

Clay Whitehead: So, yeah. I vaguely remember because they were opposed to it. They had these big balloons.

Harold Rosen: Well, that was Echo Balloon.

Clay Whitehead: Echo Balloon.

Harold Rosen: That was the first passive, but actually as I discussed in that paper there, that two of their leading scientists at Bell Labs, J.R. Pierce and Rudy Kompfner wrote a seminal paper in 1959. And it was called "Transoceanic Communication Via Satellites." And it was a very informative paper; it dealt with all kinds of possible communication satellite systems, passive or active, ones that had active repeaters in them, or passive like Echo Balloon was another project then, a crazy one called Needles. I don't know if you remember that. But among the active satellites, they discussed different orbit possibilities including geostationary orbit, which they dismissed as being impractical. They felt that providing the controls necessary in the geostationary satellite would make it too unreliable to be used for a commercial communication satellite system. They felt that the high energy of the orbit would require so much propulsion that you wouldn't have enough payload to do anything useful with it.

And he wrote a pretty convincing put-down of the geostationary orbit and this comparison on various things, and they came out heavily for what the low altitude -- a fleet of low-altitude satellites with no controls that weren't even going to phase them in their orbits. So within your relatively large number to provide yearly continuous communications, there would still be statistical gaps when there were, but very infrequent and that was their proposal.

That was their conclusion based on this study. And I've always felt that one of the reasons it wasn't stated that they opposed the geostationary orbit was perhaps they foresaw that it was a way of getting around their monopoly. With the low-altitude fleet, they considered getting transoceanic communications having a giant terminal on the East Coast, and Paris buying one, and England, and maybe in France that would provide trans-Atlantic communications and maybe later trans-Pacific communications, but there would be gateway terminals and it would all go through AT&T when it reached the United States.

They would still be part of -- it would be an essential part of the loop. But it's the geostationary satellites that can have individual systems around the world, and I think maybe the fear of that was one of the reasons that caused them to oppose it. In any event it was pretty fierce opposition to the geostationary system. In fact, when I -- did you know John Rubel?

Clay Whitehead: No.

Harold Rosen: Did you know him?

Clay Whitehead: No.

Harold Rosen: Well, he was the one who finally broke the logjam; I had mentioned him in that paper. In Washington, he had been a [unintelligible] executive, and he went to Washington to serve in the Department of Defense, and I guess when he got there one of the projects that he was -- inherited was the Advent Communication Satellite Program, which in fact was a geostationary communication satellite.

Clay Whitehead: When was that?

Harold Rosen: That was -- it was started, I guess, in 1959, somewhere around that time scale.

Clay Whitehead: By the government?

Harold Rosen: By the government, but it was like a Tower of Babel; they had -- the Army was responsible for the communication system, the Air Force was responsible for developing a booster for it, and they had -- oh, I forgot which company back east making communication system hardware, and TRW out here in the West Coast was involved in doing some of the analyses for it. It was a big deal. It was a very expensive program, and every year it was going it was getting farther away from meeting its objectives. That is, the mass of the satellite kept growing, and the projected capability, the booster kept shrinking and the difference was great in growing, and this was the situation Rubel inherited when he got to the Department of Defense.

And it so happened that soon after that, he came out to Hughes as a state - - a visitor of a monarch or something when someone high up in the Department of Defense visits a defense contractor. They roll out the red carpet. And so he was -- by that time, the company had gotten tired of supporting our communication satellite program. They were trying to get me disinterested in it. They had asked me to be in charge of the laser development at Culver City, and I wasn't a bit interested in that; I still wanted to go ahead with the communication satellite.

But I was on the agenda for Rubel's visit to talk about our laser work, but instead I told him about our communication satellite work and took him to our lab and showed him the parts that we had built and the -- and he started vibrating. He was so excited about it because he could see that it was a solution to his problem.

So he went back to Washington. When he went back to Washington, he figured out how to unlock the bureaucracy there. What had happened was because the DoD had this geostationary orbit and NASA had an agreement with DoD, that as a result they wouldn't compete with them, and they would only sponsor low-altitude satellite system. I didn't know that when we went to proposed our system to NASA, they just didn't pay any attention to us at all. No comments and no -- just disinterest. Several times we approached NASA.

Of course when we approached the -- Puckett [not CQ] kept trying to get us to sell it to the government, you know, to sell it to Air Force or to the Army, but they had their own project; they weren't at all interested in ours. So it took Rubel to form the Syncom Program. The first thing he did was find a way of aborting or cancelling that agreement between NASA and DoD. He told NASA that DoD needed this program but he thinks NASA should do it, and if they didn't, DoD would or something like that. But NASA finally decided to support the satellite development, and DoD would throw in the ground environment that they had developed for the Advent Program and that's how the Syncom Program got started in 1961.

Clay Whitehead: What were they going to use it for?

Harold Rosen: For -- DoD?

Clay Whitehead: Uh-huh.

Harold Rosen: For communications, just the same way they use satellites now.

Clay Whitehead: Well, point-to-point?

- Harold Rosen: Yeah, yeah. Well, they were going to have field terminals with about an eight-foot-diameter dish that they could get voice traffic.
- Clay Whitehead: X-Band or lower; what band?
- Harold Rosen: Well, it was X-Band for the uplink and S-Band for the downlink; that was the frequencies.
- Clay Whitehead: Back up a little bit and tell me, when did you get to Hughes and when did you get this idea for the geosynchronous?
- Harold Rosen: Well, I joined Hughes in 1956. I had previously been at Raytheon working on guarded -- anti-aircraft guided missiles, which turned out to be quite relevant because the controls required for anti-aircraft guided missiles got me familiar with how to make lightweight independent controls.
- Clay Whitehead: And you got your Ph.D. where?
- Harold Rosen: At Cal Tech.
- Clay Whitehead: OK, that's what I thought. Yeah.
- Harold Rosen: And, you know, like again, in that note I wrote, which you'll get a chance to read, I hope, I mentioned that while I was at Cal Tech, I was studying my first year there, there was a course in physics given by a Nobel Prize-winner, Carl B. Anderson where we got to the part on the dynamics of rotating bodies, which are fairly complicated and it's hard to see through the equations, I asked him if he could explain in a simple way the stabilizing effect of spin on things like footballs when you throw a spiral or artillery shells, or even at that time there were some spin-stabilized

rockets. No, that was before there was spin-stabilized rockets, so it was just the artillery shells and footballs that I asked about.

So he said, well -- we were looking at the -- whole class was looking at those equations, and we couldn't see it but we all -- worked it out together and it turned out to be a simple answer, which was if you look at -- if you have a spinning body and a similar body next to it that isn't spinning and they're both acted on by external torques, how much does the spinning body move compared to the non-spinning body. And the ratio of their motions turns out to be the angle in radians through which the spinning body turns in that time. The spinning body's turning around, so, you know, maybe ten radians a second or something like that.

So after a few hours, it's lost thousands of radians. That means its motion is reduced by a factor of thousands or even could easily be a million relative to a non-spinning body. So it was a very simple relationship to remember and I remembered it. So that when, years later, it must have been ten years later, when I first started thinking about communication satellites, I remembered that and thought I would use -- and I'd read Pierce's article about how difficult it was to control -- actively control a communication satellite. I thought that seemed --

Clay Whitehead: He was thinking about three-axis, wasn't he?

Harold Rosen: Yeah. Well, apparently, I think he was in on being a -- he was a very famous, nationally known engineer at the time and was probably involved in -- is [unintelligible] to the government, and as such, had been aware of the Advent Program, which I wasn't at the time. But he knew how poorly it was going, and he assumed that that was the best you could do. And so I'm sure that influenced his opinion about it. He later, by the way, when he retired from Bell Labs, he came by my office and apologized to me for

his opposing, for the opposition -- because he went to visit Bell Labs once with -- after we had built this company-funded model, we were trying to find us someone to launch it, they were very dismissive and they thought it was a joke.

Clay Whitehead: Yeah, they were very -- they sort of saw everything came from AT&T and Bell Labs.

Harold Rosen: Well, actually, Bell Labs was quite an international resource at that time, and I agree with your opposition to monopolies, but only -- there was one good part about it; they got -- Bell Labs got funding to do a lot of things that all you manatee benefited from.

Clay Whitehead: You know, I worked at Bell Labs.

Harold Rosen: Did you?

Clay Whitehead: Yeah. That was -- MIT had a cooperative program, it was at the master's level.

Harold Rosen: I didn't know that.

Clay Whitehead: And we divided our time between a company and MIT, and I got picked to do the Bell Labs. So I spent -- I had three assignments at Bell Labs. It was an impressive organization.

Harold Rosen: Oh, the things they gave; the transistor alone is worth trillions of -- uncountable.

Clay Whitehead: Uncountable, yeah. No, I agree, that was one of the big losses of --

Harold Rosen: [Unintelligible] even the government, you should've figured out a way of sponsoring research like that without putting the government handicaps on it -- [unintelligible] a really competent people knew what they thought it was important and whether I'm trying to guide them too much.

Clay Whitehead: I agree. I think that was one of the things we didn't -- we thought about it, but we didn't think about it enough, and we didn't really propose a solution.

Harold Rosen: I still don't know what the solution is. Well, Howard Hughes Medical Institute is one solution. I mean, that is one of the things I'm proudest of, that the work we did at Hughes helped contribute to their funding, their evaluation, which in turn is now what, ten billion is their endowment, and they're -- I get a thrill every time I see a Hughes researcher -- a Howard Hughes researcher cited for some recent accomplishment. It's part of our legacy.

Clay Whitehead: But you know, it's changed. I remember when I was doing the Galaxy Project, I spent a lot of time working with Don White, who was at that time, I guess --

Harold Rosen: President, or --

Clay Whitehead: No, he was the controller or he was the chief financial guy. And because the impact Galaxy was in on, the company profit and loss was going to be significant, and I kept telling him that we were going to make them pay taxes, and he and Allens [not CQ] kept saying, "No, no." He said, "We never pay taxes." You know, "We never pay taxes." And I said, "Well, you're going to." And --

Harold Rosen: How to they avoid paying taxes?

Clay Whitehead: Because they took the profits from the government programs and they piled them back into R&D. So the profits became a loss. In an accounting sense, it became a loss. So they always were running at a slight loss, and so in the course of working with the overall company finances, which I had to look at because of the impact we were going to have on them, I found what the dividend was that they were paying to the medical institute. And I don't know if you know how much it was back then.

Harold Rosen: Nothing.

Clay Whitehead: The company was about a two-billion-dollar-a-year company, and the dividend was \$35,000. And I think that one of the things that Galaxy did, among others, it created such a large profit that they couldn't hide it, and so they had to pay taxes, and then the medical institute began to say, "Well, you know, if you're making this kind of money then we ought to get a bigger dividend."

Harold Rosen: Well, I'm glad they did.

Clay Whitehead: Oh, yes.

Harold Rosen: That is such a nice feeling to know that our work has gone to such a useful enterprise.

Clay Whitehead: It is, it really is. So when did you come up with this idea for practical geosynchronous satellite?

Harold Rosen: Why don't you read the first page, first two pages maybe of this. Maybe you should turn off your tape so it doesn't run out while you read. Oh, you don't care.

Clay Whitehead: It's digital so it doesn't --

Harold Rosen: Oh, it doesn't run out.

Clay Whitehead: If nothing's being said, it doesn't do anything.

Harold Rosen: Oh, I see. I didn't know that.

Clay Whitehead: It's a fascinating story. Did you in fact ever put the \$10,000 into the company or --

Harold Rosen: Well, the three of us, we just agreed among ourselves that we would. We didn't.

Clay Whitehead: You didn't actually do it?

Harold Rosen: We agreed we would if we could get some support, and we went to -- went around. Don Williams [not CQ] eventually threw a check for \$10,000 onto Mr. Highland's [not CQ]desk after the thing was -- after Mr. Highland agreed to support the program, and he wanted to invest in part of it. Mr. Highland, of course, didn't have a way of making that happen, but he remembered that and that was -- the part Highland liked to quote was that Williams [unintelligible] bet his own money, but Tom was willing to sacrifice a lot more than Don was.

Clay Whitehead: But what -- I still don't understand what it was that persuaded you that this was something you wanted to do. Why; what got you so motivated?

Harold Rosen: Well, first of all, space was very exciting at that time, and it seemed from talking to people I respected like Tom and John [Mendel] that the world

really needed improvement in international communications, that it would solve a major problem. I mean, there was no international television and [unintelligible] was extremely expensive then. I mean, it was -- in today's dollars, what was it? It would probably be something like \$50 a minute or -- and it was hard to come by. International calls were hard to come by. There wasn't no capacity, so I saw it solving an important demand, creating a solution.

Clay Whitehead: Was it the Pierce paper or was it something else that first got you going on it?

Harold Rosen: Actually, it was John Mendel that told me about the Pierce paper; he was aware of this. He hadn't been at Bell Labs, so he was aware of the shortcomings much more so than I was. I had been their amateur radio operator, and I worked at a radio station when I wasn't keeping up with international communication [unintelligible].

Clay Whitehead: I was an amateur radio operator, too.

Harold Rosen: Really?

Clay Whitehead: Yeah. I still have my license.

Harold Rosen: I don't know if I have one. I know it was W5JKW. That was very exciting for me to have. I was just a little kid.

Clay Whitehead: Yeah. It was exciting for me. I'm now W6WW. I had a -- remember the Heath kits? I built a little kit transmitter and receiver.

Harold Rosen: Yeah. Well, that's how important my high school radio club, that's what we did. We built our own equipment.

Clay Whitehead: Strung up the antennas in the backyard and --

Harold Rosen: Oh, I strung mine between my house and the neighbor's tree.

Clay Whitehead: Yeah. One of the things I did, which was funny, I ran -- because of the way our house was, to run an antenna for 80 meters, it needed to be a long antenna. And so I had a tree in the front yard, but there was nothing in the backyard except a telephone pole. So I climbed the telephone pole and bolted in a bracket and connected my antenna to that end, you know, to the telephone pole, which was completely illegal, of course. And so I would go up and down the telephone pole to make various adjustments.

Harold Rosen: How did you do that; did you have spikes on your --

Clay Whitehead: No. They had the metal --

Harold Rosen: Those ladder things.

Clay Whitehead: Those ladder things, and I used a step ladder to get to the first --

Harold Rosen: Rung.

Clay Whitehead: The first rungs were pretty high up, so I used a step ladder to get up to that, and then I'd climb on their steps up to the top.

Harold Rosen: Did you have a safety strap, or were you [unintelligible] just a daring child?

Clay Whitehead: No. Daring teenager. And then when I got to the top, I bolted the thing on to hold the antenna.

Harold Rosen: That's a good solution.

Clay Whitehead: It was a good solution because the wires -- the telephone wires were maybe two feet below the top of the pole. And so I could work on the top of the pole and put all my stuff there. Well, many, many years later when I was in government and I was moving towards promoting more competition and promoting things like cell phones, and satellites, and cable television, and all that I was invited to meet with John DeButts, who was the chairman of AT&T. And I said, "Sure, I'd be happy to meet him any time. Just have him let me know when he's in Washington." And Ed Crosland, who was the chief lobbyist of AT&T at the time said, sort of pulled himself up and he says, "Well, Mr. DeButts doesn't come to Washington to meet with anyone except the president."

Harold Rosen: Yeah, they had that attitude.

Clay Whitehead: Yeah. So he said, "But, you know, you can come up to Basking Ridge and meet with him there." So I said, "Fine." And we had the meeting. And the thrust of the meeting was, we weren't going to have competition in this country.

Harold Rosen: Oh, he announced that to you?

