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CHARLES D. WALKER
INTERVIEWED BY JENNIFER ROSS-NAZZAL
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ROSS-NAZZAL: Today is November 19th, 2004. This oral history with Charlie Walker is being conducted for the Johnson Space Center Oral History Project in Washington, D.C. Jennifer Ross-Nazzal is the interviewer, and she is assisted by Rebecca Wright.

Thank you for joining us this afternoon.

WALKER: Thank you for inviting me, both of you. It's been a great pleasure just thinking about this opportunity to contribute to the Oral History Program of JSC. Thanks.

ROSS-NAZZAL: Great. We're looking forward to today then.

I think we should probably start with your career at McDonnell Douglas [Astronautics Company]. You started working for them in '77. What were some of your first assignments there?

WALKER: I joined McDonnell Douglas Astronautics Company in St. Louis, Missouri, in December, in fact, officially on December 1st, 1977, and I actually was interviewing with a small number of aerospace companies, and I was explicitly looking for a position which was at that time a rare one. I was specifically asking to have employment in an engineering responsibility that would involve design and test and operations of leading-edge technology development that would be operated in space or for operation in space, and more particularly that had the prospect of becoming commercial.

Since I had graduated from Purdue University [West Lafayette, Indiana] in 1971 with an aeronautical and astronautical engineering degree, I had been very focused in my pursuit, wanting to get involved in space systems design and development and operation, wanting to be a part of what was expected in the 1970s as the next wave of space activity, human spaceflight activity, which would have a strong commercial or private-sector involvement. The origin of my thought there is most specifically with the significant national policy transition that took place with the end of the Apollo Program and the next human spaceflight program here in America, which was to be the Space Shuttle, and all that the Space Shuttle was promoted as to bring to our national interests and space initiatives, most particularly, in my mind, the opportunity for commercial and private-sector involvement and activity in space via the Shuttle.

So I wanted to become a part of that, and interviews with companies always tended to—I would bring that out very early in the discussions, and I got really no real positive feedback from interviews with the Martin Company, with TRW [Inc.]; to some extent, interest from Rockwell [International Corporation]-Rocketdyne [Division], but I got the most interest from McDonnell Douglas Astronautics Company in St. Louis.

Just a note of perspective on my part to that company at the time, I've many times thought back and even mentioned to some of the people that I later worked with and have since retired, asking, "Why did you not just kick me out the door when I walked in and said, 'I just don't want to work on any space project, I want to work on one that's going to have commercial opportunity'"? In my interviews with the company, I was even so bold as to note that, when asked, "What are your career expectations with the company?" "Technical work, design development for a few years, opportunity to move into management, and oh, by the way, along the way, if anything I'm working on has the opportunity to fly into space, I'd like the opportunity to approach NASA to go fly with it." And I asked, "Why didn't you kick me out the door?" Some foolhardy engineer who just didn't know the reality of the world.

The response was, from more than one engineering manager that I interviewed with, "That's exactly what we were thinking when we joined this company in the fifties and the sixties, and we never got a chance to do that. With you and with the upcoming Space Shuttle generation, we saw the opportunity for engineers and scientists to do that as non-career space flyers that were just there to do a specific job, and if you wanted to do that, and if we could find a way to make that happen, and if you were qualified, why not? It would make us all happy."

So it was interesting to hear that later on from these folks, but specifically they had the opportunity, and offered me the opportunity, to come to work for the company with the prospect of, yes, joining a leading-edge, prospectively commercial program within the company. It was with company money; again, a commercial activity and an inside, a private-sector opportunity. No funded NASA positions within the company under contract, and so they were very limited in terms of the staffing they could put to it, and they didn't have a position right away, but promised me the prospect that one might open up; no true commitment.

They said, "Oh, by the way, we can hire you on. We do have a need for a test engineer in our Space Shuttle propulsion system subcontract with Rockwell for NASA." Because McDonnell Douglas Astronautics was subcontracted with Rockwell at the time to provide the aft propulsion system, tankage and structure and integrated subsystem, for Shuttle Orbiters.

So I said, "Okay. The prospect sounds great, and the job that you offer me right now, in late 1977, sounded very interesting; I mean, it's space systems and equipment. So, yes, I'll join up."

So I moved to St. Louis and began work in the Test and Acceptance Group, working on the propulsion tanks for the aft propulsion system, the OMS pods, Orbital Maneuvering System pods. My first jobs were doing bubble point testing of the accumulators that were internal to the propellant tanks, the accumulators which literally directed the flow out of the tank and into the lines to the engines for the Orbital Maneuvering System. It was white room work, writing up procedures, evaluating components; clean room and white room work in terms of component testing and then supervising technicians in assembly of components.

So I did that for about ten months, twelve months, until there was a staff position available in the Materials Processing Group of the Astronautics Company, and it was that group that was being grown, with the investment of company profit money, the company's own money, for the development of this electrophoresis process, and the application that they were funding with internal research and development money, was to develop a process, an electrophoresis process that would be used to process pharmaceuticals or biological materials in the low gravity, the microgravity of orbital space.

Now, a little background on that. McDonnell Douglas again as a contractor to NASA goes back to the late fifties, of course, when McDonnell Aircraft [Corporation] got the contract from NASA to design and develop and build the Mercury capsules, and subsequently won the Gemini capsule and systems design and development contracts, and so they had a heritage through Mercury-Gemini, components of the Apollo systems and launch system, Skylab, certainly, and was now in the seventies a major supplier to the prime contractor for NASA for the Space Shuttle system. So plenty of manned spaceflight experience as a contractor, so the people knew the prospects.

I mean, they knew the prospects of utilizing space and the unique environments of space, and the company wanted to find a way to, as is the charge and the need by stockholders for a for-profit company in a free-market economy, go forth and find interesting and fruitful ways to invest private capital to produce a profit for the stockholders. In this company's expertise, they thought they could do that by looking at what could be done in the low gravity of orbital space through the very near-term flight and operation of Space Shuttle, and even studies, they had been involved in studies for NASA through the sixties, seventies in terms of the next phase, which was expected, which was, of course, a permanent orbiting Space Station.

So how could those be utilized? McDonnell Douglas Astronautics had been under contract since 1975 with Marshall Space Flight Center [Huntsville, Alabama] and the materials labs down there to study what types of industrial processes could be benefited with their operation in space. In other words, what kind of materials could be tested or produced in space to produce products brought back for products here on the Earth. And they studied everything from silicon solar-cell manufacture in the weightlessness of space, in the vacuum of space to pharmaceuticals purification in the vacuum of space.

The company, in their studies for the Marshall Space Flight Center, learned, as did NASA and Marshall, that probably the most economically advantageous market on Earth for the use of products produced in space was going to be in the pharmaceuticals arena, the reason being that pharmaceuticals are so useful in very small quantities. I mean, the body takes only a very small quantity of a hormone or an enzyme to have tremendous effect within our bodies, and so that's a very small volume, very small mass, per unit dose in a medical application, and of course, with the inherent expense of launch to space and return from space for each pound mass, if you've got something that is of tremendous value dollarwise for very small mass quantities, in other words, more dollars value per pound mass, then that's probably the thing that you want to be working with in space, because you're not going to be able to take very much of it up and back, and you want it to be of very high value. Pharmaceuticals are exactly that.

There is a process which the life scientists and the physiologists employed by McDonnell Douglas, along with the NASA researchers, determined was probably a process that would be most applicable in this research and potential commercial application, and that process was called electrophoresis. Electrophoresis, a big Greek word which is really applied to a pretty basic process as it's been used in laboratories around the world, medical laboratories and medical research labs, for the past hundred years, in which a compound like a gel or a liquid that has a conductive, electrical conductive nature to it, probably because it's a solution of salts, is exposed to an electric field, and within that media, if you will, or that electrically conductive compound, samples of something that—like the blood. Blood is a complex mixture of proteins and cells, and every protein molecule of a particular kind has a resident charge, electrical charge to it; very small, but it's different from every other chemical type of protein or a cellular body within that mixture.

Within an electric field, they will all move as a group toward the attracting electrical pole, and they'll move at different rates, and so if you expose, within a sample, that sample to an electric field for a period of time, when you shut the field off, you'll have groups of compounds all separated from one another. So whereas you had an original mixture, at the end of that process you have purified into individually obtainable groups each component of that original mixture. That's the nature of electrophoresis.

We just extended the idea to the idea of instead of just a static device, how about a continuously flowing device, in which the fluid and the samples were continually introduced into a static electric field, and that at the end of the flow through that electric field, you collected the separated streams, now forming streams, of each particular compound within the mixture. You could do that on a continuing basis, continuing basis translating into production. So the idea was generated in studies with NASA, but NASA, while there was a laboratory and Dr. Bob [Robert S.] Snyder led the laboratory in Huntsville for NASA, he had basically a two-man operation in terms of research on this materials processing process, along with other processes, but NASA was not going to go anywhere with that, obviously.

On the other hand, we in the for-profit world saw the prospect of, oh if you can purify medical materials like hormones and enzymes, which make up the basic components of treatments for a variety of diseases, you can purify materials to become the therapeutic treatment for diseases, and you can do that purification to a degree that's impossible here on Earth. In other words, at McDonnell Douglas we did the mathematics of the purification process using fluid dynamic equations, and theorized that purities of four and five times what could be done in the same processes, the best processes here on Earth, could be achieved by taking this process to space.

