An Interview with

LAWRENCE G. ROBERTS

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Conducted by Arthur L. Norberg

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Charles Babbage Institute
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Abstract

Roberts, Information Processing Techniques Office (IPTO) Director from 1968-1973 and later chief operating officer of Network Express, begins by discussing his own research in computer science and the development of computing at the Massachusetts Institute of Technology and Lincoln Laboratory. The interview focuses on IPTO and the Advanced Research Projects Agency. Much of Roberts description of the work of ARPA and IPTO is set within the context of his interactions with Congress on budget matters. Topics include: J.C.R. Licklider, Ivan Sutherland, Steve Lukasik, Wesley Clark, ARPA and IPTO support of research in computer science, computer networks, and artificial intelligence, the ARPANET, the involvement of universities with ARPA and IPTO.

LAWRENCE G. ROBERTS INTERVIEW

DATE: 4 April 1989 INTERVIEWER: Arthur L. Norberg

LOCATION: San Mateo, CA

NORBERG: Today is April 4, 1989. I am in the offices of Dr. Lawrence G. Roberts, CEO of NetExpress, Incorporated, for an interview about his years at DARPA. If you think back to the early 1960s when you were at MIT as a graduate student, do you recall, say in 1960, 1961, what number of graduate students might have been active in computing activities? Ten, fifty, a hundred?

ROBERTS: It might have been in the fifty range; I am not sure. We had a lot of activities. But they have accurate records.

NORBERG: Certainly. I was just having a test of your memory of what was going on there at the time...

ROBERTS: I see. Thirty to fifty...

NORBERG: ... because that is where I want to start. I wanted to ask you what occasioned your entry into computing activities at MIT. I know you got your bachelor's degree there as well. How did you decide to enter the computing field?

ROBERTS: Well, I was already involved in it by the time I got my bachelor's. I did various special projects all the time while I was in school, because the courses were easy, so I just did all sorts of other things. And one of the... I took a summer job... I am trying to figure out which summer... helping the Computation Center build some equipment to convert an automatic tape unit attached to an analog tape into the 704. That was a project that I just did for them as a summer job. So I got a little involved with the computer. I wrote binary programs on hexadecimal codes, which was painful. (laugh)

NORBERG: What sort of experience had you had in your own graduate years to make you capable of doing that?

ROBERTS: I did not do anything on the computer. There was not anything I could do during those years. It virtually did not exist as a subject, or as an activity. They did not have computers. The 704 was the Comp Center's only utility. If you were one of the circle of people that worked on WHIRLWIND, fine, you worked on WHIRLWIND. If you used the 704 you were probably in a white jacket and worked for IBM. Otherwise you submitted programs from somewhere and where no students had access to them. So I did this as a job for them, which gave me some access, but relatively little to the computer. But I saw what it worked like and I used it. Then the next year they brought the TX 2 to MIT from Lincoln. The TX 2 was the first transistor computer in the world. It was the one that Lincoln built that preceded the PDP-1 that DEC built. It was a small machine. It filled a room, but it was a small machine. It was the first machine of any reasonable class that had been made available throughout the country to on-line use by people, rather than a batch activity. They did not have any plan for how their people were to use it. So I, being around there, started using it. I do not even know that it was necessarily that. It was involved... I was around the area... When I would go to the computer area, I started working with it. The first year that it was there I spent 760, or something, hours on-line working on the machine, which is, for that era, almost unheard of.

NORBERG: Yes. Doing what sorts of problems?

ROBERTS: The primary project I did, besides lots of support work for this machine and other things around the place, was write a program that did hand-written character recognition. I published that at that time. It was based on neural-nets which are now becoming very exciting, except at that point in time they were also for a short period, and then they died. They have come back. I looked at that technique and developed it some for hand-written characteristics to see if it would be effective. It worked by some odd percent, which was not quite what you would need to do anything useful. That is what everything did at that point in time before it worked. But it was my first published paper in speech in the computer conventions, and so on. But I got an awful lot of experience on that

computer. I learned how to use that computer. The interesting experience there was that I started out looking at this thing, and I couldn't figure out what this typewriter relationship with the computer was. I had no idea of why this thing did. So the guy who had built the computer showed me the prints of all the transistors. I could finally figure out, "Well, that's the machine, and that it's a finite state process, sort of. Then this typewriter connects to it over here and talks sort of at a second level." I sort of learned about operating systems from scratch, because I had to go backwards from the electronics, which I had learned in school, back up to the operating system, because nobody had taught about computers at that time. Then when I learned that this was an operating system and not the machine itself, then I could deal with it. It was a very simple operating system.

NORBERG: Who else was in the lab at that time? Who else was working with the TX-0.

ROBERTS: The people around who I still know might be Tom Stockham, who's a professor at Utah now. I don't know how much he did with it. I don't know. Very few of the friends I know at the moment worked on the TX-0. Most of them worked at Lincoln later on when they had the TX-2, which is the bigger machine. But I cannot remember many people.

NORBERG: Who was your dissertation advisor?

ROBERTS: Ph.D. was Elias -- Elias was in information theory primarily, and was great. And I worked on the perception of three-dimensional solids with him. That was basically a cross between math and computers. At that point in time we worked to try and have a thesis have all of the normal characteristics. People have changed, and now computers are recognized as an item. But this thesis had to be founded in psychology and math, and be a sound thesis on those principles as well.

NORBERG: Appealing to those academic disciplines as opposed to this new one?

ROBERTS: Yes, because you could not base it on that very easily.

NORBERG: Where did the support come from for this research?

ROBERTS: I worked for a little while at RLE, which was a research lab on electronics. I worked as a research assistant. Then I worked as a staff associate at Lincoln Labs for my graduate period, when I did my thesis. I worked on a TX-2 for both my master's thesis, which was on ? production, ? ? production, and eventually that resulted in a patent, which did the compression of the moon shots, and Mars -- stuff like that. But I started out sort of in character recognition. Then in the last years I did the ? reduction of photos. Then I went on to 3-D. In the meantime I did all operating systems and compilers and so on for the TX-2, because that needed all of the operating systems done. So I did those myself, and started running the group. I sort of took over management of the group at Lincoln Labs, because there was a shift in the management. Wesley Clark and Bill Fabian, who were running it, left. They wanted to bring a cat into the lab. Lincoln would not allow them to bring a cat in. And they decided that was unfair; they would go somewhere where cats were tolerated.

NORBERG: That seems sort of trivial, though, as a reason for leaving, doesn't it?

ROBERTS: It was really a fight over having that connection with the brain electrodes and all of that. Lincoln just did not want anything to do with it. They wanted to start doing it somehow. And so they left and went off. That left the group leaderless, so I took over. I never got appointed. I wound up going to ARPA and getting funding for the group.

NORBERG: This is still while you were a graduate student that you took over the group?

ROBERTS: Yes, took it over in reality. On paper it was virtually leaderless. But I was a staff associate there and that was funded out of general funds. There was not any particular thing. But then I went to ARPA and got funds for a project in graphics and that sort of thing.

NORBERG: Do you remember the date of that first funding from ARPA? Was Licklider already there? Were you dealing with him?

ROBERTS: I was actually dealing with Ivan after Lick. Well, yes, Lick was there most of the earlier time. Then Ivan came in, and he had worked with me at Lincoln on lots of projects. We had worked side by side. So when he got to ARPA, he came back and talked to me about, "Well, do you need funding for whatever?" So we worked together to work that out. It was really with Ivan that I did that. That was right at the start of his thing. I myself went to ARPA at the end of 1966 to ARPA. So this was probably 1963 or so.

NORBERG: Was Ivan already there in 1963? I would have thought he would have been in a little bit later than that.

ROBERTS: It might have been 1964.

NORBERG: Okay, before we go on to that period, you are alleged to have been thinking about communications and computing issues during your dissertation research. Can you tell me a little bit about that? What I am referring to is a reference that I picked up, I think, in Datamation, actually. I do not seem to have it with me, but there was some comment that you were thinking about these questions very early.

ROBERTS: I've traced back the origin of the ARPANET thinking and work to a conference at Homestead in Virginia that the Air Force put on. The point of the conference was to look at the future of computing. Licklider, and Corbato, and I, and a bunch of people from MIT went to this conference. We sat around talking all night -- Al Perlis, and a whole slew of these early people who were doing timesharing. We had all done timesharing; we knew what that was.

