An Interview with

MARVIN STEIN

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Conducted by William Aspray

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Abstract

In the first session of the interview, Stein discusses his early career and the formation of the University of Minnesota's computing facilities. After learning basic digital and analog operation during World War II, he obtained a doctorate in mathematics from UCLA. While teaching numerical analysis at UCLA, he also worked on missile simulation at Convair, Inc., in San Diego. After becoming familiar with the ERA 1103 computer Convair purchased from Engineering Research Associates, Stein made frequent consultant visits to ERA headquarters in Minnesota. In 1955, the University of Minnesota hired Stein to introduce their first computer courses and administer ERA's gift of free computer time. He describes early computer applications to crystallography and low-energy electron scattering, and the policy he established for the computer center to make users self-sufficient programmers. Stein reviews the growth of the Computer Center: the acquisition of an ERA 1103 computer with National Science Foundation support, the construction and use of a hybrid computer out of the 1103 and a Reeves Electronic Analog Computer (REAC), and the purchase in 1960 of Control Data 1604 and 1700 computers.

In the second session, Stein discusses the formation of Minnesota's program in computer science. He explains the rationale for his 1966 proposal for a graduate program in computer science and for the move in 1969 to a department of computer science independent from mathematics and electrical engineering. Stein reviews the curriculum that was intended to introduce students to a wide variety of applications so that they could introduce computer science into other disciplines. Stein discusses the difficulties in hiring enough qualified faculty members, the relations between the computer center and the computer science department, and the state's attempt to bring all educational computing under the control of the Minnesota Educational Computer Consortium.

MARVIN STEIN INTERVIEW

DATE: October 29, 1984 INTERVIEWER: William Aspray

LOCATION: University of Minnesota (Minneapolis, MN)

ASPRAY: Professor Stein, I thought that we'd start the session today by talking about Minnesota in the period prior to your coming to the University. I would like to try to get some background as to the kinds of mechanized computing activities there were at the University then. Why don't I let you just begin some place and I'll stop you at one point.

STEIN: As far as I know, there were two foci of computing in the University. Of course, the business office did the routine kinds of computing that were being done in those days, usually with IBM tabulating equipment. The School of Business had some kind of a computer center, and the Institute of Technology and some of the departments in engineering, physical sciences, and mathematics did some computing. I believe that the School of Business had an organized activity. Apparently they had some IBM statistical sorters and things like that. I'm not totally familiar with what they did.

ASPRAY: Were their users only people in the business school, or were the facilities more generally available to University researchers?

STEIN: I believe that they were open to all University researchers. Fees were charged for the services provided. There was a professional staff that operated that equipment.

ASPRAY: As far as you know, was there any subsidy from the business school or the University general administration for these fees? Or did the fees really cover the costs?

STEIN: I think the fees actually covered the costs. As I said, some of the departments did computing. In those days, there were two mathematics departments: one was in the Institute of Technology and the other was in the

College of Science, Literature and the Arts, as it was then known. The IT mathematics department had a laboratory equipped with hand calculating machines, which were used in a course in numerical analysis for engineers.

ASPRAY: You say hand calculating machines. What sorts of machines do you have in mind?

STEIN: I mean just mechanical calculators.

ASPRAY: Marchants?

STEIN: Marchants, Monroes, and the machines of that ilk. The Institute of Technology had something that you could call a computer center. It was run by two graduate students who were employed as research fellows. One of them is now a professor in electrical engineering.

ASPRAY: Who is that?

STEIN: That's James Holte. This organization had some of the most antiquated IBM tabulating equipment I've ever seen, and I've seen a lot of it.

ASPRAY: Punched card equipment?

STEIN: Yes. Before coming to the University, during my army service during World War II, I functioned as a tabulating machine operator, and later I spent a short period working for IBM. The equipment that IT had, even for those days, was museum equipment. But they did have something interesting, and that was a Reeves Electronic Analog Computer.

ASPRAY: The REAC?

STEIN: Yes. They were very proud of it. I'm not sure where the money came from; some of it probably came from local industry. My guess is that they spent about fifty thousand dollars for the equipment. That was a pretty good piece of money in those days.

ASPRAY: What year would this have been?

STEIN: I think that they acquired it in the early 1950s. Possibly in 1949.

ASPRAY: About that time.

STEIN: You might find the date in one of the files. I turned over the Reeves file, which I inherited.

ASPRAY: Yes, I think there is some information, though I don't recall the date.

STEIN: That machine was still state of the art, even when I arrived. It was being used for a number of research activities in the University, and also by local industry.

ASPRAY: Can you give me some examples of the University's uses of the machine?

STEIN: You realize you're making me think back thirty years. I don't know that anybody's memory is that good. But, as I recall, one of the people who was quite interested in that machine was Russ Amundson, who now has a building on campus named after him. He was head of chemical engineering in those days. He was quite interested in systems of differential equations that were associated with various kinds of chemical factories. I don't know if these were reactors; probably not. They were more likely processes used in refining oil and things like that. As I recall, the person who was helping him in this work, and probably had his hands on it the most, was Gus Aris. Subsequently,

they both became Regents' Professors. Of course, Honeywell Aeronautical used this equipment extensively for missile simulation, and simulation of other kinds of vehicles. I would think that people in aeronautical engineering made use of it.

ASPRAY: Do you know what financial arrangements were between industry and the University for the use of REAC?

STEIN: There was an hourly charge made. I don't remember what it was; but for those days the budget had a significant surplus. Somehow the surplus didn't come along when I took over that lab.

ASPRAY: That is to say that the charges that were placed against users were more than sufficient to cover the costs of the equipment and the personnel at the time, so that it was a money making operation?

STEIN: Well, at least it didn't lose money. It may very well be that when I noticed the surplus, the normal charges -- cross charges for the salaries of personnel -- had not actually been applied to the budget.

ASPRAY: Were there University users of the REAC other than from the science and engineering departments? Economists, for example? Psychologists?

STEIN: I don't remember. I think that in the files that I turned over there's a report on REAC usage for the year 1955 or 1956, which would have been typical for previous years. There may even be a complete list of problems undertaken on the REAC.

ASPRAY: I didn't find that. But it may still be in the files; I didn't get through them entirely.