The quantities, because you didn't have the mass limitation that the process has on the Earth, when you go into the low gravity, the microgravity of orbital spaceflight, and you could produce in a unit of time maybe five hundred times the amount that a laboratory or a production plant could do with the same process here on Earth.

So we felt there was definitive economic advantage to that, and that pharmaceutical companies would be interested in it. So in the late seventies, '77, '78, the McDonnell Douglas life science and physiologists who were resident there at McDonnell Douglas from the aerospace and, before that, the high-performance jet fighter programmatic heritage of the company—the company needed to have physiological and life sciences experts resident there, and they now were applying themselves to the prospect of this production manufacturing opportunity for biomedical materials in space.

They went out to pharmaceutical companies and pharmaceutical company researchers that they were familiar with, and doing a market survey, determined that there was one company that was most interested. It was the Ortho Pharmaceutical Company of the Johnson & Johnson Companies groups, most interested in the prospect and were willing to invest monies in research and development, looking toward the prospect of pharmaceutical factories, if you will, purifying medical materials in orbital space.

So in 1977 an arrangement was signed in which McDonnell Douglas—with Ortho Pharmaceuticals, Johnson & Johnson—McDonnell Douglas would agree to develop the laboratory equipment on the ground to verify in a 1-G environment this continuous flow electrophoresis process for pharmaceuticals purification. Johnson & Johnson agreed to invest their own monies, private monies, in product development, one particular or maybe two hormones that they thought had a market in the commercial marketplace, and that hormone could be applied to this process and would benefit from space processing.

So the work began, and I then joined this team at the time that all of this was beginning, and I was specifically to become the laboratory test engineer. That evolved into development and test engineer, so I was involved with the designers of both the electrophoresis one-gravity ground-based laboratory systems, which were the ground-based models of what we wanted to fly in space. I was then also at the same time assisting the designers in the development and testing of components and systems of the, we hoped, orbital systems. So all of that came about in late 1977, joining the company, and then in 1978 after I was moved into this group.

Of interest may be the additional facts that at the time I joined the group, the Program Director, Jim [James T.] Rose, who had an extensive history with NASA—in fact, Jim Rose is one of the original Space Task Group members from Langley [Research Center, Hampton, Virginia] that moved to Johnson Space Center as one of the original team members at the Manned Spacecraft Center [Houston, Texas] in the early sixties. He had spent the early part of his career with NASA at Langley and then at JSC, the Manned Spacecraft Center—MSC, now JSC—then went to the McDonnell Aircraft and McDonnell Douglas Corporation in the very late sixties and went back to NASA Headquarters [Washington, D.C.] with John [F.] Yardley from McDonnell Douglas. So he had NASA experience, company experience, back to NASA, and then he'd come back to the company in the mid-seventies and was now Director of this Materials Processing Study Group, which was becoming more focused in on this electrophoresis materials processing commercial investigation team in the late seventies.

So he had maybe only about three or four people working with him in 1977, and I became an additional member of that group, joining Jim Rose as the manager of the group; soon to be the director of that activity, along with Dave [David W.] Richman, John Jason, Bill Marx, and a couple of life scientists. Most notably maybe was Dr. Vern Montgomery, who had a long professional career heritage working with NASA on the McDonnell Douglas private side, as he was involved in the early Mercury physiological work for the Mercury Capsule Program at McDonnell Douglas, and he was the lead of the then Life Sciences Group at McDonnell Douglas; and [J.] Wayne Lanham, Dr. Wayne Lanham, a microbiologist, was the other side of that.

That small group, which had laboratory facilities and growing design facilities for the systems and hardware, was a very interesting group to be a part of. We all felt like that with the yet-to-be-flown Space Shuttle, but when the Space Shuttle flew, we were just all enamored with the prospect of ready access to space for all interests in this nation, both government, civil, commercial, and the prospects that we all believed were going to flow from that were just going to be enormous. So it was a period of time in which there was a lot of enthusiasm for opportunity in exploiting and applying technology and commercial opportunities in low Earth orbit via the Space Shuttle. So it was a very stimulating time.

The project itself was one in which we were allowed to—obviously within very constrained budgets, but I mean, that's just the life in the private sector. When you're spending a limited amount of monies, whether it's government contract monies, and maybe even more so in the minds of the managers when you're spending the company's money that's gained from the profits of government or commercial contract, you're even more refined in terms of budget. So everybody was looking at budget. Everybody was trying to do things the most efficient fashion with the resources that we had, and yet wanting to do things that were leading-edge and do things that nobody else had done before, taking this kind of new technology or newly applied technology, looking toward its use in space for not only profit, obviously, with working with pharmaceutical companies and creating new medical products, but I think all of us had in mind that the objective here, the final objective, was to provide useful product for the medical research community and treatments for diseases which might not have.

Such was absolutely the case in the product that Johnson & Johnson was going to, in the late seventies, early eighties, decide was the product that they wanted to see produced in space; or certainly verify for production, and hopefully by the mid-eighties, which was the objective at the time, the mid-eighties, begin production of an enzyme which would be used in the treatment of a disease here on Earth that could not be effectively and cheaply treated because it was virtually impossible to obtain this compound in pure form here on Earth. So all of us had, in the back of our minds, at least, the prospect of doing something useful for humanity, for the nation and all of humanity, in the medical arena. So, again, very interesting and stimulating times.

ROSS-NAZZAL: Were there any challenges that your group faced as they were working on this project?

WALKER: Lots of challenges. First of all, this basic process, this electrophoresis process, as we wanted to manifest it for this prospective commercial program of the company's, required development of this continuously flowing apparatus. Now, in Europe there was one manufacturer of a similar device, but it was very complex; it was very small-scale; it was very massive and expensive to buy; and they were one-of-a-kind apparatuses which had to be uniquely built for laboratories.

We wanted to make the device simpler. We wanted to make it less expensive to produce and to operate than what was currently available in this very limited design and fabricated form for laboratories at the time. We started from scratch, and so the challenge to the engineers' designers was, take the basic fluid-mechanical equations of this electrophoresis process, and, in the minds of the engineers and the technicians, turn those equations into laboratory equipment; first, ground-based laboratory equipment, where we could refine the process and understand the process at a basic physical as well as chemical nature, and biological nature, in terms of the samples we would move through it, and make that design translatable into one that could be flown in space. It would be a different design that would be flown in space, but it would be based on the same design characteristics as we had proved in the laboratory.

So all of this was a challenge to individuals who, almost to the person, were aerospace engineers and not biotechnology engineers. I mean, the word biotechnology was really of not very general use even then, but just coming into use in the technical community in the late 1970s, early 1980s. So, plenty of challenges in terms of materials, in terms of the electrochemical substances, the biology of keeping cells—when we were using living cells as either the tissue-culture source for the biochemical materials or the enzymes and hormones that were produced by the living cells in culture in the laboratory—keeping the hormones and enzymes viable in electrochemical separation process for long periods of time, because, looking at spaceflight, I mean, in the early seventies, early eighties, of course, Space Shuttle was expected and did fly for periods of, oh, up to six or seven days.

We didn't have the longer-duration solo flights until just before the loss of *Challenger* in '86 and then subsequent to that. So we were thinking about flights of six or seven days, which today sounds short, but when you're talking about biological substances who require very delicate chemical balances in the fluids in which they're immersed, to very delicate temperature characteristics; in other words, they have to have a very balanced temperature and pH to maintain those in the isolated and resource-constrained environment, laboratory environment, of a Space Shuttle cabin, is a challenge for a week's time.

So these were challenges which we were addressing for the first time. There were other researchers that were looking at flying aboard Spacelab, that were also looking at those kinds of challenges, but we weren't working with them. There wasn't that kind of sharing of information. It was really a small group of individuals, groups, separate groups of individuals that were even thinking about those kinds of questions at the time, in the late 1970s, early 1980s. So, lots of issues, lots of questions in that regard in terms of challenge, technical challenge.

And then I'll restate the constant private-sector challenge, which is limited budget. I mean, this is only one of many research programs which the company is funding with some idea of maybe an eventual commercial service or process or product, and there's only so much money that the stockholders are willing to invest in new things, so you have to cut and plan your program very carefully to start with, and then managers have to be very judicious about how they manage those resources, those money and people resources, along the way. So another challenge was, watch the budget; be very careful about the budget. Plan with knowledge and plan in depth, and then stick to your plan.

So those were constant challenges as well, and again—the long, long hours. Everybody worked many more than forty or even sixty hours a week in these pursuits, and so I would say even many of us were individually very heavily motivated and interested in doing this, but we had family lives, too, so part of the challenge was the personal side. All of us have these, I think, and I see it around me every day even today, certainly in the world of spaceflight; those of us that grew up dreaming of spaceflight, we'd love to spend most of our time working at that, and we've got to be mindful, and I think as we all age a little bit, we are ever and ever more mindful of, yes, there are other things in the world, too. So there was the challenge of just the interpersonal relations and the day-to-day life; you know, get home now and then to be with family.

ROSS-NAZZAL: Can you give us a sense of how much McDonnell Douglas was spending per year on this project? Do you recall?

WALKER: Let's see. I don't remember a number on a per-year basis. I will tell you, though, that I do remember that from, say, 1978 for eight years through 1986, there was about $20 million, in 1980 dollars, invested by the company, company's money, in this program. So from the time that we began talking to NASA about an arrangement to fly research aboard Space Shuttle, going through all of that activity until the time that we effectively ended the program after the *Challenger* accident, the company spent about $20 million of its own funds, in 1980 dollars, so that would be a lot more today.