Clay Whitehead: Yes, he announced that to me, that it was bad for the country, it had been tried 50 years ago, it didn't work, and it was bad, and no one else in the world, no other country in the world had competition, and it didn't fit, and we weren't going to have it. And I said, "Well, there -- that may be true in certain areas, but there are other areas like satellites where we have the Open Skies policy and in cell phones, which you didn't want to develop but Motorola is developing."

Harold Rosen: What year was this?

Clay Whitehead: This was probably '72, '73. And -- probably '73. And he just got more and more angry. You know, and I said, you know, "We're not trying to harm your business, it's just that we think that these other things can develop in a competitive way." And he said, "But they compete with our business." And I said, "Well, that's not necessarily bad." And he said, "There will be no competition." He said, "It just will not happen. I will not be the chairman that presides over the reintroduction of competition and telecommunications in this country." And he says, "Who are you to do this?" He said, "You've never even climbed a telephone pole."

Harold Rosen: He said that?

Clay Whitehead: Yeah.

Harold Rosen: And what did you say?

Clay Whitehead: And I said, "Well, as a matter of fact, I have." I said, "I climbed one of your telephone poles many times to put my ham radio antennas up there." And he just went ballistic.

Harold Rosen: He did?

Clay Whitehead: Yeah, he just went ballistic.

Harold Rosen: Did he try to sue you, or --

Clay Whitehead: No. But he sounded just --

Harold Rosen: He should've laughed. He should've found that amusing.

Clay Whitehead: He should've, but, you know, it's kind of, "Well, you're not supposed to climb our telephone poles, and besides, that's not what I meant by climbing a telephone pole." And he just -- anyway.

Harold Rosen: Well, there's a similar incident on the arrogance of AT&T in those days. After I finally got the government program, the Syncom Program started, Bell Labs and AT&T were really mad at that. And they -- the head of Bell Labs went to visit John Rubel, and John Rubel reported this to me later. He said, "I just got a visit from so-and-so," I've forgotten his name, "who was the head of Bell Labs, who mentioned to me that he had just finished coming from talking to the president of the United States." And -- "But what he wanted to tell me was that that traveling-wave tube that you were developing for Syncom wouldn't last one month, and you're going to have a disaster on your hands, and you really shouldn't continue with that program." So they tried hard to stop it.

Clay Whitehead: They tried hard to stop a lot of things.

Harold Rosen: But as you mentioned, the arrogance was pretty profound.

Clay Whitehead: So Syncom was to be a prototype for a commercial satellite or --

Harold Rosen: Well --

Clay Whitehead: Or it was meant to be a commercial satellite?

Harold Rosen: Well, Don, and Tom, and I wanted to create a commercial communication satellite set. We wanted Hughes to go into the business that you eventually [unintelligible].

Clay Whitehead: Hughes Communication.

Harold Rosen: Yeah. But they weren't having any of that; they just wanted -- so we'd settle for what we could get. You know, it wasn't until Tom Phillips of Raytheon -- I don't know if you got that [unintelligible].

Clay Whitehead: I did.

Harold Rosen: Did you know Tom Phillips, or know of him?

Clay Whitehead: Uh-uh.

Harold Rosen: Anyway, he and I -- he started RayTel in the few years before I did. I worked for RayTel while I was still at Cal Tech. I worked for them during the summers and one or two days during the school year. That was a very good experience for me, and then when I graduated I worked for them for a long time before I joined Hughes working on guided missiles, which is very exciting.

Clay Whitehead: Did you know Sid Topol when you were at Raytheon?

Harold Rosen: The name's familiar, I can't picture him, though. In any event, Tom had become executive vice-president at the time I was struggling to get some financing from Hughes, and I finally gave up with Hughes, and I called Tom and told him I had an idea he might be interested in. So he invited him there, and Tom [Hudspeth] and Don Williams joined me on this trip to Raytheon. We were greeted by their top management. The president of Raytheon at the time was Charles Francis Adams, III [actually the IV] I think. And Ivan [Getting], I don't know if you [unintelligible]. He just won a -- he died about a year ago, but just before he died he got a Draper

Prize for having started the GPS system. I mean, it was his concept [unintelligible]. But he was at this meeting, and Charles Francis Adams was chiding me saying, "You know you're a great [unintelligible] the president of Raytheon. Have you had a discussion with the president of Hughes?" who happened to be Howard. He was really teasing me.

Anyway, Tom found it very interesting and wanted to pursue it, but he didn't want to -- I mean, we were hoping he would just invest in us. But he wanted us to join Raytheon and make it a Raytheon project; I can understand that.

Clay Whitehead: So you really wanted to create a business that you owned?

Harold Rosen: I wanted to, yeah, but I had no way of doing it. I mean, we tried, but we did everything we could within reason. I wanted to own a piece of it anyway.

Clay Whitehead: Right, right. That, by the way, is what we should've done with Hughes Communications. We should've --

Harold Rosen: Made it a public company?

Clay Whitehead: We should've made it a separate company that Hughes owned maybe a controlling interest in, but let the management and some other people own part of it and make it [unintelligible].

Harold Rosen: Oh, that would've been nice, yeah.

Clay Whitehead: Yeah. But that didn't fit the Hughes way of doing things. So --

Harold Rosen: The government business is so much different than commercial business. I mean, I [unintelligible] Raytheon. I mean, at Boeing, you know, they just love these government projects that almost never reach a conclusion, they just keep going forever, and --

Clay Whitehead: Right.

Harold Rosen: Everyone's happy, except the taxpayers, but they don't know about it because it's all classified and so --

Clay Whitehead: Well, anyway.

Harold Rosen: Anyway, Tom said, "We'll do it. We'll make it a serious Raytheon project." And he said, "You know, I know you want to do it on your own, but you will find it's a lot harder than you think to get something like this started, and you'll need the resources of Raytheon to make it happen." And he was really right; I think it would've been very difficult.

Clay Whitehead: They were a more commercial company than Hughes at that time.

Harold Rosen: Yes. So anyway, they -- I decided to take up his offer. So I let the other two guys decide for himself; I think Tom wanted to take it up, but Don didn't. He was still wanting to hold out for ownership. So when we came back I told -- Frank [Cartrow] [not CQ] was resigning, and he brought me to see Puckett [not CQ], and then Puckett brought me to see -- I didn't believe Puckett anymore. So he brought me to see Highland [not CQ], and Highland said, "Well, we'll fund the development," which started that thing that's ended up in that report in 1960. That picture we had there, that was all funded by the company.

It was an incredibly short time. Actually, it seemed like interminable to me at that time before -- but then, nothing happened even after we built that operating prototype basically, until Rubel came along and broke the bottleneck in Washington, and then we had a program and that was --

Clay Whitehead: And who paid for it; the government or Hughes?

Harold Rosen: It was a NASA program. They paid for the development of three -- a prototype and three -- five -- models, and they paid for the launches. And the DoD supplied all the ground terminals that were used including a ship in the harbor of [Allagos] that was used for the down-range control terminal [unintelligible] launches.

Clay Whitehead: And the first one, Syncom 1 was successful, as I recall.

Harold Rosen: No.

Clay Whitehead: No?

Harold Rosen: It blew up. It's in there.

Clay Whitehead: I didn't get that far.

Harold Rosen: Well, it was launched successfully and was working OK in the five-hour torrential orbit, but the apogee motor was supposed to burn for 21 seconds, I think, and at 20 seconds all signals disappeared forever. Then there was a big, crushing disappointment, but we tried to figure out what happened. It was pretty obvious, the apogee motor had blown up and they weren't supposed to; they were supposed to have plenty of margin. So we also indicted the compressed nitrogen tank that was supplying the compressed gas from one of the control systems we had. And another

possible lead is that some wires, critical wires broke. I didn't believe either of those other two, but we changed everything before the -- including that. The most important thing we changed was the apogee motor; we changed to a JPL model from Thiokol.

Years later, when a surveyor that was landing on the moon used a Thiokol engine of similar design, and it disappeared under the same circumstances, just -- I think Thiokol went back and examined some of its tools and measuring techniques and determined that they were really machining part of the titanium case too thin in parts. So, anyway, I'm -- it was the engine that blew up, so that was really bad, but it was only -- that was in February, middle of February of 1963. And then by July 26th we had Syncom 2 launched and it was successful. And then things started to move.

We changed Syncom 3 to one of the receivers, they have enough bandwidth for some crude television. Previously it was only limited to some voice channel. And that's how we got the Olympics.

Clay Whitehead: And was that what became Early Bird, or was Early Bird a separate --

Harold Rosen: No, that was a separate -- Comsat had been -- actually, Comsat was formed by an act of Congress; I think they were incorporated on the day Syncom 1 was launched, very close to that in 1963, February '63.

Clay Whitehead: Was there a tie-in between what you were doing in Syncom and the formation of Comsat?

Harold Rosen: No, no. Well, Comsat, really, they planned to use an AT&T-type system at the time they were formed. Well, there were hearings before they were formed. There were propositions for all kinds of satellite systems, but

really, they were funded. The initial funding was partly from industry and partly from the public. And -- but they raised \$200 million in capital, which was a lot at that time. And that was in order to fund a cloud of low-altitude satellites but that was -- that planning was done before Syncom, and Syncom wasn't supposed to work. Well, when Syncom 2 worked successfully they started paying attention, and so in 1964 they contracted for a -- let me think what date it was. It was around April of '64. They contracted for Early Bird much to the dismay of RCA and AT&T who were proposing other systems, which cost -- the program cost them only a tiny fraction of the money they raised, so for the early years of Comsat most of their income came from the interest on the funds they didn't spend.

In the meantime, Early Bird was generating revenue and lasting -- working very well. Then Comsat helped create the Intelsat. They wanted partners and so they invited the people from German, and French, and Italian, and English telecommunication operations over for meetings.

Clay Whitehead: That was a Kennedy initiative, wasn't it; John Kennedy?

Harold Rosen: Comsat --

Clay Whitehead: Was Comsat a John Kennedy initiative or was Intelsat?

Harold Rosen: I don't know about Intelsat. I don't know where the initiative came from Comsat -- I mean, they needed partners to communicate internationally. I don't know that -- but he was involved. He was very much interested in our satellite program. As a matter of fact, there was a -- I'm sorry I never got a hold of it, I didn't try too hard, but I saw in a newspaper after he was assassinated what a -- his doodle pads from one of his best meetings and he had a -- something that looked like Syncom sketched on it.

Clay Whitehead: Oh, really?

Harold Rosen: Yeah, yeah.

Clay Whitehead: That's interesting.

Harold Rosen: But he did talk to the prime minister of Nigeria over Syncom.

Clay Whitehead: Interesting.

Harold Rosen: Using that.

Clay Whitehead: And Syncom was over the Atlantic, right?

Harold Rosen: Yes.

Clay Whitehead: Yeah. And then Comsat became your primary source of business?

Harold Rosen: Yeah, an only source. They had a monopoly.

Clay Whitehead: They had a monopoly?

Harold Rosen: Yeah. And then they had a monopoly until, I guess, Telsat of Canada. I'm not sure who came next. There were some domestic satellites. I think Telsat of Canada was our first --

Clay Whitehead: The Anik Satellites, I think, were the --

Harold Rosen: Yeah. So we had a nice relationship with the Canadians on that program and started [unintelligible] and then more advanced versions later.

Harold Rosen: Right.

Clay Whitehead: So as you went from Intelsat 1 -- Intelsat 1 was Early Bird?

Harold Rosen: Yeah.

Clay Whitehead: And then Intelsat 2 --

Harold Rosen: Now, that Intelsat 2 was a government program. You know what I mean, it was supposed to provide communications for the Apollo Program. They were -- the Apollo Program was starting and they wanted to have better international communications because they needed sites around the world. And so it was kind of a large Early Bird in configuration.

Clay Whitehead: Where was it located?

Harold Rosen: I think they had one over the Atlantic, one over the Pacific. I forgot how many were actually launched. The first one had a failure but the apogee motor didn't work properly so it was in a loopy orbit, but the others worked OK. And --

Clay Whitehead: Were they owned by the government or were they owned by Comsat?

Harold Rosen: They were owned by Comsat; we rented the service to the government. Then that was followed by Intelsat 3, which was a competent -- at that time, you see, the European partners were still holding out for low-altitude satellites at the time Intelsat 3 was procured. So they wanted their procurement as for a satellite that could operate either at geostationary orbit or at low-altitude or at medium-altitude orbit. So it was a terrible procurement. And we didn't win it; TRW did.

And they had some technical problems; they had a bearing in it that froze up for de-spinning their antenna that would freeze up in the summer time when the sun was shining on it. The temperature changes would cause it to freeze.

Clay Whitehead: Was it a spin stabilized of three-axis?

Harold Rosen: It was spin stabilized but it had a de-spun antenna, but the de-spun antenna wouldn't de-spin so they had to invert it twice a year to keep the sun off of the antenna, so it was kind of a nuisance for them, and I think that convinced TRW to get out of the commercial communication satellite business.

Clay Whitehead: Didn't you have a patent on the spinning satellite?

Harold Rosen: We used to have patents, various patents on it. Well, there were a [unintelligible]. Apparently when we had the NASA Program there were some words in it where NASA claimed they owned the intellectual property and it was still in dispute at that time. In fact, these people were known in the courts for 20 or 30 years, I think. And the patent we had wasn't well-written, I remember, the fundamental patent.

Clay Whitehead: That's interesting. So when did the government start procuring satellites directly?

Harold Rosen: Well, they were doing it all the time for -- Rubel was succeeded by phoning [Gene Foobeenie.] [not CQ]

Clay Whitehead: Oh, I knew --

Harold Rosen: He was a crack-pot, I thought. Did you know him?

Clay Whitehead: Yeah, I knew Gene. I think he was a crack-pot but he was a fun crack-pot.

Harold Rosen: Yeah, he was fun, but he still insisted control systems weren't reliable, so he made a satellite system for the DoD that was at geostationary altitude but wasn't controlled, just drifted around. So it was a random orbit geostationary altitude system. And the advantages of [unintelligible] coverage, but the disadvantage, it moving, but they launched enough of them. They launched them on Titans; the Titan Rocket, the [unintelligible] Rocket. They launched a lot at the time and they felt they had a lot of them so that during the Vietnam War they had some communications from Vietnam -- over the -- what was the name of the system? Not Tacsat, I forgot the [unintelligible] they used, but -- [Discus]. Discus 1. So it was an expensive and very low-capacity system, but it was -- it worked.

Clay Whitehead: Did Hughes build that?

Harold Rosen: No, no. I think Ford maybe, Philco-Ford.

Clay Whitehead: That's right, it was Ford. Yeah.

Harold Rosen: It's a terrible system but -- a terrible concept.

Clay Whitehead: Yeah. The government always had -- they had so many people interested in it. The interagency fights were so intense, yeah. So when did the CIA and NSA get interested in this?

Harold Rosen: Well, that's Bud Wheelon's doing. Bud was the one who got the CIA --

Clay Whitehead: When did Bud come to Hughes?

Harold Rosen: In the '70s, early '70s, I think. Maybe '73, I don't know. I'm going to see him tomorrow. I have lunch with some of my old colleagues once a month. We have a luncheon group.

Clay Whitehead: Yeah, he told me. I don't think he's going to be there.

Harold Rosen: He isn't? Oh, he hasn't responded to the --

Clay Whitehead: I talked to him because I wanted to try to catch him on this trip, and he's in Canada visiting his daughter.

Harold Rosen: Oh.

Clay Whitehead: He said I would probably enjoy meeting the group sometime, and I --

Harold Rosen: Oh, yeah.

Clay Whitehead: Maybe next time I'm out here.

Harold Rosen: Oh, [unintelligible] there; he's always fun.

Clay Whitehead: Yeah.

Harold Rosen: And Steve [Dorfin] [not CQ] is great.

Clay Whitehead: Well, tell them a hello for me, will you?