STEIN: Certainly I remember compiling that report, and it ought to be in the files somewhere.

ASPRAY: My guess would be that the REAC didn't get much use from psychologists and economists, except in very narrow ranges, because it was an analog machine and mostly suitable for differential equations. Is that correct?

STEIN: Well, no. It's correct that it's mostly suitable for differential equations. You could also adapt it for the solution of systems of linear algebraic equations. The University of Minnesota has a group of economists who are remarkably good at mathematics, and it did in those days too.

ASPRAY: I see.

STEIN: It's possible that there were some economists using it. I don't know what interest there was in man-machine interactions among the psychologists. But a machine like the REAC might have presented them some opportunities in that area, although I'm not aware that they were actually interested.

ASPRAY: What were the weaknesses of the REAC?

STEIN: One is that it's very difficult to program. The so-called set up time poses a problem.

ASPRAY: Could you explain that procedure to me?

STEIN: Essentially, the REAC is a collection of electronic elements that function in parallel. To solve a problem, such as finding a solution to a system of differential equations, one has to wire those elements together in the appropriate order. There is a plugboard for that purpose. One had to put a considerable number of wires into the right holes on a rather complicated looking board. There were also dials on which various constants could be set and introduced into the system. One had essentially to draw the wiring diagram corresponding to the problem, and then

actually set the machine up in accordance with this diagram. That could take a considerable amount of time. There was also a scaling problem involved. I don't want to launch into a lecture, so I'll just say that it's much more difficult than scaling in digital computation, most of which is handled by floating-point arithmetic. Analog computers don't have floating point arithmetic for that purpose. Probably the most significant difficulty was the error. Analog systems are very limited in their accuracy, even in the problems that they're suited for, which are a limited class of problems.

ASPRAY: Can you quantify what the typical amount of time that it took to set up a problem was, and what the typical error would be?

STEIN: I don't recall that I have ever personally undertaken a problem on the REAC, or on any other analog computer. But I have given some thought to analog computers and the relationships between analog and digital computation. I'd say that for a system of about ten differential equations, which might have been the outer limit of the machine that they had here, it might take a couple of weeks of tinkering around to get set up. There were also considerable doubts as to when a problem was checked out -- that is, as to whether the set-up actually reflected the mathematical equations, because people who used these machines generally did not speak of integrating and differentiating, but in more physical terms. They talked about low-pass and high-pass filters, and so on. That was another problem. Sometimes the mathematics wasn't even known. The engineers were satisfied that they had the analog of the physical system. My guess is that one was lucky to get two or three digits of accuracy.

ASPRAY: The MIT people claimed that they typically got three digits of accuracy on the Rockefeller Differential Analyzer.

STEIN: That sounds about right. In any event, that was the state of computing before I got here.

ASPRAY: Given all the limitations of the REAC, do you think it provided good service to the University?

STEIN: Yes. It was the best thing they could get at that time. There were talented people at the University and in industry who knew how to use that equipment properly, within its limitations. Consequently, it was well worth it. They got good results from it.

ASPRAY: Were there close ties between the computing activities in the business school and the ones in IT?

STEIN: I don't think there were any ties at all until I arrived.

ASPRAY: Let's turn now to the series of decisions at the University that resulted in bringing you to the campus. Who were the people involved? Could you tell the story?

STEIN: Back in the REAC days, in 1950 or 1951, there had been some serious thought given to establishing an Institute of Technology computer center on a more solid basis. They were planning to hire a faculty member with the rank of instructor. In those days, they sometimes used the instructor rank for regular faculty positions. A person whom I had worked with and knew socially as a graduate student was head of the mathematics department here. That's Stefan Warschauski. He called me and asked if I had an interest in that position. I said that I did, but he later informed me of some internal politics, of which I certainly don't know the details, the result of which was that the people involved had left by the time I actually came here in 1955. I believe that two engineering departments couldn't agree as to the organization and control of this center, so it never came to be.

ASPRAY: Were some of the people who were involved in this first attempt in 1951 later involved in the more formal arrangements?

STEIN: Yes. There was Professor Henry Hartig, who was head of electrical engineering when I came here, and Gerry Shepherd, who is now retired Academic Vice President, succeeded Hartig as head of Electrical Engineering, and was

Associate Dean of IT when I arrived. Shepherd was involved in both attempts, I'm sure. He probably had a significant interest in anything of that nature. Hartig was more or less in control of the REAC and the tabulating equipment. At least that was my understanding, since when I took over I received all the budget and correspondence files from him. There was a realization at the University that something more had to be done, that their digital computing facilities were inadequate. I believe that somewhere in the central administration somebody had decided to order an IBM 650, which had a serial kind of drum. The significant thing that happened was that a group in St. Paul, Engineering Research Associates (which by that time had been taken over by Remington Rand, and probably were beginning to be referred to as UNIVAC), were building a machine called the Engineering Research Associates 1103. It was later renamed the UNIVAC Scientific Computer. Arnie Cohen, former Assistant Dean of IT, was one of the principle architects of that machine. Seymour Cray was also heavily involved in it. In any event, a gentleman from UNIVAC named Byron Smith, in cooperation with Arnold Cohen, offered the University of Minnesota four hundred hours of use of this machine.

ASPRAY: Free usage?

STEIN: Free usage. The University then wanted a faculty member to take charge of this gift, and also to introduce to the University some courses in modern computing machinery. These were to address, essentially, what we do with these things. They also wanted a course that viewed them as objects of intrinsic interest.

ASPRAY: Not only the service aspect, but also the science of computing.

STEIN: That's right. This was the work of a study committee of distinguished faculty members appointed by President Morrill. I'm sure that that report has to be in the archives somewhere, and would make interesting reading. It addresses itself to computing at the University of Minnesota.

ASPRAY: Is this the report that had many sections, of which the subject of computing was one?

STEIN: Yes. I think it was an outstanding piece of work.

TAPE 1/SIDE 2

STEIN: It recommended that in order to make the best use of UNIVAC's gift, some new people should be brought in.