ROSS-NAZZAL: That's very significant.

WALKER: It was a very significant investment, and as I've learned in experiences and conversations with other industry folks over the past couple of decades, and with NASA as well—and we knew it at the time—we knew we were unique in our interest and our investment as a private company in a thing that would have a process or a business prospect for the private sector that would involve spaceflight activity and would involve NASA, a government agency, as a critical part of that private-sector business opportunity, because that's what it was. The McDonnell Douglas Astronautics Company, McDonnell Douglas Corporation overarching that, had in mind, again, a service, a technical service that would use at its core this electrophoresis process applied to the spaceflight environment, applied to working in the spaceflight environment, as a service for medical research organizations, primarily pharmaceutical companies.

The business plan, the concept, was that once proven and with products in mind brought to us by pharmaceutical companies, that we would then go to NASA as a transportation service to space, to low Earth orbit, and NASA would provide the transportation service, the equipment, the processing or manufacturing equipment, as we were calling it at the time, into space and charge us, the McDonnell Douglas Astronautics Company, for the transportation. This was the basic concept of the commercial side of the space transportation system as it was envisioned in the seventies and as it was being formulated and trial run in the early 1980s.

All of that changed, of course, with the change in national priorities and limited operational regime, as we certainly became aware of it, following the loss of *Challenger*. But before that awakening in January of ’86, we were really moving forward, again with one pharmaceutical company partner, Johnson & Johnson, Ortho Pharmaceutical Company, from 1977 until 1985. In ’85, Johnson & Johnson, for their own reasons, determined and decided that that product that they—and they themselves had invested probably close to 15 or maybe even 20 million dollars of their own money in the pharmaceutical research, on the pharmaceutical production side of that one particular product, which was very classified at the time.

The pharmaceutical industry, because of the tremendous competitiveness and, again, the high value of any particular product, is tremendously secretive. In fact, I came to find out that they had many more strict security measures than even some parts of our defense and military services do; I mean, tremendously secretive. So only a few of us knew what product it was that they wanted to test and eventually intended to work into a product-formulation business plan.

It’s been known for some years now, subsequent to the termination of that activity, that what they were looking for was erythropoietin, which is a compound; it’s a hormone. The hormone is produced in the adrenal glands of the kidneys. It is used in the body by the bone marrow within the healthy human being. The bone marrow is turned on by this hormone to produce red blood cells, and without this hormone, the disease condition known as anemia develops, and so anemic individuals are short of this hormone. Anemia is a disorder which affects tens of millions of people on a chronic basis in this country, but other diseases can restrict the body from producing red blood cells; for instance, cancer or cancer treatments. So there are other diseases that, as a secondary nature, induce this disorder in people.

So there's a big market, and at the time, again in 1980 dollars or thereabouts, the Ortho Pharmaceutical Company estimated that for a pure form of this hormone, the market was maybe a billion dollars a year. So with that I think you can see why there was interest in finding a way to purify this, and they could not do it on the ground in a pure enough form. What was available at the time was very limited in terms of quantity, so not all the anemic patients around the country could be treated. There just wasn't enough available, and what was available was not highly purified. It had side effects because of impurities in the best that the pharmaceutical industry could produce at the time.

We offered them the prospect, again, of hundreds of times more throughput, the opportunity to mass-produce in a unit of time with any given size device, hundreds of times more of the material and at purification levels four to five times what they could produce on the Earth. So there was tremendous interest in that and lots of investment going on.

We also, subsequently to that, later in the program, worked with the Riker Pharmaceutical Division of 3M, the 3M Company. They were interested in the same product and a couple of other pharmaceutical products. We began in 1985 also working with a Japanese pharmaceutical company; Hayashibara, I think, was the name of the company, and we'll get the spelling on that right later. So there was international pharmaceutical company interest. There was also a French pharmaceutical company [Pierre Fabre Medical], now that I think about it. So there was many pharmaceutical companies that were interested in talking to us about the prospect of this service.

But again, it was going to be something that the McDonnell Douglas Aerospace Company, who knew fluid mechanical processes, like this electrophoresis process, and could design specialized equipment, and especially knew the space environment so they could design specialized equipment to be flown in a space environment where lightweight materials, compact construction, safe construction, containment of fluids so that if you had a leak inside, that you had another layer of containment that would keep it from interfering with the crew or safety of the flight or vehicle. We knew all those things, and so we were applying all these to a new business prospect, this electrophoresis prospect or process in a prospective pharmaceutical purification process.

By the way, I might mention that the McDonnell Douglas group that started investigating this only was talking about it as the "electrophoresis process" or the "electrophoresis in space process." We adopted the name in 1980 for the group of the Electrophoresis Operations in Space Group, or E-O-S or EOS, and I was the one that came up with the name after thinking, "We need a name. I mean, electrophoresis, nobody can even spell it, much less pronounce it, so we've got to have something else that we can call this thing." The acronym that was adopted of the specific equipment, that was adopted and used by NASA, was the Continuous Flow Electrophoresis System or CFES, C-F-E-S, but that was embedded within this overall program or business pursuit, which we, again, named—my management agreed with the naming of it—as E-O-S, Electrophoresis Operations in Space.

Really the EOS thing came about because in Greek mythology, there is a Greek goddess of the dawn, Eos, E-o-s, and so all things have some symbolism, and the idea was that this prospectively what we were doing here was the dawning of a new era of the commercial use and industrial participation in space and the utilization of space for benefit here on Earth. So there was some symbolism in the naming that was involved here, too, and again, it was a fun and great time. It was looking at new and different things and the challenge and the opportunity. There just seemed to be more doors open at the time to both industrial pursuit of the utilization of resources in space as well as—the Space Shuttle at the time was going to be basically all things to all prospective users or explorers of space, and a very positive environment looking at that.

But very challenging, because, again, to repeat what I've said earlier, there were all the challenges of spaceflight that had to be applied to something that we were trying to do in a low-budget or constrained-budget prospective commercial private-sector investment environment.

So the resources, we kept the team at a small number of people. The company only applied engineers, technicians, and brought in supplier services when we needed it. For instance, as we prepared, we would talk to NASA about flying this process in space, both to test it and with the prospect of becoming a passenger, a paying-service passenger in the mid-eighties and beyond. The first discussions with NASA were keyed to a NASA policy which was adopted, as I remember it, in like 1978 or '79, adopted at Headquarters, which was the policy which allowed the prospective flight of commercial interests aboard the space transportation system, the Space Shuttle.

So with that policy in place, the McDonnell Douglas program management, Jim Rose specifically, went to NASA Headquarters and negotiated what became a milestone agreement, the first of its kind, a joint endeavor agreement, or JEA as the acronym, as everybody would call it, and that JEA was signed between NASA and McDonnell Douglas—specifically, McDonnell Douglas Astronautics Company—in January of 1980. It was basically, as the attorneys say, a quid pro quo arrangement. It was a "the one side provides these resources, the other side provides these other resources, in order to accomplish an overall objective, and there's no exchange of funds." This was the basic mechanism that allowed McDonnell Douglas Astronautics as the first in this kind of arrangement to invest in something that would be flown in space aboard Space Shuttle that had as its ultimate objective a commercial private-sector application.

There would be other companies that would follow. I think the second company that signed up was the 3M Company, which flew many kinds of materials processing work, beginning shortly after we began flying in 1982, flown aboard Space Shuttle. There were many unique aspects to this program, even before I got the opportunity to fly as the first commercial or private astronaut or commercial payload specialist.

ROSS-NAZZAL: In that agreement that Jim Rose negotiated in '80, did that include the agreement that at some point they would fly a payload specialist?

WALKER: It did not. As I remember it, the initial agreement was for six flights of the proof-of-concept apparatus, the first CFES device aboard Space Shuttle. In fact, as it was negotiated and signed, it was originally going to be flown aboard Spacelab. So it was very limited in terms of the number of flights; proof of principle. I think there was wording in there in terms of additional flights optional, to be negotiated later if the concept proved to be of merit to both the industry as well as to NASA, and that there were future needs to move into or validate moving into the commercial service utilization opportunity.

So it allowed for negotiated—which we did. We further negotiated within the subsequent couple of years. By 1983 it was for six proof-of-concept and validation flights aboard Space Shuttle, and by that time it was to be flown aboard in the middeck of the crew compartment and not in Spacelab, but there was added in the renegotiations of the JEA two flights of the prototype production system.

The production system was going to have to be fairly large. The idea was that it would operate, purifying a large quantity, I mean gallons of impure pharmaceutical-grade materials constantly, twenty-four hours a day, during a five-, six-, seven-day mission in orbit. So this thing could not possibly fit in the—just the massive size of it, the tens, maybe even hundreds of gallons of fluids, plus all the associated structure and electronics, couldn't fit in the crew compartment. It had to go out in the cargo bay.

So the JEA, as it was later negotiated, included, again, two flights, to be flown in the mid-eighties. We first thought we would fly the cross-bay, cargo bay EOS unit in 1985. As we approached my final flight in 1985, it was then scheduled out, tentatively manifested on, I think it was 61-M in June or July of 1986. So the joint endeavor agreement was modified, and by 1982 it had been modified to allow for a privately funded payload specialist to accompany the electrophoresis verification apparatus on Shuttle flights.