This conference was in 1962. At that point, I had done all of this graphics work and all of this timesharing work (operating systems and so on), and Corby [Fernando Corbato] had done that, and we had all been through most of what we imagined people might be doing with computers for the next decade. We probably had been through the next two decades in terms of where they are now with graphics and that sort of thing. But we were looking at what came next. I was, anyway. So I talked to a lot of these people about that, not in a formal way, but informally sitting around until I came to the conclusion that the next thing, really, was making all of this incompatible work compatible with some sort of networking. In other words, we had all of these people doing different things everywhere, and they were all not sharing their research very well. So you could not use anything anybody else did. Everything I did was useless to the rest of the world, because it was on the TX-2 and it was a unique machine. So unless the software was transportable, the only thing it was useful for was written technical papers, which was a very slow process. So, what I concluded was that we had to do something about communications, and that really, the idea of the galactic network that Lick talked about, probably more than anybody, was something that we had to start seriously thinking about. So in a way networking grew out of Lick's talking about that, although Lick himself could not make anything happen because it was too early when he talked about it. But he did convince me it was important.

NORBERG: Do you think this was the general feeling of the people at the meeting?

ROBERTS: Not necessarily. Corby [Fernando Corbato] was continuing to think about his operating systems and other things. I was collecting that from talking to these people; it was not clear that they were convinced. So I shifted in my research somewhat from centering on better graphics, or better whatever, -- and I kept on finishing at work -- to starting to investigate how computers could work with each other and how to do intercomputer communications and computing. In other words, what are the computing problems and what are the communication issues? I did the work that I reported with Tom Marill. That showed that computers could work with each other, and we figured out how to do that -- but we couldn't get the communications to work on it all. The telephone systems were very slow and unreliable and not effective for the computers to work together. So that was a problem which I then started thinking about solutions to and worked on in 1967 when I went to ARPA. And I had been talking about

it and so on. Ivan knew that. One of the reasons they wanted me to come to ARPA was so that I could pursue that and get something developed, which I started in 1967 with the first paper on technology.

NORBERG: Can we go back to one thing in the years before ARPA? That is, what was the structure of the Lincoln Laboratories as you observed it when you were there in the early 1960s? How big was it? What was the range of projects? Who were the people in charge, and so on?

ROBERTS: Well, at this point I forget the actual people in charge at the top, I forget at this point. It is hard to remember all their names. But there were a number of divisions and it ranged all over the buildings there at Hanscom. The funding was about 51% from ARPA. That was how Herzfeld put it to them when he told them that I was to come. But the division that computing was in had a large group working in speech with Jim Forgie and Karma Forgie and a whole bunch of people in that arena.

NORBERG: Was that two Forgies, Jim and Karma?

ROBERTS: Yes, his wife. And then there was Gold; he is still there. Maybe the Forgies are too. But in any case, there was a whole bunch of people working on speech -- more or less from a psychological point of view, to begin with, and then more and more computer-oriented. Then there was another division working on thin film memories and computer parts of that sort. It was actually part of the group that Wes and Bill left. When they left, that group wound up having this thin film group, and the guy who ran that was the nominal head of the whole group. I forget his name, but he did not care about the rest of the computing part. He just cared about these things in memory research. So he did not pay any attention to the computing people, which was the other half of the group, more or less. So the people I took over were the people who were working with the TX-2, which had been built by Wes earlier than that. That group, the Computer Research Group, had developed the TX-0 and the TX-2. Then after the TX-0, or somewhere along the line of the TX-2 -- somewhere in there -- some of the people had left to go to sell them for DEC -- General Doriot (?) and his friends. Actually the TX... PDP-6 was a copy of the TX-2 in part. So those people had

already pretty much spun off when I got there -- they just were doing that. Then Wes left. So that left a dozen people doing computer research and divide (?) lighting graphics, and on operating systems, and other things. There were other divisions doing all sorts of things in satellites, and radar, and so on. They used computers, and had big 704s down at the other part of the lab, but were basically not in computer research. So those two groups were primarily involved. Then over time the Forgies, and Gold, and so on worked closer with us. In fact, Karma started working for us. There was always an interworking, because the speech research people used that same machine that was useful to them.

NORBERG: Where were people like Gerry Dinneen at this time?

ROBERTS: He and Fred Frick and others were running the lab, basically, and then in management. I don't remember all that, but Gerry was certainly involved in the management.

NORBERG: Okay, so higher up than you were at the same time.

ROBERTS: Yes, right. It was these various sections in satellite, and radar, and so on. Those were all ordinary (?) also. Well, Frick ran the computing division, I guess, under Gerry.

NORBERG: And were you reporting to Frick?

ROBERTS: Yes.

NORBERG: All right, so the call comes from ARPA some time in the late second half of 1966. What was your initial reaction to Taylor's request that someone wanted you to come to ARPA?

ROBERTS: Well, I hated to talk to him. Several times I said, "Look, Ivan, forget it. I am busy. I am having fun. I am having a great time here and I am all involved in this wonderful research. Why do I want to go waste my time and manage the thing?" That was my reaction until Herzfeld called whoever the head was at that time. He called me in and said, "I think it's in our best interest that you think about this and it will be beneficial to your career." And so he counseled me, after Herzfeld talked to him, that it would be beneficial to get involved with all. I was also coming to the point of view, separately from that, that this research that we were doing was not getting to the rest of the world; that no matter what we did we could not get it known. It was part of that concept of building the network: how do we build a network to get it distributed so that people could use whatever was done? I was feeling that we were now probably twenty years ahead of what anybody was going to use and still there was no path for them to pick up. It would be much better in the commercial world where they could sell it at least, or something, rather than in this isolated research lab. In fact, we were doing things which only recently started being used in the marketplace in terms of three dimensional projections and techniques. There are other things that have developed much further. But what we were working on in some parts were very much ahead of where people were eventually going to find it economic and attractive to use, and have it really work. But we could not get it out. So I really was feeling a pull towards getting more into the real world, rather than remain in that sort of an ivory tower. Anyway, this was a chance to exercise that. And in the course of all those discussions, people made me aware that I would then be exposed to a lot more, because everybody comes to ARPA. They tell them everything that they want to do. So they eventually convinced me that it was a good idea -- particularly after Lincoln said that was the best place for me. Otherwise, they were in trouble (laugh).

NORBERG: While you were at Lincoln in those years from 1963 to 1966, had you had any contact with commercial outfits that you might have tried to promote these new communications techniques, graphics techniques?

ROBERTS: No. We had published papers, and I had been involved in the conferences and all of the academic efforts, but I had not had any contact with commercial firms really in terms of making it used. In fact, they were so far removed from where we were -- IBM was still making non-timesharing machines, and we were well beyond

timesharing and into interactive graphics -- that there just wasn't a vehicle out there. We would have had to do a lot more than build a platform.

NORBERG: In those early years did any of the results show up in any system, say, in the military? I am still thinking of the middle 1960s.

ROBERTS: I guess I did not look, because I would have had to have been involved in the military to see it. The military picked up things all the time, and did watch what we were doing. But we probably could not perceive that there was any possibility that it fed backwards into the military.

NORBERG: Sure. When is your first recollection that something had found its way into the military system?

ROBERTS: I do not think of military systems. I do not have much perception of that. I have really avoided military systems in large part in my whole career. We connected a number of them into the ARPANET. So that got involved with them so that they could use it, but that is the only perception I have of them. Typically, they looked so primitive to me that I did not pay much attention to them.

NORBERG: We will come back to that question, I think, as you go on. What is it you were told by either Taylor, or Sutherland at ARPA that they wanted you to do? What was the initial task?

ROBERTS: Well, to run the office, but...

NORBERG: Which office?

ROBERTS: The IPTO office, but with particular attention to getting the ARPANET activity going... not the ARPANET, but the network activity I had in mind. However it looked. Communications technology.

NORBERG: Wasn't Sutherland at this time head of or became head of the IPTO office?

ROBERTS: He was head of it. That was the period that was just before me. When I came, Bob became head -- well, he had become head just slightly ahead of that because Ivan did leave, and stayed on, overlapped me a year, I think, while I was Chief Scientist, because I had to go through all this stuff. When I went there, I went there on Lincoln's payroll, because that was the deal that Herzfeld made because their paperwork was going to take time. Nobody did anything, so when I got there I wrote my own application, my own request for employment from the government, and created my own job description. I was Chief Scientist for a while so that I could learn the office and Bob could continue doing the management. So I finished up understanding what was happening, and got involved with all the programs, and saw what everybody was doing.

NORBERG: I see. So it was clearly understood that you were going to take over the IPTO office from the day you were on?

ROBERTS: Yes.

NORBERG: Okay. What were the duties of the Chief Scientist...

ROBERTS: The same...

NORBERG: ... as you defined them?

ROBERTS: Just to take over the office. I did all of the interviews with all the people about what research they were doing and everything else and Bob handled the paperwork and ran around the world doing some of the more military

related things, until such time as I got to where I was fully up on everything, and could handle everything, and he was ready to go.

NORBERG: So what sorts of things did you handle in that first year?

ROBERTS: The budget, and the work with all of the universities, and research, and figuring out what research ought to be done -- basically the job of the director -- during that first year. It was just that I picked it up in a way that I did not have to instantly take over all of the...

