

An Interview with

CHARLES A. ZRAKET

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Conducted by Arthur L. Norberg

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Abstract

Zraket describes the Information Processing Techniques Office's (IPTO) interest in command and control systems in the early 1960s. He provides a perspective on the military expectations of computing that developed from the Whirlwind and SAGE projects. Zraket discusses the interaction between the Defense Advanced Research Projects Agency (DARPA), the MITRE Corporation, and Bolt, Beranek, and Newman. He concludes the interview with an

overview of DARPA funding trends in the 1980s.

CHARLES A. ZRAKET INTERVIEW

DATE: 3 May 1990

INTERVIEWER: Arthur L. Norberg

LOCATION: Bedford, MA

NORBERG: One of the things that seems to be a part of the Information Processing Techniques Office in approximately 1962, 1963 when Project MAC got going at MIT was a concern for the use of the computer in command and control areas. And while there is a decent amount of historical work done on SAGE and some of the earlier systems, it isn't clear what the transition is after that and what the role of the computer is in command and control issues. And furthermore, what the interest of the Defense Department, say in the Air Force, might be in using this instrument. Can you say anything from those years, 1958 through 1965 say, about the interests of the military and maybe even the understanding of the military in what this computing machine could do for them, the computing machine of that period, obviously?

ZRAKET: First, I think it is important to understand that the contribution of the SAGE effort to what happened later was very profound. Although it has been documented fairly well in the *Annals* and so forth, the fact of the matter is that almost all of the techniques that were exploited in the 1960s and the early 1970s derived from SAGE. And this was a very broad spectrum of techniques. The whole business of time-sharing really came out of SAGE. SAGE was essentially a time-sharing system. It was a system that essentially time-shared a whole set of functions with many end users in terms of workstations that existed. The displays that were developed in SAGE and later basically served the base of all real-time systems. Most of the software programming techniques that were developed in SAGE, the whole business of compilers and assembly programming and all of these techniques came out of SAGE. And most of the transition occurred through people, that is, people who worked on SAGE. Many of them ended up on Project MAC, for example. The people who started Project MAC at DARPA, Licklider was very familiar with the SAGE experience and had studied it. There was a tremendous technology transfer, if you will, at that time through that. Many of the computer science departments at a number of the universities were started by SAGE people. Alan Perlis who went to Carnegie-Mellon, and I forgot the other fellow's name who left us to go to North Carolina, and so forth.

A lot of the people fanned out into IBM, later into DEC through Ken Olson and Harlan Anderson, and many of the university computer science departments were all started by MIT digital computer people.

The other notable thing that you should really look into was the Air Force really pioneered the use of computers in command and control. They were by far the most aggressive service doing this. In 1960, they initiated a major study called the Winter Study Group. This was headed up by Gordon Thayer of Bell Laboratories. It included people from all over the Air Force, MITRE, Lincoln Laboratory. We were the principal support to the study. And that essentially was an attempt to rationalize what the  $c^3$  development approach that the Air Force should take for the future. The whole idea of computer based systems for command and control and how they were to be developed and how they would evolve came out of that study group. It had a profound influence throughout the Air Force. What the Air Force did at the time was to take all of the so-called "L" systems that they were developing, these were 465L, 485L, 438L, many of which were at Wright Field, and brought them all under the new electronic systems division.

NORBERG: Can you tell me what the "L" system is? Are these computing machines made by somebody or other?

ZRAKET: Yes. "L" systems were an Air Force nomenclature for computer based systems that were being designed for command, control, and communications. The Air Force, early on, started using computers. At Wright Field they had set up a computer division and had started using machines in their logistics command for tracking shipments of goods and things like that and records. They had started a program to use it in intelligence data processing. They had started a program to provide SAC with the capability to plan the CIOP (?) and to interconnect all the Air Force bomber bases and headquarters together by our system called 465L. So they were very active back in the late 1950s and early 1960s. Partly, as you know, they were the ones who took over in the early 1950s from the Navy. The Navy had started the development.

NORBERG: Of Whirlwind you mean?