A couple of aspects of that. I remember that while the original JEA agreement was signed in January of 1980, in 1979 we'd already been talking to NASA about flying it. NASA was interested, and here I'm talking about primarily the Marshall Space Flight Center. There was knowledge in the Shuttle Program. Glynn [S.] Lunney and other folks in Houston at the time were aware of these discussions, but the discussions were with Headquarters and with Marshall Space Flight Center Materials Lab folks and with Spacelab Program there, was to fly the apparatus again in Spacelab, and in the 1979 time frame it was being thought of, and we were beginning preliminary design of the spaceflight equipment. I was already working in the laboratory in St. Louis, and working with, having designed at least two generations by that time already, in-the-Earth-bound laboratory equipment—not spaceflight equipment, but laboratory equipment—to validate and verify the designs and the process.

But the discussions with NASA Marshall were for an apparatus to be flown aboard Spacelab, and it was going to be Spacelab-3. At that point in time, Spacelab-3 was expected to fly in like 1982 or early ’83; more like ’83. When the joint endeavor agreement was signed in January of ’80, we were still talking Spacelab-3. NASA Johnson was obviously party to the outcome of the negotiation. Discussions for manifesting this program were handed over to Glynn Lunney’s Space Transportation System Group at JSC, and Jim Rose began discussion with Glynn Lunney about, “How do we fly aboard Spacelab?” Spacelab, the schedule and manifest was beginning to slip out in time.

We made the argument, had to make the argument very strongly, that we just could not go on and on, in having stretched out the first prospective, then the second and third flights in time, that could not be stretched without some certainty, because our budget just—the business plan, the investment of the private capital, could not stand that kind of uncertainty, and neither could our pharmaceutical investment partners. So Lunney understood this. It became perfectly clear, and he said, “Let’s look at an option.” And it was Glynn Lunney that suggested that instead of flying in the Spacelab, which at the time was the obvious place and really the only place where you fly materials processing work, Glynn Lunney was the one that suggested, "Maybe we could fly it in the middeck."

Our team knew and the folks at Marshall and Glynn's folks, Glynn knew that we were talking about pretty good-size equipment here. I mean, even in concept form, this thing was going to weigh several hundred pounds. It was going to be the size of a file cabinet, a four- or five-drawer file cabinet, or bigger, and it would probably have to have another module or two for electronic control and storage of the biologic materials. So we knew it was going to be big, and Spacelab, again, was the obvious place for this kind of thing, mounted in a rack.

But Glynn was, I think, very innovative in his idea. He knew the design of the systems and areas within the Space Shuttle Orbiter very well, and his thinking was, there's a galley on the port side in the middeck of the crew compartment of the Orbiter. That thing is about the same size as these electrophoresis program folks are telling me they're going to need to fly. Why don't we on a few flights—we're not talking about many flights here—take the galley out, put in this electrophoresis materials processing device. So it was Glynn Lunney that came up with the concept.

We went home, did some design and work, and said, "This came back to the Space Transportation System Office with the engineering details. This is how much it will weigh. We'd figured the loads for attach points would look like this." So we did the interface work, and within, it seems like, six or eight months, by the end of 1980, there had been both McDonnell Douglas studies as well as internal NASA JSC studies of the opportunity to interface in that way, and they all said, "Yeah, it can be done."

So in 1980 the decision was then made to move out of Spacelab and move into an occasionally manifested aboard Shuttle in the middeck materials processing device, the electrophoresis device. So it became a milestone in terms of the use of the Space Shuttle and the crew compartment for experimental work that originated at that time, and of course, obviously, that was within months before even STS-1, before the Shuttle had flown for the first time.

So, interesting things were going on in that regard. Again, a very dynamic program turning on a dime, if you will, both the NASA program as well as the McDonnell Douglas project at the time, wanting to adapt to opportunities and to take opportunities at any turn that looked to be productive and beneficial to both our interests as well as NASA's interests.

An aspect of that joint endeavor agreement that needs to be mentioned is, again, it was a quid pro quo of NASA providing a launch, but the company, McDonnell Douglas, invested in the equipment and the pharmaceutical testing processes. No direct exchange of funds, but for NASA the benefit being gained was the opportunity to do research aboard the device.

So, again, we had been working with the Marshall Materials Processing Lab folks for a period of years. They were interested in continuing to do research and especially to do electrophoretic separation research, and their interest was, from an academic standpoint, to do this research in space. So they would like to use the electrophoresis device to do research in low Earth orbit in the microgravity environment, and the agreement embodied just that opportunity.

So about one-third of the time of the electrophoresis device operation in orbit for those test and proof-of-development flights, those six flights, there were going to be NASA samples on board that we would inject into the apparatus and would be separated and collected and photographed, because the device had a clear acrylic front to it so you could actually see the separation process when there was a coloration or a dye in the specific sample stream being separated. So NASA, in the body of the Marshall Space Flight Center Materials Lab folks, had the opportunity to do, at no expense to them other than the preparation of samples and then the collection and the analysis of it later in their own laboratories upon return home, to use a device produced at the expense of the private sector for private-sector research, but, again, allowing NASA the right to use it for up to a third of the time in orbit in exchange for the opportunity to have it there in orbit aboard Shuttle.

So that quid pro quo was working. It was later extended, as a matter of fact, into—the NASA Marshall folks, the Materials Lab folks, in maybe 1982 or ’83 became interested in protein crystal growth. Dr. Charlie [Charles E.] Bugg and Larry [Lawrence J.] DeLucas, from the University of Alabama at Birmingham [Alabama], had gone to NASA and said, “We’ve got this interesting approach for analyzing proteins,” for what was at that time a developing biotechnology called rational drug design. If you knew what atoms made up a molecule, then you could develop processes to shape those atoms and change that molecule and literally bioengineer better pharmaceuticals, drugs, treatments, and the like. But you needed to crystallize the protein molecule in order to study it on the Earth later, and space was a great place with microgravity, no gravity to disturb the crystallization process.

The Marshall Space Processing Lab folks were very interested in this, supported this, but they were looking for flight opportunities to get their samples on board. We were already working with Dr. Snyder and the other folks interested at NASA Marshall, and so they made the connection. They said, “You guys are flying already aboard Shuttle. You have some storage space that’s cooled; it’s for biological materials. Would you be interested in working with the University of Alabama folks?”

So, as a matter of fact, some of the early NASA samples, the first samples in protein crystal growth that were done by the U.S.A., specifically University of Alabama at Birmingham, was done through NASA with our agreement, the McDonnell Douglas Corporation, under this electrophoresis joint endeavor agreement. We agreed to fly, and I, in fact, operated the first protein crystal growth work in space, a little tray of protein crystal growth vials that was stowed in a little nook and cranny in the support locker, which we had on 51-D, and that was the first time that Charlie Bugg and Larry DeLucas and that protein crystal growth research activity got to fly.

With the successes they had in crystallizing proteins in that flight, they later flew with subsequent payload specialists and eventually had their own on-board middeck locker or double-locker-size apparatus, and the mission specialists became more devoted to becoming the practitioners of that. Of course, Larry DeLucas eventually flew himself as a payload specialist in a later Spacelab flight in the late eighties.

ROSS-NAZZAL: Why don't we talk about some of the missions. STS-4 was the first mission on which the CFES flew, and I understand that you trained the astronauts to actually operate the CFES. Can you talk about that?

WALKER: We reached agreement with NASA with the joint endeavor agreement calling out six test flights, proof-of-concept flights for the technology and the equipment, into the middeck. Actually, my personal interface with Johnson Space Center and with the Astronaut Office began in 1979 when, as I said, the electrophoresis proof-of-concept system was to be manifested aboard Spacelab. We were assigned by the Spacelab Office an interface to begin working with our group in the design of equipment for interface with Spacelab and interface with crew operations. Dr. Don [L.] Lind was assigned out of the Astronaut Office to work with us.

So my first experience and the group's first experience with the JSC Astronaut Office was Don, and Don, I remember briefing him in St. Louis very briefly. I think probably his first contact was with Jim Rose, the program manager, but I briefed him briefly in probably mid-1979, and then he very quickly came up to St. Louis, to our laboratory and facility in St. Louis, and he began working with us there, and we would exchange information, briefings, as well as we'd show him designs and prototypes of equipment, and he'd help us understand the basics of, you know, this is the way the astronaut will want to see procedures described for both training processes as well as for in-flight.

So we began to learn directly from Don what kind of switch designations, what kind of instrumentation, what kind of procedures and processes was mandated, basically, by the Astronaut Office, in terms of controls to the device, the design of the instruments, as well as the design of the procedures for operation of the device.

After the first iterations there, Don was still our interface, I think, as we changed over to middeck, and Don then handed off to, at that point, some of the ground support team. I think we all remember back in 1980, '81, as the first orbital flight tests of Space Shuttle were beginning, the crews were designated, but virtually all of the rest of the Astronaut Office were their support teams. There was a backup crew, but everybody was supporting each one of those flights.

I think that Don handed us off to several of the STS-4 support team out of the Astronaut Office. I most particularly remember Mike [Michael L.] Coats, and as I think, Mike probably got assigned by T. K. [Thomas K.] Mattingly [II], the commander of STS-4, as the support crew member who would do the day-to-day as-required interface with our one particular payload on that mission. T. K. also designated Hank [Henry W.] Hartsfield as the pilot on orbital flight test 4, on STS-4, as the operator of the CFES device on that first flight. So from about 1980, '81, to

’82 when the flight took place, June of ’82, there were a number of contacts in the office, but Hank was the individual who was going to operate it.