As it happened, through the good offices of a person well known to the Babbage Institute, Mr. Erwin Tomash, I was involved in some consulting work for Engineering Research Associates. If my memory serves me right, Mr. Tomash himself was involved in the design of the 1103. He may at that time have been the national sales manager for UNIVAC. He introduced me to Byron Smith. Since I was consulting, I was coming to St. Paul regularly. As I mentioned, I was also well acquainted with Stefan Warschauski, the head of the Mathematics Department in the Institute of Technology. He asked me on one of my visits if I had any interest in the position. I had an interest in it. On a Friday afternoon I paid my visit to the IT Dean's office and spoke with Gerry Shepherd, and on Monday I had an offer. Things could really move quite quickly back in those days. This was in the summer of 1955.

ASPRAY: And you took the position?

STEIN: I accepted the position, and I've been on the faculty here since September 1955.

ASPRAY: Before I ask you any more details about your own background, let me come back to something for a moment. Did the gift of time on the 1103 preempt the purchase of the IBM 650?

STEIN: It did. That was one of the first things I took care of when I arrived, because my feeling was that all that we would do by acquiring an IBM 650 would be to saddle ourselves with the need for another one almost immediately.

The machine didn't have the capacity to do anything significant in the university.

ASPRAY: At that time, was the 701 available from IBM?

STEIN: Yes, the 701 and the 1103 were the two machines for so-called "scientific computation" in those days.

ASPRAY: What inclined you towards the 1103? Was it the fact of the gift?

STEIN: No, the 1103 was clearly a superior machine in every respect. I don't want to pursue a detailed analysis of my reasons, but it was simply a better machine in terms of its computing capacities. In terms of the software available, which people didn't think much about in those days, it probably was inferior; but that's not the fault of the machine.

ASPRAY: Why don't we go back and briefly discuss your background? What was your career like prior to your coming to the University?

STEIN: I was raised in Los Angeles, and entered UCLA in 1941. I was interested in studying philosophy in those days. It just so happened for some reason that I began to be interested in the philosophy of science and mathematics. It may have been because of the visit of Bertrand Russell to the campus the year before my entrance. I was still a high school boy when he came, but, nevertheless, I was quite excited by his visit. That was the kind of philosophy that I wanted to study. I soon discovered that one really ought to know a lot more about mathematics and science before attempting to philosophize. I was a little appalled at my fellow students, most of whom were a lot older than I. They were all very glib about it, but they didn't seem to know much. They had a lot of gall. I switched to physics. In trying to understand the Michelson-Morley experiment, I soon discovered that one didn't really study physics the way that I wanted to without knowing mathematics. So I ended up as a mathematics student.

But my studies were interrupted by the war and I was enlisted in the army at the end of 1942. For some reason I was

assigned to the Signal Corps. The Signal Corps wanted to computerize the operations of its signal depots, which meant essentially that they wanted an accounting procedure to keep track of their stock. They were looking for people who had some kind of mathematical training, and my card must have fallen out of the hopper. I was assigned to the L.A. Signal Depot and actually sent to the local IBM office. I was only a private first class. I think the commanding officer sent me to the local IBM office to learn how to become a key-punch operator.

Fortunately for me, while my key-punching courses were going on, IBM was offering a course for installation managers, a refresher course. I asked the people if I could sit in on this course. I seemed to have found something that interested me, because by the end of the first week I was helping the instructor teach it. When I returned to the signal depot, it turned out that all of the higher ranking noncoms who had been sent to IBM World Headquarters had not learned all that they had been expected to learn there. And being a brash young man I said, "Listen, Colonel, I know how to do all this stuff." Since he was not really a colonel, but had been the manager of a large business and a reserve officer, he didn't believe in ranks, and he said, "All right, Stein, if you can do this, you're in charge." So I took over that installation.

At the end of the war in Europe, I went off on a special project which was working with the officers who were planning the invasion of Japan, at least the Signal Corps' part of the invasion. They wanted to know what equipment was available and what days it would be loaded onto various boats, what days it would arrive at the battlefields, and things like that. My job was to come in at night when everybody had left, balance the files, and then program the answers to the questions that were being sent to me by the planning officers. They sent them to me by teletype. I never saw any of those officers personally. So that meant programming, really: wiring boards and planning the passage of cards. I didn't realize it, but I suppose I was inventing what we call data-base analysis. I was too busy doing it to develop a theory for it. In those days I wasn't a very theoretical person. But I did learn something; I had the hands-on experience of operating equipment and doing computations.

At the end of the war, I returned to UCLA and resumed my studies. I graduated in 1947 and became a teaching

assistant. At that point, the National Bureau of Standards and the Regents of the University of California entered into an agreement to establish an Institute for Numerical Analysis on the campus of UCLA. Part of the agreement was that there would be some graduate research fellows appointed. I applied for one of these fellowships, and was in the first group of research fellows at the Institute for Numerical Analysis. At the same time, they were building a computing machine.

ASPRAY: This was SWAC?

STEIN: Yes, SWAC under Harry Huskey. I took quite an interest in that machine. In addition to that, there were programming classes for senior staff given by a very distinguished programmer. I don't know why my memory is failing me. She won the Gold Medal of the Department of Commerce for her contributions to programming. Under this distinguished lady (Ida Rhodes), I learned programming with a distinguished class of mathematicians such as Alexander Ostrowski.

It turned out that I was the only member of the research staff who had had his hands on a computing machine. The only actual computing machine we had was a Card Programmed Calculator. The machine that was being built, the SWAC, wasn't ready. We were learning to program for it, but whenever we had to try out an idea it went on the Card Programmed Calculator. I was the most junior member of the research staff, but the only member who had had hands-on experience with such equipment, so I was involved in trying out almost every new idea.

I worked with Magnus Hestenes on a number of problems in the calculus of variations, numerical methods for solving these problems. He and I were also involved at that time in the development of the conjugate gradient method.

ASPRAY: That's something I'm not familiar with.

STEIN: That is a well known method of solving systems of linear equations, that Hestenes and Edward Stiefel have the credit for developing. I worked with Hestenes in the early stages of that. Some of our work was subsequently published in the *Journal of Optimization Theory and Applications* as an important historical contribution to numerical analysis.