ZRAKET: Of Whirlwind. They had started it as a flight simulator program. It was the Air Force, through Project Charles, that said "We really ought to make an air defense system out of this." That kind of push by the Air Force in parallel with the SAGE development - they started all these other programs in the late 1950s. They were scattered around the Air Force, some were out on the west coast, many of them were at Wright Field through the so-called "L" Systems. In 1960, I think, when the old Air Research and Development Command was changed into the Air Force Systems Command and Bernie Schreever was brought in to combine all these things, he was the one who initiated the Winter Study Group. That was when they decided to consolidate all computer communication sensor based systems here at Hanscom Field and essentially transferred all these programs to ESD.

NORBERG: How were these computers being used at the time? Was it just like the SAGE system in terms of giving an indication of where various aircraft might be at a given time?

ZRAKET: Well, my recollection is in the logistics area they were really being used in a batch processing mode. That is, they were used as adjuncts. The SAC computer based system was intended to be a real-time system. It never got deployed until the mid 1960s, but it was started in the late 1950s, early 1960s. The intelligence data processing systems, I think, again were primarily stand-alone systems. They weren't netted in any kind of real-time network. As best as I can remember, the only operational system that had a real-time network and real time control at the time was the SAGE system. It wasn't until the mid-1960s that the FAA started really developing the first national air space system and SAC started deploying their real-time network and the intelligence community started to net their systems.

NORBERG: Do you remember what technical developments needed to occur for that to take place? Advances on the SAGE system basically?

ZRAKET: Well, certainly network techniques and that has a parallel history. Here at MITRE we developed something called the post attack command and control system. At the time there was a lot of concern on the part of

the Air Force as to how they were going to carry out their CIOP (?) functions in the event of a nuclear attack. The so-called PAC system was an airborne network with a so-called store and forward network technique that was actually developed here on a classified basis. Eventually the Air Force did deploy that network. It took some time, but eventually the so-called looking glass airborne command posts and UHF network of communications relays became the PAC (?) system. But, more important than that, two of the key people who had developed that network here went to work for BBN, Bolt, Beranek & Newman. At that time Licklider became very interested in the technique, and DARPA picked it up. And Roberts later took it over at DARPA and started the, if you remember, the DARPA network. BBN was the principal support contractor. What they essentially did was translate the concepts of the store-and-forward airborne network into a ground network. The Air Force and MITRE never really got any credit for that, because all we had done was issue classified reports on PACKs and the technology. But DARPA picked that up, and when that technique started developing and people started developing store-and-forward techniques, network techniques, that really pushed the whole network idea throughout the Air Force. After that you saw a lot of netted systems starting to come out of it.

The other notable thing that occurred during that time period was in 1962 in the Cuban Missile Crisis when Kennedy found out that we really did not have a reliable worldwide communication network. They initiated the so-called WorldWide Military Command and Control Systems, the WWMCCS, and the National Military Command and Control System, the NFCS programs. That was when I left MITRE Bedford here in 1963 and started the Washington division of MITRE. We were set up down there; we were asked to do this by the Defense Department. And we set up a division to support the Defense Communications Agency that was given the charter of developing the WWMCCS and the NMCCS, and we also set up a division to support FAA in developing the national air space system. That kind of push from the top to develop a worldwide command and control network that started as a result of the failures in the Cuban Missile Crisis. There was a tremendous interest then in the DOD to use computers and communications for command and control. I mean that really spread it out from the Air Force, which had been pioneering these developments, throughout the whole Defense Department. That was the impetus that really set the Army and Navy and the Air Force to a long-term program of using computers in command and control. And both the



Project MAC and the DARPA network efforts really helped in that respect, because these were technologies that people were able to pick up all over.

NORBERG: Can we go back? Let me ask you two questions. One of them is who were the two people who left MITRE and went to BBN?

ZRAKET: It was Hawley Rising and Bill Burn. They were running our computer department at the time. Also Frank Heart, who never came to MITRE but was part of the SAGE development at Lincoln Laboratory, left about that same time and joined BBN. So it was through that transfer that BBN picked up the know how in supporting DARPA in this area.

NORBERG: My second question is what were the basic elements of WMCCS?

ZRAKET: The core of WWMCCS was the National Military Command System that was established in Washington that included setting up a command and control center in the Pentagon, an alternate center at Fort Richie, an airborne command center, and a ship afloat command center as the capping command and control system for national control. The other elements were to set up similar types of command and control systems at all the operational commands around the world. SAC set one up, NORAD set one up, CINCPAC set one up, Europe established one at UCOM, and so on all the way down the line.

NORBERG: What sort of information was gathered by these centers?

