An Interview with

IVAN SUTHERLAND

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Conducted by William Aspray

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Abstract

Following a brief overview of his background, Sutherland describes his tenure as head of the Information Processing Techniques Office (IPTO) from 1963 to 1965. He discusses the existing programs as established by J. C. R. Licklider, his interaction with the research community, the budget, and the new initiatives started while he was there: projects in graphics and networking, the ILLIAC IV, and the Macromodule program. Other topics covered include: the difficulties of getting qualified people into the office, the impact of IPTO's funding in artificial intelligence, and the review process. This interview was recorded as part of a research project on the influence of the Defense Advanced Research Projects Agency (DARPA) on the development of computer science in the United States.

IVAN SUTHERLAND INTERVIEW

DATE: 1 May 1989   INTERVIEWER: William Aspray

LOCATION: Pittsburgh, PA

ASPRAY: This is an interview on the first of May, 1989 with Dr. Ivan Sutherland in the Pittsburgh airport. Let's

begin with just a few questions about the time before you came to DARPA to set a background.

SUTHERLAND: I presume that this material is being used to be a report for DARPA and will not be used for

commercial purposes.

ASPRAY: That is right.

SUTHERLAND: Right. I just wanted to get that on the tape. It is May 1. This is Ivan Sutherland.

ASPRAY: Interviewed by William Aspray. Did you have any experiences with computing, either in your bachelor's

degree work at CMU, or your master's work at Caltech before you went to MIT?

SUTHERLAND: Well, I had my first experience with computing in high school. So I have been familiar with

computers for a long time. I had built various relay machines as a young student, and had built various devices

using logic through college, and through graduate school. I had a summer job for IBM after my bachelor's degree.

The reason I left Caltech and went to MIT was it was clear that computing at MIT was better than at Caltech at that

time, and it was a clear-cut case of the right thing to do.

ASPRAY: Can you say a few words about your experiences at MIT as a graduate student?

SUTHERLAND: Sure. I had had the good fortune to meet Claude Shannon 10 years earlier. I went down to Bell

Laboratories to meet him. He apparently had remembered that visit, so when I got to MIT I called him up and said I

would like to see him, and he invited me to his house and became my thesis supervisor. He made an enormous difference as to what my stay at MIT was like. I got involved at the Lincoln Laboratory. I had a big computer there called the TX-2, you may recall.

ASPRAY: Yes.

SUTHERLAND: Wes Clark, who had been a principal designer of that was then active at Lincoln Laboratory, and helped me become a user of TX-2. Subsequently, in fact much later, he became quite a good friend, but we will talk more about that later on. I did my thesis work at Lincoln Laboratory on the TX-2.

ASPRAY: Was this the Sketchpad work?

SUTHERLAND: It was the Sketchpad work, yes.

ASPRAY: Okay. As I read the timing, you had just a very small overlap with the work that was beginning on Project MAC the last half year or so that you were there.

SUTHERLAND: Now, I gave some talks and showed my film to some of the folk who were coming to get Project MAC established, and I think Sketchpad was sort of one the twinkles in folks' eye about what you might do with computers if you had more on-line use of them. But yes, I left just as Project MAC was getting started.

ASPRAY: Had you gotten to know a number of the other people who had an interest in computing in the MIT community?

SUTHERLAND: Oh I got to know a few of them, I suppose, but not well.

ASPRAY: None of them well?

SUTHERLAND: I do not know how to answer that. I met a number of people at MIT as fellow students who subsequently became important figures. Larry Roberts, for example, one of your interviewees, was an office mate of mine. I knew a few of the faculty, but I would not say that I knew them well. Other than my immediate thesis committee, I did not have very much interaction with particular faculty members.

ASPRAY: Who was on that committee?

SUTHERLAND: Shannon was the chairman; Marvin Minsky was on it, and so was Steve Coons (now deceased). That was the thesis committee. Doug Ross also provided many discussions.

ASPRAY: What kind of work were you doing at Lincoln Labs, or was it just your work on your thesis?

SUTHERLAND: I was employed there as a summer employee working on various electronic devices. The first summer I was there I was sort of a general purpose summer intern - I might have been an employee. Then by the second summer I was there as a summer employee. I also had begun the start of my thesis work in earnest.

ASPRAY: Okay. Then what happened when you left MIT?

SUTHERLAND: From MIT I went into the Army. I had an ROTC commitment left over from Carnegie Mellon. I went first as a civilian employee to NSA. Then I went in the Army. The Army sent me to Project Michigan at the University of Michigan.

ASPRAY: I do not know this project.

SUTHERLAND: At that time it was a big Army research project at the University of Michigan. It was actually physically located at the old Detroit airport in Ypsilanti. It was called "Project Michigan." It was a major research

project, and I was part of the U.S. Army liaison group there. The colonel in charge, Colonel Mickel, gave me the task of being his technical eyes and ears in the research project, so I was able to learn a great deal about side-looking radar, and infrared, and a variety of advanced topics that were going on there. None of them had anything to do with computing. Then the Army moved me back to NSA as a lieutenant and from there I was reassigned to ARPA. So I actually became the director of ARPA's Information Processing Techniques Office as a first lieutenant. I will tell you some funny stories about that.

ASPRAY: Okay. What were your duties at NSA? Can you say?

SUTHERLAND: I was in the research group. I did a variety of things. There was a paper that was published as a result of that activity on a display system that we built. I would say it was a general computer research kind of activity.

ASPRAY: All right. How did the call to DARPA come about?

SUTHERLAND: I don't really know what, sort of, was behind it, but I was asked to go down and talk to the ARPA people about taking the information processing job. I felt at the time that it was probably too large a job for me to undertake at that age. I initially said no, and then thought about it for another six weeks. They twisted my arm a little harder, and I agreed to go.

ASPRAY: Had you known Licklider at the time?

SUTHERLAND: Yes, I had known Licklider. Not well, but I had known him a little. I knew Licklider from various conversations I had had with him, but I did not know him socially or well. I did not consider him a friend. Later on, I grew to know him much better. The man who was the director of ARPA at that time was Bob Sproull. Bob Sproull had been, I think, chancellor at Cornell, or head of something at Cornell. I do not know just what he was when he went to run ARPA. His son later became my business partner. He and I are now in business together. But I did not

know the son at that time. It was not until some years later that I ever even met the son.

ASPRAY: Yes. It is a small community though.

SUTHERLAND: Well, the Sproulls are very smart people.

ASPRAY: What was the mandate for the office?

SUTHERLAND: Well, when I got there the Information Processing Techniques Office was quite new. Licklider had established it two years before - and I think had established the mandate which was basically to support advanced programming methods, which he interpreted to mean, I think, on-line aids of computing. My understanding of where that mandate came from was a recognition in the Defense Department that billions of dollars were getting spent on software, that software productivity was a problem and that something needed to be done to improve the productivity of the software world. That problem obviously has not yet been solved.

ASPRAY: Yes. Were systems like SAGE an example of the software problem?

SUTHERLAND: Well, as I recall, the software in SAGE cost more than the machine. It cost more than the hardware. That was kind of a shocker, because people had thought earlier that it would be just simply a matter of programming (SAMOP), which it never is.

