there was also a lot of equipment [failure] simulations. You could drop [out] pieces of equipment here and…there.

There was a fairly romantic system for backup…electrical supply power, [using] diesel-driven generators. There were three or four of them. They're still there. I don't know if they still run, the diesels. But the name of the game was that if you lost power from HLP [Houston Light and Power], you would never notice it in the Mission Control Center. There would not even be a flicker, not even a half cycle or whatever. And the name of the game was there was an electric motor driving a generator with a diesel engine sitting on the end, still, but with a big clutch in between the two and a big fly wheel. The electric motor was driven off Entex [Entex acquired HLP], what is now Entex. The generator provided the power to run the Mission Control Center, the critical parts of it, and the fly wheel sat on the end of that motor/generator combination just to provide momentum.

If the power failed to the [electric] motor, the clutch closed on the diesel engine and the diesel engine was brought up to speed immediately without loss of a half cycle. Then the diesel engine would be driving the generator. No loss. Now, they've never tried that. [Laughter] Never tried a major power failure. And I kept that in the back of my mind every time they did a sim, "They've never done this."

Harold [G.] Miller, I think that's his name. I was up in the staff office one day, and they were doing the simulation, and I kept telling them, "You ought to do one of these things. Try it out."

One day he came by and said, "We're going to try that." [Laughter] He came back later that morning with a face as black as the ace of spades. They apparently had done it, but something had dropped out and they lost an entire simulation for some period of time. I still, to this day, do not know the details on that, but it just intrigued me that sometimes you wait till the last moment to try them the most fundamental things. There's a flaw in it somewhere.

That was an interesting backup system. I don't know what their philosophy is now. They've changed it several times. When they designed this design, before they actually broke ground, we were designing the communications paths from Houston into the Clear Lake area, because there weren't any. There were no—what do they call them—super group cables coming south. Highway 45 [Interstate 45] had just been more or less started. There were sections of it in place. The Gulfgate shopping center was the first shopping center in the world, I believe. [Laughter] Certainly in Houston.

So we started working with Western Electric, AT&T. Of course, AT&T was not the only carrier, communications carrier in the world. Western Union, ITT [International Telephone and Telegraph], lots of them, can't remember all the initials. On a national and worldwide basis, if you wanted to connect the world together, you had to get all these different communications carrier industries to talk to each other, interconnect each other.

We used Southwestern Bell downtown as a sort of focal point for all the meetings that involved all these folks. Of course, AT&T was very happy with that, since they were the overseer of the Bells, but other companies, like Western Union, weren't at all friendly, although they had some circuits that had to be brought into the game. So that, in part, was part of the world we lived in, that was required to come into being with all these carriers interconnected.

I can remember sitting around the meeting. AT&T, the guy would stand up and say, "We will not knowingly interconnect our cables with Western Union." Then ITT would get up, too, "We will not knowingly interconnect our cables with—" The name of the game was, that they were talking about they would bring their cables through the wall of a frame room, and this [other] outfit would bring their wires through the walls of a frame room, and then some third party, like NASA, would interconnect all this. [Laughter] The government, NASA's affiliation with the FCC [Federal Communications Commission], got some of that straightened out. Eventually they had to use frame rooms to interconnect, but the carriers interconnected and they did the testing carrier to carrier.

At that time we were still designing what circuits should be from here to Houston, because all the circuits from here were going to Houston to the frame rooms in that big Southwestern Bell Building, and from there they'd go all over the place to. You never know where you're going on a piece of wire when you go from A to B. So we wanted two circuits, two paths from Houston to Clear Lake, one that came in the front entrance somewhere, one came in the back, and they all showed up at Mission Control Center in two separate arrays. So if somebody plowed up that cable, the one coming this way, maybe this one would still be there.

The same thing was supposed to be true for the electrical supply. There was supposed to be utilities, I think from the Webster [Texas] power station, was one of them. But there was another source elsewhere, and they both came in opposite sides of the property. That was a principle generally held for most of the installations around the world wherever they could. Most of them had their own generating plants, which would be a backup or propped onto the prime to the local industry supplies. Of course, HLP would sit there and say, "Well, we don't have any outages of any significance." Yet when you start keeping records, they have a lot. They have a lot of them, although they come back themselves up, to some extent. That was a game I got involved in a lot, was that kind of integrity to the system.

BUTLER: A lot of this was when you were working in the operational facilities area?

FIELDER: Yes. John Hodge was the division chief. Most of the flight control system, it's gone through a couple of major revolutions since then. But mostly the flight control system protocols and technology was in that regime when Chris Kraft was the flight control director, Flight Control Directorate—Flight Operations Directorate, that would be. Hodge was the Flight Control Division. Was that so? Flight Control Division. Yes.

[Eugene F.] Gene Kranz was one of his branch heads at that time. Hodge was another one. Gene Kranz was designing all the flight control protocols, and we were essentially running along behind and ensuring all the system protocols, although we were not the prime managers of the contractors. It was still a Barry Graves kind of interface, or a Langley Research Center, or a Goddard Research Center.

Spent lots of time at Goddard because of their switching systems up there, which were finally transferred down here. Goddard essentially lost all of that. They'd lost the computer complex and they lost the switching complex. It was like a mammoth hall with racks of equipment down both sides as far as the eye could see…. These racks were the terminal receiving equipment from each station. Theoretically if they worked properly…the teletype signal would come in with an address on the front end of the signal, a coded address. It would be read by the receiving device and routed automatically by a mechanical switch to the outgoing transmitter, a teletype device, to that intended terminal source, that intended station.