ZRAKET: Well, all the way from status of forces, what they call planning data. That is all of their war plans were stored in these machines, instructions to forces on where to go and how to do things, control of forces. In the case of NORAD, of course, it was a worldwide network of sensors including the first deployment of space sensors for

warning and attack assessment. So all the beginnings of what you see today around the world were started then in the early to mid 1960s.

NORBERG: It seems like it would require a substantial amount of memory to do this.

ZRAKET: You mean computer memory?

NORBERG: Yes.

ZRAKET: Yes.

NORBERG: And reasonable access speed?

ZRAKET: Right. Of course at that time IBM had developed solid state versions. They had first developed the vacuum tube version of the Whirlwind machine, and then they developed solid state versions of that machine. Other people were coming up with computers. There was lots of magnetic drum memory; there was lots of random access core memory. You could do quite a bit in the 1960s.

NORBERG: When was WMCCS operational?

ZRAKET: Well, I would guess the first versions of it - you know in terms of the effort to improve the communications and the computer base command centers - probably in the late 1960s, that kind of thing. Then it went through an evolution during the 1970s. Most defense systems, if you recall those years, from about the mid-1960s to the mid-1970s were starved. That is, they were starved in terms of budget. Budgets were low and they really couldn't deploy as fast and as much as they wanted to. But starting in the late 1970s through today, I mean there has been a huge amount of money that has been put into these efforts. But WWMCCS really started getting deployed in terms of improved worldwide communications and improved command centers probably in the late 1960s.

NORBERG: Did you have any contact with DARPA in those years?

ZRAKET: Personally?

NORBERG: Yes. While you were running the Washington office?

ZRAKET: Yes. I'm trying to think of whether we did any work for them. I don't really think we did any funded work. I had been asked by Gene Fubini to take on that job.

NORBERG: Which job? The director of... the post Licklider had?

ZRAKET: Yes, before Licklider was. They had asked me first and then when I turned it down, they asked Lick to take it over.

NORBERG: Do you remember any of the discussion that went on while you were considering this?

ZRAKET: Well, I can remember when I went over and got interviewed by Fubini and Harold Brown. What they said was that they were starting this new information processing R&D effort, that it was important to the whole business of command and control and they wanted to apply all the techniques that people had been talking about and develop them. And since I had been very active of course here at MITRE... And I told them at the time that it just didn't seem to me - you know, the pay in those days was about eighteen or nineteen thousand, which even in those days was not a lot of money - so I just said I didn't want to do it, that I had other fish to fry. I turned it down. But Lick did a good job. He really was a strong advocate. He was very familiar with everything we had done at the digital computer laboratory, and he was very instrumental in setting up project MAC and I think in getting Roberts down there and getting the DARPA network started and so forth. DARPA in those days decided to go the university route. They

did not want to go in with industry and MITREs and so forth. They decided they really did not want to do this development in industry (?). And they not only set up the Project MAC at MIT, but you may recall they set up a major effort at Stanford. And most of the AI work that came out of Stanford later was set up by DARPA at the time. I remember Don, I think it was Engelbart, was out there. Also Dave Brown, who was one of my associate directors at MITRE, went out and headed up the computer science department at Stanford.

NORBERG: Stanford or SRI?

ZRAKET: SRI. It was SRI that he went to. But they did a lot of work. SRI did a lot of work for DARPA in those days.

NORBERG: Getting back to the WMCCS system and the various kinds of developments. Some of the things that I've read about command and control in those years, in trying to understand what the human side of the issue is and what sort of information commander's need to make decisions and so on, that seems fairly traditional in terms of the commanders function in any sort of strategic or even tactical circumstances. On the other hand, the kind of information that is being provided in this new technological sphere in the use of computing machines and so on and various other kinds of data processing devices seems to be an entirely new element that takes a little time to understand and to incorporate into a command and control system. One of the things that I have heard from some of the people associated with DARPA is that they felt in supporting any sort of research activity that in order for the military to capitalize on the use of this new technology that it was necessary to do more fundamental research rather than simply applying the machinery or the techniques that were available, say, in 1963. That seems a rather strong position for say somebody like Licklider to take when he first walks into the Defense Department. However, something I heard you say just a few moments ago may support his position. And that is if the Air Force was so strongly behind this idea of using this technology then they might be able to understand the argument that in order to improve the technology we need to do more basic research. Were you people at MITRE pushing the idea that more basic research needed to be done on these devices?