ASPRAY: Yes. Were there other examples that were looked to at the time as good examples of the software problem?

SUTHERLAND: We are talking about events 25 years ago.

ASPRAY: Yes, I understand that.

SUTHERLAND: My memory is hazy, so I have to answer, none that stick out. There may well have been others, but I do not know any that stick out.

ASPRAY: What did the program look like when you inherited it?

SUTHERLAND: Well, it principally looked like there were a few major contracts. There was the Project MAC contract at MIT. There was a contract at SDC, which was a major effort. There was a contract in place at Berkeley to do timesharing work, which turned into the SDS 940. That was run by a man named David Evans that I got to know through that connection. There was a contract at Carnegie Mellon, which Perlis and Newell basically were the principal characters in charge of. I would say that those were the four base contracts. Licklider had, I think, basically chosen those contractors on the basis of their general capability. I took the position that the key figures in those contracts were key sources of counsel for me. I felt that those were the kind of senior people in the field, and they had a pretty clear idea as to what good things to do were. I used to call them informally to ask them for advice on various other matters. In fact I think that my task was made quite easy by the fact that Licklider had established a baseline and a direction that the office was going. So there were essentially no great battles to fight. There was no real problem in terms of anybody questioning the quality of the research that was going on. That set of contracts was, I think, quite well done. Now there were critics. Who was the guy who wrote all the FORTRAN books?

ASPRAY: McCracken?

SUTHERLAND: Was it McCracken? I am not sure if it was McCracken, but there was one critic who was very critical of the whole timesharing idea and the notion that on-line computing was worth anything. He was quite outspokenly critical of the ARPA program, principally because of its focus on on-line use of computing. I had had some experience with that personally, and recognized the value of it. So I was not concerned as to whether we were going in the wrong direction, and I think events subsequently have demonstrated that it was, in fact, a direction that the industry has largely gone.

ASPRAY: What was your previous experience?

SUTHERLAND: Well, I had had TX-2 to myself...

ASPRAY: The TX-2. Of course.

SUTHERLAND: Just as an aside, I now have a Macintosh sitting on my desk, and I did the following computation the other day. The Macintosh that I have has about 20 times the storage capacity that the TX-2 had, and it runs at about ten times the speed. So maybe that is 200 times as much computing.

ASPRAY: Yes.

SUTHERLAND: And it is in a little box that size.

ASPRAY: (laugh) I suppose it was important that there be this strong, already established program, in the sense that you were coming at it at a relatively low rank and you were also quite young when you took over the office.

SUTHERLAND: Yes, I think that I would not have been able to establish a broadscale program of the sort that Licklider had established. I think that he thought it through very clearly in terms of who the good people were. He told me quite directly that his notion of what was needed to form a good program was to get the best people in the country putting their minds to what they thought was the best program. So he did not presume to invent the program out of the whole cloth. What he presumed to do was to select the folk.

ASPRAY: Yes.

SUTHERLAND: That turned out to be a remarkably wise thing. The principal thing I learned about that kind of research activity is that the caliber of people that you want to do research at that level are people who have ideas that

you can either back or not, but they are quite difficult to influence - that in the research business the researchers themselves, I think, know what is important. What they will work on is what they think is interesting and important. You can maybe convince of something's interest and something's importance, but you can not tell them what to do and get good research. Good research comes from the researchers themselves rather than from outside.

ASPRAY: Yes. So that also includes their peers who are among the other of the principal contractors. What kind of influence did one contractor have on another?

SUTHERLAND: When I first went to the office there was me and a secretary. There had been Licklider and he had had a colonel as a deputy, but it was felt to be improper for the colonel to be my deputy, so the colonel disappeared into the ARPA staff as opposed to the IPT staff. Then there was Al Blue. Have you talked to Al Blue?

ASPRAY: Not yet. We have identified him as somebody we should talk to.

SUTHERLAND: He is key. You should. Al Blue was the administrative guy who kept me straight in terms of what I could and could not do, what made sense contractually, how the paperwork had to flow and so on. He was very important.

ASPRAY: Was he also important in helping you with the inside culture at DARPA? You already had some experience of this yourself firsthand, but...

SUTHERLAND: The inside culture at DARPA?

ASPRAY: Or within DoD - the relationships between DARPA and the military agencies...

SUTHERLAND: You know, I have a theory that agencies develop arthritis as they grow older, and that arthritis comes about because various people think that they need pieces of paperwork that at the outset have not been

invented yet. ARPA itself was only five years old or something at this time. ARPA had been created as an organization suddenly in response to SPUTNIK. It was created with directors from outside DoD. The directors traditionally had been found outside DoD. They were not bureaucrats, but were typically university folk who were coming to try and do some reasonable technical job for the government with a minimum of fuss. There really was not very much fuss in ARPA. In fact, to get something done, what I had to do was convince myself and convince my boss. He apparently had spending authority. Now, how he in general convinced his boss who was Harold Brown at that time, is something that I was not party to. But my understanding of the mechanism was that if I could convince the ARPA director that something was sensible to do, it got done. Now I think that along the way there were a fair number of folk who were kibitzing. I mean, from an administrative point of view, Al Blue had to think it made sense. I do not think that I did anything that was so outrageous that it would be brought into question. But there was really very little required. There were justifications required. There were sole source procurement justifications required. The reason and the background for the operation had to be written. I always felt the principal hurdle to get through was to convince the ARPA director that it was a sensible task. I guess Al Blue and the administrative machinery ran smoothly enough that the ARPA orders got written. Then the actual administration of the contracts was done by somebody else. (ARPA still functions this way, I think.)

ASPRAY: Right.

SUTHERLAND: So the ARPA order was, in effect, a check, which was written to ONR, or to the Army, or whoever. One of the things that I did was try to get sensible liaisons between which of the services was going to do the administration, and what the contract was. So, for example, we liked using ONR a lot with the universities, because ONR had its own university program and understood university people well and was able to deal with them. It had a smooth-running mechanism for that. Some of the things involved activities where the Army needed to get involved so we got the Army folk to do some things. Then Rome Air Development Center got involved, and there were a few people there who showed interest in some programs. So, for example, I do not really remember, but I think when Dave Evans went to Utah I got a small contract set up with him at Utah, and we did that through Rome Air Development Center. The intention there was to get Rome more in tune with the advanced things that were going on, to try to get

technology transfer going more into the Air Force.

ASPRAY: Yes. Let's see, you said that Sproull was the DARPA director when you started. Soon it became Rechtin, I guess.

SUTHERLAND: No, Rechtin was before that. Rechtin was early. I never worked under Rechtin. Sproull was there for awhile. Then he left and Bob Frosh became director. Frosh had been running the nuclear test detection activity, I believe. There was this problem of how do you detect underground nuclear explosions. ARPA got the task of doing that, and Frosh, I think, ran that. Then he became the director of ARPA, and then he left and Herzfeld became the director. So I served under Sproull, and then Frosh, and then Herzfeld.

ASPRAY: Were there differences in the relationship you had with the DARPA director, because of personality difference or any other individual differences between the three?