Harold Rosen: I will. We take turns being the host; I'm the host tomorrow. So I'll drink a toast to you.

Clay Whitehead: Well, if I can work the schedule out, next time I'll be the host.

Harold Rosen: Well, you're welcome to join us tomorrow. There's a vacancy.

Clay Whitehead: I can't, I can't because I've got to work all day tomorrow.

Harold Rosen: What are you working on; a book, or --

Clay Whitehead: No, unfortunately. We're building a new house.

Harold Rosen: Oh, where; here?

Clay Whitehead: No, in Washington, but our architect is here.

Harold Rosen: Really?

Clay Whitehead: Yeah.

Harold Rosen: That's interesting.

Clay Whitehead: The architect is an old friend; we've known him forever and we finally decided that our house had to be torn down. It was just a -- Margaret did a fabulous job of decorating it, you know, but structurally it was just terrible, and the maintenance costs just kept going up and up and up, and -
-

Harold Rosen: Where are you building?

Clay Whitehead: It's on the same lot; we tore down the house and we're building in the same place. It's in McLean. It's about a mile or further out than the CIA.

Harold Rosen: Anyway, it was Bud who noted the success of Syncom and decided the CIA ought to get involved in space actively. Well, he pushed the various reconnaissance programs.

Clay Whitehead: And he did that while he was in the CIA?

Harold Rosen: Yeah, while he was in CIA, and then he was hired by Hughes and Allen put him in charge of the Communications Satellite Program.

Clay Whitehead: Right.

Harold Rosen: Programs. Or head of the Space Division [unintelligible].

Clay Whitehead: Space Division. Yeah.

Harold Rosen: Because as far as I was concerned that was the wind communications satellites, but we had some other things too. We had some weather satellites.

Clay Whitehead: You had the weather satellite.

Harold Rosen: Yeah.

Clay Whitehead: And you had the -- what was it called; Pioneer?

Harold Rosen: Oh, Pioneer ran out of Steve Dorfin's program. Yeah, we had some -- that was good, and Galileo also.

Clay Whitehead: Yeah.

Harold Rosen: Pioneer Venus was a fun program.

Clay Whitehead: That was good.

Harold Rosen: Then we had the Surveyor.

Clay Whitehead: And the Surveyor, yeah.

Harold Rosen: Surveyor's something I'm interested in now, by the way.

Clay Whitehead: Why is that?

Harold Rosen: Well, have you heard of the X Prize?

Clay Whitehead: Oh, yes.

Harold Rosen: Well, the first X Prize I heard of is one that a friend of mine named Burt [Rattan], well, you know, he built our -- he designed our airplane, but he wanted it for sending people up 100,000 -- or he sent his pilot up 100,000 meters, which officially is space.

Clay Whitehead: Is space, right.

Harold Rosen: Yeah, it's more of, like, an amusement-park ride but that's into his -- it's not really a step on the way to getting people into orbit because the energy is no small. So -- but he won the prize and he won \$10 million, and Paul Allen was his sponsor, and Paul Allen spent about \$20 million instructing the airplanes and the rockets that did it, but he was happy, and Burt Rattan was happy.

And Richard Branson decided to make a commercial enterprise out of it. They suffered a setback a few months ago when there was an explosion, a terrible explosion while they were fueling the --

Clay Whitehead: It was the solid rockets, wasn't it?

Harold Rosen: No. It was a hybrid rocket of some kind. I think it had liquid -- it was a liquid-solid -- I forget exactly what it was, but I know there are liquids involved. And I always thought he should've used a solid rocket, it would've been simple for them, but they used a hybrid because, I think it was so he could take baby steps with it. A solid, you -- once you light it goes all the way, but with the liquid you could load up different amounts of liquid and get -- you could try gaining altitude more slowly, at least one step at a time. We were all concerned, I guess, about going up to the 100,000 meters, but it had its own problems apparently.

I don't know if Richard Branson is [unintelligible]. He thought he could sell tickets for \$200,000. I guess so because one of my neighbors, Dennis [Tito] spent \$20 million for a ride on a Surveyor Rocket.

Clay Whitehead: There are people who will spend that much money.

Harold Rosen: Well, there are people in New York who will spend \$100 million on a painting that I wouldn't hang up in my room if someone gave it to me. So it's hard to say.

Clay Whitehead: So what's your interest in Surveyor currently?

Harold Rosen: Well, apparently you missed it, but about two months ago -- the X Prize is not only for that, but it's a general prize thing, they're trying to give out prizes to simulate -- they use Lindbergh's Spirit of St. Louis where he --

in flying across the Atlantic in response to a prize; he did that for a \$25,000 prize, and he got the senior -- some bankers in St. Louis to sponsor him, and it helped really stimulate commercial aviation and it had a major effect, and they thought that prizes could create a lot more [entrepreneuring] and a lot more inventiveness and so it's possible.

Clay Whitehead: Well, I think it's a good idea.

Harold Rosen: So anyway, this other thing caught the attention of these young kids who started Google, so Google decided to sponsor a prize for a private enterprise with no government money that would land a craft on the moon that would take pictures of its arrival and the surroundings and then move at least 500 meters and send back to Earth a moonscape that they were going to stipulate how many bits in the pictures and pixels and everything.

So the Surveyor Program was being created -- was being developed at Hughes concurrently with the Syncom Program, and one of the differences was they had about 100 times as many people on their program as we had on -- and it cost about 100 times more.

Clay Whitehead: Probably 100 times more money, yeah.

Harold Rosen: It did. It cost five -- it ended, it was bid for \$50 million, but it ended up costing \$500 million and lasted a long time. And it was kind of like the Advent configuration, it was a free-axis configuration and a very -- they did a -- based on that, they did a marvelous job in the end. I mean, because the first one worked.

Clay Whitehead: Yeah.

Harold Rosen: The second one didn't, but the first one did, and it was a difficult thing.

Clay Whitehead: And who built that?

Harold Rosen: One who built -- Hughes built it.

Clay Whitehead: Hughes built it?

Harold Rosen: Yeah. Well, I said it was --

Clay Whitehead: Yeah.

Harold Rosen: It was in the Space Division and going on while Syncom was, and all the while they were doing that it occurred to me, "You know, what they're doing has about the same basic level of complexity as what we're doing with Syncom." It's got to communicate, it's got to have a number of controls, and rockets, and solid rockets, and liquid rockets, and it's got to be able to go where you want it to go and -- so I couldn't imagine why it should be that complicated, so I looked at a spin-stabilized version of Surveyor.

And once I even went to see Dr. William H. Pickering, who had been my advisor, my thesis advisor at Cal Tech. I knew him well. In fact, he's the first one outside of Hughes that I talked to about the communication satellite. I wanted to see and get a thoughtful, independent view of whether he thought it might be practical or not. So he kind of sat on his front porch looking at what I was proposing. He said, "You know, Harold, I think that contraption of yours might work." That was his response.

Anyway, I went to see him during the Surveyor Program, they were the dark days. I probably shouldn't have done it, but I said, "You know, you

could do this a lot more easily if you use this configuration." And he was really intrigued, but he said, you know, "It's too late, too late, too late." But I never forgot it, and when Google offered \$30 million a prize -- it's divided up; \$20 million is the first prize for the first team to do it, five million dollars for the second team, and then a million dollars of bonuses distributed among the different set of tasks. So instead of going 500 meters, you go 5000 meters, you get another million dollars. If you can last through the lunar night, you get another million dollars.

But I think I can get the \$20 million first prize and the 5,000-meter roving, so I think that's possibly \$21 million, and then if I could find the sponsors, but --

Clay Whitehead: Who would build it?

Harold Rosen: Here's the thing, in order to make it really -- you could do it like they did Surveyor, and today it might cost almost as much. It would be the same ballpark, I think, considering the fact that technology's improved quite a bit but inflation has gone up, in terms of dollars it might be that same ballpark if you tried to do it like Surveyor, but I want it to be a profit-making thing. So I want it -- so they did say that they -- have you ever heard of Elon Musk; does that name mean anything to you?

Clay Whitehead: No.

Harold Rosen: Well, he's a software guy who made a mint and made a fortune in PayPal. That's that -- so for some reason, he decided he wanted to get into the space business.

Clay Whitehead: What's the name?

Harold Rosen: Elon Musk; E-L-O-N is his first name, M-U-S-K. Anyway, he formed a company to create -- he says, "The government doesn't know how to make boosters. The space program is not getting anywhere because boosters are too expensive. I'm going to make a cheap one." So he started a company that's in El Segundo not -- within walking distance of my office, and I visited him and he was nice enough to show me around and tell me what his plans were.

The thing about rockets is they haven't changed very much in 50 years; their performances are the same as they were. There's nothing you can do about --

Clay Whitehead: Physics hasn't changed.

Harold Rosen: Physics hasn't changed, and chemical combinations haven't changed. So I didn't see how -- and there was a lot of competition in the rocket business. There's plenty, but he thought he could -- so he's making a small rocket that he hopes to sell. The last number I saw quoted was \$6.7 million. That would get him a small payload into a low-altitude Earth orbit. OK. And the Google lunar prize said they recommend that we look at his rockets called the Falcon.

Well, he's years behind schedule, he postponed his first flight for a long, long time. And then finally, it was a complete failure, and the second flight was -- did better; the first stage worked but the second stage didn't. There was a problem at the separation. So he's just had two flights so far. So normally, you'd call it two failures, but he calls them successes in the sense that he learned something each time. So -- but I don't see any reason why, if he sticks with it, he can't get -- in the meantime, he convinced NASA that by using a large number of combinations of his stages, putting

them in parallel they could transport things to the -- oh, what do you call it -- the orbiting station -- I can't think --

Clay Whitehead: Space station?

Harold Rosen: It's the space station, that crazy thing we have going around.

Clay Whitehead: One of my great failures in the government was that I didn't succeed in killing the space station.

Harold Rosen: Well, I'm sorry you didn't. And you know, I failed to because we were friends with one of the congresswomen, Jane Harmon. I've known her for years, and before her critical vote on it, I spent a long time telling her how terrible that was, what a waste of taxpayers money it was, it was counterproductive to space exploration, everything. And what she did was she took my remarks and gave them to Dan Golden the next day. And Dan Golden proceeds to call me up and say, "Harold, you don't understand. The manned space program is doing so much for you, man. You don't know the medical advances we've made."

Clay Whitehead:

[REDACTED]

Harold Rosen: Yeah. So he said, "Why don't you come to Houston? We'll show you all the great things." I said, "OK. Invite me." But then, I think the next day Congress voted for a station and that was the end of that.

Clay Whitehead: I was -- the first Apollo landing was 1969, and I was the guy -- NASA had come up with this program; what do we do next after Apollo. And it was just horribly grandiose; we were going to build a shuttle to go the space station, and then we were going to go to Mars. You know, and it was tens of billions of dollars, and it was just outrageous.

Harold Rosen: Well, trillion maybe.

Clay Whitehead: Trillion, yeah. And so it felt -- and Lee DuBridge was the science advisor to the president at that time. And he just thought it was all great. You know, like --

Harold Rosen: He did?

Clay Whitehead: Yeah, let's just do it all, you know?

Harold Rosen: He wasn't that bright.

Clay Whitehead: Yeah, and he wasn't --

Harold Rosen: He was a good politician.

Clay Whitehead: Yeah, and he didn't have any sense of money, budget reality. So I was the guy who was responsible for sorting out what are we really going to do and making the recommendation to President Nixon about what we would support. And we quickly threw away the man on Mars, we threw away the space station because there was no logical, you know -- if you're not going to Mars, there's no logical reason to have the space station And we agonized about the shuttle. The model that NASA had of putting these things up once a month --

Harold Rosen: Once a week is what Fletcher [not CQ] said.

Clay Whitehead: Once a week, yeah. Was just --

Harold Rosen: Remember when you and Fletcher were advising Bud?

Clay Whitehead: Yeah. It was crazy, it was just totally crazy. So I spent a -- the question in it was: "Why do we want man in space?" And there wasn't any good answer.

Harold Rosen: Yeah, well, that's right, there isn't.

Clay Whitehead: There's no good answer. So --

Harold Rosen: They're counterproductive, actually.

Clay Whitehead: Yeah. So the issue then became: "Do we abandon a manned space program?" And that depended on one thing: what were the Soviets doing? Putting man in space. And I spent days upon days upon days talking with the CIA and other people about what are the Soviets up to, what are they going to do with their manned space program, and nobody could give me an answer; we just didn't know what the Soviets were doing. So --

Harold Rosen: But they couldn't think of anything useful in a military sense?

Clay Whitehead: No. I mean, the Air Force didn't have any use for it. So what we finally decided was that we had to maintain some kind of minimal manned space capability, and --

Harold Rosen: It's too bad you couldn't have killed it then.

Clay Whitehead: Well, but, you know, from a larger strategic point of view it wasn't prudent for the U.S. to give up that because if you gave it up and then tried to start it again it would be tremendously expensive, and it would be very hard to restart a manned space program. So we said, "What's the --"

Harold Rosen: You'll just have to justify it.

Clay Whitehead: Yeah. So we said, "What's the cheapest way to maintain a minimal manned space capability?" And the answer was the shuttle. We never thought that it would become the major launch vehicle because we thought the expendables would continue. Anyway, I did my bit to try to kill --

Harold Rosen: Well, thank you.

Clay Whitehead: -- the space station.

Harold Rosen: As a concerned citizen, I appreciate your efforts.

Clay Whitehead: As you know, I did not succeed.

Harold Rosen: And that you know, I did not succeed, but there was a lot of [unintelligible]. Well, they continue to be -- it really pains me so much when the manned program is used synonymously with space exploration; that's the antithesis of space exploration. It keeps -- it's in the way of space exploration.

Clay Whitehead: Oh, yeah. And the unmanned things are producing such great results.

Harold Rosen: Yeah, the little rovers. Yeah.

Clay Whitehead: Nixon didn't have much use for space, and do you remember the Viking program? Was that a Hughes program?

Harold Rosen: No. Was that the moon lander, or --

Clay Whitehead: That was the mars lander.

Harold Rosen: Mars lander, oh, yeah.

Clay Whitehead: And NASA had spent about half to three-quarters of the money to build that program, but it of course was running over budget. But they were close to finishing it, and the Budget Bureau convinced Nixon that it was a waste, and they killed it.

Harold Rosen: Really?

Clay Whitehead: Yup. And I thought that was just wrong; I thought we really ought to do it. In part, because I was skeptical of all this manned stuff and sending something to the surface of Mars, and getting pictures back for the first time would be a really significant edict. So I went to John Ehrlichman, who was then the head of that kind of policy stuff in the White House, and I said, "Is the president really opposed to Viking or is it just budget?" And he says, "It's just budget." And I said, "If I can figure out a way to save Viking but cut an equivalent amount of money out of the rest of NASA, would you agree that you and I will go back to the president and reinstate Viking?" And he said, "Fine."

Harold Rosen: Oh, that was great.

Clay Whitehead: So I told Jim Fletcher, I said, "Jim, we can do this." And he said, "OK." He said, "I'll bring some of my budget people, and we'll come over, and we'll work it out and see what we can do." And I said, "No, Jim." I said, "It's going to be you and me, just the two of us, and we're going to go through the NASA budget, and we're going to find \$150 million." And he came over on a Saturday morning to the old EOB where my office was, and all day Saturday we went through the budget. And I'd say, "How

about this? Here's \$10 million." He'd say, "Oh, no. You can't cut that." I said, "OK, where can we cut?" You know, and we got it here, and we got it here finally, and we got that \$150 million out, and I said, "OK, now you're going to sign that you agree to this."

Yeah, so he sent me a memo saying that he would agree to all of that. And then I took that memo and wrote a memo to the president and said, "We've offset this, and the Viking mission is important, and by the way, Mr. President, the first pictures will come back in the last year of your presidency." So I was doing a little bit of salesmanship. And so the memo came back approved, and so we saved Viking.