After getting my Ph.D. and spending another year at the Institute as a member of the research staff, I found that there were not many academic jobs available because of the Korean War. UCLA was starting a graduate program leading to a certificate in numerical analysis. It was not an extension program, but it was handled administratively through the extension division. Since the appointment to the program didn't pay a living wage, they found me a job at Convair down in San Diego.

ASPRAY: What did you do there?

STEIN: At Convair, I was a senior research engineer. They were operating in the computing laboratories some Card Programmed Calculators, and I designed some of what we called 'boards' in those days. Those are the operating systems for doing extensive computations on the Card Programmed Calculator. Primarily, I worked on missile simulations, which were being done for the Atlas missile, our first ballistic missile. I had those missiles flying in orbits around the moon, long before Sputnik was ever heard of -- theoretically, of course.

ASPRAY: Of course.

STEIN: At that time, Convair decided to go for a real digital computer -- an internally programmed one, that is , since the CPC was certainly a real digital computer. Convair chose an 1103, which was installed by Erwin Tomash. That's when I became acquainted with Erwin. It became my job to get that machine installed and operating and to begin using it properly. It was through what I did at Convair that I made the acquaintance of people here in the Twin Cities.

ASPRAY: How would that be?

STEIN: The 1103 machine that we received at Convair was probably serial number two. Serial number one was probably at the National Security Agency.

ASPRAY: I see.

STEIN: The machine was very secret. In any event, it was a very early machine and it couldn't function very well without periodic visits from the people who had designed it. We had people like Jim Thornton come out to do maintenance on it. People who were sent out as representatives of Engineering Research Associates were very high level people. We had people like Claire Miller and Abraham Franck. Because of this I was acquainted with the movers and shakers in that organization here in St. Paul. As I mentioned, this led to my opportunities for consulting work and then to accept the position at the University of Minnesota.

ASPRAY: You were doing your consulting work for UNIVAC?

STEIN: Part of it, yes.

ASPRAY: Why were you attracted to the position at the University?

STEIN: It was probably psychological. In those days, I believe, the professors used to brainwash the students. They said the good students will become the professors and the ordinary students will be out there working in industry. Consequently, when I found myself working in industry, I had in my mind the stigma of being an ordinary student. When an opportunity came for an academic position, I said, this is what I was educated for and I can always return to industry; so I will try it to see what I can make of it.

ASPRAY: Had you started to look for other academic positions while you were at Convair?

STEIN: Yes, I had.

ASPRAY: What were the conditions of your appointment here at the University? What were your responsibilities?

STEIN: I was appointed as an assistant professor in the IT Mathematics Department. My responsibilities were to oversee the use of the gift of four hundred hours of time on the ERA 1103, to introduce course work, and ultimately to do research in modern computing machinery. I introduced a course, which in one form or another we still have around today.

ASPRAY: An introductory course?

STEIN: No, it was an advanced course. It carried graduate credit. It probably involved things that are taught to freshman today, or that they are expected to know when they arrive. It attracted an extraordinary amount of interest. There were so many people there that I had to teach it in two sections.

ASPRAY: This was offered for the first time in what year?

STEIN: In 1955. I had two sections of about fifty people each, which in those days were considered very large sections. I began to try to use the gift of time in the best way that we could. Many people didn't think we ought to be expending our resources on this, and my idea was to show how valuable this gift was. So I actually went out looking for people with applications that would demonstrate this.

ASPRAY: You went to various faculty members and departments?

STEIN: Not so much. Most of these people came to me after we announced that I was here and ready to consult. There was a committee established ultimately under the chairmanship of Gerry Shepherd. It was an University-wide committee. The very first committee was actually under the chairmanship of Professor Hartig, the head of Electrical Engineering.

ASPRAY: What was the mission of this committee?

STEIN: The committee was to establish a policy for the use of this gift of time, and to allocate the hours to the various requesters.

ASPRAY: How did you fit in with the committee?

TAPE 2/SIDE 1

STEIN: One might say that I functioned as staff for the advisory committee. I received the requests, made the recommendations, and then worked with the people that were allocated time by the committee. Ultimately, they made me a member of the committee as well.

I was looking for the most likely projects among all the requests. I selected two. One was in low-energy scattering of electrons that came from the physics department. The two people involved in that were Alfred Glasgold and Warren Cheston. Cheston subsequently became Dean of the Institute of Technology. They were assistant professors of physics in those days. I worked personally with them to set up the mathematical models and the programs that would be needed. The other was a very large project in crystallography, on molecular structure, which was under the leadership of Bill Lipscomb, a professor of physical chemistry. He came over with about ten of his graduate students, and I established a seminar that they attended once a week for about a quarter. Then they went off on their own. This led to some very important work, and subsequently Lipscomb won a Nobel prize for it.

We had other things which I considered very useful pieces of research going on. But I didn't involve myself personally in them as much. There was work in spectroscopy, under Bryce Crawford. A large variety of useful research began. Even at that early day we didn't neglect the educational or instructional use of the computer. Some of that time was provided to instructors who wanted to use computing in conjunction with their teaching. Of course, I myself probably made the most use of it; but I don't think I was the only one.

ASPRAY: Can you give me an example of the way that you used it?

STEIN: As I said, I established a course. I would suggest some type of exercise that would illustrate the ideas that I was discussing. Then we would have one student who would volunteer to illustrate that, and actually carry out the exercise on the computer. That student would write a report. All the other students would receive a copy of that report and their assignment was to do a critique of it. I had a number of people who subsequently made their mark using computers in their own fields of research. For example, Lawrence Liddiard, who is now the acting director of University Computer Services, was a student in that course. I still remember the project that he undertook -- exceptionally well, I might add.

ASPRAY: What was that?

STEIN: He wrote a program to solve some systems of differential equations. Early on, the advisory committee set up policies, mainly through my advice. One was that people had to do their own programming, though we would assist them in every way possible to do the work themselves. I think this had a great trickle-down effect. It made for a much better and really a much higher level use. People would come in for their first job and instead of going away after we had done it for them, and maybe never coming back except to do that over again, they would suddenly realize what this system could really do for them. They would begin the important things that they subsequently did. There were also a lot of graduate students who were given free access for their research. As I said, a lot of these people subsequently went on to other faculties and became experts in using computing equipment in their work. I am

thinking of people such as David Campbell, who inherited the Strong Interest Inventory; he was a student of mine. We had them from many fields: Frank Baker, who is now a professor at the University of Wisconsin, and heads up a laboratory there in quantitative concepts in education, and so on.