SUTHERLAND: They are three very different individuals, so the answer has got to be yes, but I would not know how to characterize that.

ASPRAY: Well, were there differences...?

SUTHERLAND: Let's put it this way: I have remained in communication with all three of them for the rest of my life, so my relationships with all of them were certainly cordial, at the very least.

ASPRAY: Did one, more than another, try to influence the directions of your program?

SUTHERLAND: No, I felt that all three of them were very supportive of the program. You know, I think that the entire climate in DoD at that time was very supportive; that the sense of the importance of computing was strong, as was the sense that this was an exciting program and had good people involved in it, and that the key researchers in

the country were putting their minds to the important problem. I think that feeling was fairly widespread.

ASPRAY: Okay. I guess I am not trying to suggest otherwise, but it is clear that from one individual to the next there are going to be differences in how much they want to control programs, how much they feel that the programs should be more directly or less directly oriented to military tasks, those sorts of things.

SUTHERLAND: I understand, but my recollection of those differences is minimal.

ASPRAY: I see.

SUTHERLAND: I do not remember ever having a sharp disagreement with any of them but that is not to say it did not happen. I mean, I had a sense of what my budget was. There was not a budgetary crunch while I was there, so we were not in a position of having to retract and retrench. There was a small possibility of growth and there was enough flexibility in the budget to get things done that I thought were important to do. So there was no major conflict which would have brought those kind of differences to light.

ASPRAY: Was there any encouragement or recommendation on their part of particular areas in which to move?

SUTHERLAND: No. I think they all felt that the computing world was one in which they were not entirely comfortable operating, so they were pleased to leave it alone. I have to tell you an aside. When I first went there I was a first lieutenant, and Bob Sproull decided that a press release should be made announcing my arrival. So he wrote that Dr. Sutherland had arrived to run this program and so on. It went down to the Pentagon press office where the title Dr. got crossed out and Lt. got written in. That came back up to Sproull for approval and he crossed Lt. out and wrote Dr. back in and sent it back down. The result was the press release never was made. (laugh) They simply could not agree on what my title was. I think Sproull was under some pressure about that, because one of the other office heads was Major General Wineky (?), and General Wineky and I used to go to staff meetings together and sit next to each other on the sofa. I think the fact that I was a lieutenant was carefully concealed from General

Wineky. He always wore his uniform. I never wore mine. It was a very strange assignment. Well, it was not the ordinary assignment for a lieutenant, let's put it that way.

ASPRAY: Why do you think you were chosen for the job?

SUTHERLAND: I believe that nobody else would take it. I believe that over the history of that job it was difficult to find good people to fill it. I think a few good people have been found to fill it, and by and large it has done pretty well. But I think that the task of filling those positions in ARPA is getting increasingly difficult.

ASPRAY: What are the reasons for that?

SUTHERLAND: Well, I think they are twofold. One of them is financial, clearly, that the folk that I would like to have filling that job in particular are people who would take a cut in pay of a factor of two to take it. That would not be so bad, except that all of the folk of that sort have various investments in this and that and the other thing which they would be expected to divest themselves of. So that makes a very difficult situation. Then the other issue is to what extent the flexibility that ARPA had in the early days remains. I think one of the reasons I was asked to go do that was that I was fresh. I did not have any set of commitments. I was in the service, and from my point of view it was a great assignment. If you have got to be a lieutenant be a lieutenant in DARPA; it was a fine place to be. It did not change my pay scale any. I think the next two directors that followed me, Roberts and then Bob Taylor, were also kind of in that position. Roberts was fresh. He had just finished his Ph.D. at MIT, and he was just starting out. He was my contemporary. He was able to do something very important at ARPA - namely the ARPANET. That was a very key and important thing to do, but he came in at a time when he did not have a great set of other commitments to give up. I think that may be a message that you might like to carry in your report, that one of the ways to fill those jobs is by picking promising young people who are not yet encumbered with all of the difficulties that taking a position like that forces you to give up. But they have to have the ability to trust young people. I mean, Sproull stuck his neck way the hell out, in some sense, in hiring a 26 year old lieutenant to do that job. His neck was stuck way the hell out on a limb. But I think that is something that ARPA might well do. If I were asked to recommend

people for that IPTO job now the people I would recommend are folk who, if they are in academia, are folk who are at the Assistant or Associate Professor level, rather than senior people. That gets more difficult as the bureaucracy gets more complicated.

ASPRAY: Let's turn to your program for a while. You inherited what you say was a stable and, what sounds to me, was a program that you largely had some satisfaction with.

SUTHERLAND: Oh, it was a good program. They were very good people.

ASPRAY: Also, it was a program which, in terms of its being an ongoing program, ate up a large part of your budget each year, if the figures I have seen are correct.

SUTHERLAND: Yes.

ASPRAY: So that while there was some room for new initiatives, there was not a great deal of room for new initiatives. Is that a fair statement?

SUTHERLAND: Yes.

ASPRAY: Okay. So tell me how you went about making the program evolve over time: what kinds of factors you looked for, what kinds of new areas you were thinking about, how you chose people to do these.

SUTHERLAND: Well, I tried to do some things that would seem sensible. There were three things, I think, that I can mention, where I started new activities. Well, first of all, let me tell you about my major failure. Licklider had dreamed about having a network of computers, and in typical Licklider-ese he had called this the Intergalactic Computer Network. Lick was a wonderful guy; he had these wonderful words and ideas. He was just marvelous. So I thought I would have a go at that. I got the University of California at Los Angeles, which had three major computers, to put

together a program to make a network out of the three. That was never very successful. I think it was never very successful because it was not something that they wanted. It wasn't a program that they were interested in from a technical point of view, nor was it something that they would reap enormous economic benefits from, although there were some.

TAPE 1/SIDE 2

SUTHERLAND: What it took to make networking happen in ARPA was two things. First of all, there was Larry Roberts, who understood in some considerable detail what the technical detail was. He was supported by the Bolt, Beranek and Newman contractors. I think Bob Kahn actually was at Bolt, Beranek and Newman at the time, and did much of the actual technical work of making the network happen. So there were some first class research type fellows involved, one in the administrative position, and one in the research position, probably more in the research position, counting those who had a research interest in making it happen. That was an ingredient which I had not been able to find. Now, to what extent the fact that ARPA was interested in networking and had been interested in networking for two, or three, or four years before the ARPANET sort of came into being, to what extent that influenced their thinking, I do not know. You will have to ask them. It may be a little like a sculptor chipping away at a rock. You know, he hits around with a chisel half a dozen times, and then one time the chip breaks off. Now, which of those hammer strokes was important? Only the last one? I do not know whether it was a thing of that sort.

ASPRAY: Had you had other activities than this UCLA one?