Harold Rosen: Well, thank you for doing that. Well, that was great.

Clay Whitehead: And JPL was nice enough to invite me over for the first night when the pictures came back.

Harold Rosen: Oh, isn't that exciting?

Clay Whitehead: And that was really exciting.

Harold Rosen: I've been at a JPL function, similar with the Cassini Mission when they fired their big rocket -- I mean, it went for about 60 minutes, they were burning the rocket to get into orbit around Saturn. That was a thrill.

Clay Whitehead: That was a thrill. I remember -- I don't know how it is now; it's probably faster, but, you know, in Viking the pictures came back, the raster speed was maybe one line of maybe --

Harold Rosen: It's a tough communication leg.

Clay Whitehead: Yeah, it was -- I'd say it was maybe 30 seconds for each line. And so the picture came back just excruciatingly slowly, but nobody knew what we were going to see.

Harold Rosen: That's what makes it, like, an exploration.

Clay Whitehead: Yeah. No, I think NASA should put much more of its budget in that kind of thing.

Harold Rosen: Oh, absolutely. And the mission to Mars is squeezing -- even though it's so stupid and it will probably never happen, but it's managing to really disrupt the scientific program by stealing all the money. Yeah. And the leader they have now, [Anthony] Griffith, he doesn't see that. I mean, he - - "This is what the president wants." The president didn't want it. I don't know who wrote that thing for the president.

Clay Whitehead: I don't either, but it was clearly somebody who said, "We're not going to do very much and we're going to leave it to the next president."

Harold Rosen: Well --

Clay Whitehead: Anyway. So --

Harold Rosen: So anyway, I'm going to --

Clay Whitehead: You're going to do the next prize, huh?

Harold Rosen: I'm going to win it. In fact, I have a little toy in my car. Before I leave, I'll show you the -- because I did it a long time ago during this era 45 years ago. I took a skate wheel -- they used to be steel roller skates, they had pretty good bearings in them -- and I put some hairpins through the

middle and spread them out to make four legs. And then I could drop it without spinning it over. Say this table here, and poop, and it went pop upside down. Then I'd spin the skate wheel, and I'd drop it and it would just go pop, [unintelligible] every time, and I could put any kind of obstacles under it and it would always be stable when it was spinning. And it was always unstable when it wasn't, the way I constructed it.

Clay Whitehead: So what is this --

Harold Rosen: I made a new one now, but they don't have that kind of skate wheel anymore; they have skateboard wheels, which are bigger. And I didn't want it to be -- with hairpins I was kind of constrained to use an even number because I used two hair -- two isn't enough legs, four is really too many. I used two hairpins --

Clay Whitehead: Three.

Harold Rosen: So I wanted three, but -- so I had to do some soldering with some piano wire to make a three-legged device, but I made one and it's kind of cute.

Clay Whitehead: Well, what does this thing do when it gets on the moon? It takes pictures, huh?

Harold Rosen: It just takes pictures, sends them back to Earth and does what Surveyor did, but more; Surveyor didn't rove. It does what the man on the moon did; they had a rover eventually. So it goes from one place to another.

Clay Whitehead: Aren't the Japanese going to do something like that?

Harold Rosen: I don't know. The Chinese are.

Clay Whitehead: Chinese?

Harold Rosen: Chinese are trying to emulate what we did 45 -- I don't know why, but I'm glad they're spending their money on that.

Clay Whitehead: So if you did this X Prize thing, it would be a quasi-commercial venture, yeah?

Harold Rosen: Well, the sponsors are -- have the same motivations Paul Allen did or that the bankers in St. Louis did for sponsoring -- not for the profit, although the intention would be to get a profit, but you can't guarantee you'll win. You have to come in first.

Clay Whitehead: Are there other people who are likely to --

Harold Rosen: Well, the only design I've seen -- a weekly paper called *Space News*, I don't know if you're familiar with that. It's got some --

Clay Whitehead: Yeah. I don't read it, but I know about it.

Harold Rosen: Well, they had a front-page article a couple weeks ago by Carnegie Mellon Institute that claimed they're going after the prize, except they're going after it in a much more complicated way, and I don't think they understand the problem. They think they're -- they've got a shot at it because they made robots, robotic cars that sense [unintelligible].

Clay Whitehead: I remember that. So is Rattan interested in this, or is --

Harold Rosen: Rattan?

Clay Whitehead: Is Burt Rattan interested?

Harold Rosen: Oh, no. Well, I haven't talked to him about it. He's consumed [unintelligible] other things. No, no, no, no. Yeah, I'll show you what the --

Clay Whitehead: I know a guy who might be interested in putting up some money.

Harold Rosen: Well, let me show you what I've got. Let me show you what I've got. This is just some brief announcement of the prize.

Clay Whitehead: Will it have two-way communication?

Harold Rosen: Well, yeah. I mean, you have to command it. It has a command -- it has mainly a telemetry thing, but it also has a wideband downlink for the video, however --

Clay Whitehead: How about a communications uplink?

Harold Rosen: Well, it -- that's just a command link to this -- but there's nothing to communicate to, but this --

Clay Whitehead: But you could communicate data to make it a repeater, right?

Harold Rosen: You could, yeah.

Clay Whitehead: You could?

Harold Rosen: You could. You could. Oh, if you wanted to get messages from the moon, yeah, you could do that.

Clay Whitehead: Yeah.

Harold Rosen: That would be no problem. This is what the Surveyor looked like. And it was really a complicated beast; it had all kinds of -- the mission was complicated by the fact that it wasn't spinning.

Clay Whitehead: Right.

Harold Rosen: This is the -- now, it had an easier job in one respect; it [unintelligible] that was Centaur and the Centaur put it in a translunar trajectory. But Centaurs -- I mean, to go on a Centaur these days you got to spend \$100 million for the rocket or something on that order for an [unintelligible] with Centaur or -- any rocket that we do similar to the Surveyor program would cost \$100 million besides the cost, so I want to use the six-million-dollar rocket.

Clay Whitehead: Right.

Harold Rosen: The six-million-dollar rocket looks like this. This is the Falcon; that's Elon Musk's thing that's being built.

Clay Whitehead: Assuming he can make it work.

Harold Rosen: Well, he's going to make it work. He's got some government funding now to help for -- and he's committed to making it work so -- and there's nothing about it that precludes him for solving the problems except -- so this is the payload that goes into this payload compartment up here, and it consists of -- this is the Star 30 Rocket, which is the apogee motor for all our 376 Programs. So we have a lot of experience with this and it works very well. And this gets you from this low-altitude orbit into the translunar trajectory. And then this is -- when you get close to the moon,

you have to kill your approach velocity and that's what this does, the big solid rocket. And then you have to --

Clay Whitehead: Eject that.

Harold Rosen: -- eject it, and then you'll land this thing that looks like that. And this whole thing is spinning including -- the legs aren't spinning; it has a de-spun part that has a communication system. Anyway, I built a model of this with a skate wheel, some pieces of piano wire, the top of a herring jar -- it was just the right size for this top -- and a cap of a felt-tip writing pen for this. And I can spin it up and show you the difference in behavior when it's spinning and not spinning but that's only -- that's kind of one of the interesting features of it. You see, this thing, you have to know your approach vector velocity, and it had three Doppler radars on it to see the velocity in the three directions and to resolve the vectors.

This thing has a single radar that's spinning around and these -- the Doppler modulation gives you the vector velocity. This thing had these complex landing gear that had to have shock absorbers in it to keep it from bouncing too much when it did hit, and this just has some springs here, something like a pole vault, part of a pole vault.

I'm really -- and this is the [unintelligible] from our 376 Programs, the spin-to-spin interface. So anyway, it's based on a lot of stuff we've done.

Clay Whitehead: And then how do you propel it across the surface once you've landed?

Harold Rosen: That's my -- another little trick I have up my sleeve. It doesn't say it has to roll; it says rove.

Clay Whitehead: Rove.

Harold Rosen: Rove.

Clay Whitehead: Uh-huh.

Harold Rosen: Kangaroos rove across Australia by hopping. This thing is going to hop. It still has some propelling left in these control tanks, and after it takes its survey here it's going to go from there over to there, take another survey, and then it's going to hop; it doesn't have to roll.

Clay Whitehead: And then you can aim it and hop in the right direction?

Harold Rosen: Yeah.

Clay Whitehead: Huh, interesting.

Harold Rosen: Well, the aiming is -- you use the -- it doesn't show the rockets here. It's got hydrazine rockets around the periphery here facing down the liquid rockets that will -- that's used for the final part of the descent. This takes out the gross velocity and then the [unintelligible] descent control is with some hydrazine rockets here, but they'll be used to take it off again, vertically basically, and then the radial rockets will be used to move it over laterally in the desired direction, and then it comes down again and -
-

Clay Whitehead: So you give it an impulse to bounce it up?

Harold Rosen: Yeah. You give it an impulse and it keeps -- after you turn off the rockets it keeps rising for awhile, and while it's rising you compile the --

Clay Whitehead: Translate.

Harold Rosen: You translate, and then you descent again. So it goes like that.

Clay Whitehead: How high would it go?

Harold Rosen: Well, it depends on how far you want to go in one leap; if you just want it to win the prize and go 500 meters, you can do it in one leap. That would be the easiest, they might not like that. So I got -- I'm corresponding with them now to try to get a better handle on what the details of the rules are because that would be the easiest thing to do, but if they want it more continuous it takes more fuel.

Clay Whitehead: How much would it cost to do this?

Harold Rosen: Well, it costs six-million dollars to buy this. And I don't see why it should cost any more than that to build -- first of all, this thing costs a few hundred -- most of the mass is this. I think -- I haven't priced it yet, but it's a few hundred thousand dollars, I think, for this and less than that for this, and then this thing is just less than 50 kilograms worth of stuff. This is -- we have to be about ten times lighter than Surveyor on everything, and it looks like, to me, it's possible. So I would --

Clay Whitehead: Are things like this [Baptist????] still being manufactured?

Harold Rosen: They are. They are, but I -- from one of our military programs, one of our classified programs uses it, but I would start with the drawings and scale it down and make one that was nice for this project.

Clay Whitehead: And where are you going to get the money for this?

Harold Rosen: I'm going to do what Lindbergh did; see if I can find a --

Clay Whitehead: Find a group.

Harold Rosen: -- find a group that is interested in the publicity.

Clay Whitehead: Is your brother going to help, or --

Harold Rosen: He's helping, not personally; he's already retired from that. But he's trying to find contacts for me.

Clay Whitehead: Good. My son is at Stanford in the Business School, and he's getting his MBA.

Harold Rosen: Oh, yeah?

Clay Whitehead: And he knew he wanted to do something in business. He was in a consulting company in New York after he graduated from Princeton, and he decided he wanted to go to business school, and he really liked Stanford because of the --

Harold Rosen: That's a great school.

Clay Whitehead: -- entrepreneurial --

Harold Rosen: Oh, the Google guys.

Clay Whitehead: And he's really interested in all this new technology stuff, so he got early admission to Stanford and he's just ecstatic, and now he's in his second year. But this summer he took a job working for one of the senior partners at a venture-capital firm out there.

Harold Rosen: In Stanford -- in Palo Alto?

Clay Whitehead: In Palo Alto, yeah.

Harold Rosen: Oh, there's so many of them there.

Clay Whitehead: There's so many of them, yeah. And -- but this is one of the bigger, more established ones. And he just fell in love with it.

Harold Rosen: Yeah. Venture capital?

Clay Whitehead: Venture capital.

Harold Rosen: That's my little brother's --

Clay Whitehead: I know, I know. And his boss has encouraged him to not only do the venture-capital stuff, which is looking at lots and lots of companies, you know, and figuring out which ones you ought to invest in, but also to do some entrepreneurial activity of his own. So they've told him based on his work this summer that they want him to come back permanently when he graduates in June, and he's really excited about it because he really likes it.

Harold Rosen: What's the firm?

Clay Whitehead: Venrock.

Harold Rosen: Oh. I know that firm.

Clay Whitehead: Yeah. You know it?

Harold Rosen: Yeah, yeah. [Unintelligible] Rockefeller, yeah.

Clay Whitehead: Rockefeller, yeah, yeah. So --

Harold Rosen: Oh, that was a great team; I talked to them once on --

Clay Whitehead: Did you? Yeah, they're very good people. So I think what he's going to do is he'll join them and he'll -- and they've given him an office to use during the school year, you know, so that he'll --

Harold Rosen: Uh-huh. Oh, that's terrific.

Clay Whitehead: He'll stay involved, but he's -- he'll spend probably half of his time doing traditional venture capital and the other half of the time they've said they would give him, you know, like a million-dollar stake to go start one or two entrepreneurial companies on his own. So he'd be part of his own entrepreneur and then part the other. So he's very excited with that. And one -- the partner that he works with mainly there is an aviation guy. Aviation, it's an interest of his.

Harold Rosen: What's his name?

Clay Whitehead: His name is David Siminoff.

Harold Rosen: I've heard the name. I don't --

Clay Whitehead: He made his money in, you know, Yahoo, Google, Facebook, MySpace. He was one of the earlier investors in all those companies. But --

Harold Rosen: They have incredible valuations; what is it, \$15 billion for one of them according to Microsoft?

Clay Whitehead: Yeah. Well, he's worth a couple of billion himself now.

Harold Rosen: I see.

Clay Whitehead: But he's really interested in aviation; he has his own airplane he flies and all that.

Harold Rosen: Oh, yeah.

Clay Whitehead: So he might be interested in this.

Harold Rosen: I would love to talk to him about it if that could be arranged.

Clay Whitehead: Yeah. Well, I'll see if we can do that. This kind of thing really excites me.

Harold Rosen: Oh, me too. I mean, I'm just in it for the fun of it. That's what the Google guys said, "What are you doing this for?"

Clay Whitehead: For the fun of it.

Harold Rosen: For the fun of it, right, right. But your idea of -- I couldn't understand what you were getting at when you were asking for communicated both ways, but you're right; you could -- there's nothing that would prevent you from broadcasting a message except you'd need a big antenna to receive it, it's far away.

Clay Whitehead: Well, it depends on --

Harold Rosen: But if you wanted to have a message from the moon, that would be -- you'd be the only one to do it. You know, if --

Clay Whitehead: Depends on the bit rate you want.

Harold Rosen: Yeah.

Clay Whitehead: But you can store stuff.

Harold Rosen: Yeah. Oh, yeah.

Clay Whitehead: Storage is cheap. So you could send stuff up slow [unintelligible].

Harold Rosen: Oh, yeah. There's no problem.

Clay Whitehead: And if you'll pardon my commercial mind.

Harold Rosen: Uh-huh.

Clay Whitehead: You could sell people e-mails from the moon. You know, I could let you -
-

Harold Rosen: Yeah. Well, they mentioned that in that --

Clay Whitehead: You send an e-mail up to the moon and it gets sent back to somebody from the moon.

Harold Rosen: Uh-huh.