I was the test engineer on the project, and again, we were a very small, lean team at McDonnell Douglas. I basically volunteered right off the bat in ’79, and again, my management knew, “This guy wants to get close to the flight operations thing.” Again, they had in mind if the opportunity should develop, then they knew that I wanted to be the first to have the opportunity to go fly, if somebody from the private side should have the opportunity to fall into one of those payload specialist positions.

So I was interfacing with the office; got to know, through our Program Integration Manager, the Astronaut Office. Charles [E.] Chassay in the Program Integration Office was assigned to be our Program Integration Manager, our PIM, for the electrophoresis project, the CFES project. Charles introduced me and some of the rest of us to individuals in the Astronaut Office. They were, again, readily designated in terms of their support functions for the up-and-coming STS-4 flight.

So I briefed, basically, Mike Coats. I think maybe Dan [Daniel C.] Brandenstein was also a support crew member. I briefed them on the procedures. They helped refine the procedures. They’d go back and talk to Hank and T. K., and then more and more, as we got closer to the summer of ’82 when [STS]-4 was to fly, I would work with Hank. And I say more and more; these were more or less irregular blocks of time that were scheduled by the flight management team, the crew themselves, in defining what training activities, what interface activities, would take place as they prepared for their flight.

I would get phone calls often from the Astronaut Office or from other engineering offices working through the questions of the technical interfaces. Now, not to say that I was the only individual on the electrophoresis project at all, by any way or means. Al Rose was leading the mechanical interface team, design, and interface team for McDonnell Douglas, so Al was in constant contact with both the Safety Office as well as MOD [Mission Operations Directorate] and the Engineering Office at JSC, as well as down at KSC [Kennedy Space Center, Florida], for the physical and processes interface of the equipment in the middeck of *Columbia* for STS-4.

But I was the key for the crew procedures and crew training. It was scheduled intermittently, maybe only a few hours in a day every month or so through the winter of ’81 into ’82, and more and more down to maybe—I think the last time I probably talked to Henry before that flight was probably within—now that I think about it, it was during crew quarantine before they went to KSC. So when he and T. K. went into medical quarantine, I remember now that I and the computer expert in our team, Vic Ratkowski, got a physiological approval. We got checked out by the Flight Medicine Office for no communicable diseases, so we were allowed into quarantine to go through a little bit of last-minute training and simulation exercise with Henry on the electrophoresis device.

We did that with a simulator. We had part of our investment in our business pursuit to this program on the McDonnell Douglas side was to create a high-fidelity simulator. We actually had a device, which was not a fluid device, but it was basically a full-scale photograph of what the machine would look like, and you could draw on it visible lines of separation in the fluid flow fields. I’d say, “Now, Henry, this is what’s happening in there now. What do you see and how do you respond to it?” And he could do some mechanical things, change some valves here, or go over to the computer, and it was a fairly simple computer at the time, of course. He could go over to the computer on a double-middeck-locker-size electronic control and monitoring device, ECMM, and he could look at the readout, punch in some commands, look at the readout, temperatures, flow rates, electric field, and he could make some judgments per the procedures which we had for him.

But we had built up a duplicate of the flight electronics device, and we used that as a simulator. We would bring that down. This thing weighed about eighty pounds, and you'd have to pack it very carefully; ship it on board the plane with you in luggage as you came down; unpack it very carefully; get it into JSC; set it up. In the weeks before the crew went into quarantine—we were probably over in Building 4 now and then, doing a lot of the training right there in or around the Astronaut Office—we'd go out to the trailer, at least that one time I mentioned, and set it up and Vic Ratkowski, the software guy, and myself would go through the procedures with Henry, and Ratkowski would be like a little one-man Sim Sup [Simulation Supervisor], and he would program the computer to simulate a problem, and I'd tell Henry, "Now, this is what you're seeing. Is that right?"

"No."

We'd go through the whole thing, one-on-one with Hank. So I got to know Hank pretty well, and T. K. as well, in preparation for that flight.

During the flight, I was in supporting it, as was the project manager, Dave Richman, who was another one of the original team of Jim Rose's Materials Processing, soon to become the Electrophoresis Group in St. Louis. Dave Richman became the project manager for the CFES project in our team, and he was one of the support team in the back room at the MOCR [Mission Operations Control Room] at JSC during those early flights.

Myself, I was leading that ground support team. Dave Richman was supporting it. Vic Ratkowski was another individual supporting it. We would do shifts to be at our little console in the back room, where there were a few other investigators. Those early orbital flight tests were mostly there to deploy a payload. If you remember, Hank and T. K.'s flight was a DoD [Department of Defense] flight, so that was interesting in itself, at which there were a lot of Air Force blue-suiters walking around who couldn't tell you what they were doing and what was going on up there, and they had their own isolated back room area.

In addition, in those early years, the first two years of the Shuttle Program, there was no TDRS [Tracking and Data Relay Satellite] in orbit; that was first delivered on STS-6. So there was ground coverage. Just like there had been during Mercury and Gemini and Apollo, the Shuttle would fly over ground stations, and you didn't talk to them unless they were over a ground station. So there were plenty of periods of voice-out, or loss of signal, so unlike today and unlike we've had for the past fifteen years, there was plenty of time in which you're sitting back there wondering, "What's going on now?" and you can hardly wait until acquisition of signal, and then you hope that the crew said something about what you were doing.

Because one other aspect of what we were doing, on those, well all seven of the flights that we flew in the middeck, we had no telemetry with the ground. Again, it was another part of the lean and mean research for private objective and research with a tight focus and on a tight budget. We didn't interface with the telemetry systems on board. That was an added complexity and an added expense, both for NASA, if we'd wanted to do that, as well as for ourselves and our equipment, so we relied upon the crew looking at that little computer interface that we had there for them and making visual observation of the apparatus and reporting down what they saw and hopefully recognized, and through the training that we'd given them, they would understand some of the things that they could see visually. They'd read down data, and we had in the procedures, of course, at each period of planned communication with the ground, an opportunity of a few seconds or maybe a minute for them to downlink, either on their own initiative or requested by CapCom [Capsule Communicator], certain data.

But that's how we interacted. We didn't have electronic data streams. We got numbers read down to us, and they were coded in a computer code. We'd sit on the back console in the back room behind the MOCR, decoding the words that the crew would send down, and trying to figure out what does that mean in terms of what's happening. So, again, it was a very interesting and challenging time to try to, first of all, with the fairly low-priority payload that we were, to get the Flight Director interested and the payload operations console interested enough to even ask the crew now and then; of course, in training, to get the crew interested enough in what we were doing to want to think to even talk about it on their own once in a while in orbit.

I remember one of the things that we requested from JSC Mission Control Center support was tapes, audiotapes of the crew's commentary on each pass, because sometimes the pass was maybe so short and there were so many things going on otherwise, with the vehicle or with other primary payloads, that the crew would just give a quick verbal burst of information. "I've gotten on point-three-point-two, Charlie Oscar, three five—." It was a readout from a computer.

"Okay, so we wanted to make sure we heard that right." Everybody's got three people scratching down what you thought Hank said, but we wanted to get a tape later on, or as soon as possible, an audiotape, and listen to it during the loss-of-signal times or during the crew's nighttime, so we could assess what had gone on as best we could without error and try to formulate any correction to problems to pass up to the crew.

There were some things that we had trained Hank and later crews that they could do with the computer with certain problem situations. So there was the opportunity to make, in the case of the device, some physical change, changing valves, changing flow rates, but there was also the opportunity in the computer to change pump speeds and electric field and that kind of thing, some critical parameters. So there was the opportunity to interface. The crew was to some extent trained in how to self-diagnose that, but largely it was up to us in the back room, with all the resident knowledge of the equipment, as well as the chemical and biochemical processes and the samples, it was up to us to try to guess, learn, from the crew's downlink what was going on and what we thought was going on and what the best action and reaction was.

Very much different than today, when there's just virtual instant, with a little bit of time lag, between both Mission Control Center and Station or Shuttle and the payload control centers, because there are separate payload control centers today that are directly linked. They have their own mission voice at those POCCs [Payload Operations Control Centers] that talk to crews on Station today. What we were doing back then was just the precursor of that. We could not talk to the crew directly ourselves from our back-room console; that was CapCom that did that. So we had to go through the payloads officer in the front room, who then took it to the Flight Director, who then okayed for the CapCom to ask such-and-such a question of the crew on board.

So it was a very much different situation, especially limiting since, again, that was our only link with any data on how the experiment was going. We had no telemetry. So, interesting circumstance, especially in comparison and contrast to the way it is today with virtually instant com [communication] with the crew all the time and directly from both the main Mission Control Center as well as for payloads from payload operations centers.

ROSS-NAZZAL: I can imagine that would have been difficult.

I think this would be a good time for us to take a break.

[Tape change]

WALKER: There are aspects to the industry-NASA interface that I think were lessons learned that haven't adequately been followed up on or utilized in as efficient a manner. This joint endeavor agreement was used extensively, but it was, for some reason, then shunted aside for more complex arrangements, and I think that was a bit of a mistake. I think it worked very well. It served us very well, and all the feedback that I got in the mid-eighties and later from those at NASA Headquarters were very pleased with the benefit that NASA got from utilizing an industry investment with nothing more than just the marginal cost of accommodating a private company in a research development activity on board Space Shuttle. It was very effective and very efficient. I think it was pioneering, and there were things learned there that still could be utilized today in an effective fashion.

ROSS-NAZZAL: Let's finish talking about STS-4.