TAPE 1/SIDE 2

NORBERG: This was a fairly influential year, was it not, for network development?

ROBERTS: Part of what I did was develop my own view of what the network ought to be and build the plans for the ARPANET. I wrote that first paper which outlined the structure of it, and started working with the universities as to how they would be involved.

NORBERG: How did that come about? Do you recall any of the details? How did you bring the message to the universities?

ROBERTS: Well, the universities were being funded by us, and we said, "We are going to build a network and you are going to participate in it. And you are going to connect it to your machines. By virtue of that we are going to reduce our computing demands on the office. So that you understand, we are not going to buy you new computers until you have used up all of the resources of the network. So over time we started forcing them to be involved, because the universities in general did not want to share their computers with anybody. They wanted to buy their own machines and hide in the corner. So, even though Lick was very vocal about this subject, I do not think

anybody else wanted to be involved. Although they knew in the back of their mind that it was a good idea and were supportive on a philosophical front, from a practical point of view, they, Minsky, and McCarthy, and everybody with their own machine -- wanted their own machine. It was only a couple years after they had gotten on it that they started raving about how they could now share research, and jointly publish papers, and do other things that they could never do before. All of which was a great boon to them and the artificial intelligence community for sharing information, for example.

NORBERG: In the BBN history of the ARPANET, they comment on the significance of a PI meeting in early 1967 that was held at Michigan. Taylor's view is that he does not even remember that that meeting was that significant, and yet if you look at the steps that occurred both at the meeting and shortly thereafter, there are a number of papers written, and a number of research projects established, and so on to start developing things like the interface processor and so on.

ROBERTS: Well, at that meeting we undertook to lay out my view of what each PI would accomplish and encouraged them to work with us. We encouraged them rather strongly, but on the other hand, at that point it didn't help to be twisting arms too hard, because we had not got to that point yet. So we said that this was going to happen and they were going to be involved, and not only from the point of view of any contributions they could make to the network, but also with their computers. The PIs were going to do work on both sides of it. Those PIs who had ideas about the network were encouraged to support that, and for example, Wes Clark did. He had to use a small machine to export some of this from the machine.

NORBERG: This is Wesley Clark.

ROBERTS: Wes Clark, yes. So, somewhere during the cab ride from that PI meeting that people report on, Wes told me that he thought of a better approach, than I had outlined in terms of integrating the software into each machine. He would separate it into mini-computers outside the machine, so that it was separable from the machine, in that

respect. He had worked on the only minis in existence. I don't know that any minis would have ever been built if it were not for Wes at that point in time. So he thought it was a good idea, and we all agreed. I thought that was good. So when we put out the RPQ we incorporated that in pencil. The same thing happened with all of them. We encouraged them all to support us in giving any ideas for making any facet of it possible. So Wes contributed that concept, and others helped with the host-to-host protocol and so on throughout the process. It was at the Gatlinburg reunion when I gave my paper on it and Donald Davies' group from England gave their paper, that they spent all night with me arguing about the thing back and forth; and I concluded from those arguments that wider band widths would be useful. But I was thinking of doing it with 9.6 kilobit lines, because it worked in terms of the traffic levels, for example. They made me think about the possibility of the 56 kilobit lines, (or 50 kilobit at that point in time), because of the response time potential. Stepping up to that was a big expense but it looked like it would work well. So we designed it with the higher-speed lines and looked at it seriously, and it looked like it would trade off economically. You could get more through them so you would not have to buy as many, and you would get better response time. So that was a good idea.

NORBERG: Was it expected that you would be able to get these high speed lines readily?

ROBERTS: At that point in time what you did was you bought what they called a 50 kilobit line with a very expensive modem that tied a whole bunch of lines together. So you used five lines or something to get it. That's what we did. But there was a price on it from AT&T. It was available under the Telpac tariffs for the government. I could get them reasonably economically because Telpac would let me buy those lines very cheaply. After I checked into the pricing and everything else, I found that I could buy them on the basis that it was reasonable. I did the numbers over and over myself to see what sort of response time and other things they could get, and that looked like it was effective. But they convinced me to look more seriously at it, because I had not done so at that point. They also generated the main packet, which came from England.

NORBERG: When I read the agendas from the various PI meeting over the course of the years from 1965 until about 1971, they are very opaque. It just says that there will a discussion among the PIs, and there will be an exchange of information about projects. Nothing is said about what projects are more significant than others, or less significant than others, as the case may be. One of the things that is specified in the BBN history is that networks was a principle issue of the PI meeting in 1967. Yet that doesn't show up in the agenda. What were the other principle topics? Do you recall?

ROBERTS: Generally the agenda was speaker by speaker. The PIs presented what they were doing. There were no general topics typically, although later on we might have all talked about artificial intelligence and where it was going. I think in 1967 this was not happening. We were just talking... Minsky was talking about what he was doing and so on.

NORBERG: Was there somebody assigned to summarize those things at the end of the meeting?

ROBERTS: No, it was basically an interchange between all of the PIs. In 1967 we introduced the concept of having a subject, and that subject was a project that ARPA was going to take on, which was a network. We took a piece of the meeting and we started writing about it -- I did, in terms of the presentation. I thought that was a good idea to do. I do not that we put it on the agenda or had a need to. We just started into the meeting at some point, and I do not know exactly how it was structured. I went into talking about this new project and what it was going to take.

NORBERG: What were the projects that ARPA was already involved in at that time when you arrived?

ROBERTS: Well, if you look at the contract list you will do better than my memory, and that's pretty good. The contract list exists by year, I'm sure.

NORBERG: Yes.

ROBERTS: But my memory is we had a bunch of timesharing projects, which is a bunch of what resulted from a timesharing thing -- the various university projects at the various places. Engelbart had gone on into interactive writing and that sort of thing. Durand was working with their direction in that and not just to universities. We used all of those research labs. Lincoln was continuing with the graphics lab as well. And so on. So there were all these people doing these various directions of research. Wes was doing as many computer modules. I do not know that he was... I think that's what he was doing, his macromodules. Each one was doing their own thing. Now the ILLIAC was an ongoing project that I had just started. That was the first big project, if you will, in which the sense that it was an undertaking. And that was ongoing. After that point in time I started creating initiatives in, say, artificial intelligence, and speech understanding, and other things that were sold to Congress as an initiative, as a direction, as a section. But at that point in time there were no sections really. So they budgeted. I can remember when we had all these projects, and they were doing various pieces of computer research done in various ways. And I started organizing it for Congress so I could sell it. The ILLIAC and the network were two areas, and then we had the artificial intelligence -- as we came to a point where we believed we could sell it, we did -- and then speech understanding and other things that came up.

NORBERG: Okay, if I correctly understand what you just said, there were a series of continuing projects largely in timesharing at the time, and a few other smaller projects that were being supported, like those things that were included in Project MAC other than timesharing. And then there were some new initiatives. There was networking at first, and then you introduced some new things in artificial intelligence like speech understanding, and another one. But there was a shift in the program, then, during your years as the IPTO director.

ROBERTS: Oh, there was a huge difference. When I went to IPTO there was a 16 million budget. Lick had double-funded most of those projects, so I did not fund them for a year. I funded new projects for the next year. So I brought our spending to 30 million, and then I went to Congress and said, "Hey, I'm spending 30 million. Now give me 30 million." They said, "Okay." They did the same thing the next year -- I brought it to 45 million.

NORBERG: What years are we talking about?

ROBERTS: 1967, 1968, 1969, I think. It was right in there it just expanded very quickly.

NORBERG: Well, what the congressional records show is that the appropriated amount in 1967 is 18 million and then it goes up by these smaller amounts until it splits into IPT and DIS activities in 1971, which there shows it to be about 28. [shows list of data]

ROBERTS: What is DIS?

NORBERG: Distributed Information Systems, which was a 6.2 category at the time...

ROBERTS: Oh, yes.

NORBERG: ... to show that there was some exploratory development going on in addition to basic research.

ROBERTS: ... and research.

NORBERG: DIS didn't exist until 1971.

ROBERTS: And what is this DIS?

NORBERG: This is the requested; this is the appropriated.

ROBERTS: Oh, I see. There is a piece missing, because we were actually operating at 50 million, and we only have about 30. So you may be missing the 6.3 or something.

NORBERG: Could be. Oh, yes, we have no 6.3. I wasn't even aware that...

ROBERTS: Well, we kept on using money of various types. There may have been another 6.2 category or whatever, but the 6.1 was a relatively... We put projects in whatever category was useful and I moved projects back and forth depending on how it was selling in Congress. But the actual net went from 15, or perhaps 18... (Actually, it was 15, I think, the year before, but maybe not. Yes, you have that here.)

NORBERG: Yes. Sounds about right.