Clay Whitehead: You could get pictures of the moon with a person next to it, you know?
And those --

Harold Rosen: Oh, well, before we get to --

- Clay Whitehead: Those kinds of things would sell, I'm thinking. So there's a revenue source there to offset the investment cost.
- Harold Rosen: Well, in order to make that really credible, we'd have to design it to last the lunar night. Now that would take a little more doing because you have to test everything for the cold temperatures it would be exposed to, but it's not impossible because I talked to [Roni], who has more or less created this program, Bob Roni. [not CQ] I'm going to see him tomorrow, by the way. What was my thought? I lost my point.
- Clay Whitehead: That's OK.
- Harold Rosen: Oh, no, about the Surveyor, about the Surveyor; at first they wanted it to last through the night, but then they felt it was going to be too hard, it complicated it too much. So they -- it was no longer a requirement. But then they found out that it did last through the night. The sun had come up and it would come alive again. So it isn't necessarily designed for it, they were just lucky, but if you were going to sell a commercial service like that you'd probably want to test it at the cold temperatures first. But it's possible because Surveyor did it; we can do it too.
- Clay Whitehead: But it wouldn't operate during lunar night, it would only operate --
- Harold Rosen: Well, no. And it's hard to get an energy source for it; you have to get an atomic supply. They're [unintelligible] everyone else, no. It's solar powered.
- Clay Whitehead: Anyway, it would be a lot of -- it would be fun.
- Harold Rosen: Yeah, that would be fun. That would be terrific.

Clay Whitehead: Yeah. We ought to talk about that some more.

Harold Rosen: OK. Well, you got to see my gadget before --

Clay Whitehead: I will see it.

Harold Rosen: It's in my car trunk. When I go, I'll --

Clay Whitehead: Yeah. You and I have always said we wanted to find a way to work together.

Harold Rosen: Well, this would be a -- this would be really fun.

Clay Whitehead: I would love to do it if we could find something.

Harold Rosen: OK. Well, I like your son's entrepreneur [unintelligible].

Clay Whitehead: Yeah.

Harold Rosen: [Unintelligible] go met him.

Clay Whitehead: Can I come back to the satellite business?

Harold Rosen: Sure, absolutely.

Clay Whitehead: One of the things that, you know, the government through the classified programs put a lot of money into satellite development, and I'm curious about how much of the --

Harold Rosen: You mean communication satellite or --

Clay Whitehead: No, just --

Harold Rosen: -- intelligence and --

Clay Whitehead: Satellites in general.

Harold Rosen: Oh, yeah.

Clay Whitehead: The intelligence and the --

Harold Rosen: You know, the biggest thing was the reconnaissance probably.

Clay Whitehead: The reconnaissance but also the signal intercepting stuff.

Harold Rosen: Oh, yeah. Uh-huh. Oh, yeah.

Clay Whitehead: And so there's a lot of money that went in there to develop technologies, and I'm curious about how much of the technological development once the satellite business -- once the satellite industry got going, how much of the technology came out of those government programs, and how much of it came out of the commercial programs?

Harold Rosen: I don't know. I know at use, I would say the commercial programs did most of the pioneering compared to the government programs. But the fact that the government programs existed made a bigger market for some of the fundamental components, like solar cells are used by both of them. So there was a bigger market, it helped stimulate those improvements I'm sure. And then the hardware for three-axis control, there was a big market for that for momentum wheels for example. So I think the government business combined with the commercial business -- it's hard to say which

was more important in creating that industry which gave the -- and the thrusters, they all improved over the years as a result of the general market. I don't know how to divide them.

Clay Whitehead: Did the ideas for new improvements mostly come out of commercial considerations or the commercial part of the business?

Harold Rosen: From my view point, I would think so. If I look at the use, commercial and government programs, I think most of the improvements originated in the commercial and were picked up by the government.

Clay Whitehead: And was that because of competitive pressures or just because the people were more -- you had more freedom in the commercial programs?

Harold Rosen: Yeah, I guess so. And we were -- we felt the competitive pressure and wanted to stay ahead of them. So we kept making improvements as fast as we could.

Clay Whitehead: Yeah. And once we had the Open Skies program --

Harold Rosen: When was that?

Clay Whitehead: Well, we announced it in 1969.

Harold Rosen: That would permit competition among satellite systems.

Clay Whitehead: It would allow multiple satellite systems. Basically that's --

Harold Rosen: [Unintelligible].

Clay Whitehead: Anybody who wanted to could put up a satellite. And we -- it got its basis --

Harold Rosen: Was that your idea?

Clay Whitehead: Oh, yeah.

Harold Rosen: Oh, thank you for that. I didn't know that.

Clay Whitehead: It came about because -- what's his name -- Rosel Hyde was the chairman of the FCC, and when the Nixon Administration came into office, I became identified as the guy who was responsible for all the communications business. So Rosel as the chairman came over and gave me a briefing about what were the issues before the FCC. And he said one of the issues was that they had seven companies that had applied to put up domestic satellite systems. And I suppose you had been encouraging all of them through ABC, NBC, CBS, AT&T.

Harold Rosen: Western Union.

Clay Whitehead: Comsat, Western Union, there's the Corporation for Public Broadcasting.

Harold Rosen: Comsat wanted to have a monopoly for them.

Clay Whitehead: Oh, yes. Joe Charyk fought hard for that. He fought very hard for that to the point of writing his own letter to the president, which I wrote the response to.

Harold Rosen: I can imagine what it said.

Clay Whitehead: You can imagine what it said. But Lee came to me, and Rosel came to me, and he said, "You know, this satellite thing is the most intractable thing we have because we have seven companies that want to do this, and we can't pick between them, so what are we going to do?" And he said, "Here's the idea of what we're going to do, and we just want to see if you agree with it." He said, "We're going to create a monopoly."

Harold Rosen: You cringed at that word I bet.

Clay Whitehead: I cringed at that word. And he said, "It's going to be owned in equal parts by each one of these companies." So Western Union, ABC, NBC, AT&T each owns one-seventh of this company. And each of them gets one seat on the board of directors. And so here, you know, you've got a telephone company, you've got a telegraph company, you've got networks who are mainly users, and he said, "Now, we know that with all these different companies it will be hard to reach decisions sometimes. So if they can't reach a decision, then the FCC will have a representative on the board, and the FCC will resolve any differences and the FCC will make the decision."

Harold Rosen: Geez.

Clay Whitehead: And I said to myself, "Oh, my God. Not only do we have a monopoly, but we basically have the government-run monopoly." And I said, "Rosel, would you please just hold that --"

Harold Rosen: Hold that thought.

Clay Whitehead: "Just hold that thought and we'll get back to you." And I talked to some people including the people at the Justice Department who were very interested in promoting competition, and we came up with the idea that if

we designed the systems properly so that we could put satellites close enough together, which required a certain size or a station, that we could in fact accommodate seven different satellites in seven different orbit positions. So we could make it possible for each of these companies if they were really serious to put up their own satellite.

Now, we knew that that wouldn't happen, that only two or three of them might actually do it, but we worked out the geometries, and we worked out the spacing and just how big the Earth stations had to be, and we came up with four-and-a-half degrees was a conservative spacing. And based on that, we told -- we sent this letter to the FCC saying, "You should do this, and then you should allow each of those companies, if they want, to go ahead and put up their satellite system." And that was Open Skies.

Harold Rosen: And he agreed, didn't fight it?

Clay Whitehead: Well, by that time, we had replaced him with Dean Burch, and Dean was very willing to go along with this.

Harold Rosen: That's just a wonderful solution. That was marvelous. I didn't know you were behind that.

Clay Whitehead: Yeah. And that was the thing that really sucked me into communications rather than doing NASA stuff and other stuff.

Harold Rosen: Well, that was terrific.

Clay Whitehead: I think that made a big difference because it created more business for you because you had more people to sell to, but it also --

Harold Rosen: Created competition all around.

Clay Whitehead: From my point of view, it took a new technology, and I remember thinking to myself, "If we can't make this new technology competitive, then how on earth can we make the rest of the communications business competitive?" And there were a number of people, like MCI and Daytran -- I don't know if you remember them, but -- that really seriously wanted to compete with AT&T in the phone and [unintelligible] business.

So I set up the Open Skies thing as a sort of prototype of how you would do competition in the communications industry, and then we applied that to MCI and some others, similarly competitive things. I guess where I was going with that was, that gave you more customers, and people were wanting to do slightly different things with satellites. And I'm curious, did that -- from your point of view, as the guy who designs and builds satellites, did that change the pace of development? Did that change innovation?

Harold Rosen: I think it did, yeah.

Clay Whitehead: Yeah. Because you were selling to more people, right?

Harold Rosen: Yeah. And the people we were selling to were looking at different sources. So, you know, we just got to outdo them. So it's a lot of pressure to stay ahead.

Clay Whitehead: Yeah.

Harold Rosen: So we did it for a long time. Hughes had a really good market share for a long, long time until they changed management in a way that lost interest basically.

Clay Whitehead: When was that; when they sold it to Boeing?

Harold Rosen: Yeah, Boeing has very little interest in the commercial arena. In fact, they have the commercial satellites imbedded in something called the -- well, it's really their government or their defense business unit. They have two major business units at Boeing; one is a commercial aviation division, Boeing Commercial Aircraft I guess it's called, BCA. It's half their company, and the other half is the -- they keep changing the name so I forgot what it's called but it's basically the government defense business.

Clay Whitehead: Yeah.

Harold Rosen: And we're in the -- imbedded into defense and it hadn't been a good marriage. So -- but I'm having fun. In fact, I recently came up with my first serious look at an Angio System. But it was for a purpose; the crowding of the geostationary orbit. I began -- are you familiar with the Russian Molniya Orbit System?

Clay Whitehead: Uh-huh.

Harold Rosen: Well, I asked myself, "How many satellites would it take in the Molniya Orbit to get service equivalent to geostationary satellite in the sense that you could use small fixed antennas to -- user antennas on the ground?" And because of the nature of the orbit and the fact that that it runs that apogee it has for a little while the same angular rotation as the Earth at that latitude, it seems to hover. And so if you put enough of them up, you can replace one with another in the sequence of that.

Clay Whitehead: There have been proposals in the past to do that, haven't there?

Harold Rosen: Well, I looked -- I couldn't find any that involved using fixed antennas on the ground. In the proposals, all the systems I'm aware of use tracking antennas, but tracking antennas are OK for a handful of them, but if you want 10 or 20 million of them it's nice to have them fixed, like the DirecTV systems. So I wanted it to be like a DirecTV system. So for that, it turned out if I used C-Band, C-Band can be used for DirecTV practically because the orbit crowding means you have to have a big antenna on the ground. FCC says, I don't know, five meters or more, I think for -- four-and-a-half meters for C-Band.

So it turned out, with six satellites properly faced, you could do it. Now, it's -- you'd have to make them cheap, so we worked out a way of making them cheap.

Clay Whitehead: Do you want some water?

Harold Rosen: No, thank you.

Clay Whitehead: How much time do you have, Harold?

Harold Rosen: Well, how much time do you have?

Clay Whitehead: I'm pretty flexible. Do you want to have lunch?

Harold Rosen: That would be very nice. I have time for lunch.

Clay Whitehead: We can either go over to the restaurant, or we can order room service and keep talking here.

Harold Rosen: Which would you prefer? I'm easy either way.

Clay Whitehead: I'd probably just as soon keep talking here because I've got the tape-recorder here.

Harold Rosen: That's fine with me.

Clay Whitehead: What would you like?

Harold Rosen: Tuna sandwich.

Clay Whitehead: Should be able to get that.

Harold Rosen: While you're doing that, I'm going to get something from my car.

Clay Whitehead: OK. What would you like to drink with that?

Harold Rosen: Water.

Clay Whitehead: Water? Anything else?

Harold Rosen: I'll have one of your bananas.

Clay Whitehead: OK. I'd like to order lunch for two. Harold, what kind of bread do you want?

Harold Rosen: Wheat.

Clay Whitehead: Wheat? Can I get a tuna sandwich on wheat bread? Tuna salad on wheat bread. No, not toasted. Just lettuce. Lettuce. Right. And, oh, gosh. I guess, do you have a club sandwich? What's the toasted club? And that's -- is that a chicken club, or what is that? Oh, OK. I'd like a chicken club, toasted, of course, and a Diet Coke. Right, and I guess a fresh pot of

coffee. We have the cups here already so we just need the pot. Yes, please. No, we have that here too. Probably some fruit, yeah. OK? All right, thank you.

Test, this is just a test track. Harold and I are taking a brief break, and we'll come back on track 121, I believe.

Let me go back again a little bit, what -- it seems to me and I know in some of the work I did, the ground segment was almost as important as the space segment because you had to have economic ground stations. We were mostly looking at systems for television that required lots and lots of ground stations. Even for the Galaxy we were going to, I think, 10,000 cable systems.

Harold Rosen: That many cable systems?

Clay Whitehead: Yeah, potentially.

Harold Rosen: They were still fairly large, right, though?

Clay Whitehead: They were quite large.

Harold Rosen: Five meters or so?

Clay Whitehead: Yeah. And we -- getting the size down was very important, and getting the cost down was very important. Did you work very much with ground station engineers and technology, or did you -- you must've.

Harold Rosen: Oh, yeah. I helped push that. In fact, early on while the FCC still had removal that the Earth stations had to be 30 feet in diameter, I started a program where we used a 10-foot dish to -- and built a [unintelligible]

noise receiver for it so that we could get television off the satellites as a precursor to [unintelligible], try to shrink them with time. And it was a start in the trend that ended up with our 18-inch dishes.

Clay Whitehead: Right.

Harold Rosen: But the great big breakthrough there as far as television distribution was concerned was compression; that was the biggest single step that made that practical. It's huge. It was kind of a welcome surprise as far as I was concerned that it became as effective as it did.

Clay Whitehead: When did that happen?

Harold Rosen: I don't know when -- it gradually evolved over the years. I think they were using them for video conferencing compressor sats. They cost about \$20,000 each. So, but as Moore's Law progressed and they were able to get more and more processing on chips, it got cheaper and cheaper until, I guess, it was the late '80s or early '90s that came to realize you can get it on a chip, the [decompressor] on a chip.

Clay Whitehead: Right.

Harold Rosen: And that made a world of difference in both the effectiveness of it, the fact that you could reduce the bandwidth by some huge factor.

Clay Whitehead: A big factor; like six to one or something.

Harold Rosen: Yeah. And then the other technologies that came along, which was the error-correcting codes that permitted you to deal with much less powerful signal. When we started with analog communication systems used for AT&T type of multiplex communications, they had specifications that

were so hard to meet on the details of the transmission system. Everything kind of -- they wanted to deal with, I guess, what amounted to a 50dB signal-to-noise ratio they needed. And so their reference signal was one millowatt. And 50dB below that was, you know -- somehow they used a -- oh, I know, the reference was millowatt, and relative to that millowatt they allocated a total of 10,000 picowatts of noise, 10,000 picowatts.

And they'd count your picowatts and every little thing, and cross pull, and the gain slope variations across the pass band where you had to have essentially perfect filters. All those requirements have gone away in the digital age. I mean, it's so much easier. You can deal with imperfections that would've wiped out [unintelligible] or made them unusable, those old analog systems. And now you don't even see them. And the new codes are almost matched [Carchen's][not CQ] new records and predictions of how good they can be.

Clay Whitehead: Yeah.

Male Voice: Hello, room service, may I come in?

Clay Whitehead: Yes.

Male Voice: Thank you very much. Thank you. Thank you.

Clay Whitehead: Uh-huh. Will you take that other pot of coffee?

Male Voice: OK, sure.

Clay Whitehead: You know, Andy [Baturvie] [not CQ] was very big in that.

Harold Rosen: Oh, yeah. Yeah, he was, like -- yeah, the Baturvie Code was one of the ones we used, actually.

Clay Whitehead: When did you go to on-board-type processing on the satellite?

Harold Rosen: That was Spaceway, I guess, was our first big one.

Clay Whitehead: Was that analog switching or was that actual-signal processing?

Harold Rosen: That was -- let's see, we demodulated all the uplink signals. The uplink signals were digitally modulated. They were demodulated in the space craft and rerouted to a particular downlink beams, organized into the appropriate ones that were addressed. That's like the uplink [unintelligible] address with the downlink beam on it. The downlink beams weren't constant in time; they covered the whole country with, I think, 24 hopping beams in which the duty cycle determined the average bandwidth available to different locations.