SUTHERLAND: Not of any importance. But I considered that Lick's efforts at networking basically were largely talk. My attempt, which I actually spent some money on, was a failure. The later folk, you know, did better and made it happen. So that was one that I think was a failure. Then, the second one that I got started, and I had some trepidation about it, was the macromodule work at Washington University, St. Louis. My trepidation, principally, was that I knew the people very well. Wes Clark and his people from Lincoln Laboratory that I had worked with as a graduate student had gone off there to establish a new research program with some NIH funding. ARPA put some

16

money into that in an effort to stimulate a more flexible kind of computing activity based around some modules that you could plug together to build special purpose computers. I had the very highest respect for the researchers, and I had to think through very carefully whether or not the fact that I knew them well and personally was influencing my judgement, whether or not this was a good activity to do. I was trying to follow Licklider's view that the trick is to get the best people that you know, and get them to work on the tasks that they think are important. We went forward with that program.

ASPRAY: Because of that uneasiness did you depend more heavily on outside advice in evaluating this program?

SUTHERLAND: I do not recall what it was that eventually made me go forward. But I recall that there was quite a lot of unease and some delay - I took some time to make that decision. I may well have sought outside advice, but I do not remember a key dis cussion with an advisor that turned my mind around. So there was that one. Then I had gotten to know Dave Evans from Berkeley and he wanted to do this work in graphics, and we got that started. That seemed important to me for many reasons. I understood that field well, and moreover, Evans had had some key ideas as to how to do it. It was not until two years later (I had gone to Harvard after I left ARPA) that I went and joined Dave in Utah.

ASPRAY: To what degree was the funding of the macromodule work ARPA's and to what degree was it NIH's?

SUTHERLAND: NIH had a fairly large, rather stable contract with those people which went on for a long time. As I recall, ARPA was something less than half of the total. I do not know. If you forced me to guess how big that contract was I do not think that I could.

ASPRAY: Okay. The reason I ask is that in our research so far, among government agencies NIH looks like the only competitor to ARPA in terms of having the ability or at least the willingness, to give large contracts to do computing.

SUTHERLAND: Is that something you want to follow up?

ASPRAY: Yes.

SUTHERLAND: Bruce Waxman is the man to talk to. Bruce Waxman is now at the Defense Mapping Agency.

ASPRAY: Okay, and what was his position?

SUTHERLAND: He was my counterpart, or I thought of him as my counterpart at NIH. He was there many years after I left ARPA, so he is familiar with that whole history and scene.

ASPRAY: Do you think that that is a fair hypothesis, though, that those are the only two agencies that have this kind of money to support computing at the large scale? Of course, ONR is giving all these small grants, but they are of a different kind.

SUTHERLAND: Well, I think there was a good deal of classified stuff going on. One should not discount the importance of the intelligence folk in terms of their, I would say, quite vigorous support of equipment. I am not party to all of that they did, but it is quite clear that there was lots of very advanced computing stuff being purchased for their own purposes. You know, you guys can have a fascinating time with how those procurements, which are largely classified procurements, end up being capabilities and the suppliers that then filter into the civilian economy.

ASPRAY: (laugh) Okay. Fine.

SUTHERLAND: You know, the history of science must be a fascinating business, because what you can see is only a piece of it. I went to Project Michigan and infrared was a big subject, and that was in the mid-1960s. That whole area had been classified. It was just a thing that somebody had decided, that "Infrared research activities are something we will keep under our hat." It is only recently that any of that has been getting out into public use. The effect of the decision to classify that activity must be enormous. I could not decide whether it is a plus or a minus. I

guess my own conclusion is that it is about a wash; that we gained an enormous advantage in terms of heat-seeking missiles, in terms of ability to detect what was going on, and night vision, and all kinds of things, and we took enormous advantage out of that, at the price of, you know, heat loss from buildings, the cost of... You know, when you step up to a urinal in the men's room, it flushes itself when you walk away because of the little infrared thing that senses you are there.

ASPRAY: Yes.

SUTHERLAND: We probably could have had those things 15 years earlier. How would you like to play that tradeoff? Would you rather have sidewinders, or...

ASPRAY: (laugh) ... automatic flushers.

SUTHERLAND: ... automatic flushers. I cannot tell, you know (laugh). But I think computing has the same property; that many of the biggest computers were purchased for working on intelligence programs and there was a conscious effort to stimulate faster and better machines - particularly machines, but also programming systems.

ASPRAY: As far as you know, was the intelligence community supporting academic research as well?

SUTHERLAND: I think it was to a lesser extent than it supported commercial research. In terms of the academic community you probably have it right that NSF had some programs, but the number of dollars it had was relatively small. There was a very interesting, informal group which I do not know if you have met with before. I am trying to think of what the name of it was. Essentially the various heads of information processing programs in the government used to get together for coffee. This was an organization with zero charter. Do you know the name of it?

ASPRAY: Licklider has told me about a similar group that in earlier times...

SUTHERLAND: Yes, this was the same group. He introduced me to it, and took me to the first meeting I went to.

ASPRAY: I see.

SUTHERLAND: These people met. There was no charter, and the group had no responsibilities, no budget, no purpose, but it was a great thing. I would go to these things and I did not know anybody but I met the guys from the AFOSR; I met the guys from the Navy, and the guys from NIH, and the NSF people used to come, and all these different people would come. We would discuss what was important, what was current, and what was going on. It was a wonderful way of getting information flow between the agencies. I always felt it was important to go to those meetings, precisely because it had no charter, so you could get some informal information. I wish I remembered its name. It had a five letter acronym, or something.

ASPRAY: Licklider gave me the name, but I just do not recall it.

SUTHERLAND: I wonder if he invented it. I would not put it past Licklider to have invented it.

ASPRAY: He certainly did not say that, but he is a modest kind of guy and it is hard to know.

SUTHERLAND: Yes, ask him straight out, "How did that get started? Did you start that, Lick?" (laugh) I think it is the kind of thing he would have recognized the importance of, and might well have started.

ASPRAY: I interrupted you, or got you off on a tangent from talking about your program. You have talked about a failure and two successes.

SUTHERLAND: Yes, I have talked about the one failure, which was the Network, and I have talked about macromodule work. What was the other one?

ASPRAY: Graphics.

SUTHERLAND: And the graphics thing. Then the biggest thing I started was the ILLIAC IV. I do not know how I got involved in that. Slotnik came into the office I guess, and he seemed to have very interesting ideas about what to do. I tracked that for awhile. He settled down in Illinois, found a job in Illinois and made a proposal. It was a pretty good proposal. I recall calling together a meeting of half a dozen key people. Sid Fernbach from Livermore was there. This was a meeting that Herzfeld, who was the director of ARPA at the time, attended. But Herzfeld was there; Al Newell might have been there. I am certain that somebody from Carnegie was there. I do not recall who the others were, but there were about half a dozen people that I had called together to discuss this issue, and to see whether it was an appropriate thing for ARPA to go into. They concurred that it was a good idea, and Herzfeld thought it was a good idea, so we went ahead and did it. I started that program fairly late in my tenure, so it did not come to fruition until several years later. It went on for a decade, or more. It was a major program in the office over a long period of time.

ASPRAY: Was the objective of the program parallel architectures, or high-end computing? Just how was it put together?

SUTHERLAND: Well, I felt it was twofold. Parallel architecture was clearly a thing of importance. But a second factor of importance was that it was a mechanism for stimulating the raw stuff out of which computing was made. Slotnik was determined to get the industry to produce the best stuff that he could for each of his processors.