Most of the time it worked, but it was all paper-punch interfacing. To provide a—what would we call it—a safety loop, the signal would come in [and] punch tape. It was either five- or seven-dot wide tape punch, paper tape punch. There would be a loop. Then it would go into a reader, and that reader would read the tape for its signal and then do the necessary instructing. This is a very noisy operation, and every line that came in had a paper tape loop in it as a backup. The name of the game being if for some reason the equipment, switching equipment failed, you could go tear off the tape loop, wait for the signal, the end of the signal to come, because the guys could read these tapes as if they were alphabetical characters.

If for some reason a loop is not reswitching or had gone down, they would go watch this loop coming out of this machine until the end of the signal, end of the message, came. They'd tear that tape off, and they'd run to the [designated] transmitter frame, terminal frame, shove it in the slot, and it would then automatically go okay. And that was the backup…this mechanical method of tearing off tape loops and [read]ing them and finding out whatever address letter box you were supposed to stuff this thing in.

When they originally designed the thing, the Goddard engineers said it would never work, that we would spend all their time running up and down the corridor in this hallway with loops of tape, putting them in slots. Indeed, there were occasions when there was a fair traffic and pedestrian running, but most of the time the system worked, but it was enormously noisy, all these paper tape punches clacking away.

Of course, in the next three or four years, the world of solid-state switching came into being, which rendered all of that equipment null and void. I don't know if you remember—I only saw it in movies—whenever somebody dialed a telephone number, it would somehow romantically go through the wire and you'd come to these switching things which were big mechanical devices which went up, down, and switched, selected things as it went through, the number. Well, the teletype switching equipment was just as crude as that. It was huge mechanical relays that would clack for the number of times that the code said, one to ten. Fascinating. Western [Electric] designed that, and it was probably the last major mechanical switching system they ever put in, and it was put in at Goddard.

The voice network, which was an overlay over the data network, was also switched by an operator, an individual who manned a telephone operator's station with eighteen stations on it. He would plug them in and he would monitor, and if there was anything went wrong, he would try and fix it.

Teletype operators had a strong union, or maybe it wasn't the teletype operators, but the civil service grade that operated at that level in that equipment environment had a strong union, so you had to have these particular guys. Gee, I can't remember their names, but the one guy who was eligible, from a union viewpoint, to operate that terminal as the major operator eventually kind of had a—not a stroke. What would you call it? It got too much for him.

BUTLER: Like a nervous breakdown?

FIELDER: Yes. He really was unable to operate in the end. He did that for maybe a year, a year and a half. Most people would say it was, gee, a whiz of a job to be talking to all these people around the world, but—

BUTLER: Sounds like a lot of pressure to make sure that it all went right.

FIELDER: Some people just thrive under those environments, and some don't.

So where have we gone?

BUTLER: Actually, we're at a good point right here. If we could pause for a minute and change out our tape.

You were just talking about some of the differences between Goddard and the computer complex up there and the mechanical switching. You talked a little bit about coming down to Houston and setting up the communications there. What were some of the other differences between the Cape control center and the Houston control center besides the communications and the changing technology?

FIELDER: Goddard was the switching center and the communication center and the computing center for the Cape control center. So there was a strong operational connection to the Goddard system. You might even say that they were the network managers, in a technical and operable sense. The mainframe computers were at Goddard. All the orbital predictions were done at Goddard, and all the solutions were fed down to the flight dynamics officer and the other flight controllers at the Cape. The interminable switching was at Goddard, with all the tape relays and so forth. And the voice switching was at Goddard. So there was a sort of interface between the Cape operations that was of a technical nature, sort of network managing focus of the control center, which dealt with the interfaces at a technical level with Goddard.

So, I guess, in a sense, there wasn't a lot of communications management system at the Cape. That's understating it, because obviously there were connections, with the launch control center at the Cape, with the tracking facilities at the Cape, and all the down-range stuff, all the down-range tracking and acquisition. But most of that went up to Goddard, got turned around and shipped back again.

When we moved to Houston, or when the Houston system design was nurtured, all of that went to Houston, and not without some major debates by the Goddards and the

Langleys, because they had a fairly hefty investment, not only hardware-wise, but personnel-wise and prestige-wise in that role that they played in that program. But the decision, nonetheless, was to locate the computer complex in Houston. I think they were 460s, IBM 460s, what they installed. The communication switching was relocated to Houston, with some concerns at the time, I believe, but they did resolve the issues. All the voice switching was brought to Houston.

So essentially the circuits still went through Goddard, because Goddard was the way station to get to many of these locations. If there was any switching, it was simply to connect them to Houston, and that maybe when Houston wasn't running a mission, they were connected elsewhere to run other missions, like the unmanned missions at Goddard. But when they were running manned missions, the circuits were all locked together through to Houston, and Houston essentially was the technological center, system center for the network.

That was a fundamental transition between one and the other. Now, there were dozens of other transitions. There were two Mission Control Centers and double everything so you could, in theory, run two at a time, or switch from one to the other without any major trauma.

There was a large VIP capability at the Houston one, compared with a very small capability—in fact, it was so small, it was almost not there. DOD [Department of Defense], the military support at the Cape was very much involved [in the design] of the mission control centers down there. They had their own for all the missile work that was being developed, and the public [access] was just not an item on their agenda. When we said that we would have a VIP viewing area, it was not well received. Several attempts were made to sort of move them so far away that it really wasn't there.

Of course, in Houston it's an intimate part of the game. In fact, it was—I don't know if it is anymore—the new viewing setup on the new control centers is nowhere as intimate, for my money, as the old system used to be. Thereon, maybe it's not that popular anymore. It used to be a popular place to be when there was a mission, in the VIP viewing area.