Clay Whitehead: But are most of the satellites today still just repeaters without on-board processing?

Harold Rosen: Well, I don't know what you mean by most of them. I think most of them are what they -- I hated the term, but they called them bent-pipe repeaters. Most of them are.

Clay Whitehead: Still that?

Harold Rosen: Yeah. But there are a lot of people making processors of various kinds with that. [Unintelligible] expensive [unintelligible] power [unintelligible] so --

Clay Whitehead: And do you still use the same kind of antenna systems or are you using phased arrays or --

Harold Rosen: Well, it's basically used pretty much phased array. I've had [unintelligible] 50s and 100 [unintelligible] developments on it. Each one, I had 24 different inputs, I guess, to create the 24 beams that [unintelligible].

Clay Whitehead: Are phased arrays common in satellites today or were they still parabolic reflectors?

Harold Rosen: I think they're mostly parabolic reflectors. Parabolic is not quite right. We introduced an antenna technology shaped beams.

Clay Whitehead: I remember that.

Harold Rosen: And that was very effective. They're nearly parabolic, but the difference is [unintelligible] get the beam and the shape, which was as simple as creating beams that cover design contours.

Clay Whitehead: That was very clever.

Harold Rosen: Yeah. It was Robert [Nujan] [not CQ] who brought that to us, an Indian descent who comes from the same town that the famous Indian mathematician, [Srinivasa] Ramanujan came from, so I always thought they were related; he got some of his genes.

Clay Whitehead: Some of his genes there, huh?

Male Voice: Do you want this cup?

Clay Whitehead: Yes, we got fresh cups.

Male Voice: All right, [unintelligible] you guys, then. Thank you very much. Have a great day.

Clay Whitehead: Thank you. Shall we move over there.

Harold Rosen: Sure, thank you.

Clay Whitehead: On this side's your sandwich.

Harold Rosen: Oh, wow. I got something I didn't ask for, which was delightful: the fruit plate, too.

Clay Whitehead: Their food here is pretty good.

Harold Rosen: That's all I got to be able to tell.

Clay Whitehead: It's a very nice hotel. We weren't sure we wanted to stay here, but we made a reservation and then the fires came and we discovered that every hotel room in the city was taken.

Harold Rosen: Oh. So you were forced to endure it?

Clay Whitehead: We were forced to keep our reservation here.

Harold Rosen: Wow, this looks delightful. Yeah.

Clay Whitehead: Boy. It's so big, you can't get it in your mouth. I've developed slightly low blood pressure.

Harold Rosen: Oh, how low?

Clay Whitehead: Oh, it's about, I guess about 100 over --

Harold Rosen: Oh, that is low.

Clay Whitehead: It varies. It goes as low as 100 over something, and it's nothing serious but part of the doctor's prescription is to eat a lot of salt. So contrary to all of the health.

Harold Rosen: Well --

Clay Whitehead: Considering the people who have high blood pressure and have to eat low salt, I'm supposed to eat high salt.

Harold Rosen: I more or less avoid salt, but it tends to keep my blood pressure -- I actually take a medication for it, but it keeps it where I want it. I'm not supposed to have salt.

Clay Whitehead: When did you retire from Hughes?

Harold Rosen: Ninety-three; that's 14 years ago. [Unintelligible] Steve Dorfin [not CQ] and Toni Iorillo arranged a fantastic retirement party for me. It was at a country club near my house; Riviera Country Club. I can't get this open.

Clay Whitehead: You need a knife, or --

Harold Rosen: Yeah, a sharper knife. It's teasing me. I'm getting it.

Clay Whitehead: Packaging is one of my pet peeves. Everything seems to be --

Harold Rosen: I got it, I got it.

Clay Whitehead: You got it?

Harold Rosen: Yeah. [Unintelligible]. I'm thinking it will [unintelligible].

Clay Whitehead: Everything is packaged so that it won't come undone in transit, but --

Harold Rosen: Yeah, they're hard to --

Clay Whitehead: But it never comes undone when you want to use it either.

Harold Rosen: Uh-huh.

Clay Whitehead: So have you been a consultant of Hughes/Boeing ever since?

Harold Rosen: No. For awhile, I was working with my brother on a venture.

Clay Whitehead: Oh, yeah.

Harold Rosen: Rosen Motors, it was called.

Clay Whitehead: Right.

Harold Rosen: Building a hybrid-car power train somewhat before its time. And I thought we were doing pretty well. We had an agreement with Mercedes, and arrangement with Mercedes, I should say, where they looked like they were going to introduce it to one of their sporty new models. But they changed management, and the new management decided to [unintelligible] out their newer technology, which turned out to be a disaster for them only to the extent they spent \$400 million investing in

Ballard fuel cells, and fuel cells never stood a chance, I don't think, for cars because they're costly with liability and the fact they needed hydrogen, which you can't get. But that was the end of Rosen Motors.

Clay Whitehead: Did you recover anything from it or was it just --

Harold Rosen: Uh-huh. No, we did. Well, there was a -- the gas turbine engine that we cofound, the Capstone Company, as I mentioned, it went public and made a little bit of money off of my stock.

Clay Whitehead: Oh, [unintelligible] did you?

Harold Rosen: They did not succeed in the long run; they're still struggling. But the other part of it, the flywheel is now being manufactured for uninterruptible power supplies, and when the grid goes down and the hospital has to maintain its power or an industry or something, they have these diesel generators come on, but they're not running all the time. So you need something to sustain the load while they're cranking up. They have the [unintelligible], banks of batteries for it traditionally, but no one's happy with the batteries, and a flywheel is a way of replacing the batteries with something that basically will last forever and it doesn't take up as much space, and it doesn't emit chemical smells or -- so that's -- after a long struggle the company that bought our intellectual property is still -- last month they had their first million-dollar sales month, so that was a good deal.

Clay Whitehead: That's good.

Harold Rosen: And I mean, their prospects look very good right now.

Clay Whitehead: Is Deborah still working?

Harold Rosen: No. She's enjoying life to the fullest.

Clay Whitehead: Good.

Harold Rosen: She's my primary health-care consultant and reads up on all the latest vitamins, minerals, exercises, [unintelligible].

Clay Whitehead: Well, Margaret does the same for me.

Harold Rosen: Well, I used to think Deborah overdid it, but now I'm beginning to think that maybe she's onto something because she prepares these little packets for me to have with my meals.

Clay Whitehead: Really?

Harold Rosen: And -- although most of them might not be useful, I think at least some of them are. And since I don't know which are which --

Clay Whitehead: And the rest of them don't hurt, so --

Harold Rosen: The rest of them don't hurt. So I follow her advice.

Clay Whitehead: I only do that at breakfast and dinner. So -- my doctor's [unintelligible] is just go out and run everyday, run or walk everyday.

Harold Rosen: Do you do that? Good.

Clay Whitehead: Well --

Harold Rosen: We've taken to walking on the bluffs in Santa Monica. It's called Palisades Park on Ocean Avenue there. They've really made it nice. And we try to time it just before sunset so we can watch the sun set.

Clay Whitehead: [Unintelligible].

Harold Rosen: Oh, it's so wonderful, and the people there are just fun to watch.

Clay Whitehead: We go over to the canal and run on the towpath, which is very pleasant.

Harold Rosen: I didn't know that.

Clay Whitehead: Well, Margaret just finished her Ph.D.

Harold Rosen: Oh, wow. In what?

Clay Whitehead: It's in American studies, which is a branch of history, I guess. And it took her some time because she was doing it part time, meanwhile taking care of the kids, and taking care of me, and helping design the new house and all that stuff. But anyway, she graduated in May.

Harold Rosen: Oh, wow.

Clay Whitehead: I say I now travel with my own private doctor.

Harold Rosen: You do.

Clay Whitehead: I'm not sure what she's going to do with it, but I think she probably wants to teach there. She got the degree at George Washington, and they're interested in having her teach a course or two.

Harold Rosen: Now, which of the universities is in downtown Washington, and which is a little removed?

Clay Whitehead: One's Georgetown and the other's George Washington.

Harold Rosen: Which is --

Clay Whitehead: George Washington is right downtown; Georgetown is in Georgetown. And then there's George Mason, which is out in Fairfax County.

Harold Rosen: I don't know that one.

Clay Whitehead: And the University of Maryland is just over the line, the D.C. line in Maryland to the north. So there are four, and I guess if you counted American University there'd be five, reasonably good universities in the area.

Harold Rosen: Uh-huh.

Clay Whitehead: [Unintelligible] a distinguished visiting professor at George Mason.

Harold Rosen: Are you?

Clay Whitehead: Which gives me an office and gives me access to students as research assistants.

Harold Rosen: That's nice. That's great.

Clay Whitehead: Occasionally, I'm supposed to teach a course. I've only taught one course so far. That was in the law school. I enjoy teaching.

Harold Rosen: Well, this story of de-monopolizing the communication industry is so interesting and important. You should be telling that to all the classes.

Clay Whitehead: It's a story that really hasn't been well-written.

Harold Rosen: Uh-huh.

Clay Whitehead: I find that people at large are sort of -- there's some kind of psychology about communications today. When you present people with a new kind of communications, the general reaction is, "Why would I want that?" I remember when I was in government I had a telephone in my government car because it was part of a national security network. But I could dial nine and get out to the public that way. So I would just use it as a telephone, and it was really a very handy thing to have. And people would say, "Well, why would you want this? What would you do with that?" And when Motorola was providing the cell phone, the same reaction, "Why on earth would people want cell phones; what would you do with a cell phone?" And then when you give it to them, you know, two days later they can't imagine how they got along without it. In fact, they can't think about what life was like.

I say to people today, "Do you remember how we got along without e-mail?" And people, like, stop and think. So it's -- there's something about new communications that people don't identify with in the beginning but they accept almost immediately, and then it becomes a part of their lives.

Harold Rosen: I think it started with the telephone; people were very skeptical about that, I think, [unintelligible]. But that spread around the world very quickly.

Clay Whitehead: And the same with wireless; you know, nobody really thought that you could use -- everybody thought that the application with wireless would

serve as a replacement for telegraph or telephone. And the idea of broadcasting just really never occurred to anyone.

Harold Rosen: For awhile [unintelligible].

Clay Whitehead: Really, until Davis made this connection and started actively running the broadcast stations as a business in order to sell his radios. And then it just caught on like that. But it took -- the technology was there for several years, no one did anything with it. But it sounds like -- well, was the technology for Syncom there for a long time before you actually did it?

Harold Rosen: No.

Clay Whitehead: No?

Harold Rosen: Well, I guess the main thing, from pure technology development that occurred was the metal-ceramic periodic permanent magnet focused traveling-wave tube. That was -- I think John Mendel had been experimenting with that while he was still at Bell Labs but it wasn't any tube you could go out and buy. And he proposed that for our program. I'm glad they offered, that made it work. As far as the controlling [unintelligible], that's one concern there were. Well, parts existed in various places for different applications, but I'm glad we put them together in that particular way.

That little sun sensor that [unintelligible] created that's -- little slit, stuck my hands together here and at one angle you can see through it.

Clay Whitehead: Uh-huh.

Harold Rosen: He made in his garage, it was the V beam where you use the time between the two beams to tell you the elevation angle of the sun. It was used in a World War II radar, there was a height-finding radar that had two fan beams, one of which was like this, the fan beam going across, and the other was like this. And the time difference between the pulses of those two beams would give you the elevation angle. So there was something similar in World War II, but he adapted it to this very simple, lightweight optical system. So that was a neat thing.

The communication system, it just kept evolving. The rest of the communication system as transistors got better and better, but we started out using [unintelligible] we could get in terms of the transistors and made us have to develop some cumbersome, very difficult to develop multipliers to get to the one for Syncom. To use the Army stations we had to have the uplink at eight gigahertz to get the local oscillator signal for converting it down to our IF frequency.

And we had to use a times-32 multiplier with diodes, high-frequency diodes that Tom Huds bath designed in a very lightweight configuration. That was a real challenge. So he didn't invent the diode doubler, but he sure invented a times-32 multiplier with a cascade [unintelligible].

Clay Whitehead: I'm confused here. Were you saying that there were transistors on Syncom 1?

Harold Rosen: Yeah.

Clay Whitehead: Really?

Harold Rosen: Uh-huh. Yeah. The communication system, there was only one tube, it was a traveling-wave tube, the final power amplifier, but all the rest of the electronics was effected in transistors. Transistors started in '48, was it?

Clay Whitehead: Yeah, but I didn't realize that they were practical for that kind of thing that early.

Harold Rosen: Well, they were evolving so they were borderline for the frequencies we were using.

Clay Whitehead: So you used them for the receiver?

Harold Rosen: Uh-huh. And for the telemetry command, and the communications receiver, and they controlled amplifiers to send up electrical signals to the valves to operate the thrusters.

Clay Whitehead: And when did you start using solid-state amplifiers instead of TWT's?

Harold Rosen: The TWT's have not been replaced in general. There are some applications where the solid-state amplifiers are usually lighter but less efficient, much less efficient than the traveling-wave tube, which have become incredibly efficient. As a result of which, they now -- we take more power from the power system, but the solid state also require a lot more thermal dissipation area. So -- and it turns out that in orbit, these traveling-wave tubes have been at least as reliable as the solid state amplifiers.

So [unintelligible] there are a number of solid-state amplifiers, particularly at the lower [unintelligible] like, 211 displaced all in the traveling-wave tube. And at the higher frequency bands, that's all there are. Well, I shouldn't say that. The Spaceway has a 20-gigahertz solid-

state power amplifiers because it has that phase array and active array, so it's got 1500 amplifiers, all very low power.

This is a delightful lunch, by the way. They really [unintelligible].

Clay Whitehead: Yeah. I wish I had gotten the fruit instead of that.

Harold Rosen: [Unintelligible]?

Clay Whitehead: No. I had some for breakfast. There's a story that I --

Harold Rosen: That travelled-wave tube [unintelligible] is 70 percent efficient, it's really amazing.

Clay Whitehead: That's pretty good.

Harold Rosen: We started out with about 20 percent, which was --

Clay Whitehead: Linear.

Harold Rosen: Well, no, they're not linear, but they can be linearized by linearizing amplifier ahead of them that makes them satisfactory, especially for today's digital communication.

Clay Whitehead: Uh-huh. There's a story that I tell that you may or may not remember. But it involves you, so I'll tell you the story and you see if you remember it. One day when I was at Hughes, I took Margaret and the kids and we went out to the Date Festival in Palm Springs, which is in Indio, so it was -- and it was really just kind of a county fair environment. And there was this -- there was a tent, and beside it was a truck with a trailer, you know,

just a little flatbed trailer. And on the trailer was a satellite dish, which was about eight feet in diameter.

And so I was curious, and I stuck my head in the tent, and there were a few seats in there and a television set. And they were showing television. And I said, "What's going on here?" And they said, "Well, you know, we're receiving television from the satellite." And she said, the woman gave me a demonstration, she says, "You know, see, there are 12 channels here, and you throw this switch and you got another 12 channels," and of course, horizontal and vertical polarization. And I said, "Gee, that's interesting." I talked to her a little bit and I said, "That second set of channels isn't as sharp." I said, "It got a little fuzzy, you know, compared to the first." I said, "Why is that?"

And of course, I knew that it had something to do with the way the polarization was set up, and she said, "Oh, Harry just hasn't got it quite right." She says, "Harry, kick it again." Harry kicks the trailer like this. "OK, that's good." So I'm looking at this and I said, "How much does this cost?" And I think she said something like \$1,500. You get the dish and the receiver and [unintelligible]. And I thought that was pretty interesting because it was a high price but it was in the range that people could afford if they didn't have any other way to get television, and it was only an eight-foot dish.