ASPRAY: I see.

SUTHERLAND: There was some trouble over that because Texas Instruments, I think, reached too far. They were going to do this discretionary wiring stuff, which would have been wonderful if it had worked, but it did not work. So I think there was a case there where some of the contractors may have reached a little too far. That probably was good in a way, because it showed how far you could reach. But it caused some expense and delay that might not

have...

ASPRAY: Burroughs was the main contractor.

SUTHERLAND: Burroughs was the principal contractor, yes, but then, I think, TI was the subcontractor that produced the processing element.

ASPRAY: I know that much of this went on after your tenure, but can you speak to the relationship between Burroughs and the projects? Or can you tell us who to talk to?

SUTHERLAND: Well, Slotnik's dead, so...

ASPRAY: Yes.

SUTHERLAND: He was a colorful guy - Slotnik. You never met him?

ASPRAY: I had talked to him on the telephone three or four years ago.

SUTHERLAND: He was a funny guy. He had been brought up in Brooklyn. He was the smallest kid on the block and became quite feisty as a result.

ASPRAY: (laugh) That is consistent with my conversation.

SUTHERLAND: Yes, it would be, right. I guess I was not party to the relationship between the project at Illinois and Burroughs very much. Contractor selection was going on about when I left, so I guess the answer is that I just do not know.

ASPRAY: Those are the major initiatives in the programming of your period?

SUTHERLAND: Yes, I think so. There were a bunch of other little things. I remember that there was a company called Applied Logic. It was a Princeton spinoff, doing mathematic theorem proving by computer. We started a small contract with them to encourage them. I do not know what happened to that. There were a number of small things of that sort, where there were targets of opportunity in which interesting proposals that I thought were worthy of funding came our way. I did some of those. I cannot think of any that were particularly distinguished.

ASPRAY: Within the program, what we would now label as artificial intelligence research was being done, as I understand it, under some of the block grants - Project MAC...

SUTHERLAND: Well, the two places that were good in artificial intelligence at that time were Carnegie and MIT. They always have had quite different approaches, I think, to AI. I think the reason for that comes out of Newell's background as a psychologist - that the Carnegie folk were always interested in taking protocols of human behavior, trying to model human behavior, and understand what thought was. The MIT folk, I think, were more interested in getting interesting results, no matter how. So it was quite appropriate, you know, that LISP was invented at MIT and has become an important ingredient of that. I think, lots of interesting results applicable over a wide variety of things have come out of MIT. I think the Carnegie people have been much more scientific in the sense of trying to understand what the relation between computing and thought really is - a much harder topic.

ASPRAY: Thinking back to that time, were the differences in the two approaches already clear and were their research agendas pretty established about this time?

SUTHERLAND: Oh, yes, it was absolutely clear. You had only to talk to the principal people involved. The difference is clear today. I mean, go talk to Newell, and go talk to Minsky.

ASPRAY: Yes.

SUTHERLAND: It is perfectly plain. It was then; it is now.

ASPRAY: I see. It was not clear to me that these were not programs that had solidified in their minds over a period of time.

SUTHERLAND: Oh, I think not. I think if you look at the early papers you would even see that is reflected in the early papers. The kinds of things that they did were quite different. I mean, the MIT people got interested in theorem proving, and integration. Slagle did this thing on how to do integration fairly early on. Clearly you do integration by having a bag of heuristics that you apply. You can integrate by parts. You know the heuristics.

ASPRAY: Yes.

SUTHERLAND: Then you have strategies that you try. Then you get a tree of all the things you could do, and you try and prune the tree back to the promising ones of... trigonometric substitution gets pretty hairy, and then you want... You know how to do all that.

ASPRAY: Yes.

SUTHERLAND: But it is not clear whether the machine does it in the same way that people do it... I do not think Slagle ever collected a protocol on how a human being does integration. He simply plowed in and wrote some code, tried different things, and pruned the tree in various ways, and did it with rather little concern about how people think about it. In that same period Newell and his people were collecting rather thoughtful protocols about how people solve problems, and they were trying to understand whether there were any keys, whether the area could be unlocked by understanding the one existence proof that we had, namely people.

ASPRAY: Artificial intelligence seems to me a good case for asking this question about its reception within ARPA.

It is an area where the research may not have immediate, obvious defense relevance. Can you talk to that point?

SUTHERLAND: Well, it is kind of interesting. I remember when I did my thesis talking to Larry Roberts about stacks and lists. It was pretty hard to understand what they were all about. One of the things we worked on was trying to get the structure of those things better. The idea of a hash table and the notion that you could sort of characterize first programming as something that you just did, was unheard of. The artificial intelligence people, I think, pioneered many of the advanced computing techniques: non-numeric programming; dealing with compiler languages; describing languages and so on. I think that that whole effort has now reached a point where it is what is taught to undergraduates as computer science. That has got to have enormous impact. And the idea that one ought to use a list for some purpose, as just the natural thing to do, is something that grew out of that early activity. So I think the defense relevance of the work that was going on then is pretty easy to defend now. But, you know, relevance has a time scale associated with it. If I were the official responsible for a large budget, what fraction of the budget would I be willing to bet on a ten year time scale, or a twenty year time scale, versus what fraction do I want to bet on a two to five year time scale. I think that that is a hard judgement call to make. There was a fair amount of criticism on and off about the artificial intelligence stuff. It has had its ups and downs.

ASPRAY: From within or without the agency?

SUTHERLAND: Well, I do not recall being hit with too much of that while I was there. But as I watched afterwards, I noticed that there were periods when more AI work was being sponsored, and it was okay to do AI work. Then there were periods where it was not okay, and big questions were raised. I think there was a Jason summer study that was brought to bear on the question of whether it should be done at all. There is always the hope that computers will do something that is really hard. Even when I was in ARPA, the Army had this set of tank and non-tank images, and one of the problems was, could you recognize tanks in aerial photographs? There was this wonderful set of tank and non-tank images - I think there were a hundred images. Some of the tanks were half under a tree, and some of them were recognizable mostly because of the tracks, the trail that they leave behind. For 20 or 25 years there has been the hope that some artificial intelligence program or vision program would be able to recognize tanks reliably. The last

one of that sort that I became aware of was DSP study done about four or five years ago that looked at one such proposal. The result was not very satisfactory, as I recall. There was a period fairly recently, I think, where the artificial intelligence stuff came under fairly strong attack from within ARPA. Bob Kahn probably was the guy in charge of IPT at that time, and he probably can tell you about what the events were. I did not get involved in it.

ASPRAY: You added a few new programs, and some of the projects that Licklider had started were clearly going full blast while you were still there. Does that mean your budget was increasing during this time? Do you feel like you had enough money?

SUTHERLAND: Well, it increased slightly. If I remember, it was 13 million the first year, and 15 or 16 the second year, or something of that sort. Well, you must have the budgetary figures, but it has been monotonically increasing ever since.

ASPRAY: We have partial budget figures. It is surprising how hard it is to put some of this data together.