ROBERTS: And it was about 50 when I left. It was actually running at about 50 for a couple years. So there is another ? . Then it actually took a dip the next few years as new heads of ARPA came in and Lick and other people had trouble selling things, and the concepts changed. Bob brought it back up way above that in more recent years. In any case, that was what I was doing on this page. I was taking the money that was already appropriated, that was double-funded in the programs and expanding it under new programs -- and generally, new programs like the network, which I could sell. And using the big projects like the ILLIAC that I could sell -- things that were visible enough that I could sell them -- I created lumps that were visible enough to Congress. So I could talk about artificial intelligence or speech, and get a program where we could talk about it to them and get a budget put together.

NORBERG: I guess I am not clear on what you mean by double funding.

ROBERTS: Lick funded multiple years for Project MAC. When I came there Project MAC was funded three years into the future. First of all, Congress did not like that too well. Secondly, because he didn't have other projects, he

put it into the same place, which is great, because he built up a fund so that I could just not fund it for two years and still keep the project going. Then I could go to Congress and say, you know, "I need my 15 million, or 18, or whatever," and I could go out and spend that, but I spent it on a new project. And the next year I could go back and get the rest.

NORBERG: How were these new ideas sold inside ARPA?

ROBERTS: ARPA was quite responsive. Herzfeld, and Rechtin, and Lukasik were very responsive to the whole concept of it. As long as we could find a way to sell it to Congress they were happy.

NORBERG: Could you be more specific about how you interacted with those people?

ROBERTS: Well, I would work on preparing an order and think about what I was doing and what I wanted to do, and then I would work with them on whether this would sell, whether they believed in it, whether they thought it was a good strategy. We had budget reviews, and reviews of every project, and so they watched what was being done and how we were proceeding with it, and how we were getting the projects done. Clearly there were some headaches as the ILLIAC 4 got delayed and that sort of thing, and they watched those issues. But in large part, they were looking at the bottom line. The bottom line was, is this done well such that we can get the money out of Congress, and are we doing a good job in terms of what we are doing? Are we able to sell what we are doing? Then we'll get more money? They were happy to put more money proportionally into IPT than strategic missiles or something else. That was to them, as to me, a bigger contribution to the country, if they could make it work. If it was good projects that were salable and effective and so on. So everybody was coming with their projects from all over the industry. That was the benefit of being in ARPA. We listened to everybody's projects. Anybody who had and idea. You knew you were on top of the field because you heard everybody's presentation.

NORBERG: Was this idea of certain objectives of the nation explicitly discussed by people in the budget meetings, or evaluation meetings?

ROBERTS: No, we avoided the concept. We had to make it work for the military. That was the selling objective that we had to work under, and clearly a particular responsibility. But it was clear to me and the directors that this was something that was serving the nation in every field, and clearly serving the military as well. There was hardly any question about that. If we did something which was clearly off the mark as far as serving the military as well, then we knew we would not get good support, and it wouldn't work. Our selling case might be bad. So we did not do things that were too far off. Once ARPA did try and float one program of building tunnels that Steve tried to sell and it did not work. Congress turned it down because they figured that although the military needed them for certain purposes, it was much more highways and other things. There was a whole bunch of new technology that could have gotten us hard rock drilling to a point way beyond anything we have done today. We could have gotten it to where we could make tunnels at 10 times the speed of the day. But they said it had to be outside the military and nobody ever was organized like ARPA to do it, so it would never happen. So it did not happen. We did make it happen in computing. We managed to keep the focus on the military. They were so dependent on it that anything we did was effective for them and we could sell it with that. Everything we did was effective and beneficial to the military, but they were only one consumer, and we knew that. In every program throughout, I think, even in Congress, everybody understood the game: this was to help the country as long as it was helping the military.

NORBERG: That suggests a rather informal way of arriving at programs and assembling dollars to fund them.

ROBERTS: Well, it was very formal internally with me, because I was looking for the best things to make real gestures to make substantial progress in the field. So I was throwing things out, like I went back to MIT and said, "I do not want to work on compilers any more. Compared to other projects that are being proposed, it's not serving anybody enough. I do not have that much money to throw away. So get off working on things that are not going to

produce more than a 10% improvement. I do not need a new language." We even quit working on operating systems after the TENEX system because it was just not worth building another one.

NORBERG: How did this sit with the receiving audience of this message?

ROBERTS: Oh, the university researchers were upset with that message, because they did not want to quit doing that. The management of the university understood that they did not want interference with research going on either. They wanted the professors to be able to do whatever they wanted. So it conflicted with that. What I told them was, "You can fund that as university research if you think that is appropriate. But we do have a clear direction here: we want to make the most out of our money." Now, there were some 6.2 issues coming in to all this talk, that with the direction of Congress we had to have more and more research that did something; more 6.2 rather than 6.1. But I was even directing 6.2 research to be productive, saying that if it was something we had done over and over and it was now getting only marginal improvements, it was not worthwhile. We wanted something that would really have a big impact if it was worked on, like the networks, or like the speech, understanding, or whatever, rather than something that was going to have much more minor impact. So we directed the research like that, with the concept all along that it had to be a step in front of what the industry was at. That is, if industry was doing it, or they could be doing it, then forget it. Yet it had to be not so far ahead that they would never do it. It had to be two years, three years beyond what they would consider funding themselves. It was very clear what that pattern was after awhile and what you could do. You could just leave the ? . At the moment ARPA is looking at gigabit networks. I am not sure that they are not two steps ahead, because industry is now just getting to 45 megabits and ARPA has skipped 100, 200 and gone to a gigabit. We skipped an order of magnitude and tried to jump very far. Is it doable? It may be the right strategy today, but it is a much bigger step than we took. We took more that one step. But of course, nobody was doing anything to do with networks either. So when I started that, the Defense Communications Agency people around me basically said I was crazy, they felt I was absolutely out of my mind.

NORBERG: (laugh) How did they express this to you?

ROBERTS: They even stood up in meetings when I made speeches and booed and hissed and made nasty comments, because they just could not get their mind into a new focus, that this was popular work. The buffers were going to run out. There was just no way it would work. So I remember meetings where people just were caustic. But the computer people were not, so I did not have that from every front.

NORBERG: I heard two criteria. One of them was the selection of projects that had rather large improvement possibilities, not just 10% of compilers and those things. So one had some flexibility there at the high end. Secondly, there was a case selection, or selection of cases where the industry would be willing to come along, perhaps in the not-to-distant future, but we did not want to be too far ahead. Were there other criteria being used, and how did you arrive at these criteria at the time?

ROBERTS: Well, on a larger ? I myself have worked with upper management and Congress. Congress did not provide anything but yeses and noes. So we hardly ever got a lot more out of them. Well, there were schedules somewhat out of context, but largely we would pick that up from Congress by being kicked in the head here or there. We knew what routes would not work with Congress. So Congress clearly provided direction, even though it was more by stamping on you now and then. And Steve Lukasik, who I mainly worked with through all of these years, and I watched very carefully where we were being stamped on in the other programs as well as ours. We were not stamped on very often. I carefully constructed ARPA budgets so that we would avoid those problems. But that was only part of the input, because clearly Congress did not know what was good and bad either. So I really developed a lot of that. I worked with Steve; I worked with Ed Rechtin -- in particular, those two directors -- and looked at where it was useful to go, where we could get the maximum effect. The other tool I used was I looked at how the military ran a lot of their programs -- the Air Force, the Army, ONR, and other programs where they managed research programs -- and I looked at the effectiveness. I found that they were able to hire a person of a certain caliber in the office; maybe a Colonel, or whatever. And if you looked at it like a corporation, that person was effectively in charge of a budget which might be $200,000 or something. He then doled that out in $10,000 pieces or something. But $200,000 is only

three people full-time, or something. So he was essentially managing three people, or maybe he had that in man-dollars in one of his managers. But he had a fairly small group. He then made a lot out of it; he doled it out in small pieces in order to make something of it. None of this was very effective, however, because he really only had three people working for him. So he accomplished virtually nothing, and spent a lot of time and effort doing it. Therefore, they could not get anybody who was better than a three-person manager to do that job, and his decisions were no better than that. Nobody would come and do that job -- to dole out $10,000 pieces, or whatever it was if they were better than that. Now, what I wanted were people who were really managers like they would be in industry -- substantial managers with substantial groups. To do that I had to give them the budget individually, not to their staff, not spreading it around to a lot of staff. So I took the staff down to a minimum and had just two or three people in the office, and each person was handling ten million dollars or something, so that you had a substantial capability of a person. When Bob and I were there, I will bet there were about 10 million or 20 million dollars a person, more or less. Then the budget went up and we started bringing in people: Bob Kahn and others. So we basically got to about four people, I guess, by the end of the period. Now, it has changed a lot since then, but the concept was that you really want to bring in somebody who can manage at that level. And you can bring in a person who is a manager at that level.