So I came back and I remember I talked to you and I said, "Harold, I just saw an eight-foot dish receiving television." I think it was a West One or a West Star satellite. And you said, "Impossible."

Harold Rosen: Did I?

Clay Whitehead: Yeah, "Impossible." And --

Harold Rosen: Did I really say that?

Clay Whitehead: Yup, you said that.

Harold Rosen: I'm embarrassed.

Clay Whitehead: And you showed me the link budgets, and you said, "You have to have a satellite dish this big." And I said, "But Harold," I said, "I saw it," you know, "and it was working." And so you went off and you came back to me and you said, "I found it." You said, "It's in the margins." See, because the satellite guy assumes there's a certain margin, the uplink guy is in the certain margin, the receiver manufacturer is in the certain margin. So in terms of the overall specification of the link it's not possible, but if you eat into the margins you can do it.

So that got me interested and I started a contest, and it was you and Ed [Horowitz]. Do you remember Ed Horowitz?

Harold Rosen: Uh-huh.

Clay Whitehead: And Irwin Jacobs, who at that time was running -- what was that little Maycom subsidiary he had that was doing Earth stations?

Harold Rosen: Well, he's at Qualcomm now. I don't know what --

Clay Whitehead: Yeah, it was before Qualcomm.

Harold Rosen: I don't remember the name. I don't --

Clay Whitehead: Well, he had a little company that made Earth stations. And we started looking at ways that you could reduce the size of a dish. How small could you get a dish and still receive television? And of course, one of the things we did quickly -- I think it was your idea to go to Ku band. And --

Harold Rosen: Well, because it was the orbit crowding that --

Clay Whitehead: That was it, but also the dish is just -- you get more gain with the same size dish.

Harold Rosen: Well, no, that's not quite --

Clay Whitehead: Is that not right?

Harold Rosen: No. You get more gain, but it's not the gain that counts, it's the size. The catch area, which is related to the physical area for giving flux density from the satellite. You can just imagine, you have a certain number of watts per square meter, picowatts per square meter, whatever it is, and the more [unintelligible] you have, the more energy you -- the more power you capture. It depends on the size; that's independent of the frequency.

The higher frequencies have more gain, which means you have to narrow a beam. You have to point them more accurately, but if you look at the expression for the capture area of a receiver in terms of its gain, it's equal to the gain multiplied by the square of the wavelength divided by four Pi. That's what it is; [unintelligible] square over four Pi. So as you go up in frequency for a given size, what gain goes up? But the inverse proportion of lambda squared, but the lambda square gets multiplied so I mean, the area doesn't change; the area is just dependent on the physical size.

Clay Whitehead: So what is the -- why can a Ku-band dish be smaller than a C-band dish?

Harold Rosen: Because, well, for example, if you're looking at geostationary satellites, you have a certain orbit spacing. That's two degrees for Ku band and for C band it's still two degrees; they're two degrees apart. The Ku-band dish will have a narrow beam, one-third the beam width, roughly, of the C-band dish. So it can discriminate against the adjacent satellites at a smaller size than the C band can.

Clay Whitehead: Oh, OK. So it's the narrower beam width?

Harold Rosen: Yeah.

Clay Whitehead: That gives you -- allows you to use the smaller dish.

Harold Rosen: Yeah. You can see that in this [unintelligible] in an Angio System I was looking at, the [Balneo] Orbit, I wanted to use C band because I wanted the catch area, but I wanted it in a dish that was big enough to capture the signals. If I had done the same thing that took six satellites spaced properly for a C-band system to use a -- what was it -- 66-centimeter antenna on the ground, I would've had to use a -- excuse me -- a 22-centimeter dish at Ku band to get the same beam width. I needed the beam width to be big enough to encompass the satellites. I was looking for a big beam width. That's why I wanted C band, yeah.

Clay Whitehead: Yeah. Interesting. Well, anyway, we moved to Ku band. There were some -- you worked with the issue of the margin in the satellite. Irwin was working in the margin on the Earth stations, and I guess Ed was working on the acceptable signals and high ratio kinds of television issues. And we prided ourselves with the coming generation of Ku-band satellites, that we could do it, we could get decent television with a one-meter dish,

which we deemed would be commercially acceptable; people would put a one-meter dish on their house.

And so then I came up -- based on that, I said, "Well, where would we do that?" And the United States was not a good answer because we had cable TV, and other parts of the world didn't have the money to support it. So Europe was the obvious choice, and I came up with the idea of doing this direct satellite to home in Europe. And Allen just wouldn't have any of it. He --

Harold Rosen: And why was that?

Clay Whitehead: It was too flashy. It put, you know -- he used communications -- the idea was, we could buy the satellites and then we'd operate them.

Harold Rosen: Uh-huh.

Clay Whitehead: So we were selling time, we were selling transponders, we were dealing with the end users. And in a direct satellite to home thing, we'd be selling transponders or leasing transponders to media companies. We basically would be in the media business. And he just didn't want that. He just didn't want that.

Harold Rosen: Well, it's turned out to be a very interesting business. I don't know how many direct-to-home terminals there are in the United States now. It must be over 30 million of them.

Clay Whitehead: Uh-huh, it's big.

Harold Rosen: When Deborah was at [unintelligible], she and a colleague at [unintelligible] wrote a paper -- this is before there were direct-to-home

satellites -- about the possibility of direct-to-home satellites being a competition to cable. In fact, that was the title of the paper. And they concluded it would be. And that compression was a big deal in the equation that made it attractive for satellite.

Clay Whitehead: Yeah, because you could have so many more channels.

Harold Rosen: Yeah.

Clay Whitehead: Well, the cable companies are compressing.

Harold Rosen: Now, they are, yeah.

Clay Whitehead: HD.

Harold Rosen: Everybody is.

Clay Whitehead: Well, we get it pretty much uncompressed because we're getting our television from Verizon's fiber system.

Harold Rosen: Oh, you have fibers in the home?

Clay Whitehead: Fibers in the home.

Harold Rosen: You're one of those lucky few communities that have that.

Clay Whitehead: Yeah. Yeah, it's just a little fiber wire and I just run it into the basement and plug it into their electronics, and --

Harold Rosen: Uh-huh.

Clay Whitehead: It's a beautiful picture.

Harold Rosen: Oh, I bet.

Clay Whitehead: It really is.

Harold Rosen: We used to go to the other end of being -- how far -- we're -- what does a system look like, where does a -- do they give you other services besides the television; do you get phone and Internet?

Clay Whitehead: All of them.

Harold Rosen: So that fiber goes to a switching center someplace.

Clay Whitehead: Somewhere.

Harold Rosen: How far away does your individual fiber go before it gets --

Clay Whitehead: I don't know. I just -- all I saw was when it came off the telephone pole. But I don't know where the switch is.

Harold Rosen: But you have your own personal wire; there's no -- the original cable systems were draped along telephone poles. You'd get your signal just by puncturing a hole in the outer conductor and signaling [unintelligible] in coupling off a little bit of the power going on the cable. But the fiber's different, isn't it, in the sense that you have an individual fiber going to your home from somewhere, and I don't know where it goes -- what's at the other end.

Clay Whitehead: I don't know where they -- somewhere they break it up for me but that one fiber is two-way and it carries --

Harold Rosen: Oh, so infinite bandwidth [unintelligible].

Clay Whitehead: It's TV, telephone, and 15-megabit Internet.

Harold Rosen: Does any server give you service at that speed?

Clay Whitehead: No, no. Not that I've seen.

Harold Rosen: Not yet.

Clay Whitehead: And I get two megabits up.

Harold Rosen: Reverse direction?

Clay Whitehead: Reverse direction. So I have a -- I've got a similar thing at my office. So I've got a two-megabit virtual private network between my office and my house.

Harold Rosen: That's terrific.

Clay Whitehead: Yeah.

Harold Rosen: Well, I don't know how much it costs per subscriber to provide fiber to the home but that's the best communication system when you get it because it's unlimited bandwidth.

Clay Whitehead: But it's expensive, but I'm sure they're losing money on it. Maybe sometime they'll connect.

Harold Rosen: Has it been trouble-free so far?

Clay Whitehead: Uh-huh. The only problem it has is once or twice, the system has gone down, and then it has to re-cache all of the program information in the box in the house. So you turn it back on and you have to wait maybe -- it takes maybe ten minutes for the system to upload all the cached information about the program and the schedules and all that. You can still change channels, but it won't display which channel it is or what's on that channel. But for the most part it works just fine.

Harold Rosen: Well, that's always been the -- when fiber first evolved with its properties you could see that when it ever got to the home, that was going to be the ultimate.

Clay Whitehead: Oh, yeah. My generation knew [unintelligible]. As you say, the bandwidth is infinite, so they could give me a lot more than --

Well, one of the themes of my book -- would you like some more coffee?

Harold Rosen: No, I'm fine. Thanks.

Clay Whitehead: One of the themes of my book is the technology provides -- to some extent the market pulls the technology, and to some extent the technology pushes the market. It's really a feedback process, which in the case of the AT&T monopoly worked fine in some ways. You know, the microwave networks they put up after the war was --

Harold Rosen: Fantastic.

Clay Whitehead: -- fantastic. But in other ways, it kept things down because they interfered with the basic economics of the network. And it seems in a way that satellite technology just sort of came from nowhere. Now, you were

drawing on technologies that existed, most of which had come out of the military, is that --

Harold Rosen: No, I wouldn't say that.

Clay Whitehead: No?

Harold Rosen: Well, the communication part, I would say most of it came out of the commercial area. As far as, I guess, the rockets originated in the military. I would say that. But the -- it was both.

Clay Whitehead: Both? But the technology is what drove the creation of the communication satellite. Oh, you got to market -- you want to do in a business, so you were really -- you wanted to be an entrepreneur, right?

Harold Rosen: I wanted to be, but it wasn't successful in that arena anyway.

Clay Whitehead: Well, you were successful in another way.

Harold Rosen: Yeah. I became happy but I didn't become rich, I'll put it that way. I became happy and I got a lot of awards for it.

Clay Whitehead: But most entrepreneurs don't get rich or get awards.

Harold Rosen: But I got rich enough and I got plenty of rewards actually.

Clay Whitehead: Yeah, you did, and you deserved them all. The satellite business would not be what it is or was without you.

Harold Rosen: It's hard to tell, but perhaps that's right.

Clay Whitehead: I don't think there's any question that that's right.

Harold Rosen: It may very well have gone AT&T's way, and there would've been these uranium-type systems with big global gateways at the coasts and no other applications than transoceanic communications which would've been displaced as soon as the fibers came in and that would've been the end of it.

Clay Whitehead: Uh-huh. When did you see fiber as a competitor?

Harold Rosen: Oh, I guess 20 years ago or so. I'd say -- I remember the Australians talking to me about it before we put up the first Australian satellite that the phone companies were advising the Australian communication satellite company, AUSAT, not to bother because they would be at the homes with fiber in another few years, they said. That was about 25 years ago I guess. So they were pushing it pretty early.

Clay Whitehead: So Ford's time.

Harold Rosen: Yeah.

Clay Whitehead: One of the proposals I had just before I left Hughes was a Ku-band system that would operate much like Spaceway. It wasn't as advanced, but it would put terminals on major office buildings and provide reasonably high-speed data to connect businesses. And with a thing that I think would've worked, but by the time -- and I had lined up funding from General Motors and Bank of America and somebody else, but by the time -- that was another thing that Hughes didn't want to do.

Harold Rosen: Whoever they funded probably used network services, which [unintelligible].

Clay Whitehead: Which was their business. But in any event, this idea, it was hard to get the funding together from people who saw the business applications of it, but we were getting very close, and then fiber came along and it just was clear that in a few years fiber was going to drastically change the economics of transmission. So it didn't make sense to go ahead with the thing.

Harold Rosen: Well, each [unintelligible] has a big business operating these Esat terminals, I mean the point -of-sale antennas that are all around the country verifying your credit cards. Some of these [unintelligible] in the business, I think. Fiber's got a long way before it's ubiquitous. They can do terrific things like they're doing in your home, but I don't know what fraction of the population is being served that way now. I don't think --

Clay Whitehead: Small.

Harold Rosen: One or two percent maybe.

Clay Whitehead: Uh-huh, at most.

Harold Rosen: So it will take awhile.

Clay Whitehead: A long time.

Harold Rosen: Uh-huh.

Clay Whitehead: It will take a long time.

Harold Rosen: In the countryside, maybe never. I mean --

Clay Whitehead: Well, and the cable operators say they're not going to do it; they're going to take fiber to the neighborhood, and they'd go over the coaxial cable.

Harold Rosen: I remember we were out to see AT&T and the communication networks. Do you remember a gentleman named Fred Friendly?

Clay Whitehead: Oh, of course.

Harold Rosen: Did you know him?

Clay Whitehead: Yeah.

Harold Rosen: Well, he left CBS -- he was Edward R. Murrow's producer, but he left CBS in a huff because they once had the third rerun of "I Love Lucy" instead of some breaking news that he was interested in.

Clay Whitehead: I remember.

Harold Rosen: So he went to the Ford Foundation. And when he was there he contacted me with a plan. He wanted to have us design a satellite system that he would then use to distribute television to the networks. And he would use the profits he would make from this enterprise to subsidize non-commercial television. That was his plan.

So we designed a nice satellite, a domestic satellite for him that could do the job. It wasn't really much of a challenge at that time, but he had a real challenge trying to promote his system because the phone company was mad at him, the networks were mad at him because -- and he never was able to make it. And I thought it was the nicest, interesting concept.

Clay Whitehead: He was an interesting guy. He was a very creative guy but unconventional.

Harold Rosen: Yeah. And he really -- those were the early days of my geostationary satellites. I remember you told me about the problems that you had with Telstar. Telstar had gone up a year before Syncom. And Telstar was one -
-

Clay Whitehead: Telstar was --

Harold Rosen: Was a low-altitude satellite.

Clay Whitehead: But was it an active or --

Harold Rosen: Active, an active repeater. It was a ball; it was shaped like a ball. And it had no altitude controls. It had an equatorial belt of horns that were -- that provided [unintelligible] directional pattern, like a dipole pattern basically. And it provided transoceanic communications when it happened to be there.

Clay Whitehead: When it --

Harold Rosen: Well, it provided communications to you when it happened to be where you were, which wasn't very often or very long.

Clay Whitehead: Who put that up?

Harold Rosen: AT&T. But the nice thing about it was it was their own money. I mean, it was -- AT&T paid for the development, they paid for the launch.

Clay Whitehead: OK.

Harold Rosen: They put up two of them actually, and I think that one of them was more or less wiped out by an atomic bomb burst in the -- at altitude that -- we were bombing --

Clay Whitehead: Doing testing?

Harold Rosen: [Unintelligible] bombs all over the place in those days.

Clay Whitehead: When we discovered EMP.

Harold Rosen: Yeah, right. And it helped the early demise of Telstar, but it wasn't going anywhere anyway. And Fred Friendly told me about one program he had to produce that was going to be over Telstar. And he was given a -- they weren't quite sure when it was going to be available, but it was standing by and he got an instruction over the air, "OK, we'll be in about 20 seconds," and it was [unintelligible] cows or something. And the cows were supposed to be moving by the [unintelligible]. Anyway, it was funny the way he told it, but it related to the transients of the Telstar system.

Clay Whitehead: Telstar could handle the transmission of a TV signal?

Harold Rosen: Oh, yeah. It had the first transoceanic television. I remember we were in our laboratory working on Syncom when we saw that -- it was in July of 1962 that they had their first transmission. We weren't going to go up until the following year.

Clay Whitehead: Do they have tracking antennas on the ground?

Harold Rosen: Oh, yeah. Yeah, they had these -- one of the antennas they used in that system later did something very useful; it discovered the cosmic background radiation and got Nobel Prizes for --

Clay Whitehead: What was that?