SUTHERLAND: That is amazing. My memory is that the first year I was there it was 13 and the next year it was 15 or 16. That's it. It was a very small budget compared with today's numbers, although I do not know where it sits if you take the inflation into account. Russ Kirsch was the guy at the Bureau of Standards, and he might be worth your talking to. Russ Kirsch had been one of the early pioneers in Bureau of Standards in computing. At the time I was in ARPA, I got to know him and his view of how the government did its research work in computing. Russ thought on a fairly broad scale, and was very broad based. He told me something that I thought was very useful. He said, "One of the things to do when learning about your professional budget is to compare it to your personal budget, and complete the ratio of your own annual income to your professional budget. Then keep that in mind when you are spending your professional budget, because it tells you which things are big and which things are not big," By that measure Project MAC was an automobile, and some minor study programs were lunch. That was an important notion, to keep things in perspective. I have used that ever since. It is awfully easy, I think, for groups to get bogged down when they are talking about amounts of money for corporate spending that are amounts that they

could spend personally, because they get emotionally involved and think those are big amounts. So they will devote more time to amounts in the range that they could spend personally than they do in amounts that they would not even think of spending personally. It is just a thing to avoid, I think - you have got to focus your attention on the big stuff.

ASPRAY: But you clearly had a limited budget, and you had to make some choices about programs. Can you tell me something about the way that you would put together your annual budget, annual program of support?

SUTHERLAND: I do not really recall. It never seemed to be very hard. You know, I had not gone into the office with a 20 million dollar program in mind and I had to clear away space to make it happen, so that I did not have that problem. The way, in fact, that I chose things to fund, I think, was basically on the basis of principal investigator - that the program had to make sense, and the guy in charge had to know what he was talking about. Those seemed to me to be the two most important ingredients. Now, I saw on the list of contracts that you mentioned this stuff about the walking machines, and things at GE. That was not out of my office. You failed to put on your list the most important piece of information, which is where these contracts were written. These are ARPA order numbers?

ASPRAY: These are ARPA order numbers, yes. This is not our final list. This is one that was given to us.

SUTHERLAND: This is obviously SDC. I do not recognize these by their names, because I thought of them more by their location. Okay? So as you promote this, you ought to list what the organization involved was, because that is much more valuable.

ASPRAY: We are in the midst of putting together a database that has about 10 fields for each of these that includes amounts of money, contractors, who the contracting agent was, and so on, as well as titles and brief descriptions of the program.

SUTHERLAND: The list you made me had on it the walking machine stuff at GE, which, although I found fascinating,

was not in my office. I do not know who was doing it. ARPA supported a guy, Ralph Mosier, who was building a walking robot at GE. That machine actually worked. It had force reflecting servos and it was a kind of interesting thing. It was very hard to drive. But that was not part of the ARPA IPTO office.

ASPRAY: Yes. Do you remember some of the large ticket items that came in for consideration that you turned down?

SUTHERLAND: No, I do not. I just do not. You are asking if there is any of those things that I am saying, "Gee, I am glad I did not do that."

ASPRAY: Or, not necessarily whether you're glad or not, but just the ones that came up for consideration and did not get funded.

SUTHERLAND: I just cannot remember.

TAPE 2/SIDE 1

SUTHERLAND: The reason, I think, is that the proposals that came in were mostly unsolicited proposals. The ones that came in formally, that came in as fat written proposals and so on, were probably too late in the sense that they were already formulated too clearly and too fixed in form to fit into the programs that I had going. The way that the office in fact worked, was that proposals would be developed over time through conversations between myself and the principal investigator and other people. By the time a piece of paper was written down, it was already pretty much decided what was going to happen. Sole source procurements were possible in those days, usually on the basis of some key ideas that investigators had. We did mostly sole source procurements, and I think that in this particular area that is quite appropriate. The concept that you can go out with an RFP for research activity when what you are buying is the cleverness of a few individuals anyway seems to me to be a conflict in terms, but I guess that is because I grew up in an earlier era.

ASPRAY: Well, that suggests to me that you were in regular contact with the research community, at least with your PI community. Were you making many trips to see them? Were there conferences called on a regular basis? Were you on the telephone with them regularly? What was the mode of operation in the office?

SUTHERLAND: Well, I was out of the office more than half the time. Somebody kept score and remarked to me at one time, "Do you realize you are on the road more than half the working days?" I was - and quite purposefully. The way I found out what was going on was by going to talk with the people, and meet with them. When new ideas came into the office I would go and try to visit people at their own site, and talk to the PI and the people that were working for them, and try to recognize whether it was an interesting bunch of people.

ASPRAY: Yes. So new projects came about out of conversations you might happen to have with them on one of these trips.

SUTHERLAND: Yes, or they came about when they came to my office, or in a variety of ways. The three projects that I mentioned worked this way. In the case of the macromodule thing, I had known the people for a long time; as for the Utah thing, Dave Evans had been a contractor of the office, and I got to know him as he was running the project at Berkeley. The project at Berkeley was clearly a good thing. The project at Berkeley did two important things, I think. First of all, it developed a whole computer system, which SDS subsequently sold as the 940, with the design of the SDS 930 basically modified onto the 940. Then it provided a training ground for a whole collection of people - the most notable of whom was Butler Lampson, who is now a senior engineer at DEC, one their principal key figures. Who else went through that program? Mel Pirtle, who subsequently ran the ILLIAC project, had gone through that Berkeley program as a student of Evans. There were a number of others, but their names do not come to mind. So, I had known Evans. I got to know him, and when he moved to Utah he came in and said, "I am going to Utah and I have got these ideas about graphics, and I would like to get something started." I gave him some very modest funding which I think Taylor subsequently increased. Then with the macromodule thing, I had known those guys for a long time. As for the ILLIAC IV project, I don't know how it got started. I think he came into the office

one day and said...

ASPRAY: Yes, we have heard that the proposal came in over the transom. That was the expression that was used.

SUTHERLAND: Yes, but it did not come in as a document, or it may have come in as a document originally, but that was not what it turned out to be, because Slotnik did not have a place to work. I got to know Slotnik when he worked at Westinghouse. He came into the office and said, "Basically, I want to do these things and I cannot do it at Westinghouse, because they will not let me do it. Where should I go?" I introduced him to some of the university folk. So that one was fairly a long time in the doing.

ASPRAY: Yes. Were there principal investigator meetings run during your time there?

SUTHERLAND: I recall calling a few such meetings. There was a machine at IBM that had been built that had a very large memory. It had a million words or something of memory. It was the biggest memory around. Some of the artificial intelligence guys wanted to get a hold of that machine, wanted to use it for various purposes. So I called together a meeting of the relevant people and the IBM folk, looked at how we would get a contract in place that would let them use that machine. So, yes, I would say that there were some specialized meetings of principal investigators. I did not make a regular habit of principal investigator meetings. That did not happen until later. I think maybe Bob Taylor started that one out. I do not know for sure.

ASPRAY: That sounds right from what Taylor said to me.

SUTHERLAND: Yes, Taylor would have done that sort of thing. He was my deputy, you know; he was at NASA and came over and worked with me.

ASPRAY: I want to ask you about that in a few moments, or you may even talk about it now if you like.