ZRAKET: No question about it. First the use of this machinery by the Air Force was a resounding success. They went from the scrapboards that they wrote on with grease pencil to this very sophisticated system. The people loved it. It was a big success right from the start in terms of the people interfacing with the SAGE system. But we had a whole department at Lincoln Laboratory and later at MITRE that was devoted to this subject under a psychologist by the name of Jim Deegan. And Ed Bennett, who later started Viatron, was part of that department. So we were spending a considerable amount of money. The Air Force was paying for our department of maybe thirty people who were doing basic research in the use of - in fact, the guy who later became head of the American Psychological Association, a very famous clinical psychologist was a member of that department, Miller I think his name was. And so we spent a lot of time doing basic research in the use of machines in these kinds of systems.

NORBERG: What kind of research specifically?

ZRAKET: Well, it was not only clinical research and trying to figure out what was the best way to interface these machines with people but running laboratory simulations and tests with operational people. We set up a whole laboratory here. In fact it was called the ESOP Lab at the time, and it was the forerunner of what Ed Bennett used when he took that technology and started Viatron. His problem was that he was five years ahead of his time in terms of VLSI systems and what he could make it for. So we actually did experiments. We had operational people come in, and we did all kinds of tests of various ways to use the machine. How you would split up the jobs amongst people, how you would display information to people, and so on. So there was a considerable amount of research done here in that area. One other thing you ought to get a hold of also is we sponsored three major unclassified symposia in the early 1960s down at Homestead that looked at the larger picture of how these systems fitted in and so forth.

NORBERG: Were you present at least the first two?

ZRAKET: Yes.

NORBERG: Can you tell me anything about the first one, because I haven't been able to find any proceedings for that. There are...

ZRAKET: For the second and third one.

NORBERG: There is a publication that emerged from the second one.

ZRAKET: Quite frankly, it's a blur in my mind. There was one incident that occurred there that sticks in my mind, but I don't remember whether it was the first one. This was a talk Dan Elsberg gave.

NORBERG: Of Pentagon Papers fame?

ZRAKET: Yes, it was a top secret talk that was billed as an unclassified talk. And the only reporter who caught it was a guy from the *St. Louis Post Dispatch* who ran a story on it. This preceded his release of the Pentagon Papers, but he basically gave a talk on how the White House and the Pentagon reacted during the Cuban Missile Crisis from a command and control viewpoint. That is, the lack of any real command and control systems to aid them and what went wrong and that kind of thing. At that time that was all classified information.

NORBERG: What is it you do remember about any of the meetings? Maybe we can sort of get to some of the other details through that.

ZRAKET: They were driven by the fact that the key people who were formulating the agenda and running the meetings was this department that I told you about that was doing the research on how command and control systems fitted into the military, what could they be used for, how could they be used and so forth. So that was the motivation for the meetings. I don't remember the particulars now; it's gone in memory.

NORBERG: Certainly Licklider and Fano and even Marvin Minsky were at the first one.

ZRAKET: See the people we had here knew all those guys. I mean, they were one community, and the purpose of the meeting was to discuss this whole research subject of how do we want the development of these systems to go. How do they fit in with people; how can they be used in the military for command and control. That kind of thing. So it was not a technically oriented meeting. I was there, and my guess is that I was so tied up with all the administrative aspects of the thing I just can't remember the substance. But you might want to talk to maybe Ed Bennet or Joe Spiegel who would probably remember in substance.

NORBERG: They were the editors of the...

TAPE 1/SIDE 2

NORBERG: DARPA had a bias against MITRE?

ZRAKET: Yes. From my viewpoint they saw us as a competitive element to their program. That is, we had been all the people involved in, you know, the original developments; we were doing a lot of work. My guess is that they felt if they leaned too heavily on us to carry out the work program then we would basically control what was going on. They wanted to broaden the program and get other people involved. This is not a criticism of them. So we were never very close to the particulars of what they were doing.

NORBERG: What sort of evidence would you cite for that?

ZRAKET: They never asked us to support any part of their program. They intentionally never talked to us or asked us to support any part of their program in over ten years. There was no way they would give us any work to do or even consult with us.

NORBERG: Did MITRE actually request any possible contracts?