ASPRAY: I see.

STEIN: So I think this gift was really the nucleus of everything that has happened since, and a lot of other good things.

ASPRAY: The work of Baker in education is one example, at least later in his career, of something outside the sciences. What percentage of jobs that were done with your free time on the 1103 were not science or technology projects?

STEIN: I think among the files that you took were all of the usage records. I have to say that if you counted them in terms of time used, the physical sciences and engineering used the most time. But if you counted in terms of projects, then projects from education, psychology, business, statistics, agriculture, etc., were very well represented.

ASPRAY: The gift of the time was a gift to the University as a whole, not to IT. Is that correct?

STEIN: That's right.

ASPRAY: So there weren't any restrictions independent of the project that said that preference went to IT, or that preference went to, say, agriculture?

STEIN: No. There were no restrictions. It was an University-wide committee that operated the gift. The gift was

renewed in 1956-'57. In the summer of 1956, Dean Spillhaus appointed me Director of the Institute of Technology Computer Center, which consisted of the kinds of equipment I mentioned previously, plus the gift. While it was a gift to the University, the administration of it was in the hands of IT.

Also, at that time there was some consolidation. The tabulating equipment throughout the University, which was mainly in the School of Business and IT, was all consolidated and put under the directorship of Professor Kenneth Clark of Psychology. (He subsequently left here and became a dean at the arts college at the University of Rochester.) Then we soon found that we weren't able just to do what had to be done with the gift of time that we had.

ASPRAY: That is, the number of requests for use were greater than the amount of time allotted.

STEIN: Yes. One thing that happened was that the project on which I spent most of my personal time, which was the scattering project, raised some money from the Atomic Energy Committee and from a research program that had been set up at Convair under Charlie Crichfield, a former professor of physics at the University, who was director of research at Convair at that time. We used to go out to San Diego -- in those days one had to travel to use these machines. We spent quite a lot of time out there finishing the computations that we'd begun via the gift. We simply didn't have the time here. So we decided that we needed our own machine. Warschauski applied to the National Science Foundation for a grant. Leon Cohen, I believe, was the program director for the mathematical sciences then. He came and visited us. On that grant, I don't know whether I was the principal investigator, or if Warschauski was. But in any event, we received a hundred-thousand dollars from the NSF. There were other moneys that were raised, up to about a quarter of a million dollars.

ASPRAY: Through the University?

STEIN: Yes. Some of that may have come from alumni; I really don't know. The advisory committee had people like

Gerry Shepherd, Russ Amundson, and Jack Darley, who was subsequently a dean of the graduate school, on it. At that time he was a professor of psychology. Al Meier was on the committee. You can see that it was considered an important committee.

ASPRAY: Yes.

STEIN: The committee managed to raise the money. At that time, Los Alamos was offering its MANIAC free to anybody that wanted to cart it away. So Gerry Shepherd, Leroy Anderson -- now Emeritus Professor of Electrical Engineering -- and I went down to Los Alamos to have a look at it. We discovered that it was a "breadboard" machine that couldn't live away from the people that had designed and built it. While we were there, the people at Los Alamos, Metropolis was leading the group there -- he offered us their plans for MANIAC II, which was to be an advanced version of the machine, with a CRT memory. All we had to do was agree to build the machine. So we actually did that. We used this as part of our money-raising activities, although the idea of building a machine wasn't all that exciting to me. But you have to remember that Shepherd and Anderson were electrical engineers and were much more comfortable with the idea of building a machine. As I now recall, that was the vehicle for raising the rest of the money that we did get, the money to build that machine.

ASPRAY: I'm confused at this point. Did all of the money that was raised go into the building of that machine, or did you also purchase a machine?

STEIN: You see, we never built the machine.

ASPRAY: You never built a machine, you just said you were going to.

STEIN: Yes. Russ Amundson was consulting for UNIVAC in those days. A gentleman named Stutzman was quite high in their organization. He subsequently founded his own process control business in this area. Amundson came

back and said, "They'll sell us an 1103 for a quarter of a million dollars." Just what we happened to have.

ASPRAY: Wasn't that convenient.

STEIN: So we decided that we would buy the 1103. I very reluctantly at that time rejected another offer to build a machine. This one came from Seymour Cray. I had lunch with Seymour at the Campus Club. Control Data had just gotten off the ground then. He sketched the machine on the back of an envelope and said, "Why don't the University and Control Data jointly agree to build this machine? We'd build it on the campus of the University of Minnesota. And after a certain number of years, maybe three years of joint use, it would become the sole property of the University." It was a very attractive machine that he sketched, which ultimately turned out to be the CDC 1604. I had no doubt that they had the ability to build the machine. But we were under pressure to get a machine immediately. There was the waiting period, and the fact that there was no software. We already had a lot of work underway with the 1103. This was also a consideration: Control Data was not financially a very strong company. They didn't have the space to build the machine, and they didn't have the capital to build the machine, judging by their offer. And then we would have had to share the machine for that period of time as well. So knowing that ultimately I would certainly like to have that machine -- and ultimately we did acquire it --I reluctantly had to turn him down. Then, of course, there was the fact that they were being sued by Remington Rand. The outcome of that was not known. Frankly, it didn't look very good for them. I still have never understood the settlement. Of course, I wasn't privy to any of that.

We acquired the 1103. At that time we organized an University-wide center which was called the Numerical Analysis Center, with the 1103 as its heart. The center was budgeted with something like twenty-four thousand dollars, which seemed like a lot of money at the time. I was appointed the director of the Numerical Analysis Center. I told you that the tabulating equipment had been put together. They gave us the tabulating equipment, and we had the REAC and the 1103.

ASPRAY: What size staff did you have?

STEIN: I had a very small staff. Well, actually, the tabulating staff was probably the biggest part of it. I had myself, a secretary, the people who provided the tabulating services. Maybe six, I'm guessing now, my memory is failing. About six to ten half-time research assistants. But, again, I provided you with the budget statements for all budgets that we had in those days. So we can determine the exact size of my staff if we look at that.