SUTHERLAND: Well, I did not start any formal set of meetings, but when there was a special reason for one I did not hesitate to get people to them. I remember one meeting that we had in which and the subject was character sets. This was before ASCII, and there was some problem about how would people communicate, and what character set should we use. And Al Perlis put the whole thing in context. He came into the meeting and said, "I am absolutely in favor of character set standards." He said, "My character set is available as the standard." (laugh) Do you know Perlis?

ASPRAY: I have not met him, no.

SUTHERLAND: He is one of the world's most articulate people. He has got a wonderful sense of humor. This is absolutely typical of Al Perlis. In one sentence he expressed the whole difficulty of getting standards together.

ASPRAY: (laugh) Okay, did you bring in help - deputy, scientific directors into the office during your time?

SUTHERLAND: Just the deputy. There was a secretary there - always had been. Shortly after I was there I got to know Taylor. He was at NASA doing various control system activities. I brought him over from NASA to be my deputy, and then when I left he took over the office. I do not remember exactly when that was. I was there for two years so it must have been somewhere in that period.

ASPRAY: Yes. As your deputy, what were his duties as you saw them?

SUTHERLAND: Oh, this office was informal enough. It was not formalized. We worked together on things.

ASPRAY: Yes. Was there a division of labor, though, in fact, if not in form?

SUTHERLAND: I am trying to think back. There must have been, but I do not know what it was. It certainly was not a formal division of labor.

ASPRAY: Part of the reason I ask you about this is that Taylor comes in with a rather different background from the other directors of the time. He comes in with much less technical knowledge of computing than you had, or Licklider had, or Roberts had. So, that was the underlying question.

SUTHERLAND: Right. But what Taylor had was a much higher degree of people skills than either his predecessor or his successor, and that probably was important at that stage. I mean, if he in fact started the PI meetings, which he probably did... You know, I cannot remember any PI meetings until Licklider's second tour. I remembered going to a PI meeting somewhere where Licklider was chairman of the meeting basically. That was the first one I can remember. They may have started earlier than that.

ASPRAY: Tell me about Roberts coming on board and what you know about that.

SUTHERLAND: Well, Roberts is one of a handful of smartest people I know. He is just very, very clever. I think he had a pretty clear picture of what the computing field was. I knew him real well because we had been graduate students together. I think when I was leaving there was some question about how to get a successor and who the appropriate successor would be, and so on. I remember there were two or three people that we tried to bring in, who for one reason or another either did not want the job, or could not do it, or something. I do not know what the timing was. Do you know when Larry actually first went down there? He worked with Taylor for a while, didn't he?

ASPRAY: That is right. He worked with Taylor for about a year before he took over as...

SUTHERLAND: Yes, so there was sort of the brick wall kind of phenomenon going on there. That is, Taylor and I overlapped and then Roberts and Taylor overlapped. I do not know what happened when Roberts left. Is that when Lick came back?

ASPRAY: Yes.

SUTHERLAND: Then Lick came back, yes.

ASPRAY: The reason I ask this question is that we have heard slightly differing accounts about the reason that Roberts was brought into the office, whether it was to run the networking program, or to get him ready to take over directly as the director for the office.

SUTHERLAND: Well, my thought about Roberts before he went there was never focused on network. My thinking about him was never focused on network. I did not recognize that Roberts was a force in networking until later. That is all that I can remember.

ASPRAY: Okay, fair enough.

SUTHERLAND: I cannot tell you what other people think it was but...

ASPRAY: Sure, all right.

SUTHERLAND: My guess is that one of the problems that you historians have is that you have to filter through what we, the subjects say, and try to get something that approximates reality out of all of the different accounts, right?

ASPRAY: Yes, that is always a very difficult task.

SUTHERLAND: Knowing the characters that you are dealing with here, I am sure that the accounts differ widely. (laugh) Perhaps I have said enough.

ASPRAY: Yes. Before I turn to some topics from after you left the office, are there any more things that you want to

tell me about your time there? Are there any major issues that we have not addressed?

SUTHERLAND: Well, I guess we have not talked about SDC at all. SDC was part of the main thrust of great activity. It was always kind of a puzzle as to what SDC was about. It was clear that they were one of the major suppliers of software for the Air Force and they needed to have some push into the time-sharing world. They had this big computer called the Q32 that they made a time-sharing system on. I think that was an important way of getting technology transfer going, but it was awful damn expensive. I remember trying to get rid of the Q32, because it cost a million dollars a year just to keep the doors open. That was just the support costs for the machine. I remember going to Strategic Air Command (SAC), who had the only other existing machine of that type, and offering it to them for free, that we would ship it to them. They did not want it, not even for spare parts. I think finally we just turned the key and shut it off. But then they had some quite good people that made important contributions. This book on LISP came out. You must have seen this. Was it Weissman or...? It was a manilla paperback, about that thick, which was the first decent book on LISP. The SDC guys wrote it. Of course, Jules Schwartz was one of the key players there. He had done important compiler stuff. They were working on various improvements in compiling. But it never had quite the same spreading impact that the university programs had. As I think of where the key players in the information processing business have come from, I find that a large faction of them were students or otherwise supported in the university programs by the ARPA research program. You know, that would be an interesting thing for ARPA to look at. If you take the 500 key players in the information world today, how many of them at some time were influenced by that program at ARPA? I'll bet it's about 80%.

ASPRAY: Yes. It would certainly be not very difficult to put the genealogies together of students and teachers, or people who worked on programs, those sorts of things.

SUTHERLAND: Yes. I think the impact of the university research was fairly clear, that the university has a property of disgorging people. I think Licklider recognized that early on, and set the program up as principally a university research program. Now, if I look at what has happened in ARPA since, there is some core base of university research out there, but there is a much larger piece now that is industrially based, and that is still specific, probably, to various

companies. I wonder about the efficacy of that, in terms of its long-range impact, and I am not sure that the dollars get the same multiplier over a five-to-ten year period that they could get by doing good university research.

ASPRAY: Another question that comes to my mind after you said SDC is, what was the relation at IPT with IDA during your period?

SUTHERLAND: There were some studies that IDA brought on that were never very big. There were a couple of guys that I used to interact with there. Do you remember any names?

ASPRAY: No.

SUTHERLAND: One of the things SDC did while I was there was they did this study of on-line versus off-line programming. Are you familiar with this? It was an amazing result. They did a double blind, properly four squares - whatever the psychologists do - the right kind of experiment and ascertained the value of on-line programming. They asked, are programmers in fact more productive when you give them the terminal to sit at? And the answer is that the programmers all like being at the terminal better, but the differences between good and bad programmers are way larger than the differences between on-line and off-line programming. The bottom line is, if you give a good programmer any damn programming tool, he is a lot better programmer than a bad programmer with the very best programming tools.

ASPRAY: I see.

SUTHERLAND: It is just a very hard thing to quantify what the value of it is. SDC did those experiments. It was one of those things.

ASPRAY: Okay. Why did you leave the office?

SUTHERLAND: It was time.

ASPRAY: What do you mean by that?