ZRAKET: Oh, yes. We always tried very hard. The door was always shut in our face.

NORBERG: By whom? I mean by that an office rather than a person.

ZRAKET: Well, it was the Information Processing Office. Roberts, in particular, was very hostile towards MITRE. I think he had his own fish to fry. I think he felt if he gave the program to MITRE we would control it and not him.

NORBERG: I see. Are there other areas in which that sort of tension would be evident? For example, was there a strong sort of competitive tension between BBN and MITRE?

ZRAKET: No. I think BBN did their work and pretty much stuck to their knitting. We never felt any kind of tension with BBN. It was definitely with DARPA and not BBN.

NORBERG: Then you may be right about the personalities, if that's the case. There are two other ways that I would look at that. One of them is the possibility that MITRE would be seen as more the development or exploratory side of this - the 6.2, 6.3 kind of budget associations. And therefore, if they were pushing 6.1 funding, they would not see MITRE as a possible contractor. Now thirty people working on research here constituted what sort of percentage of total employees of MITRE at the time?



ZRAKET: It was considerable. I would guess it was 20%. In those days, the Air Force was pretty flush. We had a very independent program and we were devoting about 20% of our budget to research, what we called technology base work. We were devoting about 20% to advanced planning and 60% to systems engineering. The other thing is they might have felt we were already flush, you know, and they were going just to be another player within MITRE. You know they were going to have an effort that was just - we were Air Force dominated and controlled, and they wanted to be DARPA in control. I can understand it in retrospect. I think in Roberts' case it was a personal thing. He really was very hostile to MITRE.

NORBERG: Let me try to explore this in another way. How would you contrast Rand and MITRE at that time?

ZRAKET: Well, I knew Rand very well because I visited them four or five times a year, and I had lots of friends out at Rand. I thought Rand was doing some very first class pioneering work in what I would call systems research in this area. Very first class work. They had Jim Digby, Frank Eldrich, Bayer, Willis Ware; they had just a bunch of first class people who were... It was Rand's heyday. I mean, after that decade, as far as I was concerned, they went downhill. But during the mid to late 1950s and early to late 1960s, maybe mid 1960s, that decade say from 1955 to 1965, they were doing first class work at Rand. They clearly had a lot of good ideas. A lot of the things I started at MITRE derived from ideas I took from Rand. We had a very close working relationship. I was out there half a dozen times a year. I worked very closely with them and had a good relationship with them.

NORBERG: Would you say their distribution of activity was similar to MITRE's, the 60-20-20 you just mentioned?

ZRAKET: No. I would say it was almost all in advanced planning and research, very little in actual engineering of systems. In fact, some of them were jealous of the fact that we had so much systems engineering, because it ended up... I remember Henry Rowan complaining that we always had much more influence in Washington as to what happened in command and control and air defense because we had all these big programs than they had because they were just doing... they were looked on more as academics. But they were doing very good work.

NORBERG: They had a contract, of course, from DARPA.

ZRAKET: I knew that.

NORBERG: They had the computing laboratory activities. And Licklider claims to have reduced that.

ZRAKET: He reduced it?

NORBERG: Reduced it.

ZRAKET: He may have.

NORBERG: He was not interested in continuing that sort of research activity.

ZRAKET: Well, I thought it was very good. I thought that Rand was doing a first class job.

NORBERG: That was really not the kind of answer I was looking for, but more trying to make a contrast to see whether or not if they were a similar organization to MITRE. Then the reductions in their money from DARPA would substantiate the point you just made about the prejudice against MITRE.

ZRAKET: Well, my feeling is he would probably drop the work at Rand because they were not capable of building an experimental system. DARPA has always been very high on demonstrating their technologies. Rand was not able to do that. They did not have an engineering capability to go out and actually build and demonstrate something in an operational setting. I suspect that that is the reason he would not fund Rand.

NORBERG: But why then wouldn't they come to MITRE, if that's the case, because MITRE had that capability?

ZRAKET: As I said, because we were, one, flush with Air Force money, the Air Force was giving us, I don't know, we must have had two or three hundred professional people. So you're talking about twenty, thirty million dollars a year. Their money would be kind of 5% of MITRE. I'm sure that that is what bothered them.

NORBERG: But you think it wouldn't have been a small part of BBN?