The display system went through some major, major upgrades in the transition from the Cape to Houston. If you can find anybody who used to work for Barry Graves back in those days and get them to tell you all the technological tales of woe that they went through—well, they're not all tales of woe, but it was a lot of transient technology. Some of it was coming up, but wasn't really quite there to be reliable, and others were just going over the horizon as antique, but it was the only way around at this moment. So we had to join some of these old systems to the new systems to get through the interim, so to speak.

There were some really interesting transitions in display technology. There was nothing like today's computer monitors, nothing like character generation as we do it with these. Character generation in some of those old systems, there was a screen inside the television tube with the characters cut out as stencils. The electron beam was pointed at a—and this was an array of characters, all the alphabet, all the numbers, and all the other characters that are involved in a display generation—and the electron beam was first pointed at a character by a set of magnetic coils. After it had gone through [and became] the character, it went through another set of coils which positioned it on the screen [at] some [location].

The image was persistent and stayed on the screen long enough for it to write the entire screen by switching different characters, each character then being put in a different place on the screen, probably in a line-by-line continuum. The persistence of the screen was enough to keep the first one there until you wrote the last one, and it would go back and refresh the first one again. I can't remember the name of that particular technology… It was fairly expensive and slow, amongst other things. Yet we in the Mission Control Center had got this demand for everybody to have one of these displays, and they could switch to different display sources for different technical applications.

The technical guys, Barry Graves' division when he was here in the center, had the responsibility to come up with this display system. So we had television cameras, television screens, with fairly good resolution. You could actually take a television camera and monitor one of these alphabetically written screens and transmit it to terminals, which were just standard television terminals.

So the name of the game was, rather than trying to put these character generator systems in each terminal, flight control position, you would put a more standard video display, and you would have all these character generators, each of them having a different set of information on them would be in front of a television camera. Then with the television camera you could mix the signals, you can switch the signals, people can select from different channels to make up whatever displays they want, [something] you couldn't do with the—I think they were called—charactrons, something like that.

So the solution that they came up with was a rack of equipment. Each rack, each stand had a charactron in it with a camera and a local display generator, and they would convert the charactron to a distributable television signal. That was the two ends of the state of the art. The charactron was a well developed, well exercised—it was extensively used in the military for information presentation, but it was obviously kind of a complicated gadget to run. The video displays, this was all analog television back in those days, was a sort of upcoming, switching setup for what was then standard television signals. It was all well before the typical digitally-driven computer monitor.

That was a big issue, and it took about, I don't know, I'd say a year, but I know we went to several industrial presentations of different display technologies of getting from the data to the display. Some people were charactron-oriented. Some people had other different approaches to generating characters. Barry Graves' crew did all the decision-making that came up with this system. Now, I believe it was only recently that they tossed that system out. Should have been archived forever. At least one of the racks would have been archived to show how the evolution took place in the technology.

There were things like that going on all the time. The voice setups for the—each console had its own array of channels that the guys could pick up on. Some of the consoles were coupled together because they were part of a unit that would communicate with each other on a medical problem or a flight dynamics problem or a whatever. So they had their own loops that were set up. And you just didn't sort of punch into loop nine, so everybody wanted nine. They were all hard-wired, and they were hard-wired in the frame room, where guys laboriously connected wires together to loop up these push button whatevers. Today it's all done by magic, with chips. In fact, I think they got rid of the frame room ages ago. So that was a transition that the world went through.

While I was still—where was I? Got it hanging up on the wall. [August 1964]. Would that be one of the first satellites?

BUTLER: One of the—

FIELDER: Can't even remember the name of the satellite now. Isn't that terrible? It was a communication satellite, a military communication satellite.

BUTLER: That's before the TDRS [Tracking Data Relay Satellite system], right?

FIELDER: Oh, yes. This was COMSTAR or something like that. I was out at Hughes Aircraft [in California], working on some project. The military had just launched a communication satellite. It was COMSTAR or TELSTAR or one of those stars. Whatever the reason we were there, there were several different NASA units and a couple of other agencies. They dragged us off to this dish in a mobile truck and proceeded to show us how you could communicate back and forth to this satellite. It still was in the days where there was this two-second delay. Is it two seconds? No, it's not that long, is it? It's a fifth of a second to a satellite, I think. But it's very aggravating, because if you got a feedback system in there, you got your echo coming right behind you all the time. And it was before they had all the clever techniques for eliminating that.

So I called Sig [Sigurd A.] Sjoberg, because they could let you dial telephones over this system, back here in Houston, introduced him to the fact that we were amongst the first people to communicate by satellite. I have a plaque up on my wall that says that.

BUTLER: That's pretty interesting.

FIELDER: I think it was in [August 1964]. I'm really not that sure about the dates, but it just tells you that nearly all of the first three sets of programs, through Apollo, AAP, Soyuz, Apollo-Soyuz Test Program, were all done without any satellite service. It was all done with ground communications, ground-based communication services. And now you can use your cellular phone to call around the world. Just amazing. Just amazing.

We started TDRS shortly after the Mission Control Center had been located here at Houston. I was no longer really involved in any of that stuff. I was now in the "advanced" world, which was AAP, Skylab, Space Shuttle, Moon landings, Mars landings, weird stuff, and a satellite that would support our programs. There were satellites now up that supported military communications, and I'm not even sure that we didn't have some commercial satellites up there by that time.