TAPE 2/SIDE 1

NORBERG: You mentioned that you went from three to four people inside the office and that you were looking for a particular kind of person in order to manage these large projects. And the larger the amount of money that could be managed the more likely you were to get a really good person. Where did you go to find these people?

ROBERTS: Well, sometimes I went to the projects that we were running to the research lab and so on. For example, Bob Kahn was from BBN, which was part of the research community. I needed somebody who knew the networks; he did and he had a good research orientation. In other cases it was people who were locally available, like the

colonel that I had working for me who was from the military. I can't remember his name but he eventually took over the office for awhile too.

NORBERG: Was it Russell?

ROBERTS: Yes, Russell. He was from the military, and worked in another office and so I knew him. He knew the operation even though he wasn't a technical expert in that particular field. And also I got people who were just younger people in the field, who I thought were really bright and capable of doing things rather than people who had already established a substantial activity. They were harder to get in, and I wanted somebody to come for a few years who really had the potential but had not been locked into some place yet. I did not want anyone who was staff. The whole concept was to keep it relatively short-spaced, three to five years, so that people would not stagnate in the office. It was Civil Service. We tried to get it out of that, and we tried to work with PL positions. We did not really want to be in a situation where people could stay indefinitely and stagnate.

NORBERG: What are PL positions?

ROBERTS: Public law positions are non-Civil Service positions that are slightly outside the system.

NORBERG: During this period did you have any interaction with IDA?

ROBERTS: Yes. I worked with them from time to time; not too much. I went to meetings there.

NORBERG: So they did not play any influential role during your period as they had in the earlier time when ARPA was getting going?

ROBERTS: No.

NORBERG: Among the people that worked for you, what were their specialties? The colonel from the military must have had some experience that attracted him to you.

ROBERTS: Well, he was primarily in management for us, because he did not have a particular background except in the nuclear area that he worked in before. So that that was a fairly broad management capability. Bob was in the network area. I do not think I brought in anybody else who had particular technical specialties.

NORBERG: Who were the other people in the office in the late 1960s?

ROBERTS: I do not remember them all. There was one young person that I obtained who was just a very bright kid that was in the military. He was not being used effectively elsewhere; he was a lieutenant or something like that. I had him for awhile. But I didn't actually have a lot of people, and I do not remember who that person was after Bob. It was maybe Wesley.

NORBERG: All right. To whom did you turn outside of the office for advice, for a sounding board perhaps?

ROBERTS: Well, the PIs, generally. The PIs were the primary group that we worked with, both in the PI meetings and individually, in order to get a consensus in the community of what was good and bad. I used them as a sounding board a lot. Keith Uncapher was very influential and valuable and so were a lot of the others.

NORBERG: But the names of the others do not come to mind quite that readily, I take it.

ROBERTS: Well, Wes was always valuable. Al Perlis and clearly the Sutherlands, Ivan and Bert, were both involved all the time.

NORBERG: Could you be kind enough to take me through a budget cycle?

ROBERTS: The budget cycle. Let's say, we had just gotten that approved from Congress. Start there?

NORBERG: How about going back before that?

ROBERTS: Are you talking about a budget year, or an idea...

NORBERG: No, I was thinking of a budget cycle where you have a new idea, and you have to go through the whole thing to sell it internally, and then to Congress, and then you find a contractor to do it.

ROBERTS: Well actually, we worked pretty much in a reverse mode in most cases. That is, we took part of our current funding that we thought we could manage within the intent of the congressional approval and started to use these funds, which might not lead to funds yet, to go after initial programs. So then we started talking to contractors about. In the ARPANET I developed a lot of the ideas. I wrote down, I did the analysis, and I decided what we needed to do, and I then wrote the RFP and went after the particular technology I wanted. In most cases we let the contractors impose the ideas. So the ARPANET was very different in that that was my project in terms of design and control. Then the universities and everybody got tied into it. If you take the speech understanding program, for example, what I did was I said, "I believe that I could sell a program, and it is important for the country to have a program, and we are at a point in time when it would be valuable to try and apply some of our artificial intelligence to see if we can really use speech. Then when computers are powerful enough the techniques will be available. The computers will be powerful enough, more or less, at the right time for the rest to take place." So I looked at the time scale of where computing power was going, and where our capabilities were in artificial intelligence, and what we had already achieved in speech, and said that if we attacked it now for the next five years, computers will have then been developed far enough that it will be possible to build machines that will be useful in that program. Clearly that would be valuable. We looked at the pros and cons of speech control and speech support of machines, and it was very

valuable. So then I first talked about that with all the PIs. I threw this idea out to them individually, to get a feeling of whether they all believed that was true. Then we refined that concept to where we decided that it was an attractive, sound concept: that we could achieve something -- that it was probably achievable, and that it hadn't already been achieved -- and that it would potentially make a significant difference, it would be at the right forefront distance and so on. So that was the program concept. I think we had to go a step further before I could do anything with Congress, so we used our AI funds that we already had to go out and try to find programs that would be, in fact, in this area. Then, when we at least had conceptual ideas of how this could be done, I went to Congress -- or maybe I did it the other way around... Let me try it both ways. And I cannot tell you how I did it in every program. One way I did it was I actually laid it out for Congress, at that point, and said, "Here is the speech understanding and here are the elements and we're going to fund it." On the other hand, without particular contracts in that area, you're never going to get anything approved by them. So what I think I normally had to do was to go out and fund the contracts within the section of budgets I already had approved. Then for the next round of Congress I would organize them into a section, which I would call speech understanding and tell them about it. I would explain how valuable this was, and have an over budget amount so I could then start extending new projects. That budget had to be dependent largely on existing projects and have real things, and yet I could not get real things unless... It was a chicken and egg. So to get to a point where they were approved you would have to use existing funds for something similar -- go after contracting with Rand to do something, or Carnegie, or whoever it was, and find that -- and then come back to Congress and put it in the budget and say, "Okay, now I need to do another project. I need to expand this one or build another one." So that that budget for that area would then go up over time. Now, the actual work with the contractors was to go and make it known we were interested in that area. We went through and got everybody to bid the best projects they could and reviewed all those. Actually I used the PIs and everybody else to help in the review; it wasn't totally an ARPA process in that case. In other cases, we would see a proposal come in. Somebody would come in off the street saying, "I have this new thing I want to do." We would evaluate it: read it, understand it, go see them, and do whatever the review of the project was. If it really was exciting, and it fit in, and everything else, with the funding at some level, we would go ahead with it. It was not very often that we were not talking about it with the whole community before that happened. I think occasionally somebody had such a good idea that we did

not pursue some sort of a peer review. But the peers were there, nd it was real valuable to make sure that nobody had been doing it or thinking about it, that they thought that we were not all off track. And so, pretty much everyone helped in the process, even if it was not conscious to them. They probably did not even realize that there was a lot of that going on.

NORBERG: Can you cite any examples of areas where peer review did not work to the advantage of the program, as you perceive it, of course?

ROBERTS: Well, in the network program the vote on the ARPANET would have been not to do it. I mean, if you asked all of the PIs they would have said, "No, we do not want to participate at this point. It is probably a good thing to do some day, but we do not think that it is time. We do not think we want to get involved. We do not want to use up our computer." Especially when they knew that their computer was going to be attached to it. But on the other hand, we asked them for support and understanding of the technology and how it would be done and so on, and they helped a lot with that. Once we said it was going to be done, then they were very supportive of the technology. At some point they probably would have preferred that we terminate the ILLIAC IV, because they saw it as a sucking of funds that they could have.

NORBERG: Did you feel that way?

ROBERTS: Actually, I felt that we were getting more funds out of Congress due to the ILLIAC than the ILLIAC cost. I felt that way about any big project, that we could sell big projects and they helped sell our whole budget better than anything else, because the Congress could see what it was. I mean, independent of how good the ILLIAC was, I could sell it as something that worked. It was the fastest machine in the country at that point in time, and it helped solve the military problems in a way that nothing else could. So clearly it was beneficial, rather than harmful, to my getting money. It generated more money than it cost. So I let people understand that when they argued with that approach. Now, whether it was good to continue with it the way we did we made some mistakes. I think we made a

mistake vying for ECL [emitter-coupled logic] in that program, because it was not there. It would have been better to deal with what was available. And the technology would not be so much slower. But I did not make those decisions strongly enough early on, and get involved. That was what the University wanted to do, and I wasn't directly involved enough in that level of decision at point in time. Later on, I got to where I was involved at that level, saying that this is not the right use of our resources. That is a dangerous approach, to try and go for the fastest when you are also doing the newest.

NORBERG: Before we lose something, I want to go back to the budgeting process because two things occurred to me in the course of your discussion. When you were saying that in order to increase the budget from the Congress it was necessary to have some projects going, in order to be able to demonstrate that there was a value and that you needed more funds to expand the effort, do you think that was typical in DOD programs generally?