ZRAKET: No. It was not a small part of BBN. They had a whole division, I think, devoted to their DARPA work. They were a very small outfit at that time, and they were controlled basically by DARPA.

NORBERG: A last area I'd like to get in. I know you have to go. How did you people keep abreast of the developments that DARPA was supporting in the information processing techniques area?

ZRAKET: Well, mostly directly through the people who were doing the work. We had a liaison with Project MAC. We freely talked to one another. And similarly at SRI through Dave Brown, and as I said through Rand we had a very open liaison. So it was mostly through professional liaison with these outfits that we...

NORBERG: Part of the sort of Cambridge-Boston community.

ZRAKET: Exactly, right.

NORBERG: Because I have a notion - that I must say the Advisory Committee does not quite agree with - that there is a convergence between the interests of the research community in the Cambridge-Boston area specifically and the interests of various people in the Defense Department. I would have said the defense community - based largely on the sort of thing that you were just describing, the fact that the Air Force and other offices in the military agencies of

the DOD were very interested in computing and its use in command and control. Therefore, the sorts of things that they might be interested in pursuing, or at least supporting for a while, would be similar to the sorts of things that this research community would be interested in, and therefore there would be a convergence of interest between the two sides. They object to that. They object to that it seems to me on two grounds. One of them is the - did they use the word hostility? It came close to that. The suspicion, I guess is a better word for it, that exists between the academics on the one hand and the military people on the other. They hardly ever talk to each other according to them. And while there might have been a very strong interaction between the two sides in the late 1950s, that that interaction fell off through the 1960s and now it hardly exists. I don't particularly believe that.

ZRAKET: I don't either. The military is not that way at all.

NORBERG: That is my feeling from what I saw at places like Westinghouse when I was there in the early 1960s and later on in studying this field. The second argument that they presented had a lot to do with the kinds of programs that have been supported. That is my second point on the study that we are doing. That is that there seems to be a good deal more coherence in the strategy of the program that DARPA was pushing in information processing over the years that led to a number of important developments in various technical areas. And that that coherence is in contrast to other places like the National Science Foundation that came in and out of programs with whatever the wind was blowing them to do. Therefore, I would see a coherence and a convergence. A convergence between the interests of the two communities and a coherence in the program that supported that convergence of interest. Now they sort of disagree with that. But what I heard you saying is that that obtained.

ZRAKET: I agree with you. DARPA has done very, very well over the years in this area. For example, I remember back in the 1970s, Andy Marshall at the time got reinterested as part of, it might have been a DSB study that said, "We've really got to do more research in command and control in terms of how these systems really help commanders and how they should use them and interface them and how should they be designed in a macro sense." And he

called a whole series of seminars together that brought together the military and the MITREs and all the academic people doing research in a series of seminars that the military supported very, very strongly.

NORBERG: It was in the late 1970s, did you say?

ZRAKET: Yes. It was in the 1970s, and I'm guessing it was in the late 1970s. Mid to late 1970s. You might talk to Andy. He has a whole set of proceedings that came out of these meetings, even a couple of books. It resulted in his office actually sponsoring research at a number of universities as the output of these conferences.

NORBERG: Which office?

ZRAKET: The office of net assessment in DOD.

NORBERG: Because his name has not come up before.

ZRAKET: Oh, yes. He has been fundamentally interested in this problem for at least fifteen to twenty years. And he, with his limited funds, has sponsored research, 6.1 type research, at a number of universities in this area. And he's got a good body of literature out on the subject. We have worked with him primarily on a pro bono basis. I mean, the kind of money he has is trivial by our standards, but we've helped him quite a bit in these efforts, over the years. And we get along much better now with the information processing division at DARPA and the current DARPA management. We have some very good programs for DARPA today that we're supporting.

NORBERG: Such as? Are these classified or unclassified?

ZRAKET: No. We're doing work in AI exploitation with them. We're doing work in a number of command and control areas that they are interested in, from transportation planning to a lot of the drug interdiction efforts that are going on and so forth. So we have a considerable amount of work with them now.

NORBERG: Would you say that the command and control issues are still essentially the same as they were then?

ZRAKET: Yes, very much so. I think very much so. I think with the new technologies even more so now. How these systems are designed and used by people is just as important as it was twenty years ago.

NORBERG: Is any of it driven by the technology?