I got involved in writing one of the early specs for what became TDRS, Tracking Data Relay Satellite system, and wasn't very popular because the focus for communications management was in Headquarters. They were taking the prerogative for whatever satellite development was on the horizon for NASA. But any NASA institution, any person in NASA could write a proposal for an advanced program, and if you put it in the right channels, it had to be responded to. I think it was a mechanism by which any good idea would at least [get] a look at, and no bad idea went unnoticed. There was an opportunity to draw from everything. It was an unsolicited proposal mechanism, and it still exists, I believe, in NASA. Anybody can—it's advisable to use your management chain as part of the mechanism, but theoretically anybody can write a proposition and just launch it into the system, and it has to be recognized and responded to, one way or the other.

We launched this proposal for TDRS or some such—I don't know [if] it was TDRS or TDRSS back in those days—but we launched the proposal from [the] Johnson Space Center to Headquarters for a satellite system that would serve the Apollo Program. We wrote very fundamental specs for what the bandwidth ought to be, what the groupings ought to be, what the performance should be.

I think it sort of came in the middle of work that had already been going on at Headquarters, not necessarily known to us, about developing such a system. And since we were obviously outsiders, it took a while to get them to respond to us as having any intelligence on that subject. But we did stay in harness, and because of that initial proposition and getting a connection to the management office at Headquarters, I know we had a "TDRS office" here at Johnson Space Center after I retired for some time. Whether we still have one now, I don't know, because the thing has gone pseudo-commercial now.

But at that time it was a set of satellites dedicated to NASA's services. It would have made a world of difference to the way the network worked back in Apollo. Of course, once Apollo was out of orbit, once it was on its way to the Moon, the timing was entirely different. You could use just three or four stations, stay clocked in for—line of sight, [that] was the best part of eight hours for any one station. So you only needed three stations to keep yourself hooked into a lunar activity. So that was usually somewhere on the West Coast, Ames Research Center and their array of antennas, somewhere in Australia, wherever they had antenna built, and somewhere in Spain or Madagascar, as I vaguely recall. They were roughly 120 degrees apart Earth-wise. So as the Earth rotated, you could switch from one to the other and stay hooked into the spacecraft as it was on its outgoing leg, and similarly on its return leg.

The Apollo era was replete with these communications blackouts, as the spacecraft went around the back side of the Moon. So we then worked on a lunar communication satellite system, an advanced planning concept that said you never had to be out of contact with the spacecraft, because you could put a satellite essentially around the Moon, rotating about the Moon, which would always provide you a path from a space station or a spacecraft that was behind the Moon from us, that could see a satellite and the satellite could see the Earth. So you'd always retain that.

Well, the Apollo Program demised before that really became an obvious advantage, but it had some interesting technological facets to it. We got involved in all these things like lagrange points, which is where the gravitational fields [sum to zero] at different locations. There's one between here and the Moon, there's one on the far side of the Moon, there are two on either side, halfway between. The lagrange point at the far side of the moon became a target for a satellite that could then be used to relay back and forth. So it had some interesting facets such as that. I don't think, to this day, there is a plan afoot to put a communication satellite around the Moon. But it would be a relatively simple to do in today's technological world. Maybe they ought to have done that for the Mars missions. So that was one of the facets.

The use of the Saturn V, Saturn IV-B upper-stage, as a space lab, we got involved in all those designs, and that was a very strong proponent of the Marshall Spaceflight Center. So Marshall had the kind of lead for that program for a long time in its design and development phases.

So we wound up working with the Marshall types, which is where I first met Wernher von Braun and all his merry men. That's an impressive group to get involved in, those guys.

The thing that impressed me probably most of all, although I didn't realize it at the time, is that I was just a junior guy in the world at that time. I think I was a junior guy. I'd got a lot of experience, but he was sitting up there with big guns, when you got Wernher von Braun and Gilruth and a few other guys sitting around the table hemming and hawing on things. When von Braun brought all of his lieutenants into the meeting, you could fill an auditorium with his technological team.

We were up there essentially—in some case we were criticizing the design of having to assemble that thing in orbit, which was on the original designs, flush out an S-IVB, and refurbish it. I remember giving pitches up there, and they would sit and listen, and they would question you, and they would never criticize you. They would never make you feel stupid. Not that I thought that we did anything stupid there, but they may have after we'd left. [Laughter] They [revised] their opinions. But they were very polite and very attentive. Von Braun was always on top of everything. Nothing got by him, in that environment, anyway.

The Shuttle was a very early concept, because what we had done during the early Apollo era, once the Apollos were up there flying, it was just routine stuff. In its earliest phases, it was planned to go on forever. There was Apollo 24 and 25 and 26. So we were wrestling with that kind of program outlook. What should follow lunar landings? Well, something in lunar orbit. What should be a precursor to that? Well, something in Earth orbit. We wrestled with an Earth-orbiting thing, space station, if you want to call it that, as an element of an….extensive, extended lunar program.

If you ever want to go down to the Moon, you wrestle with the energy management to get stuff into Earth orbit, stuff into lunar orbit, and out of lunar orbit down to the Moon. You

[wind] up wrestling with the fact you really needed some kind of warehouse in Earth orbit to store all this stuff, then get the launch vehicle fueled in Earth orbit, then transport it to the next step, which is lunar orbit, and then get it down from there. So there was this relay of fuels, hardware, vehicle parts, and whatever. Lots of plans.

There was quite a large community involved in that level of planning, and it was freelance. There wasn't any national commitment to a lunar program beyond Apollo, but there was a sort of general commitment to look into the future. It became a kind of romantic world where the Ames [Research Center; Mountain View, California] research scientists were dominant in that planning environment because they were all kind of teed off at Apollo, because science and Apollo didn't really come along until around Apollo, maybe, 14 or 15. It was present, but it was a back seat to the fundamental mission. So when you went into the future, the scientists dominated the design approach, the mission specification approach. So most of the design environment was at places like Ames and some of the other more research-oriented centers.