ASPRAY: Were you doing any teaching?

STEIN: Yes. I always taught. I had all the duties of a professor in mathematics, and luckily for me, after one year as an assistant professor, I'd been promoted to the tenure rank of associate professor. I spent my time developing research and coursework, and developing the Numerical Analysis Center. I was joined in those early years by Bill Munro who is now associate head of the Computer Science Department. We were pretty informal in those days: he was associate director or co-director. He was Acting Director in the years I was on sabbatical. I could not have accomplished nearly half as well without his advice, and his help in almost every project. That was starting in the second or third year I was here.

ASPRAY: So that was about 1957 or so?

STEIN: Yes, he was on sabbatical when I first arrived here. It didn't take us very long. Probably by the end of the 1950s, it was clear that we had used up the capacity of the 1103. So we set about looking for a replacement for it. Another interesting thing that we did was mating it to the REAC. We designed and built one of the first hybrid computers.

ASPRAY: So you took your 1103 and tied it to the REAC?

STEIN: Yes.

ASPRAY: What was the purpose of that?

STEIN: I've always had a great interest in simulation and in continuous system simulation. There is something known as the Stein-Rose sorting algorithm, which is the theoretical basis for continuous system simulation. The kinds of continuous systems that one simulated in a way were analog computers. Part of the simulation is that you have to describe the system that you're simulating. Parts of these systems were better described by analog computers and other parts by digital.

TAPE 2/SIDE 2

STEIN: Describing the system and describing the control had analog and digital aspects to it. I thought that this kind of hybrid machine would function very well in problems like that. Historical users of the analog system were quite interested in this. For example, simulating missile flights and missile control looked like a very good thing to do. It's the kind of thing I'd been involved in myself. Convair and Honeywell Aero had an interest in it. So we actually built a machine to do that. I have to admit it was not a great success. One thing we learned is that you should never put your prime machine into that kind of a system. That's where I learned about programming difficulties.

ASPRAY: Will you elaborate on that?

STEIN: What happened was that we found that our digital computer was tied up all the time while we were tinkering with wiring up the plugboard for the analog for checking, testing, and so on. So the effective use time on the digital machine was comparable to what one would expect of an analog machine.

STEIN: Yes. Also, I didn't feel all that comfortable with the part of my empire in the Engineering Shop. But as we did

our own maintenance on the 1103, we had to have it. But looking forward to our next machine, which was obviously on the horizon then, I knew we weren't going to do the maintenance on it. We thought we would go out and get a commercial hybrid computer. At that point I worked with N.R. Amundson, and we obtained about a half-million dollars for that purpose from the National Science Foundation and the NASA; we had to agree to install this facility in the Space Science Center. We went out and we bought, or had designed and built for us, a hybrid computer based on an Engineering Research Associates' computer. And we had a Control Data 1700, which was a small computer that CDC developed mainly with process control in mind. We also went out and got the 1604, as I said I had known we would eventually.

ASPRAY: In what years were these acquisitions made?

STEIN: We got the 1604 in the sixties, in about 1960. I'd have to look at the record.

ASPRAY: And the hybrid machine?

STEIN: The first hybrid we built in the late 1950s. The second one came about -- the planning, money raising, design, and then building -- all went on in the early sixties. We actually got that machine in about 1966.

ASPRAY: Was it a success?

STEIN: No. It was more of a success than our first one. But by the time we actually got it, digital computing had improved so much that there wasn't a lot of interest left in analog or hybrid computing. The good cases just became too specialized. It was useful as a hands-on facility because our digital facilities were behind glass; our first one had been all hands-on and open-shop. It had some interest in another way because after all it allowed us to do parallel computations. The two machines ran simultaneously and had to be synchronized. So it led to some thinking about parallel computing, which was not all that important a subject in those days as it obviously is today. I'd have to say

we were among the first people who were involved in and thinking about parallel computation, just how to use two machines that could run and work at the same problem at the same time.

We developed the use of the 1604. It was a great machine; I really loved it. I think Seymour designs beautiful machines. We had it loaded down, and it became clear that it was time to go out and get our next machine. President Wilson came in about the time we were thinking about 1604. His advice was to get the best machine we could, not to worry about what it cost, and not to get something obsolete -- not to think about things that were obsolete, because we couldn't conceive of raising enough money. As it turned out, he was right. We got a half-million dollars from the NSF, which was at that time one of the biggest grants ever given by them for that purpose. We received an appropriation from the legislature, which may have been their first direct special item for buying a computer. That was a quarter of a million dollars. So we came up with three quarters of a million dollars for that system, which was retailing for about a million and a half. We managed to acquire it for that amount of money.

ASPRAY: Before we go on, why don't we talk briefly about the 1103 owned by the University, and some of its outside uses. What sorts of problems by outside groups worked on the 1103?

STEIN: We had outside users, but we didn't actively go out and solicit outside business. One of our restraints was that we didn't care to be in competition with various manufacturers with whom we had to do business in other ways, and who were operating service bureaus. We allowed outside use if there was clearly some justification for it: if we had some type of unique program, or if it was one of our students who had received his or her degree and had gone to work for an outside organization, and wanted to come back to do something on the equipment that he or she had written the program for and was familiar with.

ASPRAY: So continuity was a criterion?

STEIN: That was the kind of thing we looked for. I remember turning down offers from Honeywell to buy thousands

of hours, primarily because it seemed that we ought not to be in competition in that way. Also, our faculty and students were making good use of the time. We were pretty heavily loaded. We didn't want to get into a position where we essentially said, "Too bad for you, but we need the money." Our system was blind as to whether the user was paying for the usage or not. It might have been naive of us, but that is the way we operated. Students had as good access as research projects that paid. And I was a little worried that these outside users who were putting down large sums of money would demand priorities that at that time I didn't want to concede to them. Maybe if we needed the money, or if I knew more about money in those days, we would have done it; but we didn't. What the applications were, I don't remember. You could probably find them in the files somewhere.