ZRAKET: Certainly the cheapness of the technology in terms of capabilities compared to what you had twenty years ago has made a big difference. In software there's another area that a tremendous amount of research has to be done in, and that's something we've been working with Barry Boehm on. We have a much better relationship with DARPA over the past few years than we've ever had in the past. I used to go and complain to Bob Cooper when he was running DARPA that why were they ostracizing MITRE. And he says, well he wasn't as a matter of policy, it was just that his people decided where they wanted to get the work done, and they felt that MITRE was already doing a lot of work for the services and why did they have to do more?

NORBERG: Why did they have to do more? Supposedly that is what the agency was for.

ZRAKET: Right. They're using us a lot more now. For some reason or other this particular administration in DARPA wants to make a major push in C<sup>3</sup>. That's one of the four or five areas that they want to do research in. And they've decided that we can be a big help to them. That's the first time that has ever happened.

NORBERG: Would this possibly be synonymous with the start of the strategic computing program?

ZRAKET: No, we were left out of the strategic computing program. Primarily because Bob Kahn had an even greater hostility towards MITRE than Roberts did. Although now that he's at NRI, we've become friends again. He's decided that we could be a help to him.

NORBERG: Well, I don't quite understand his position in this and why would he care. By the time he became head of the IPTO office, that would have been 1978, 1979. And at that point the world had changed. The last question. What sort of advice would you give me to pursue some of these areas in command and control? You mentioned Andy Marshall as one possibility.

ZRAKET: Andy Marshall. You ought to talk to Ed Bennett and Joe Spiegel certainly. You should talk to Herb Bennington, he's back at Unisys SDC in Washington, because Herb was very active in these areas, both at SDC and in the government, as you know. He can give you a different perspective than I can. He didn't join MITRE until after he left the government in the 1970s. But during that period he went through the SDC and then the government experience. In fact, he was in the Pentagon from, I think, 1961. First he was a principal in the Winter Study Group, and then he went and worked with JCS and then DDR&E in this area. And he could probably give you a pretty good perspective of what was going on. He may remember also the Homestead conferences better than I did. You might talk to Frank Heart if you haven't talked to him.

NORBERG: We have. One of my colleagues interviewed him.

ZRAKET: And to Hawley Rising, who I think is still at BBN. He's either there or just retired. He can fill you in, because he was the guy who developed this PACs concept of store-and-forward communication system here at MITRE. He headed up that department at MITRE. We had two research departments. We had the systems research thing that I spoke to you earlier about under Deegan. Then we actually did a lot of hardware research in Hawley Rising's department. We actually built experimental computer and communications systems and tried them out and

so forth. He would be somebody you ought to talk to. I would talk to Fubini. You know, Fubini was really the driving force behind setting up Licklider's office. He had a lot to say about it. He could give you a much better macro perspective than the people who were actually involved.

NORBERG: Indeed. I think that's right.

ZRAKET: Let's see, you probably ought to talk to someone at MIT. I'm trying to think of the best person. I don't know whether Mike Dertouzos was that heavily involved at that time.

NORBERG: Not until 1974. I interviewed him already. I talked to him about the changes in the LCS after he became director.

ZRAKET: How about the guy that preceded him? His name begins with an "L" or an "F." Not Fano but somebody who may have worked for Fano who actually did the work on Project MAC. He was a professor at MIT.

NORBERG: All I can think of at the moment is Corbato.

ZRAKET: Yes, it's Corbato.

NORBERG: We did talk to him because he was very instrumental in both CTSS and then later on in MULTICS.

ZRAKET: Have you talk to Dave Brown at all?

NORBERG: No.



ZRAKET: You ought to talk to Dave Brown. He not only managed the research at MITRE - I was the technical director - he was the associate technical director who managed Hawley Rising's department and Jim Deegan's department. Then he also went out to SRI and then did a lot research for DARPA.

NORBERG: Where is he now?

ZRAKET: He's still at SRI as far as I know. Still involved with them. I think he may have retired recently, but they have him on as a consultant.

NORBERG: All right, good. This has been very helpful.

ZRAKET: And Bob Everett. Have you talked to Bob?

NORBERG: I haven't, no.

ZRAKET: You ought to talk to Bob. He at the time, I think, had a better bird's eye view than I had of what was going on and probably had a closer knowledge of what was going on at MIT than I did. You could catch him here very easily.

NORBERG: All right, I'll do that.

END OF INTERVIEW