So I wound up at those more often than not bringing simple engineering to the table, not always well accepted, because they always liked to do way-out stuff. One of the guys who was a curator of what was the lunar research center, before they got rid of it, just down here at Clear Lake?

BUTLER: LPI, Lunar Planetary Institute?

FIELDER: Right. One of the guys who was a curator of that was very dominant in the advanced planning for lunar missions. I don't think "curator" is the right word. He ran that institute there for a couple of years, and was in and out of this university-oriented, science-oriented planning environment. But the Shuttle became an element of that kind of planning at one point in time. Something reusable.

The expense of just throwing stuff away all the time was becoming prohibitive, and there was a lot to see if you can reuse stuff, recycle stuff, make it more useful, use it as part of something else. So lots of space stations were conceptually designed with spent stages, or things that looked like spent stages. Then there was the sort of get stuff up there which is primarily energy fuel, move the fuel around somehow. Then solar arrays, solar energy became another part of the game.

At some point in time, there was another program going on in NASA that was through the Department of Energy, which was an energy efficiency management thing, because if NASA was all wrapped around the axle on solar array, solar energy conversion, solar arrays on all their satellites, etc., etc., then surely they could help solve some of the terrestrial energy management problems. There was a whole program that was done under the Engineering Directorate back in those days through the Department of Energy, that looked at solar energy and solar management as a part of that.

Part of the stuff that the advanced guys were [planning] was putting these big mirrors up there [in space] which would collect solar energy and either convert them at that point to RF [Radio Frequency] energy and beam that down, nobody like that very much because it fried everything that was in the target area, or beaming down the solar energy or converted solar energy, and then they got down to stuff doing it on the ground. None of that matured, although there were some interesting concepts.

One of the ones I like the best was converting solar energy on the ground into some storable energy. They do it in a couple of European countries up in either Norway or Sweden. They convert solar energy during the day to run pumps to pump water from a lower level up to a dam high in the mountains. Then at night they run the water back down through generators to provide energy during the day, sometimes during the day, but [usually]during the nights, peak overloads, that kind of stuff. And it just keeps recycling. During the day the solar energy pumps water back up, the water runs down through generators during the day. So I'm saying, well, that's great. And here we have all this solar energy down in Texas.

So we worked with Rice University on this for a little while. Big bunch of mirrors, not solar conversion like from solar to electric, but from solar to thermal, that generates steam to run turbines. What you have is this huge concrete circle out in the Gulf that goes all the way down to bedrock or whatever is down there. Before you get off the edge of the shelf, you're in twenty-fathom water, I believe, something like that. It goes a long way before it drops off twenty fathoms, so 120 feet. Is that right? So we were wrestling with the design of a cofferdam, that's really what it is, a complete circle. You pump water out of it during the day, let the water run back in during the night, generators, holes in the walls, so to speak.

There were two concepts. One was a big circle. Another was two concentric circles. So you pumped from the inside one to the outside one. It turned out to have better energy management. You can generate enormous quantities of energy this way. What you do is you run it off into the [electrical power bus], just [connect the output to]…barges with electrical towers on them, just run hydroelectric power back to the grid system offshore. I still think it's got conceptual promise, especially since it doesn't cost anything once you get this thing working, rather than depreciation of all the equipment. It still has merit. There was a preliminary study done at Rice. There's even some models in the Space Museum set up down there. But that was some of the advanced kind of world.

The Shuttle became a very elemental part of that [Earth orbit, translunar, lunar orbit, lunar landing outlook]. There was a single-stage Shuttle, a two-stage Shuttle, a single-stage to orbit Shuttle. All the whiz words that you hear now has been part of the stuff that they're working on in much more detail than we did, were part of the energy management schemes that we were using for some of these advanced program concepts. And they were always big programs, big in the sense that they had all sorts of elements in them. There was an Earth-orbiting community of satellite stations. There was a lunar-orbiting community of stations. There was a lunar base system of communities, here and there and on the far side. All of this was dynamically ticking away.

It also became the energy management system that you started from for the Mars missions, because you could assemble all this stuff in Earth orbit in a fairly leisurely environment, but a well-controlled environment. The Shuttle became an elemental part of that. It turned out that if you could get something back and forth that had the fundamental commonality of the cargo bay, then all the elements in this system were cargo-bay-sized, or could be assembled from cargo-bay-sized elements.

I've got some of the old pictures of some of the old Space Station concepts, and they're all tubes connected together, and they're all tubes that fit inside the Shuttle cargo bay. So the Shuttle became an element of these very extensive advanced programs.

So when it came [President Richard M.] Nixon's turn to pick his piece of the program, the only common denominator that was around, for my money, at that point and time was the Space Shuttle. So there had been several looks at how you would come up with this Space Shuttle element, single-stage, double-stage, two-stage to orbit, then whether the engines were on board or in the boosters or wherever. So eventually the only element that was being wrestled with is the next [start] in NASA's advanced programs, was something called a Shuttle.

I don't really argue that it was a spinoff of all these advanced programs, but a lot of the background to it was available from those programs. See, you can develop pretty quick arguments for how big should it be, where should the engines be, is two stages better than one stage, etc., etc. When I say two-stage Shuttle, the first stage returned as well as the second stage, came back and landed. Huge thing. Now they have the recoverable boosters, which is some kind of economic, but still a rather laborious procedure.

So the Shuttle became the focus of the next major new stop. Apollo was on its last go-around. There was the inventory of hardware left over from Apollo, launch vehicles and spacecraft, which served in the cause of AAP and the Apollo-Soyuz Program, which just about depleted anything that was usable at that point, but that was going to take another few years. So in the meantime, what was going to follow all that?