ROBERTS: My view of Congress was they would not plan anything that was not already there. So the problem was to get it there. That is, that they would allocate funds for continuing programs that you could demonstrate were valuable and reasonable. They almost would rather do it on the basis of, "Well, it exists so I 'll go along with it rather than firing the people," than on any other basis. When you would come at them with a new program like, "I want to do a new initiative," we did not get hardly any response. Typically, it was very hard to sell that approach. So that what you do is you get it started within another area that was going and then break it out as a new area that was exciting and expand its budget. You could always get a 10 or 20% expansion of a program, or more.

NORBERG: How did you learn this? By experience, or from someone telling you in ARPA?

ROBERTS: Pretty much experience, although clearly that experience was being fed back through the director, Lukasik, or Rechtin in large part, and their experience with Congress, because they were the ones who sat there and worked with them. So the rest of the directors got their experience through them in large part. We went occasionally, but it was usually them. So we were all watching the process and we were all learning. I suspect that my experience

was slightly different than somebody else's in that same process of how they approached it. I mean, in the strategic missile thing they might have just said, "Okay, we're going to go do an ion gun," and got it approved. But I usually did not have very good success with that in the computer field, because it was not so specific a military need.

NORBERG: Back to my question, do you think it was typical of the Department of Defense to do things that way?

ROBERTS: Oh, probably. It could have been. It made it a lot easier to sell to Congress.

NORBERG: The second thing that occurred to me while you were describing the budgeting process was the flexibility that you seemed to have. How much flexibility was there in your funds? Ten percent, twenty percent?

ROBERTS: No, actually there was more on my funds, because the director of ARPA liked the program and -- even though Congress might keep ARPA at 250 million or some other number, more or less consistently in those days -- he was willing to go in on a request for more for us and less for somebody else, because we had better programs. They were better structured; they were better put together and so on. So the internal competition was to have sound, solid programs that were working well, that were producing high, exciting results and that he found were effective and that you could also sell to Congress. So by having good results and presenting them well, and having good things to talk about, exciting stories to tell about what we were accomplishing, we were able to get a bigger piece of ARPA's budget as it went from 15 to 50 million. ARPA didn't change.

NORBERG: How did this affect your relationship with the other office directors in ARPA?

ROBERTS: There was competition. They were all willing to compete and they changed from time to time. They were not being difficult about it. Some of them might have been somewhat less than friendly, but...

NORBERG: Can you think of a program that you terminated later in your tenure there?

ROBERTS: One of our computer programs?

NORBERG: Yes, one of your programs.

ROBERTS: Well, I do not know the history of all the programs. I know that I terminated programs.

NORBERG: None of them so large though that they come to mind automatically.

ROBERTS: I do not know exactly what happened to the SRI program. Eventually that was not functional anymore and we stopped doing as much with the SRI automated employee program. There was a continual close-down of programs and expansion of new ones. Some were traumatic -- but not too many. Usually we came to a point where that program was not doing that much anymore. The principal had left, or something like that, and the change was more reasonable. For example, when the people left Rand we closed down the Rand project eventually and started the ISI program. There was a little bit left of Rand for awhile but it was not doing anything. It was not much of an issue with the people, either.

NORBERG: Do you remember any big change in budgeting after the ILLIAC IV went to NASA Ames?

ROBERTS: No, we had programmed the funds to be on that cycle anyway. And I was then able to do what we had been planning for, you know, with programs like speech understanding and so on. That had all been planned pretty much. It was not a windfall.

NORBERG: Do you remember your reaction to the Mansfield Amendment in this period and the insistence on greater emphasis on the military mission in DOD programs?

ROBERTS: It had its impact, and we worked with that. A lot of what I have told you already is in relationship to the Mansfield Amendment and how it affected us. We kept on looking and presenting with the military needs presented. That was one issue. The second issue was to move the presentations and some of the funding away from basic research. In large part it was to maintain the basic research at the levels we had and expand it somewhat, add a lot of element programs, because we saw we could add those more effectively. So for me, the Mansfield amendment said that there were more 6.2 funds available and we continued to use and continue with the 6.1 we had. And some of it turned into presentation, like in the speech understanding and artificial intelligence. I turned it into presentations which sounded more supportive of the military roles.

NORBERG: Were they?

ROBERTS: More than they were before they were restated. They were always supportive and I suspect now the military has a lot of expert systems in running ships and other things. And I am sure that it has benefitted the military as much as it has the rest of industry, and in fact may benefit a lot more because it has very complicated systems in all the bases... But it is just so much in parallel with everything else. There is no special type of computer for the military.

NORBERG: What I remember reading in the public presentations of the director of ARPA, either to the general public or to the Congress, is that after 1971 or so you begin to see reference to specific programs in the military, like the ADEPT program and the TDMS program, as being beneficiaries of something that happened in either interactive computing, or later on in networking. Do you remember being associated with the military in any close way in those periods in which you oversaw the implementation of some of those programs? They were partly funded by ARPA.

ROBERTS: Yes. I never did much of that personally. But Russell and Kahn got involved with particular programs under my direction, and did work with the Army group or whoever. For example, we did a lot of work in packet radio with an Army group who wanted our packet radios, who had wanted to look into that. It was very valuable to have a

customer for that technology in terms of selling it and in terms of having a customer. It was always valuable to have a customer. Packet radio was considerably ahead of its time. It has still not come into public use. It is in amateur use in Canada and hasn't done anything in the U.S. But it is being looked at in the military still because of those programs being used. I do not know exactly how far. We did have those relationships. But personally I did not have much need to get involved, nor was I very interested in getting involved. So I oversaw the fact that they did that and that was about it.

NORBERG: Okay. I want to turn to one other issue area here, and that is the procedures inside the IPTO office when you were the director. You mentioned that when you first came you were learning the procedures under Taylor's direction. What was the procedure when you took over officially as director? When a proposal came in how was it evaluated, what happened to it, how did it get funded, and so on?

ROBERTS: Well, if a proposal ever came in full-blown, I would read it and then bring the person in for a meeting. Usually the people came in for a meeting first to find out what the direction was that they could pursue, or how to develop their idea, or whatever, within our context. We would advise them how to proceed with the proposal process. So we would meet with the potential people all the time. All day long there would be interviews with various groups that had ideas that they wanted to sell or programs to do or expand. Or I would go to those locations on occasion, or Bob would, or anybody else. But with Bob and I, it would come under my responsibility to evaluate the programs. So I did that, and that was true even after they left. As the office grew, some of my people were responsible for evaluating them up to a point and then I'd get involved. But in any case the researcher would come in, or the group, and talk about what they wanted to do. We would evaluate whether there was a thing there. If you want to go through a particular case, for example, the University of Hawaii had a program in packet radio. In fact, it was a new contract. We had not noticed anybody from that university before. We did not know anybody there and so on. Actually, I think that program started in part because they had made a proposal to a program where we had accepted a few small proposals. But I do not know; it may have been done that way. There was this one program where a bunch of... I'm trying to think of a program where I can tell you about a ? ? , because generally the

process was very introverted. That is, we would go to MIT and see what new things they were proposing. Then they would make their overall proposal for the year, after we had met with them and said no, yes, no, yes, on all of the various pieces, and had had an extensive meeting telling them what was acceptable and what was not. Then maybe we would go through two rounds of proposals, saying, "Was it written poorly? This is not supportive. This is not effectively going to support our selling it," or "I will not do this piece of it." We probably used the Congress as a reason a lot. In reality, the biggest decision factor, colored by whether we could sell it, obviously, whether it was going to affect the nation effectively. Were we going to get a substantial increase in something out of this? Was it something that we wouldn't get from industry? So we looked at those factors all the time and had a meeting about that with out contractors. New contractors were not that common. In the case of the networking on NRP, we got a proposal, we went through the review of it, we met with the people and went to the site to find out how good they were and how good the researchers were, and then we started with something we thought was effective for them, that would work. Usually that did not involve any approval of Congress, because we were way down on a ? that point. We were starting with a $50,000 program or something.

TAPE 2/SIDE 2

ROBERTS: Well, one final part of that process was that then, at that point when we decided it was a goal and we had a proposal that was viable, Al Blue, who was our manager of the contracts and so on, would take it and would work with them to get the contract done. Then there was the whole process in which we worked with one of the Army agencies, or Air Force agencies, or whatever, to do the contract thin. We told them what we wanted, and actually just forced the process through fairly rapidly. It was not a very long process. We had good red tape-cutting capabilities here at ARPA.

NORBERG: Did you need any formal evaluations of these proposals in order to go ahead with an ARPA order?