We had other kinds of relations with outside organizations, because all computers have user organizations. We were active in the national user organizations: the UNIVAC users' organizations when we had the 1103, the CDC users' organization with the 1604 and, subsequently, with VIM, which in Roman numerals you can interpret as 6000. Also, I recall that we had a sort of a Twin Cities users' organization that included the University, industrial, and some business users, I believe. I served as the first chairman of this organization, and I remember the trials and tribulations of trying to arrange programs.

ASPRAY: What was some commonality of interests between these various local groups?

STEIN: Just computers. I believe that in the Twin Cities, there's a chapter of the ACM, the Association for Computing Machinery functioning now. That chapter grew out of this group. I participated in getting it off in its beginnings. I was the first chairman of the group, and I was the first program director. We had people like John W. Carr III, who at that time I believe was the president of the ACM, come out and speak to us. Mainly our programs brought in academic and not so many business people. I presume it was because those were the people I knew the best.

ASPRAY: Again, on this early period, where was Minnesota in comparison with some of the other universities that

are regularly compared with it - the big research midwestern universities like Wisconsin, or Illinois, and Michigan?

STEIN: In terms of hardware and software facilities, we were equal to any of them. We developed most of our software facilities ourselves. In terms of the amount of money that was being spent, we were lagging far behind. In terms of the national publicity that we were getting, we were way behind. That was probably our own fault. For what we were doing, we should have had a lot more publicity. I think we ran a computer center that was the equal of anybody's. There was one professor down in the medical school who always complained about our center. He was one of these guys that walked in the door the second the computer would go down. We used to make it hard for people to take their work elsewhere, especially if they had financing. But we allowed him to take his to the University of Wisconsin, where he claimed that they had a program much better than ours. Within a month, he was back and very apologetic. I think that in terms of what we had we were up there. In the early days with our 1103 and our 1604, we always had the best machine available. That even became more so when we went into the 6600.

I was on sabbatical in 1963-64. All the time I was gone, I kept thinking that we had come to the end of our rope as far as the 1604 was concerned, and that we had to get a new machine. When I came back we began to work on getting a CDC 6600, which was the supercomputer of its time. We had a grant of over nine hundred thousand dollars from the NSF toward that machine. We also received authority from the regents to borrow the balance that we would need beyond that. I might add that that grant from NSF was one of the biggest that they had ever given for that kind of a thing. The only bigger one that they had given up to that point was to the University of Texas. And since Texas had the President, and we only had the Vice President, that's what we had expected to happen. But we received almost as much as they did. The regents, I think for the first time, agreed to borrow money. They had various negotiations, and we finally arrived at a contract with CDC. The machine that normally would have gone for about three million came in for about a million and a half. I'm sure the actual contract is on file, so you can check those figures.

At that time, I thought we had established a computer center that was second to none in any university. It was a supercomputer and put us in a position to really take off. We'd built up the staff to about seventy full-time i We had

leased the NSP building out on Highway 280. We put in a network because our main computer was out on Highway 280. We then had a concept of it as being the center of a network of subsidiary computers at different locations on campus. These would have the ability simultaneously to do some local kinds of work, which would be tailored to the local interests, and to send work back and forth to the main machine at Lauderdale. We actually established that with such centers on the West Bank, in the Medical School, and on campus in Experimental Engineering and in Space Science. It was a very successful concept, and at the time, we were looking ahead to tying in Duluth and all the other branch campuses. And I felt that in order to properly exploit the potential of this supercomputer center, which was still called the Numerical Analysis Center, we needed a graduate program in computer science.

DATE: 7 November 1984

TAPE 3/SIDE 1

ASPRAY: This is the a second [session of an] interview with Marvin Stein in his office at the University of Minnesota on the seventh of November 1984. The interviewer is William Aspray of the Charles Babbage Institute. In our last interview [session], we discussed the development of the computing center. Computing activities, especially the machinery that was purchased or donated to the University up until the founding of a graduate program in computer science. Let's go back and discuss some of the educational issues -- the development of programs, the pressures to build up a program in computer science -- and then talk about the formation of this graduate program.

STEIN: When I arrived here in 1955, my mandate, as I took it, was to introduce the use and application of computing machinery to the University, to introduce course work about modern computing machinery as devices of intrinsic interest, and ultimately to introduce research about computing and computing machinery. I began with a course in 1955, a three-quarter sequence whose name I don't remember, about the hardware and software organization associated with modern computing equipment. There were so many people attending that first meeting, as I recall.

Maybe a hundred people, which at that time was considered tremendous;~p thirty or forty to a class in those days. We immediately split that course into two sections, both of which I taught. That was the beginning of a successful course. It contained all the elements of what we teach in computer science today, except for numerical analysis. At the same time I was starting the course I just described, Bill Munro was beginning a year sequence in numerical analysis for engineers. All these courses were in the Institute of Technology Mathematics Department. I'd say that out of those two sequences almost all of the current curriculum in computer science developed. What's left of the course I started is the content of our two-quarter sequence, 5101 and 5102. The attendees were mainly graduate students.

ASPRAY: In science and engineering?

STEIN: In science, engineering, psychology, education, life sciences.

ASPRAY: What were the prerequisites for taking the course?

STEIN: I'm not really sure I recall. Probably the prerequisites were something like upper-division standing and a year of analysis. As I viewed it, the prerequisites were just a reasonable order of intelligence and some kind of experience dealing with symbolism and its manipulation.

ASPRAY: Were undergraduates admitted?

STEIN: Yes, and there were undergraduates in the course. But I'd say the majority of students were graduate students. A number of the students have gone on to make names for themselves in computer science, in the application of computational techniques, and in their own areas of expertise.

ASPRAY: Were the students in this three-quarter sequence expected to do a certain amount of laboratory work?

STEIN: Yes. We began to use some of the time that had been given to us on the Engineering Research Associates 1103, in connection with this particular course and also in connection with the numerical analysis sequence. The students developed quite an expertise in dealing with computer equipment. This was not only the students from engineering, physical sciences, and math, but as I said from a wide spectrum in the University. I recall one graduate student in sociology, who upon completing his degree went to another Big Ten university as an assistant professor. He came back on a visit and stopped by to see me and just wanted to tell me how useful the course was. He had become the expert in his department, and he didn't have to believe the so-called experts in the computing center when they told him, "Oh, that can't be done." So he was quite enthusiastic about that course and the kind of education that it gave him.