The manned spaceflight focus was the Shuttle, or something called the Shuttle. So we got involved in the front-line work on that. It was essentially conceptual configuration arguments, and it was mostly math modeling. As the Apollo engineering was waning and the other programs that related to it were being dissolved, the work force in the engineering departments started to look for something to get their hands on, some major, major project. All the contractors, all the North American-Rockwells, or whoever they were in those days, and the Boeings, or whatever, were all looking for something major to get involved in, because that's where their livelihood was.

FIELDER: The concept of a shuttle started to have all those properties. It had boosters. It had flight stages. It had all sorts of stuff that involved all the major contractors and all the resources of the agency, and it made some sense in advanced missions and efficiency. So we did a lot of the lead work on that. I say "we," the people already involved in advanced programs, which involved all of the agencies.

One of the things that all this communication [led to was that I] went to every field installation that NASA had, on the American continent, anyway. I got to know a lot of the people in all those other agencies, and that served [in the] cause for the [future] programs, the flight programs, but then when you get into the advanced business, it served that cause, too. So I think probably I was one of the few people that had that much background in the agency as well as the field installation itself, [the] Johnson Space Center. That served a very good cause.

In fact, it really turned out, in many cases it was only guys [who worked] in the advanced programs who got to go to all the other centers and sit in all these weird meetings with all these strange people with these ideas about what future programs should consist of and what they should not consist of and so forth. So you got identified in that context, and it was a different world in those places.

The Space Shuttle had a pretty broad baseline to it, and we were able to contribute that dimension to it as it evolved toward design specification. Once it got there, it then became the domain of the aircraft, major aerospace industry designs and it was being made into hardware.

The issues were always, well, how many of these [advanced] things ought we to have [in the Shuttle design]? For my money, the Space Shuttle has always been one of the elements of this huge advanced program that goes back to the Moon and to Mars in a manned-oriented sense, big major space industry thing. [In practice] it has never actually progressed [towards future programs], but it could have done, and it could still to this day.

The so-called International Space Station. I got involved in whatever the first space—Space Station Alpha, was that what it was called? The one that was done out of Reston, Virginia. The first International Space Station.

BUTLER: Freedom?

FIELDER: Yes. I think it was [President Ronald] Reagan's Space Station. I still think it was a good Space Station. It may have had a little poor, not…poor, but overkill management. Even now I can sit back and see those meetings, the Monday morning meetings, which were every morning, where everybody and his brother who had anything to do with space station evolution was in these meetings, guys talking about international aspects of it, national aspects, design concepts, problems, successes, whatever, contractor relationships—all came up in this same—everybody knew what was going on. At least I thought they did.

It did not present an efficient program. In fact, it was probably the opposite of that, where you would have culled down the management till there was only one guy running the show. You would have culled down all of the staff so that there was the bare minimums to get you to communicate with the people who really did the stuff, which were the contractors. It was entirely the opposite, which is a good, for my money, the way planning gets done.

You throw everybody in the ring and say, "What are all your problems?" [Laughter] And then you wrestle with what should be solved. You don't have to solve all the problems, but it's nice to know what they all are, so you can sidestep some and solve others. That was the environment then. I still can't remember the guy's name who was the program manager of that.

A lot of the people in that planning environment were ex-Apollo people, and they brought Apollo conceptual design to that meeting. Apollo was nurtured during the—getting the man [returned] safely was one of the dominant criteria. [That] you did it was critical. How much it cost was not that important. So Apollo was a fairly expensive program, as was Gemini and Mercury, relatively. But Apollo was an expensive program, because the crew's safety was the paramount thing on the front line. Most of the guys who transferred to the Space Station Program took that philosophy with them. It's a very expensive design philosophy, and I'm not too sure whether it's the best design approach in the world, but you do get to see all the issues.

I don't think anybody was actually spending money on hardware on the Space Station at Reston; they were spending money on mockups. They were spending money on designs for space stations, which is people, which is expensive. But when you get to the hardware, you lay off all that contractor support. So anyway, the Apollo philosophy was rooted in the original Space Station Freedom, which ran into political problems. It was when [Daniel S.] Goldin first came into the arena as the NASA Administrator.

Shortly after that, what was I doing? I was doing something that was Space Station-related. I was looking into the Russian Space Station Program. That's right. I got that as a contract through another NASA Headquarters group, back through TADCORPS through

[Manfred H.] Dutch von Ehrenfried, and I was just researching the Russian space program, when nobody knew anything about it, as a support element to the Space Station Program. That continued up until the time they terminated the Reston capability, which was rather severe. It was almost like an Arrow cancellation. Everybody was fired. Then they started up whatever the next space station was called and the transition to the Space Station Project Office here.

I remember going through the hallowed halls of this Russian experience behind me, not Russian experience, but knowledge, because there really was a Russian interplay into the Space Station Freedom. It was still an unknown quantity, like, what is the Mir, what does it do, and how big is it, and how many people have been there, and all those kinds of good things. So we were trying to feed that into the Freedom Space Station as another part of the database. How did they do this? How did they do that? If they did it at all.

So I went over to the [new] Space Station Program Office here [at Houston] after they'd restarted it all. Of course, there's not a white hair in the crowd. When you went into that crowd at the Freedom Space Station meetings, a lot of white-hairs sitting out in the crowd, all venting forth with their wisdom and knowledge, or at least experience. There wasn't one in Space Station. You felt like you were in there with all your grandsons. I'm not even sure there wasn't even a policy to eliminate the white-heads out of the program at that point in time. Maybe that's a reflection on some of the Mars mission events in the last few years.