SUTHERLAND: Well, I went. I said I would stay about two years. I had a career to get on with. It was time to go do something else. If I recall, I left at the beginning of a summer and started teaching at Harvard the next fall. Harvard had offered me a tenured position, and it was too good a deal to turn down.

ASPRAY: I see. Do you think that the time at IPT had helped your career?

SUTHERLAND: Oh, absolutely. No question.

ASPRAY: In what ways?

SUTHERLAND: I got to know everybody. What is maybe more imp ortant is everybody got to know me. It was absolutely super from the point of view of getting an insight into what was going on - very important.

ASPRAY: When you went to Harvard, what was your relationship with the office then? Did you become a contra ctor?

SUTHERLAND: No. It was friendly. I got some money from Bell Laboratories and I got some money from the CIA, but that is a whole other story. That was in the era when students were protesting that kind of thing. It was very exciting.

ASPRAY: (laugh) I bet.

SUTHERLAND: I was at Harvard two years. Then I went to Utah to join Dave Evans, and we started the Evans and

Sutherland company with private venture money. I worked at the University of Utah and did some of the research which was at that time supported by ARPA. So my graduate students at the university were ARPA-supported.

ASPRAY: Were ARPA-supported, I see. Did Evans and Sutherland ever get money from DARPA?

SUTHERLAND: Not that I know of. While I was there we had some ONR research money in small amounts. But no, the Evans and Sutherland company was principally product-oriented and privately funded and basically did not seek ARPA support.

ASPRAY: This is not a question that I told you I was going to ask you about, but I was wondering if I could prevail on you to give me an overview of graphics history in a few minutes.

SUTHERLAND: Well, I do not have much overview, you know. I have this little peephole to look through.

ASPRAY: Well, but the brightness of light that comes out of a peephole can illuminate things.

SUTHERLAND: Well, whatever you say. I did the Sketchpad thing, and then when I was at Harvard I had gotten interested in the head-mounted display. I think we pioneered the three dimensional activities.

ASPRAY: Well, what other work was going on at the time?

SUTHERLAND: Well, there was quite a lot of stuff. The Utah guys were doing things. The other stuff that I am familiar with was the things that NASA was paying for, for example, to do simulators, which turned into the program that GE now has and continues. I did the work at Utah with Dave, which I think you probably know about. Then Bob Sproull and I wrote a paper, under ONR sponsorship actually, which was called "A Characterization of Ten Hidden Surface Algorithms" and which we basically said, "The hidden surface problem is a sorting problem." That seemed to me to sort of tidy up a loose end, and I stopped doing graphics for good - have not done any since.

ASPRAY: I see. Okay.

SUTHERLAND: Instead of it being a mystery as to "how are you going to do this?" it became clear that it was a known problem, and all of the known techniques could be applied to it; it was just a matter of applying them. A lot of people worked with this very effectively - I mean, the stuff that has come out since then is just gorgeous. But I went off to do other things.

ASPRAY: Fair enough. Now I want to give you an opportunity on tape to make any general comments you want about ARPA and its importance or problems over time.

SUTHERLAND: All right. I would contrast the ARPA approach to sponsoring research with what I will call the NIH and the NSF approaches, which are basically peer review approaches. It's perfectly true that an office director in a peer review situation can cause to happen any damn thing he wants by who he chooses for the review. Nevertheless, there is the perception that the peer review mechanism applies, and that perception permits Congress to say, "Okay, this money will not be wasted because good folk will be watching." You know, a lot of people are watching. The ARPA approach has never had peer review mechanisms. It has been done basically on the individual initiatives of people in the office, with whatever advisors they have chosen to seek. But the director of ARPA and the director of IPT have had, in fact, a good deal of spending authority. I think that there is room for both of those mechanisms in the government. I think they are both important. But I think they are able to do quite different things. When what you want to do is to provide a large base of research to carry a field forward in the steady progress that you want to have in a field, as NIH does, then it seems to me that the peer review mechanism is excellent. For example, it's important that the government put a lot of money into the medical field, and it's important that it be well spent and spent broadly across the country. What the peer review mechanism is weaker at is activities, like in the computing area, where there is a big outburst of things happening, where an insight like that which Licklider had, that on-line computing is important, or like that which Roberts had, that networking is important, where an insight like that by an individual can make a big effect. It seems to me that that happens mainly in fields where turnover is very rapid,

where progress moves quickly, like in computing, where you have had this factor of two a year kind of thing.

ASPRAY: Right.

SUTHERLAND: Peer review is rather more cumbersome, because it tends not to take those courageous moves. I always felt, when I was in ARPA, that one of the strengths of the U.S. government was that there were multiple funding agencies. If I was a researcher with some computer-related research idea, I had three or four places I could go. If I did not get along with ARPA, I could get along NIH or NSF, or with the Army, or the Navy, or whatever. It seemed to me that a strength of the operation was that there were alternatives. What I hope is that ARPA will not become hide-bound and tied up in a peer-review mechanism which would make it like most of the other agencies, so that it would be unable to make the courageous moves. I do not know to what extent organizational arthritis is setting in. But I sense that there is quite a lot of it. For example, the number of sole source procurement is way down. The need to initiate programs and then go out with RFPs in a very rather formal way, and evaluate the RFPs in a rather formal way is stifling to individual initiative. If that is true then maybe the thing to do is to take ARPA and turn it into a stable peer-review kind of organization and start something else that is not peer reviewed, so that you have a place where individual leadership can be exercised. I do not know who in the government worries about that question. I rather suspect that no one does; that what happens happens for a variety of nonstrategic reasons, and arthritis sets in to organizations because the bureau of the budget says, "Oh, we need a new report this year and annually hereafter," and there's enough fuss from various contractors who didn't get selected that sole source procurements go out because there are abuses to that - thousand-dollar hammers - and Congress says, "Oh, we cannot have that." On the other hand, when you cannot have that happening there's a lot of other things that you cannot have happening too. I am concerned about that.

ASPRAY: Can you give me specific historical examples of areas where the peer review programs did not support an area of research that ARPA did?

SUTHERLAND: Well, I do not think that ILLIAC could ever have started with a peer review. I do not think that the

ARPANET would have started. To get the ARPANET going one had to move against the grain of the folk. It was a very interesting phenomenon which I think you really ought to look at. Maybe you have. My observation of it is that the folk who now swear by computer nets - would not be without them for the world - are the very same people who resisted Roberts' influence. Roberts both had the technology in hand and got a good contract, with BBN, to build the network devices with good technical support from Kahn and others. But he also had the clout to say, "Okay, you are an ARPA contractor. I am providing your money. You will install one of these on the machine I am paying for." Like it or not, the ARPANET grew up, and once it was there they loved it. I think it had a big effect on the cooperation of that community. I sensed a decrease in the "Not Invented Here" (NIH) attitude of groups in the computer science departments at the universities of this country as a result of the ARPANET. I think that that is because people could go to another institution and demonstrate their software, and they could easily communicate with their colleagues at other places. So collaboration grew up where none had happened before; you could borrow software and trade it back and forth. There was a sense of community: "We are the ARPANET users. We have some important thing in common that other people don't have, so we became a group."

END OF INTERVIEW