WALKER: Yes, and I think we also didn't maybe finish talking about me becoming a payload specialist, either, but we can get there.

ROSS-NAZZAL: Yes, I thought we'd get to that. What did you learn from that flight about the CFES itself?

WALKER: What we learned from that first flight of the CFES was, we first proved that the equipment would operate as we expected it would operate in the weightlessness of space, in the weightless environment of orbital space. Now, remember this was a fluid process. These were pumps pushing gallons of fluid through a very thin chamber—I mean, literally 3 millimeters thick and 16 centimeters wide and 120 centimeters in length—and had to do so without bubbles forming, because bubbles would literally block the process. So it had to be bubble-free. It had to be ultraclean because of the biological nature of it.

So we learned that we could operate it without bubbles, that we could operate it in a controllable fashion, that the temperature, the electric field and electrochemical nature of it was controllable, as per our predictions, and that we could keep it biologically clean. In other words, part of the preparation process at the Kennedy Space Center was to chemically, with the flowing through the entire fluid system, within five days before launch, of a pretty caustic chemical compound to kill all the bacteria. You had to sterilize it chemically, internally. It had to be sterilized and then serviced with the buffer compound, the electrochemically conductive buffering compound that you wanted to use during its experimental operation. It had to be serviced after being sterilized, had to be serviced with this compound and filled up, no bubbles, and that had to stay in there for the period of maybe three days, two or three days, until launch.

Access to the crew compartment, those of us inside the business know how hard it is, I mean, it's very tightly controlled access to the crew compartment during those last few days and hours up until launch. It's very hard to get in there with the kind of equipment that's necessary to pump in big amounts of fluid and liquid and do all this. So it's got to be chemically sterilized well in advance, and then serviced with the flight fluids well in advance, and it has to stay chemically clean.

So we've verified processes to do that and to maintain those conditions throughout a multi-day, a weeklong flight. We validated all of that. We proved that its operation in its separation mode, separating biochemical compounds—actually, we used simulant on the first flight, on STS-4. We sterilized it, but we didn't use biological materials on the first flight. We used small styrene beads, as a matter of fact, which was a simulant that was proposed by the Materials Processing Lab folks at Marshall. These micro-size styrene beads were dyed with different colors. They were mixed together, and in the chamber they would separate into the different color streams, and so on STS-4 Hank could readily see and photograph the results of the separation, and then collect those, also, for return to the ground.

So we validated the mathematical modeling of the separation process, and so that proved that, number one, the apparatus worked in the environment of space, as we had designed it to; and number two, that mathematically we could predict the ability to separate within the device for a product of a given and known electrochemical nature, molecules of certain sizes with charges of like thus and such, with given electrical charging. So we validated the modeling.

So those things were the basics that we needed to validate and verify, and we did that on the STS-4 flight.

ROSS-NAZZAL: Did you have to change anything as a result of the first flight?

WALKER: We'd planned to make some changes. I'm sitting here and I'm trying to think, Jennifer. I don't know that we had to change anything as a result of what we learned. In other words, did we find a problem that we didn't know about and had to correct it? No, that's not true, now that I think about it, with stumbling around for a minute or two here in conversation, it did come to mind. There were some software changes in the computer, some program changes we had to make in the computer.

Now, again, back to my point, there were preplanned changes between each planned flight of the equipment. Again, Space Shuttle, the crew as a resource, the vehicle, is such a, yes, expensive and valuable asset that you don’t fly a second time to just do the same things you did the first time. You advance. It’s scientific and technical research and development. You prove what you wanted to prove, or you find out you’ve got a problem, and then on the next flight, you already have plans to go further in terms of the scientific or the technical investigation. You do more. You stretch the envelope, as we say in the flight field. Also, if you had problems the first time around, you fix those, and you demonstrate the fix in those problems.

So we knew we wanted to make changes for the next flight, like, for instance, we wanted to add better cooling; we wanted to add more electric separation capability. We wanted to have different samples. We wanted to include biological samples on the second flight. All of that required changes in the software, anyway, so the programming changes were fairly easy to make. We already were going to make changes, and that was all that was required as a learning experience from the first flight. But, given the successes of the first flight, we knew we could also then advance to the next level of challenge; again, different samples, more samples, more electric field for greater separation, more flow, and we could do that in the second block, we called it.

That first CFES device was CFES Block 1, Continuous Flow Electrophoresis System, Block 1. That was the design term or title that we gave it for that STS-4 flight in June of ’82. Then in ’83 our next scheduled flight was on STS-6, and that was the first of the Block 2 configuration, which was, again, a slightly different design, more electric field and all the things that I just mentioned. So it was different capability and was going to demonstrate more and more in the way of production capability. Again, that was our objective, to be able to launch highly reliable electrophoretic separation equipment that could separate large quantities of material for long periods of time. So we wanted to develop more and more capability to do that as we went through this proof-of-concept test phase of the program.

ROSS-NAZZAL: When did you find out that McDonnell Douglas and NASA were talking about sending up a payload specialist?

WALKER: Interesting that you ask at this point the question, because this is when it happened in time. We had the success that we had in proof of concept with the CFES device in the middeck of STS-4 onboard *Columbia* with Hank operating it, and we came back from that, analyzed the results, briefed Glynn Lunney and others at Johnson Space Center, as well as the Marshall folks, on the results. The Marshall folks had samples back. Again, the Marshall folks had their samples on board and were doing their analysis to do electrochemical modeling of this electrophoresis process. They wanted to mathematically understand it to the nth degree. They wanted to be able to predict what any given material would do and all kinds of detail.

We weren't interested in all the detail. We were just interested to know, well, if you put in this kind of sample with this kind of electric charge, would it come out of those—I mentioned there are 200—actually 198—exit ports at the top of the separation device. We wanted to know, for the practical purpose of being able to collect pure enzyme *x* with an inherent electric charge of *z* volts, predict what tube—and we're talking about little exit tubes out of that array of 198 exit tubes that are maybe one half of a millimeter in diameter—predict which one of those tubes it comes out so that you can collect that in pure form, compound *x* in pure form, versus all the other compounds or all the other liquids which you didn't want, were of no use to the pharmaceutical company.

So you wanted to be able to predict where it was going to come out, so we were very practically oriented, in terms of our objectives, and not really oriented toward proving theoretical predictability. The Marshall folks were. So they didn't quite get the results they wanted to or the level of predictability from the samples, and in fact, they saw some differences in the performance of the device from what they thought was going to be the case. So they had other questions which they had and they wanted to get verified on the second flight, and so, okay, NASA gets one-third of the research opportunity, so that's fine. They'd tell us what they wanted to do, and we would integrate that into the performance plan and the test plan.

But from our standpoint, we had proven that we could predict adequately for production processing what we needed to know. We briefed on that, and we advised the Space Shuttle Program management what we wanted to do for the next flight; got that approved through appropriate processes, and at the same time—I can remember, I was in a meeting in which Jim Rose and I briefed Glynn Lunney in Glynn's office in Building 1, and Jim told me, going down, he said, "I just want to tell you, as we walk into this meeting if I get an indication from Glynn that he's happy with the results, too, from the NASA side, I'm going to ask for a payload specialist opportunity." He said, "Are you okay with that?"

And I said, "You know I'm okay with that." So that's exactly what happened. Glynn got the briefing. He said he had heard from his folks that they were very happy with our interface, that it was working well from the operational standpoint, and that he believed that NASA was getting what it needed out of the joint endeavor agreement and the interactions.

Then Jim Rose said, "We want to ask for the opportunity to negotiate for one more thing." And basically it went something like, "You know, Glynn, the astronauts that we're training, Hank's a great individual, obviously a great test pilot, a good engineer, but Hank doesn't know this electrophoresis stuff, and the other astronauts, mission specialists that we're going to train, they're going to be able just to spend a little bit of their time working with our device. They've got lots of other things to do. That's the mandate for the mission specialist. We really would learn the most we possibly can and more than we can do with a mission specialist if we get the opportunity to have a payload specialist devoted specifically to the electrophoresis device and its research and development activities during a flight."

As I remember it, Glynn chewed on his cigar a little bit—you know, that's when you [got to (could)] smoke in the office—chewed on his cigar a little bit and said something like, "Well, we've been wanting to move into this payload specialist thing, so if you've got somebody that is qualified, can meet all the astronaut selection criteria, put in the application. Let's do it." What he was referring to was not in the normal process, the application process for the career astronauts, but was "Put it in. We'll run it up individually as a special case, up through Headquarters, and it will obviously be Headquarters that will make the final determination." But we did that, and I think Glynn said something like, "Do you have somebody in mind?"

Jim turned to me and looked at me, and Jim said something like, "You're looking at him."

Glynn said, "You, huh?"

And I said, "Yes, it's me. I'll be the man."

I think maybe there was some side conversation then about the fact that in 1977, before I came to McDonnell Douglas, in fact, while I was interviewing, I was in a position with the Naval

Sea Systems Command at the time, and I was looking at private industry, aerospace industry, interviewing. While I was doing that, I also applied for the first Space Shuttle astronaut selection. So I submitted my SF [Standard Form]-171 and all the other paperwork and didn't get—I don't know how far down the line; I certainly didn't get to semifinalist, much less to finalist. You know, 35,000 other folks applied, I think, for that filing.