You take that experience away, it's not that you need the experience itself, you need the transfer of the acquisition of that experience to the people that are coming up in the system, and you do that just by communications and experiences in meetings and project designs and future program designs. The guys who are out in left field doing these weird and wonderful mission designs for programs that will never exist, what they have done is they've developed an amazing ability to communicate amongst a diverse group of people.

You've got the scientific community and the technology community, and you've got people who have nothing to do whatsoever with the actual missions, who for some reason are project managers, who often come from an administration, a very good administrative background, and they're trying to nurture future programs because that's the assignment they got. So you have this diverse group of people plus a few old-timer engineers like me, a few others, who anchor these programs down to reality sometimes. That's the kind of diversity of involvement you got in some of these advanced mission environments.

It was amazing to me that people would get up and say these outrageous things, me knowing that you couldn't possibly do it that particular way, but you let these people go ahead and you keep feeding in little constraints. [Laughter] You can't sabotage these guys, because not only is it a good fundamental idea, but it's also their mainstay. It's where they're coming from. They go back and report to their management how successful they are or how successful the project is going along. So you join all these people together.

An offshoot of all this was the experiences, lesson learned, the Project Management Institute. Is that what it's called now? PMI? It's the Headquarters' management derivative? Frank Hoban? That ring a bell? Frank Hoban was very instrumental in creating the Project Management Institute. It's got a web page now.

After I retired, and after I'd retired almost completely, Frank Hoban nurtured the Project Management Institute concept. (A), you got all the institute elements of the agency together and subject them to a lessons-learned experience with the project managers from other programs within NASA, and then some without NASA. And I got involved in supporting that from an indirect process.

Throughout my almost entire career at NASA, because of all this diversity business, I started keeping, for want of a better word, I think it got called a lexicon. It was really a dictionary of terms. It's not trying to define a word as being a specific thing, but how many specific things is that word used for. Simple words like "program" mean an entirely different world to so many different people, but they'd all be sitting around in these same meetings. If you get computer gurus and project managers and administrators all sitting around in a meeting, and they'd all say, "Yeah, yeah, that's a good program," and they'd all leave, and you know most of them went out [of the door] with an entire different understanding of what actually transpired. So we focused on communications in these diverse environments.

It was very simple. Everybody just said, "Well, what do you mean by that?" And they would sit there and they'd give forth with their opinion of what that word or that concept meant. And you'd see a strange expression coming over some of people's faces. "That's not what I meant at all." So as part of this PMI thing, I took all those definitions. It was really how many different ways is this word used, or this abbreviation? That's where some of it started, was the alphabet soup world. Then it got into the terminology world also. Is that when you sit in these meetings, the people rattle off alphabet soup like it's common language, and you know the people come from all over the world in some cases to these meetings for the first time. They're not about to sit there and say, "Well, what does that mean?" They sit there and let it go by.

So we started wrestling with the fact that if you do that, you're going to lose the meeting purpose. So we started this lexicon thing. The name of the game was, when everybody didn't know what the other guy meant, or thought they didn't know, or thought they knew maybe, then throw it open, get that word or that concept defined so at that point everybody else understands what we're talking about. It's the common language, not the unique language we were looking for.

So I wrote this lexicon. It was that thick when it was published, and it's never survived being published. I don't think you can get to it in the library, but it is online. It is online with NASA definitions of terms, and NASA definitions of abbreviations. The language that's used in the reference section for that is exactly the language used in the front of this lexicon document. Now, the only way I can get you to it is you have to go to my web page and you have to go to my—what's it called? DEF Enterprises [Inc.] section in my page. The lexicon is a link on that page.

BUTLER: We'll have to check that out, definitely.

FIELDER: In fact, even Frank Hoban calls here about once a year and says, "We're still working on the lexicon." He's working now at—I think it's the [George Mason University, Fairfax, Virginia].

I've got some contracts back to NASA for the PMI thing, management experience, Planning Institute, lessons learned. John Hodge started a lessons-learned thing at the project level, and we had lots of meetings. NASA picked it up from Headquarters management, and PMI is really a Headquarters operation. They've contracted it out to some outfit that's got that lexicon. There's still room to improve it, but it's wonderfully elegant compared to the documented version. They've got it all done with gadgets and things.

However, the business of communications, I suppose it stems back from the old network days. You had to make sure that everybody knew what they were talking about when they went out of the room. That was easy when you had your own staff meetings and you're all grown up together. But when you started talking to other divisions in your own department, it sometimes got tricky and when you were talking to other centers, it got tricky, and when you were talking to outside agencies, especially the university complexes, it was very important. Otherwise, you really did wind up miscommunicating issues, not only the verbal, but the written as well.

So this follow-on thing that I got involved in after I retired for a while, this lexicon business, is really the essence of the communications issues that we worked on all the way through NASA for all the programs, at least my part of the contributions to the programs, was more often the communications comprehension part of it as well as the technological achievement of the communication between ends.

I don't know how [much] that's dealt with anymore. It's a big issue. Frank Hoban understands it. John Hodge understands it. I'm not sure all flight controllers understand it, because they were so regimented. Gene Kranz is a great dictator, which is good, but the flight control organizations were essentially dictatorships, and I think probably they had to be in those days. So the communications was rigid and there was no room for error.