ROBERTS: No. We did not have to have anything but the office and the director of ARPA's approval. So that we typically needed my approval and Lukasik's approval when I was there, to fund a program. Of course, we had to have the Army Office or the Air Force Office, or whatever, do their crosschecks on the authenticity of accounting and other things like that.

NORBERG: How did you convince, say, Lukasik? Was this done in writing, orally, sometimes both?

ROBERTS: Almost always with a meeting where I had it on paper and I presented it. I would say, here are the new plans and I would explain orally what we were trying to do, and what this was and a number of programs for him to review or whatever. After he had reviewed it and I had explained what it was all about for him to approve, then we put the ARPA order forward to him at some later date. Hopefully, we had did have any glitches in it. He would read the paperwork and decide what was okay. But the paperwork was written to correspond to the concept of the program that we had put forward to him already. But if he had not heard about it the whole time, he would probably ask us what it was.

NORBERG: Licklider, in his early years, was making these rather large programmatic grants, such as Project MAC. How did that change during the course of your tenure at ARPA? Did you require, or was it required of you to go to finer and finer depths to define projects? Or could you still fund things like Project MAC with whatever percentage of your budget you wanted to?

ROBERTS: Well, Project MAC was probably a bigger percentage of his budget, but it was actually expanded while I was there in terms of millions of dollars of activity. And the ILLIAC was expanded even more, and so on, so that we had larger programs. We had no problem with large programs. In fact, that was my intent. I wanted large programs rather than small programs, because the paperwork involved did not fit my concept of this manager strategy. I needed large programs in order to have not too many managers. Otherwise the paperwork would get out of hand. So I guess my instruction to everybody in the office was that we have got to keep the average contract for a million

dollars, or some such number. You can have a small one, but you better have a big one, because we cannot handle the paperwork if it gets more, and I am not going to hire more people to do this.

NORBERG: How does one keep quality control over projects under those circumstances?

ROBERTS: Well, it is a lot easier to afford a trip to a million dollar facility, and review what they are doing, and do the normal management reviews than it is to review ten hundred thousand dollar activities. So you can actually keep on top of them. You do it in aggregate: if you have got ten people working on a piece of software, you do not need to interview each one of the ten. You just look at what the production level on that software is. If you have got ten little projects that are broken down at that level, each with one person working on software, then the programmatic review at that level is impossible for us. So we were working with larger programs in general. At MAC they collected a whole bunch of things and presented them all to us. They might have been able to hide some little things, they had that possibility, but if they did not produce good enough results overall, then we would be affecting their funds, and they would have the same problem at the next level.

NORBERG: Did this limit the kind of activity that the program could engage in? If you had to find people who could propose half a million, one million...

ROBERTS: No, because we could do $50,000 projects, but we typically encouraged them to go somewhere else, like Air Force, or to somebody else who had broken their program down into small amounts. And typically, that was better for them anyway. Those who would spend the time with them if it was exciting, liked to work with them. So we either would do that, or, if they were at a place where we already had funds, they would go under MAC, or go under something else, rather than be defended individually. If there was something that was really exciting at 50,000, we would do it at 50,000 and hope that it would expand into something better, because something at 50,000 probably is not going to pay enough to even mention to Congress, and will not pay enough for the country to be a big thing. So either it could start as a bigger thing, which is fine, or it got accumulated somewhere else, or it was done by one of

the other offices. But we really did have to keep our resources, so that we normally did not do that. We kept the other offices doing those things. If they then grew them to a project size, which ARPA could handle, and it was really great, then we might undertake to fund them. I do not know that it happened very often, but...

NORBERG: This is on the management side. How about on the intellectual side? Did you have an overview of the computing activity, computer science field, that you were trying to stimulate, and therefore you gave particular attention to some areas, but probably ignored others?

ROBERTS: Well, you first realize that everything in the computer science and communications field had been proposed to us. So I had a broad view of everything, all the potential research, because we did listen to everybody who came in. Every brother and their crackpot friends told us about their projects that they wanted to do. So we had a very good view of what was potentially possible, and what were the things that were ongoing. We sort of looked at things like amorphous semiconductors very cautiously, because we just did not believe that was real, or whatever. I think the materials office got involved in that a little bit, but I would not. But we watched everything that was happening. I do not think that there was any discrimination, in the sense that it was a field I liked, or I didn't like, or something, or that it was networking, or not, or something like that. The discrimination was much more on whether I could find a real rationale that that was going to have an impact, that I could look at it in five years and be proud that it had happened in the country, that I had done it, or I had been involved in it, or something. Or that I had not, that everybody would have forgotten it; it was not that important. I mean, would it have an impact on industry and the military? I had to make sure the impact on the military was equal to any other thing, not less. If it was more, fine, but there were not many of those. In fact, I doubt that there was anything that was more military-oriented than not, nor could I expect to find anything, because in our field if the military could use it, so could industry, most likely. That is not true of a gun, but it is true of a computer. So I did not have any trouble with anything that was proposed. I really saw a broad spectrum of what was going on in this field. The biggest set of decisions were: do we go off into high-speed computing, is that going to pay off? Do we have enough money to make a dent? Is industry going to do it? Or do we go off into speech understanding? Or do we go off into automatic programming? Is that going to pay off?

Is there going to be something happening there? We did do a lot of automatic programming, and it never did much. It may some day, but expert systems seem to be a better approach, at the moment, at least in terms of what people are managing to sell.

NORBERG: How about things like secure systems? There was a fairly large programs in the 1970s.

ROBERTS: We did a lot of research in that and, I think, we managed to achieve a substantial improvement in what people were doing, in recognition of effects, and so on. That is really as valuable in the private sector as it is in the military sector; it was totally valuable to both.

NORBERG: Turning back to the private sector, when you left Lincoln it was because it was in the interest of Lincoln. What was your interaction with Lincoln over the course of the years while you were at IPTO?

ROBERTS: Relatively uninvolved. I supported the program that was there for a period. I do not know how long it continued, how important it was. It was not one of the most important programs that we had, and it was not one of the most exciting after I left. So I did not have any particular bias towards Lincoln, but they were continuing to be involved at some level. So my involvement with Lincoln actually decreased considerably because I was not there and I was not working with the same people there. When Britt(?) [Burt?] left, it got even less interesting, and that was not that long.

NORBERG: During the course of projects that involved commercial outfits such as Burroughs, and General Electric and then IBM, these were done, as I understand, by subcontracting through the major project at MIT in a couple of these cases, and in the other case, at the University of Illinois. What was the involvement of the IPTO office in decisions about those subcontracts, if any?

ROBERTS: Oh, I was at every meeting with those. I sat in and was in charge of basically making the decisions with the University. There was a very heavy involvement with those, because it was our money, I had an overview of the thing, of what they were doing, so if there was any decision I could have made that disagreed with them I would. Generally, as I said, I probably would have made more decisions, like staying out of ECL as I learned more about how to run such a project. But to the extent that I personally had the capability to make such decisions and knew that it was the right thing to do, I did. I was in all the project reviews and meetings with Burroughs, with the Illinois people. But there was a level of detail that they went to that I could not. If they were involved in a circuit design or the conceptual level of the design, I would never get there, and they would be working with the engineers on the side. But at the higher level of program slips and the decisions about how we attack, you know, the overall plan of what we use for memories and so on... Actually, I made the memory decision with the Illinois people. It was probably the decision that killed thin film memories in the country, because we decided to go with semiconductor memories, which had never been used, by the way. Thin films were ready to go and were competitive, but we decided they were not quite as good, so we decided not to, and therefore nobody ever built them. And semiconductors, of course, quickly overtook everything.

NORBERG: I would think that was a hard decision to make though in 1968 through 1970, as to whether you would go with semiconductors or some other means.

ROBERTS: Yes. That was one that we looked at a lot. Of course, the Illinois support of my process was real. They were looking at it very seriously. But I was listening to all the other news and trying to make that decision with them. If I had differed, I would have won. There probably were things that we had forgotten.

NORBERG: Sure. Do you remember who the people were from the Burroughs' side who were involved in these negotiations?

ROBERTS: Do you want to mention names?

NORBERG: No. I will find out from Bitzer, or somebody like that at Illinois eventually, but I do not know of any names now.

ROBERTS: I do not know the names.

NORBERG: Shifting to the one other major contract, were you involved in the discussions with General Electric when they got the subcontract from MIT for developing the 635 timesharing machines?

ROBERTS: That was before me. That was when Sidney (?), Lick and ? , or Ivan, did that.

NORBERG: Did you have any contact with them afterwards, after you became...?

ROBERTS: I had contact with GE, because I was mad because they would not proceed with it. We -- not me, but MIT and ARPA -- had done this work and gotten the machine to a point where it was valuable. We wanted other military groups or other groups in the community to be able to use this machine, and they would not sell it with Multics. They would not sell that. That was not a part of ? . So I had a lot of fights with GE at the corporate level. We would attack them at that level with our buying power. And we got them to keep them on moving a little bit in that direction, although not very seriously.