But I had tried; I'd wanted to, and I thought—well, I just kind of studied the processes which NASA was talking about putting in place for the Space Shuttle Program, the opportunities for Space Shuttle Program, and I knew there were three categories of career astronauts that were going to be flying Space Shuttles—pilots, obviously; the mission specialists, obviously; but there was this category called payload specialist, and at the time, there was just the talk of maybe a dedicated scientist payload specialist that would be selected by peer groups of the researchers that were already selected to fly aboard Spacelab missions, and there will be international astronauts that will be offered up by their international space agencies. And I thought, "That's one opportunity, but I obviously don't work for a university. I'm not a Ph.D. in any one specialty, so maybe the industrial part; maybe the private-sector researcher-engineer."

So that's what I literally had in mind as one part of my professional pursuit when I was interviewing with McDonnell Douglas and the other aerospace companies in 1977, looking for that project that might actually produce in their design and development something that NASA would be willing to fly and that eventually would be of such interest and maybe practical use that there would be the real need for a payload specialist researcher to go along with it.

Truth be told, I very clearly acknowledge that I just got lucky. I found the company and the project that, at the time, was virtually the only thing in this country in the aerospace arena that was being proposed to NASA from the private side that looked like it was really going to produce something of real benefit to the country and to the commercial side of our economy, that could be done in space; and managed to get into an early key position with that project.

So Glynn Lunney then opened the door, and the application went in. That was in, again, the summer, probably July or August of 1982, and paperwork went in in September time frame. I answered a few questions here and there, both the company did, as well as, "How will you support this individual? Is McDonnell Douglas going to continue to pay for him? Because he's not going to become a career astronaut; he's not going to become a civil servant." So there were questions like that, and obviously, that was the circumstance. The company was willing to keep me employed. I was going to stay employed with the project, working with the project at McDonnell Douglas in support of the flight activities, while training on the training schedule that would be given to me by the JSC trainers in preparation for assignment to a flight.

So all that back and forth, what there was, went on during the end of 1982 into early '83, and I can remember the holidays around this time of year in 1982, in which I had talked to my mother and my father that was recently deceased. So I'd go back home and talk to my brother and my mother, and they'd ask, "Well, have you heard anything?"

"No, haven't heard anything yet."

As I found out later, there was just a lot of internal processing within NASA between Johnson Space Center, working through all the chains of management decision making at JSC and with Headquarters, for something that hadn't been done before. This private sector nonacademic scientist-researcher payload specialist, it was something that hadn't been done before. So I was the first out of the chute in that regard, as well, and all of the decision making process and the NASA management instructions had to be tailored and reviewed and tailored to match the consideration of just such an individual in that capacity. So I was the trailblazer in terms of that private sector payload specialist, non-Spacelab payload specialist position on a Shuttle crew.

I think the next obvious question might be, well, when did I find out, and the answer to that is, interestingly—let me go at that answer in this way. Of course, I was still working all this time at refining the electrophoresis process and equipment in St. Louis, designing and working on the Block 2 equipment and validating that in preparation for the upcoming manifested flight on STS-6, and I was training the crew for STS-6. In that case, the designated operator and backup was Story Musgrave as the primary operator on STS-6 *Challenger* flight, and backup was Don [Donald H.] Peterson. So I was in the process of briefing their support crew and training them in the operation of the device during those months, and it was not a secret at all that the application had been put in, so there was occasional banter about, "Did you hear anything yet?" The answer was always no, from me.

I remember that I finally got a phone call in the middle of the workday. I was at my desk doing something else, and I got a phone call from Craig Covault, a reporter with *Aviation Week and Space Technology* magazine. Now, I had met Craig over the preceding couple of years, because the electrophoresis device and the program had gotten visibility in the aerospace industry, in the media, and so Covault had interviewed Jim Rose and myself as a member of the team for some news stories in *Aviation Week* in the preceding summer, around the flight of STS-4. Craig called me and he said something like, he says, "Charlie, have you heard anything back about your application to be payload specialist?"

I said, "Nope, haven't heard a thing."

He says, "Well, maybe I'm the first to tell you, then. I just talked to Headquarters, and a source who I won't name said that they have finally approved it, and you're going to get to fly."

"Oh, man." [Laughs] So it was a great moment, but it wasn't a call from George [W. S.] Abbey and it wasn't a call from anybody at JSC that first told me; it was this reporter who had a contact at NASA Headquarters. But I think then it was followed up within a day or so by a call to Jim Rose, the program manager from—and I don't know who at the time; it may have been "Chet" [Chester M.] Lee, who was the head of—probably it was called Code M at that time at Headquarters, the Office of Space Flight, or whatever the equivalent. Maybe it's the Office of Manned Space Flight at the time. He was the Associate Administrator, I believe, and so I think Jim Rose got the call from Chet Lee acknowledging that.

From that point on, then I started getting phone calls, of course, right away, from the training office, MOD and training down in Houston. There were other payload specialists who were in training at that time, of course, but they were the payload specialists for STS-9, for Spacelab-1. There was a Payload Specialist Office set up under MOD. Payload specialists were not a part of the Astronaut Office at that time. There was a separate Payload Specialist Office, and it was basically no more than a secretary, some gray government desks and a couple of file cabinets and a corner office area over in Building 32.

Jay [F.] Honeycutt was the manager in charge of that office, and our secretary was Lynn Collins, whose husband, Mike [Michael A.] Collins, also worked at the Center at that time. Not the Astronaut Office Mike [Michael] Collins, and I don't remember this Mike Collins' middle name. Lynn was a great friend and a very lively personality. Her hometown was New Orleans, Louisiana, so had real lively conversations with Miss Lynn all the time.

When I started going down, then, to work with the training folks, to get my syllabus of training, to work the schedule between St. Louis and Houston, because, again, I was the lead development engineer for the electrophoresis program at McDonnell Douglas Astronautics in St.

Louis. Home was in St. Louis. So I was doing that job, training crews for the upcoming middeck flights, STS-6, then STS-7 and -8, all in 1983, at the same time that I was starting my training in that summer and fall of 1983.

I can't remember; I think it was very quickly after I was named that I was manifested with the 41-D crew, the first flight of *Discovery*. So that was quite an intriguing and a little energizing circumstance to learn about, that here the first industry payload specialist, the first non-Spacelab, nonacademic payload specialist, was going to fly on the maiden flight of one of the Orbiters, the first flight of *Discovery*. So, again, very energizing circumstance.

ROSS-NAZZAL: Once NASA made this announcement that you were going to be the first commercial payload specialist, what was the press interest like in this story?

WALKER: Very great. I say "very great," relatively speaking. I mean, heck, for me, I grew up in a little town in the Midwest and still was living and working in the Midwest, for the most part. It was pretty great. There were a lot of requests for interviews. The company managed all of that. NASA Public Affairs deferred all of those requests to McDonnell Douglas Communications, Public Affairs.

I didn't do very many. They were filtered quite a bit. We took our lead, I think, from NASA's Public Affairs, in that you accommodate the astronauts' desires—hometown, certainly. You talk to the hometown newspaper when they call, and the immediate local newspapers. But I think our Corporate Public Affairs was very attuned to company image, so when we got a call from the *Los Angeles Times*—McDonnell Douglas had a big presence in Orange County, California, and the Los Angeles area, and so we got a call from the *Los Angeles Times*, a goodsized publication, you get a call from that, yes, you probably set up an interview to do with the reporter from the *Los Angeles Times*. But it was heavily filtered.

I was still working as well as training with NASA, working on the project in St. Louis and training with NASA, so there wasn't a lot of time to do interviews. But it wasn't the isolation, or relative, I say, isolation from public affairs that the career astronaut candidates go through in their one year from selection through their astronaut candidate training year. It wasn't that kind of isolated at all.

ROSS-NAZZAL: Can you talk about the training that you underwent?

WALKER: To start with, it was not the full mission specialist training. It was a syllabus, and I remember there was quite a bit of discussion that I heard on the periphery and heard about later on, within JSC and, I guess, with Headquarters as well, in terms of just what training would this guy get.

Let me add a footnote here that, again, I wasn't a civil servant. I wasn't brought on as a civil servant. I was still a McDonnell Douglas employee, so it was a factor, to some degree, that the company felt was negotiable, as to how much of my time, as company time, would be spent training to fly, as probably—and at that point, it was thought by everybody that I would fly once. I mean, a payload specialist—there's not such a thing as a career payload specialist, so you probably fly once to validate and verify that the equipment is working, and then later on you would train more mission specialists to operate the equipment at the increased level of attention that would probably be required at that advanced stage of development.

In any case, it was a negotiation between McDonnell Douglas and NASA about how much training was required, and NASA didn't want to spend its own funds training me in addition to the cadre of astronauts that they had to keep trained, or new astronauts that might be coming and need to be trained. I would be a load on the system.

But there was one other aspect, which was that as the joint endeavor agreement was modified to, yes, allow under the joint endeavor agreement a payload specialist, at the discretion of NASA management in concurrence with McDonnell Douglas management, to fly a payload specialist if needed, if the need was really there, that McDonnell Douglas would pay NASA for my flight. The negotiated terms of that were that the costs that would be covered by the McDonnell Douglas payment for my training and flight would be marginal costs. In other words, okay, there's already trainers at JSC. There already is a training program for astronauts. What would it cost to just add this one guy into that training schedule for those trainers? And when he's on board, when he's one of the crew members on board a flight, how much additional cost is it to add the food for him, the oxygen for him, the water, etc., the air? So it was the marginal costs that were the negotiated expense of my training and flying.