We even went through the business about the guys back in the Mercury and Gemini days, they were writing the messages down and giving them to a teletype operator. So first we wrestled with the teletype operators. Then we said, "How about just writing these things down? How do you do that?" Like, what is the mechanism for writing? Do you do it all caps? Obviously, if you let them hand-write it, it's gone forever, and if you do it in all caps and they make a mistake, then what do you do with it? How much of it do you erase to start again? Where do you start again if you do that? Because you're going to give it to this guy, and he's just going to read it. He's going to type it. He doesn't know what it is he's typed. He's just going to type what's on that piece of paper. You could asked questions afterwards. "What was it on the message you typed?" "Haven't the vaguest idea? I was talking to Charlie at the time." So that's where we were coming from, and I supposed that's where I've rested for some time, is the correspondence quality of the programs.

The Shuttle's turned out to be a pretty good program, [except] the traumas which never should have happened, the *Challenger* [51-L] thing, and that was a month after I retired. I didn't go back, but when they went back through all that stuff, you could see the decisions that were made that shouldn't have been made. Too bad. Since then the program's got pretty well streamlined, at least I think so.

But now the question is where it's going to go. The Space Station Program, I have my own opinion on all that. I think fundamentally it's a good design, but they just allocated the pieces wrong, incorrectly, and it's been stalled for two years. Hopefully, in July it will become unstalled. I read the reports on the Space Station issues on the Internet, mission reports on the Space Station, and batteries have been charged and working well, stuff like that. But then you get little traumas in there. The rate of decay is a mile every week. Then you start saying, "Oh, a mile each week."

When we were designing space stations and simple things like Apollo and the Skylab, all those things that were up there, once the decays get going, they're exponential. Get it up there 250 miles, it'd just sit there, maybe a few feet. When it gets down to 220, 230, you're starting to pick up half miles. When it gets down to 180, you're really starting to come in fast.

The Space Station has been progressively getting very low, to the point you can't get enough energy back up there to rescue it. It hasn't gotten to that point, but it could get there very easily. I've been watching the decay rates that were cropping up, and they were getting pretty fast.

It's a great program, and it should have been internationalized long ago. They should have had other resources to draw upon to keep the program up. It could have been planned so much better. I think it was planned politically. It was planned politically in a poor political environment, not poor that the U.S. in any way was malperforming, but the international situation was just very difficult, very difficult to deal with.

During the time I'd been studying the Russian space program, it was an active, ongoing, very successful program. The ruble was worth twelve rubles to the dollar. The Soviet system was evidently broke, but it was going strong. The country was in reasonably good political shape and a technological state, albeit communist, but it was a very successful program. I knew a fair amount about the launch facilities and the distribution of the resources between the different states. They were just different states. That was all it was. It was all part of the U.S.S.R., all run from Moscow.

Then [Mikhail] Gorbachev and his merry men, who didn't institute it, it was just the time at which it happened, wrestled with the disassociation of the states and formed this C.I.S. [Commonwealth of Independent States]. I forgot what that means. The ruble went very quickly from twelve to the dollar to three thousand to the dollar. You only had to wrestle with that, and that was just about the time that I became no longer associated with it, but all the time I'd been involved in that Space Station Program, I kept saying, "Watch the political situation in Russia. The more you guys become dependent upon it as an element of the space program, of the international spacecraft, the more risk you're taking because of the potential threat of instability in that world."

That went over like lead balloons. Nobody wanted to hear that story, and I understand why. Since that time, there's been so many difficult situations evolved politically, that revolve the Russians selling their nuclear personnel to any country that will pay their salary. That's judgement of the individuals, not necessarily the Russians, the Soviets. It was very difficult to me to concede that you would give any extensive control part of an international station into that environment. But decisions that were made back in those day to divide the spoils, to maintain the Russian technological industry with external financial inputs, all made that program very difficult to manage.

What's going on today is [evidence] to that. But when you look at the way that the only way the Russian citizenry could survive, many of them, was to essentially strip the local environment of anything worthwhile and sell in on the black market, which they proceeded to do with all the launch facilities at Baikonur. It turned out that the security at Baikonur was provided by the Russians in the forms of military personnel from Russia, and they weren't paying the soldiers any salaries. The institution belonged to that state—a

BUTLER: Kazakhstan?

FIELDER: Kazakhstan, who were just as broke as any other state at the time, but decided they were going to take over Baikonur because it was a resource of some substance. So by the time they got to it, the only launch site that was left was the one that was launching what was then being used for Mir and is now going to be used for the International Space Station. The rest of it's all stripped back. See, that's been going on at Baikonur. Think of what's been going on nationally. And that's as much as I know about the Russian economy and Russian politics, but it was a subject that should have been a 30 percent item in the program planning, for my money.

It's a lesson that possibly has not been fully learned, because it's tended not to be an element of the Space Station Program itself. It's been an external factor fed into the NASA program. I don't suppose NASA's really has its own international office of strength from that viewpoint, but I think it should do in the future. An International Space Station has to have that. What's even more miraculous to me, for my money, is that they're going to reconstitute the Mir. In fact, if they haven't already done it, with American investment, or international American investment. [Laughter]

BUTLER: They just don't want to let it go.

FIELDER: Well, I never predicted that. I thought the Mir would just slowly run out of speed. I don't how many times it caught fire, and it had also some other interesting issues, but it all managed to survive, get over them somehow. An amazing collection of stuff. They never threw anything away, and I don't think anybody should, because all that mess becomes momentum. Your orbit decay is slower the more you weigh or the more mass you have. So you just keep all that stuff, slow yourself down.

Anyway, I'm running out of speed. What else? Other subjects do we have?

BUTLER: I think we've covered things in pretty good detail in general. There were some other questions I had that would be looking at some of these programs more specifically, but this might be a good point to kind of stop for the day and give us a chance to review and pick up from there, if that works for you.

FIELDER: Sure.

BUTLER: Thank you for talking with us today.

[End of Interview]