NORBERG: Did that occasion then shift to Honeywell and the introduction of Multics in other areas?

ROBERTS: Well, MIT finally made that decision. Their decisions were with their vendors and we did not have to do much with them in that respect. I observed a lot of that at MIT before I even came to ARPA, but what I got involved in with ARPA was the remaining stuff with getting Multics and seeing if we could make any use out of it, because it was a valuable commodity, but we never could. So we eventually concentrated on Tenex, which we could get

production of and military supplied. So Tenex was a major operating system activity. I did not realize how much we had gotten involved in it early on. It was actually probably a lot of my support, but I had not conceived of it as supporting ARPA systems that we had around the office. I was doing programs at those places, and that was what they happened to do with some of their work to do their work. We wound up with an operating system, and then had to put money into getting it to where it was. Then I started negotiating with DEC and other people to support it, to create it. They took it on and made it into one of the versions of PDP-6, because we could not afford to continue with that endeavor. We had to get it into commercial. So in many cases I got involved in the commercialization of things, if possible. That is where we got involved more with them. I don't know which case you're thinking of with IBM. You had mentioned IBM.

NORBERG: Well, IBM got the contract with Lincoln for the timesharing machine after they lost the original on the...

ROBERTS: Yes, that was while I was at Lincoln, not at...

NORBERG: Two last areas that I would like to close with. One of them is, how did you come to hire Robert Kahn and what did you want him to do when you brought him into the office?

ROBERTS: Well, probably the reason I hired him was because he was at odds with his boss. He was one of the brightest people on the project and I wanted to keep him. I could see that he and Frank [Heart] could barely get along. Bob was telling me that he was not staying if something didn't happen. I knew that, and I knew Frank. I knew Frank was the kind of manager who acted like a director and father to his people, and if that person was not of that personality type that could accept that, they just could not live there. And Bob was not. He was bright, and he was tremendously capable, but he would not fit into Frank's environment -- not that I totally approved of Frank's style, but it worked for a group of people, so I let Frank do his thing. So I could have supported Bob in moving anywhere, but I did need somebody to help with the network activity, and he was one of the brightest people in the field. He was willing to come help me with it. We had worked together on the big ICC show where we showed off the network.

He was clearly somebody that was bright, one I would lose otherwise. He was someone that I could use and did need in the office.

NORBERG: So he did not come in under the same conditions you came in on, that ultimately he would take over the office as you did from...

ROBERTS: No, not at all. In fact, his interaction with people, particularly with Steve Lukasik while he was there, was such that I would not have put him in as director under Steve, because that would have been a failure. Bob was so brilliant that he thought at a level where he could not explain his thoughts to other people, because he could not connect them all up in a way that he could show the logic of getting to it. He said, "Don't you see it? It is all there." He would touch the mountaintops, and thought that it was unnecessary to explain the rest of it. Nobody at the director level, for several directors, could accept that until Bob found a director later on that he could work with. It was very difficult for Bob to find a director that he could really work with effectively, because of his way of presentation and his approach. So I did not view Bob as ready, nor did I view him as capable of selling it -- because of his presentation skills, not his technical skills. Eventually he was ready and he was great. But that was because he wound up with a director that he could work with, and he had developed his skills a lot too.

NORBERG: I would like you to wax philosophical for a moment. You made a number of comments in the course of the last couple of hours that suggest an answer to the question of what you might think the influence of IPTO specifically and ARPA generally, might be in the field of computer science. But I wonder if you would try to explore that question a little bit more directly. What do you think the influence of IPTO was during your tenure as head of the IPTO office, and in general over the last 25 years?

ROBERTS: Well, I think that the one influence is the one I mentioned in relation to the net, that is, the production of people in the computer field that are trained, and knowledgeable, and capable, and that form the basis for the progress the United States has made in the computer field. That production of people started with Lick, when he

started the IPTO program and started the big university programs. It was really due to Lick, in large part, because I think it was that early set of activities that I continued with that produced the most people with the big university contracts. That produced a base for them to expand their whole department, and produced excitement in the university so students went to those departments and more students went to computing than ever before. The numbers were astounding. It was partly due to the success of industry, and partly because it looked like the field to go into, because there were jobs. But the reason that there were jobs was also partly due to the fact that these jobs were there in industry which we had funded in the research area. So it was clear that that was a big impact on the universities and therefore, in the industry. You can almost track all those people and see what effect that has had. The people from those projects are in large part the leaders throughout the industry. But the change in the government over time made it such that we could not change and influence in massive form when I was there. In other words, I continued funding the universities with the more basic research throughout my period as much as Lick had, and somewhat more. But I could not get it to 50 million for that. It had to be other things. Nor would it have been necessarily appropriate, or necessary to get it to that level. So it stayed more or less at the level that Lick had established at 15 million, or something like that. And we continued with that. Lately it has actually pressed much higher, to where that may be in trouble because of ARPA's current view. Over the last several years the universities have been having tremendous trouble in getting the same level of funding and that may hurt. So that is one area. Secondly, it has created unique technologies which have led in each sector, like artificial intelligence. That is why we have expert systems. Without it, we would not have expert systems or anything like it. It is still going to take another decade or two to figure out how valuable that would be to computing. But they are starting to be used in virtually all complicated systems, management programs now. I suspect that people are finding them very effective. Thirdly, we clearly would not have had the networks in the same time frame. Eventually somebody would have developed network technology. They tried in England with Donald Davies. They had the ideas, but they did not have the money. As a result they never got anywhere, because they could not get it funded. So it was critical to have the money to fund it, and make something happen that was visible so you could see the result of the experiment. Industry was so set against packetization as opposed to channelization -- and still is, almost -- that there was just virtually no way for AT&T, or the existing industry to do anything about chain ? . When I was at GTE I

tried to get a new switch built, a packet switch, and I got it through as long as I was there. There was always a fighting faction from the channelization groups at the labs. As soon as I left though, they won with the president, and the project got killed, because there was not the political presence to do that. That same thing has happened at AT&T. It has happened at every major place where they have tried to do a packet project for voice. It clearly will work for voice. It is the right approach for voice. There is virtually no one in the industry anymore that believes that it is not the right approach but nobody's built a switch, because the engineering groups are just threatened. They have one technology that they know. They do not want to lose their position to some other group within an organization and they fight it. They kill it. I have been approached by small companies who are in the multiplexor business who say, "I need somebody, as an outside corporation, to do a project because we cannot do it internally. Our people are channelized thinkers. They think in channelized stuff. It is just impossible to build it in." This unwillingness to change is still a problem within industry. So what happened by doing the Arpanet with computing people and with going in and just getting new contractors who started from scratch to do it, was probably something that made a major shift in time. It was too big a shift for people. That is the biggest benefit of such a program: being able to go out and do something which is a major shift in thinking -- that would not happen at IBM, or AT&T, or somewhere -- because it is the next thing to do once you are ready. And maybe they will do it, two years later than when you did it. That is not so valuable. Like the ILLIAC IV probably was not as valuable, in that respect, because the machine used ECL for memory and everything else. But it was valuable in the sense that it introduced parallel processing, which nobody was willing to undertake. In as much as it would just be a computer, that is faster than anything else we would be wasting our time, because they will get there. Faster is better, and everybody knows it. And there is a question in my mind what the program that undertook faster semiconductors could accomplish. Although I was not involved in that, so I do not know exactly what the imp act was. But anytime you are just leading industry by a few years in what they will get to, you are not changing the world that significantly. What we did where we could were things that would take a different thinking. So you had to start a project that had support all the way through to the funding. You could not get cut on this new concept, like parallel processing, like artificial intelligence, like networking. You could go all the way through the completion and show what the result was without getting killed in the process. I think GTE must have spent 50 million on the switch that eventually was killed, which is

more than we probably spent on some of the programs internally. But they could not get it through to completion where anybody ever saw it. It is just absolutely critical to have unfailing support throughout the process; that is, basically the financial support to be able to finish a project, even if it was within IBM, or AT&T, or something. If we could have funded it within AT&T it would have worked because they would have had the outside funding.

NORBERG: If you identified one characteristic about IPTO that contributed to these two major elements that you just mentioned as successes in programs where the people added to the stream and the innovative projects that developed into something worthwhile for the economy and the nation, what would that characteristic be?

ROBERTS: The characteristic of...?

NORBERG: Of the office. Of the office activities, behavior, people, whatever.

ROBERTS: Well, the first characteristic is that the office had bright minds... [people who were short-term oriented, and were young people who saw important possibilities in the field. The second was that the office had little red tape. There was the possibility of fast development of programs, and fast approval of projects.]

END OF INTERVIEW

Bracketed passage from interviewer's notes.