Harold Rosen: Arno Penzias, and the Wilson [Robert Woodrow], whose contribution to science basically was cleaning the pigeon poop out of the horn to make sure that wasn't the source of the noise they were hearing.

Clay Whitehead: Right, right. I read that story.

Harold Rosen: Did you?

Clay Whitehead: Yeah. It's interesting. So the technology, it still seems to me that the technology of satellites was sort of exogenous to the market.

Harold Rosen: I don't know what that word means.

Clay Whitehead: It means outside the market. Well, coming from the military and having some support from the government programs, but really coming from --

Harold Rosen: Well, the communication parts were -- didn't originate in the military; they originated in the commercial arena. The transistors and traveling-wave tubes, those are --

Clay Whitehead: Didn't they come from radar, TWT's?

Harold Rosen: It came from -- well, it was invented by [Rudolf] Kompfner at Bell Labs, then went to Bell Labs, I think it was primarily for communication, but I'm --

Clay Whitehead: Yeah, I guess you're right because the radars --

Harold Rosen: They use them in radar, we used them in our radars, but they were -- that was a special high-powered development that was required. It was also done at the [unintelligible] tube [unintelligible].

Clay Whitehead: I guess radars mostly used magnetrons.

Harold Rosen: Magnetrons were the great invention of an Englishman named Professor Oliphant. Do you know the story of the Magnetron?

Clay Whitehead: No.

Harold Rosen: The number one [unintelligible] you might not remember, gave 50 destroyers to England during the dark days of World War II. We weren't in the war.

Clay Whitehead: We're not in the war, but we were.

Harold Rosen: Helping England. In return for which they gave us some of their technology, and one of their technologies was their resonant cavity magnetron, which they then presented to Raytheon to produce. And the guys at Raytheon looked at it and decided that when they considered how many radars they wanted to build, there weren't enough machines in the country to machine the cavities that they would need. There were eight cavities precision-machined and they gave it to one of their ingenious production engineers, and they asked him what he could do with it. And he looked at the drawings and he told them, well, he'd like to take it home for the weekend to study it and he'll tell them his opinion on Monday.

They say, "Can't do that," national security, international security, something. "So well then, I can't do it." So they relented and let him take it home, and he came back on Monday with a plan for low-cost manufacturing magnetrons, which the big deal [unintelligible] without world [unintelligible] radars and [unintelligible] instead of machining the cavities, he figured he could stamp them out of lamina and just get the pattern from one lamina and go boom, boom, boom, boom, boom and then stack them and put them through this chamber. He developed a continuous process where the raw material would go in one end and the magnetrons would come out the other basically. And he was a legend in the Raytheon board when I joined the company.

Clay Whitehead: Interesting.

Harold Rosen: But he got them and that propelled him to the top of the World War II radar producers. They were great devices.

Clay Whitehead: My impression is the war really made Raytheon.

Harold Rosen: Yeah.

Clay Whitehead: So when AT&T first started its microwave network, they were using TWT's or were they using some other way of generating the microwaves?

Harold Rosen: They were using triodes, microwave triodes.

Clay Whitehead: Huh. And a question I have which nobody's been able to answer is why was the band width of the AT&T microwave network what it was? It was about 94-and-a-half megahertz.

Harold Rosen: I don't know how those frequencies are allocated or divided up in those days. No, I think it was broader band than that, I thought, because they were sending -- I mean, they use them in addition to the voice traffic, which was substantial. The three television networks used it. And television wasn't compressed then, so they were several megahertz each. But you mean individual bands?

Clay Whitehead: Individual channels.

Harold Rosen: Oh, I don't know who decided that. That's a question within itself, how you decide.

Clay Whitehead: The question I have is that it was designed primarily for telephone use, and they had a modulations theme for scats for staffing telephone signals in the microwave band. But it just turned out that the bandwidth was sufficient for a television signal.

Harold Rosen: I guess for --

Clay Whitehead: For one television, for one analog television.

Harold Rosen: Probably for 500 voice channels or something equivalent to 500 voice channels or something like that.

Clay Whitehead: And the question that I have, which I'll probably never get an answer to was, did AT&T anticipate carrying television when they designed it or was it a happy coincidence? I've never been able to find an answer for that.

Harold Rosen: Well, I can't help you on that because I don't remember when they started the design of the microwave link. It must've been during World War II. It didn't exist before World War II, I don't think,

Clay Whitehead: Oh, no, no. It --

Harold Rosen: It's right after the war.

Clay Whitehead: The first one was early '50s.

Harold Rosen: Early '50s? So there's already television, so they must've known they would have that.

Clay Whitehead: They probably anticipated it.

Harold Rosen: Yeah. Interesting.

Clay Whitehead: But the satellite technology was tremendously important because it opened up a competitive -- from my point of view, it opened up a competitive -- a way for communications to go expand apart from AT&T and the three networks.

Harold Rosen: Yeah.

Clay Whitehead: And it allowed both telecom voice and data applications, but it also allowed television.

Harold Rosen: Yeah. Entrepreneurs there.

Clay Whitehead: And made possible HBO.

Harold Rosen: How about Ted Turner's --

Clay Whitehead: CNN.

Harold Rosen: Yeah.

Clay Whitehead: So it was a technology that in a sense did not come out of the marketplace. The technology that presented itself to the marketplace and people found ways to use, which I think was kind of the opening wedge of getting competition into the communications business. And the role you played for so many years of advancing what satellites could do was tremendously important in that.

Harold Rosen: It was fun.

Clay Whitehead: You were at a very pivotal point at a very pivotal time.

Harold Rosen: Well, it was certainly fun. I've enjoyed every moment of it.

Clay Whitehead: Did you?

Harold Rosen: Yeah. Except the one moment when Syncom 1 blew up; that was a downer, but --

Clay Whitehead: That must've been a downer.

Harold Rosen: After all that struggle. But it didn't stay down very long.

Clay Whitehead: Had you already built Syncom 2?

Harold Rosen: It was mostly finished. It was fun, that whole trip was fun, and I'm having fun now. I mean, I'm involved in various enterprises and this, I'm doing this lunar thing because it looks like it's going to be so much fun, and when I saw Larry Page on YouTube explaining the prize, and when he said, "The main reason we're doing it is to have fun. We want you to have fun, too." He's talking to potential competitors. I understand that completely.

Clay Whitehead: The thing that got me to Hughes, which I really wasn't attempting to come to Hughes, but Bud set up a dinner with him, and me, and Allen Puckett.

Harold Rosen: Oh, yeah?

Clay Whitehead: And Allen and I agreed that what it was all about was having fun and making money. And I said, "Yes, I think that's what I want to do; I want to have fun and make money."

Harold Rosen: And you've done both.

Clay Whitehead: And we did. And we did, yeah. That was great.

Harold Rosen: Well, I'm going to have to get going pretty soon, so --

Clay Whitehead: Oh, I'm late. I've got to go, too. Well, this has been great. I'd love to spend more time with it.

Harold Rosen: Next time you're out, give me a call.

Clay Whitehead: I will.

Harold Rosen: How often do you come out here? I mean, you have to visit your architect now.

Clay Whitehead: Well, yeah. He comes back to see us a lot, but we have not been able to travel for a variety of reasons, partly Margaret was --

Harold Rosen: In school.

Clay Whitehead: This last year she was crashing on her dissertation, and before that I had some pretty ugly chemo treatments that made me feel pretty bad.

Harold Rosen: In addition to the radiation.

Clay Whitehead: Well, this is after the radiation, yeah. Because if the first-stage treatment doesn't work, then the cancer begins to spread throughout your body. And the good thing about it is that it remains prostate cancer; it doesn't turn into bone cancer or something like that. So they can treat it and they, you know -- I've had this for five years now, and they just keep it stable. I have not had any symptoms whatsoever from the cancer.

Harold Rosen: That's great.

Clay Whitehead: So it's under control as long as I keep the medication going, but some of the medications produce side effects that are pretty unpleasant so that kept me from traveling. But now, I go for longer periods where I'm not on any medication, which is wonderful. And then the newer chemo treatments have pretty minimal side effects.

Harold Rosen: Well, that's nice to know.

Clay Whitehead: Yeah. So now I can travel, and Margaret's free to travel because she's not holed up with her dissertation so we're planning to come out here more often.

Harold Rosen: Well, that's good.

Clay Whitehead: We have a lot of friends out here still.

Harold Rosen: Good. I'm sure you do.

Clay Whitehead: Of which I'd hope you are one.

Harold Rosen: Oh, I'm happy to be called that, yeah.

Clay Whitehead: So next time I'm out I will give you a call, and if I --

Harold Rosen: What is your son's name, by the way; the one you mentioned?

Clay Whitehead: Clay.

Harold Rosen: Clay?

Clay Whitehead: Clay, like me.

Harold Rosen: Oh, I wonder how he got that name.

Clay Whitehead: We have different middle names but he goes by Clay. Yeah. If you don't mind, I'll talk to him about this and --

Harold Rosen: Oh, yeah. I'll let you have some of these.

Clay Whitehead: I think it would be fun to work on that. This is the kind of thing I love to do. You know, I have a pile of it as well.

Harold Rosen: Here, you can have just as a reminder.

Clay Whitehead: OK.

Harold Rosen: That's [unintelligible]. I don't know if --

Clay Whitehead: He probably knows somebody who would be interested.

Harold Rosen: As opposed to the other guys, I think we can do it for less than the prize money.

Clay Whitehead: Which is still a lot of money.

Harold Rosen: Oh, yeah.

Clay Whitehead: But the good thing is the venture capitalists now are in a situation where there's kind of a surplus of money. There's too much money chasing too few ideas.

Harold Rosen: Well, I wouldn't try to sell this as a venture where the object is to make money; I would only sell it as a venture to have fun and to try new -- maybe make a little money.

Clay Whitehead: Right.

Harold Rosen: Yeah.

Clay Whitehead: But it must have some -- would it have any further applications once you've done it?

Harold Rosen: None I've thought of. I don't know any reason to go back and move at all for anything right now since we already know as much about the moon as we need to know for anything.

Clay Whitehead: Well, if the Bush model prevails, we're going to have a base on the moon.

Harold Rosen: I don't think we're going to. I mean, it's possible, but I don't know. I shouldn't say that. That's so much -- they've got the work distributed in so many congressional [unintelligible] that it's -- General Eisenhower, President Eisenhower's warning went unheeded.

Clay Whitehead: Well, it was Lyndon Johnson and -- who was that guy; Webb? He was the head of NASA?

Harold Rosen: Yeah, James Webb.

Clay Whitehead: James Webb. And they very purposely designed the location of the centers the way they did to get congressional support. And it seems to work.

Harold Rosen: Yeah, but -- plus somebody got a good -- I mean, if you want adventure like that, we ought to build a station at the South Pole, really at the South Pole. We have a bunch of scientists who will go there and they do pretty [unintelligible] things. That boomerang experiment a few years ago that really first proved the Big Bang, you talk about exploration, using this balloon that was looking at the cosmic background as it circumnavigated the -- the winds at the South Pole circumnavigate the poles. So two weeks after they launched it, it came back to the beginning and they had all that

data, but there are all kinds of interesting scientific experiments going on at the South Pole, but they don't even have a power system there. They hauled in -- half of the cargo they bring to the South Pole was fuel for their generators. They ought to have an atomic power plant down -- we need an atomic power plant down at the South Pole in the winter [unintelligible] the [unintelligible] people say in the winter, they have to dress like astronauts; they can't expose anything to the outside. That would be immediately frozen.

Clay Whitehead: Do you know the guys that run General Atomics?

Harold Rosen: No, I don't know them.

Clay Whitehead: It's two brothers, the last name is Blue; B-L-U-E. I've forgotten their first names. I've just called on the board of the Hudson Institute, which is a real think tank back in Washington. And one of the brothers who -- they bought the company. It used to be public and they took it private, and they own it and they run it. And they have a design for a new nuclear reactor that is much, much simpler and much more safe and much less expensive.

Harold Rosen: Is it a pebble reactor?

Clay Whitehead: I can't remember.

Harold Rosen: I'd like to keep up with that. I'm very interested in nuclear power.

Clay Whitehead: I'll send you some of the stuff. I think you'd enjoy meeting this guy. I thought the two of you ought to meet. They're down in San Diego. By the way, do you know this guy?

Harold Rosen: I know of him, the physicist [unintelligible].

Clay Whitehead: Yeah.

Harold Rosen: Yeah.

Clay Whitehead: I went to a lecture he gave at George Mason.

Harold Rosen: Oh, yeah?

Clay Whitehead: And he was talking, and he mentioned this book so I'm reading it. It's sort of a, what do we know about the laws of the universe, and I'm discovering that I remember -- at one point I studied about 90 percent of the math that's in here. And I now remember about ten percent. But he gave a talk about the Big Bang. And he said, "You know, the idea that it was a singularity is an interesting idea, but there's an alternative." And he talked about how black holes tend to coalesce and grow, and he said that, "If that's how the universe evolves with more and more of the mass collecting into black holes, and then they come together, it produces a kind of a Big Bang but it's a Big Bang where the singularities propagate past the Big Bang." So it never becomes an absolute singularity. And he said, "If that's true, then that accounts for a lot of the background -- the variations in the cosmic background."

Harold Rosen: Now I got to read his book.

Clay Whitehead: Yeah. So I don't know. It was just an interesting idea.

Harold Rosen: No, I liked him. I mean, I've read various of his pronouncements over the years. We have a friend who's a modern cosmologist at Cal Tech, Sean Carroll. He's just written a series of lectures for the Learning Company. I

don't know if you're familiar with that. They had him on the cover of their monthly ads about last month, and we've been watching his cosmology lectures at night. [Unintelligible].

Clay Whitehead: Are they good?

Harold Rosen: They're wonderful. [Unintelligible].

Clay Whitehead: I'll have to get that.

Harold Rosen: It's called "Dark Matter, Dark Energy: The Dark Side of the Universe," by Sean Carroll, and it is fascinating.

Clay Whitehead: I will get that. I will get that. Well, thank you for coming by.

Harold Rosen: It's my pleasure.

Clay Whitehead: It's great to see you.

Harold Rosen: And I'll take my toy with me because I won't need one [unintelligible].

Clay Whitehead: Yes, of course, of course. I like it, I like it.

Harold Rosen: I better make a bigger model soon with more stuff on it. So if he found this interesting, I would be very happy to talk to him about it anytime.

Clay Whitehead: Yeah. I know he would be interested. The question is --

Harold Rosen: Can he do anything about it?

Clay Whitehead: It's a lot of money, you know? It's not a million -- [unintelligible] drag it up, there it is. You can throw away a million dollars on a lot of things. But when you get to ten million dollars, that's --

Harold Rosen: Then the whole board has to get together.

Clay Whitehead: That's serious money.

Harold Rosen: No, it wouldn't be a venture; it would have to be for an individual who would otherwise buy a painting or --

Clay Whitehead: There are people up there with that kind of stuff.

Harold Rosen: Yeah, yeah. Well, that's someone we're looking for, someone like Paul Allen [unintelligible].

Clay Whitehead: Well, how about Paul Allen?

Harold Rosen: Well --

Clay Whitehead: He's a little crazy, but he's --

Harold Rosen: Yeah. He may have had enough with --

Clay Whitehead: Maybe [unintelligible]. Well, let me think about that.

Harold Rosen: OK. Well, thanks a lot.

Clay Whitehead: You say hello to Deborah for me.

Harold Rosen: And it was a real pleasure meeting you again and Margaret, and say I'll say hello to Deborah.

Clay Whitehead: Yeah, maybe we can get all four of us together for dinner or something sometime.

Harold Rosen: That would be terrific, next time you're here.

Clay Whitehead: We'd enjoy that. Good to see you.

End of recording.