So the point that certainly is of interest to me today is that I was the first private working passenger in space. Also interesting, and I'm sure will be of interest, is, well, how much was paid? How much did it cost for me to fly? This was before full-cost accounting, way before full-cost accounting. NASA charged McDonnell Douglas about $40,000 for each of my flights.

ROSS-NAZZAL: That's inexpensive.

WALKER: Pretty good, huh?

ROSS-NAZZAL: Yes.

WALKER: If you could get that today, you'd be booked up.

So the training itself was a short course of what the astronauts get. It's basically all the categories, except for maybe the big-expense items, I would say, the items like emergency training. I didn't get the emergency water training. I didn't get the survival training in the deserts or the jungles. But I did go through all the systems, Orbiter systems, subsystems, the spacecraft systems training, both briefings as well as stand-alone simulator training, so I knew what systems did, like the electrical systems, like the control panels that controlled the electrical systems on board, environmental systems. I knew the computer interfaces.

But as it was finally decided by NASA for me and my circumstance, the training was basically familiarizing with those systems "so he knows what's going on around him, but he's not going to operate any of those." Here I was, I had a 500-pound payload down in the middeck. It had its own electronics. It had its own cooling system. It was basically contained except for power, which was like two circuit breakers over on a circuit breaker panel just above the waste-collection system, down on the middeck, also.

So I knew where those circuit breakers were, but I couldn't open or close those circuit breakers. That had to be done by one of the mission specialists. There was no computer interface, so I had no reason to operate the computer system, but I knew how to do that. I was trained on how to do that, just so I would know what was going on around me, which is all, I think, very good, and I only note that just for the record. Nothing implicit in that; I'm not saying anything in terms of criticism. I completely agreed with, and still to this day agree with, the segregation of responsibilities.

I was there as a working passenger. I wasn't a full-fledged crew member, and I knew that going in, and I took no real exception to that. Occasionally there were circumstances in which it was made clear to me that "You're not one of us. You're along for the ride, and you've got a job to do." But it was only a few individuals, some in the Astronaut Office, others outside the Astronaut Office, from whom I got that impression. There was no belligerence, really, expressed openly, and no offense on my part taken.

Again, I really saw my role and my place in this, this was a great adventure, and more than an adventure, it's a great challenge, both to people as well as to technical systems. I think I know my limitations, and I know that I'm not nearly as qualified to make critical and rapid decisions in some of these flight environment circumstances, as the men and women that have been selected by the agency through grueling processes, to do just exactly that. I mean, these are great folks, they're great skilled folks, and they're good at what they're skilled doing, and they're trained to do those things. I'm not there to do that, so I don't need to even think about myself as having a problem with that. I was getting a great opportunity, I felt, both for the company that was my employer, for the commercial as well as the prospective societal benefits from the work that we were proposing to do through and with the Space Shuttle. And certainly, certainly a tremendous personal opportunity for me, and I was just happy to be there.

So, back to the point of the training, was basically familiarization training. The most important and the part that really took the most time was the training to become one of each of the crews that I flew with; in other words, the crews getting to know me, and me getting to know my fellow crewmates for each flight, so that we knew, at least to a significant degree, each other's characteristics, and we could work together and feel good working together and flying together as a team. That's what took the most time, and that time was, I would know when integrated simulations were taking place, and it was largely at the discretion of the trainer to suggest to the crew commander when Charlie Walker should be part of a crew's briefings or a crew's training activities, and then the crew commander would make the final decision as to yes or no; no, he doesn't need to be a part of this particular thing.

So I would fly back and forth between Houston and St. Louis, home in St. Louis, for activities on and off. Again, stand-alone training activities, but more often than not, integrated activities with the crew, briefings, or, as we approached the last few months before flight, integrated simulations with the crews. Integrated with Mission Control Center, as well as myself with the crew in the planned integrated mission sims [simulations].

So it was that kind of training, and I've got to say I think that it was—well, I think NASA learned from my experience, because there was a lot of interaction, and I was very up for it. I mean, hey, I had spent the previous two years, of course, training the crew members for the first four flights of my electrophoresis devices and apparatus and processes. So my head was in the training process, and I could see the way the astronaut corps—these folks of largely aviation background and the mission specialists with science backgrounds now in an aviation environment—the way they liked and found most comfortable and most rewarding to be trained. Of course, I could see the mission's success based upon the extensive, in-depth training that NASA does with its crews, and that had just become part of what I saw as the right thing to do.

I also, I think, adapted to my place, my role in upcoming flights as a payload specialist crew member, and so I talked to the training folks and management in debriefing them after my first flight and then subsequent flights with, "Hey, I think that for future payload specialists, the following improvements could be made." So I think that there was a great deal of learning by the agency as well, by JSC and the training, MOD, in terms of how to train the itinerant astronaut, the outsider coming in who is just going to be there for one flight.

Again, I think as you know, of course, it was after my selection, there were a few other payload specialists, certainly the ongoing Spacelab payload specialists, selected and trained, and they had different training. Their training at JSC was basically the same as mine. The difference was, they had additional training in Spacelab, the Spacelab simulator, and the Spacelab-specific equipment and science, mostly at Marshall Space Flight Center. But starting—when was it? Maybe in 1984 when I was ready to fly with *Discovery*, the first flight, with Hank's crew, 41-D, NASA also announced that other payload specialists were going to be selected and flown for other payloads, primarily satellites.

NASA was promoting the use of Space Shuttle as the space transportation system for satellites and commercial work. The other commercial work that was there to be flown were commercial satellites, and so the next payload specialists were from RCA [Radio Corporation of America], who built satellites that commercial communications companies were buying and wanting to fly, was a Saudi prince. His country purchased a satellite and the Saudis wanted to have flown one of their nationals, so Prince Sultan Salman [Abdulaziz] Al-Saud was selected. So the selection process, I think, for them, and the training process was benefited by my experience earlier on.

ROSS-NAZZAL: Can you give us a sense of some of those lessons learned that you passed on to the trainers?

WALKER: I think it was, be mindful of and work with the payload specialist's home organization. I say it in those terms; maybe a company, in my case. In the case of RCA, a private company. In the case of Sultan, the Saudi government and probably the Ministry of Communications or Telecommunications. In other words, the essence of what I was trying to say there was, you don't own these people. They're not civil servants; they're not NASA employees. They have organizations behind them that have their own needs and the need to have these people around to continue whatever their training is with a particular payload in preparation for that payload to fly, so you need to be considerate of that, mindful of that, and really negotiate, not just demand a schedule like such, but negotiate a schedule.

I also think there was probably some aspects of procedures, emergency procedures and the like, that my, and I think my commander's, Hank Hartsfield's experience, for instance, reflected back to the training folks, "Maybe they need a little more than we trained them on for that flight. They need a little more in the way of emergency systems training."

Now I mentioned already that I was basically told that, "This is familiarization to Orbiter systems, just some familiarization training. You're not going to operate any of these." The fact is that that's the way it turned out just before I flew on STS 4[1-D] the first time and later. The way it started, Hank Hartsfield had me and had the trainers training me on—I was up operating the remote manipulator system, the RMS, in the trainer, and that went on for a few weeks. I was training with the crew. I was working the RMS in the simulator, and I knew the system, I knew how to work it, even though I was not in the flight plan to deploy any of the satellites or to have to use the RMS, as might conditionally be the case. I don't think on STS 4[1-D] we had any required use of the RMS, but we had as a contingent, the operation of it. But it was later like, "No," the management said, "Charlie Walker doesn't need to be trained on it, because he's not going to be using it, we're not going to spend any time training him on it."

The same thing for water dumps. A standard Orbiter operation process, doing water dumps. The mission specialists are the ones that normally do that. Hank wanted me trained to be able to do a water dump, and he wanted me to do a water dump. Just like, "Hey, you're on board. Why not."

"No, no," management finally said.

My comments were that I think this is a good thing. Let the payload specialist do some of this, too. He or she is going to feel like more of a cohesive part of the crew. It's just a good psychological thing, even though you don't need their hands to especially do that. The MSs [Mission Specialists] can all do that. The pilots can do that. But no, the management said no. My input, which wasn't really accepted, was, "Yeah, let them do that. A good psychological thing. It blends them in, allows them to feel like they're more part of the crew. Good psychological and teaming experience." But no, not the case.

I think one of my inputs that probably was heard, certainly, was something about the timing of payload specialist training. In my case, it started more than a year before I flew. Again, I was the first in this cadre of private payload specialists, so they were learning as they went, and I was in training for a year, and part of my feedback was, you don't need to take a year to train them. Again, contingent upon what their schedule will allow and negotiating that, but I'd say a maximum of maybe a year, maybe ten months more realistically as a maximum, and a minimum of maybe six months of training.

I think that the agency and JSC used some of that insight as they prepared "Jake" [Edwin J.] Garn for training, for instance. Because remembering that still to date, the only two congressional payload specialists—well, not counting Senator [John H.] Glenn [Jr.], who flew after, but Senator Garn came into training and then flew on 51-D along with myself; he was the other payload specialist on 51-D.

Right about the time that we flew, there was the agreement with the agency to fly a member of the House of Representatives. So "Bill" [Clarence W.] Nelson came into training then in 1985 and, of course, flew the STS-24, the first flight of 61-Charlie in January of '85. But I think, again, part of the lessons learned maybe was that those guys actually can be trained in just a few months' time, over a few months' time, and become a good, acceptable working complement to a crew.

ROSS-NAZZAL: I'm going to stop here for just a second.

[End of interview]