ASPRAY: Did you teach the students about some of the equipment that was available at the time other than the ERA 1103? Say, the IBM punched card equipment you had at the time?

STEIN: At the very beginning we didn't have any punched card equipment, and we worked with paper tape. When I arrived at the University I was given an office and next door to it another office that was called a lab. The sole equipment in that lab was a Flexowriter, which is a kind of typewriter that is equipped to read and produce paper tape. This was our sole source of input and output on the ERA 1103.

ASPRAY: At certain other schools --I'm thinking of Wisconsin and Michigan -- over a period of time, the faculty had to develop new compilers or other kinds of operating systems, and various kinds of software to help with the coursework for the mass teaching of students. Was that your experience here also?

STEIN: Yes, except that I became the director of the University Computer Center, which was originally called the Numerical Analysis Center. I had staff and they helped with developing software that would be useful in the instructional aspects of computing as well as with the software that would be useful in the research aspects. We

always tried to run an integrated center which was accessible for instructional use and research use without either group of users feeling put upon by the other. I think we were very successful in this endeavor. We didn't have any political or other quarrels among the actual users of the equipment.

ASPRAY: Can you give me some of the examples of this software either for research or instructional purposes?

STEIN: For one thing, we had developed, the University of Minnesota Fortran. It was developed under my direction, but under the direct leadership of Lawrence Liddiard, who is now the acting director of University Computer Services.

ASPRAY: When would that have been?

STEIN: That started about 1960. We developed a number of Fortran systems. This was particularly true when we began to use the CDC 1604. It had been the habit of Seymour Cray, the designer of the 1604, to develop some software that he used in the factory which generally was not the official software that purchasers of the machine would get. We had access to the software that Cray himself used. Using that as a starting point, we began to develop our own University of Minnesota Fortran and also our own operating system. We repeated that when we went from the 1604 to the CDC 6600. This was also a Cray-designed system. Again, we obtained the software that he had been using during the design and testing phases of that machine, and improved it to what ultimately became the University of Minnesota Fortran -- UMF, as we called it. A very well known and widely used Fortran system.

ASPRAY: Used well beyond the University of Minnesota?

STEIN: Yes. We had a number of Canadian universities that used it. It was used by the Tel Aviv University in Israel, the Hebrew University in Jerusalem. I believe that the University of London made use of it, and there were a number of others. In addition we developed our M-O-M-S, or MOMS system, our operating system which served us

in good stead until after I'd left the Computer Center. Then a fundamental change in management philosophy occurred. There was a decision made to go with the official software that was produced and maintained by the organization from which we had purchased the hardware equipment. Those decisions were connected with the so called "unbundling" that occurred. I forget the exact year.

ASPRAY: 1956?

STEIN: No, it would have to be in the 1960s, or maybe even in the early 1970s when it became a significant thing. Software became a separate item that was purchased. In the first contracts that I wrote, I purchased three systems, software was never a consideration. We just received whatever software the manufacturer had that would be given to us free of charge. When I came back as the chairman of the committee that negotiated the contract for a major update of the CDC-6600 into the Cyber 74, the majority of the language in that contract was devoted to discussing software. Probably in that kind of environment the University couldn't depart too far from the official softwares. In any event, we did things like that on a grand scale.

In 1966 and 1967, we had many plans for introducing a computer network, and the CDC 6600 was installed. When we purchased it we decided we'd install it on campus in the Experimental Engineering building. After the architects that we employed presented their plans, we put them out to bid. The cost proved so prohibitive, that we decided to lease a building in Lauderdale, on Highway 280, from the Northern States Power Company. This building had been their computer center and research lab up to that point. We were able to install the CDC 6600 there at a very low cost. But it was a site four or five miles off campus, so we immediately began to think about communications and networks. Our design was that we would have the CDC 6600 as the center which could then communicate with medium-sized remote stations, the capacity of, say, a CDC 3200. These stations were to have the ability to communicate at about five to six thousand characters per second with the 6600 at Lauderdale, and then simultaneously to carry on work designed with the interests of some local area such as IT, Space Science, Education Psychology, Physical Sciences, or Medical Sciences in mind.

Now, it was our intention to put in a number of these. We actually installed stations like that in the Medical School, based on a CDC 3300, one on the West Bank to be used by the School of Business that replaced their computer center, and also by the Life Sciences Research Center. Those activities, local activities, then became centered on a CDC 3200, and they also had the facility to communicate directly to the 6600. We also had a terminal in the Experimental Engineering Building and one in the Space Sciences Center. We had plans to install one in the new Psychology Building, which was being built at that time, for the use of Education and Psychology, and one in the St. Paul Campus. Longer range plans included tying in the more remote campuses, Duluth particularly. We were looking into microwave communications. We then began developing software to implement these concepts. A particular aspect of that software was to give us the ability to submit a problem to the local activity of the remote computer, and then to have that problem shifted over to the 6600 batch. It would be sent out there, returned to the local site, then returned to the originator. We developed these facilities to go from that local remote use (that is, remote from the main computer) to the central computer without having to remove the problem and start over again. This was also one of the contributions that we made. We also, as I mentioned in our last interview, devised hybrid computing systems.

ASPRAY: Analog-digital.

STEIN: Right. We developed simulation languages for so-called continuous system simulation that would simulate the hybrid systems on a purely digital system. These are just some of the samples of software developments that we were doing. I think I've gone somewhat astray from your question.

ASPRAY: That's fine.

STEIN: I'd say that the two courses I mentioned were the only two courses in what we might call computer science, which really didn't exist at that time. Those were the numerical analysis sequence and the one that I developed. They

were really supported by the University Computer Center, even though they were given through mathematics. Students could use these sequences for plan-B papers, and they could be examined in the content of this material as part of their written preliminary examinations in mathematics. Subsequently we brought in courses in systems and non-computational mathematics and artificial intelligence. But these were mainly ad-hoc courses that would be given under some special number.

ASPRAY: They would be given course credit, though?

STEIN: Yes.

ASPRAY: Usually through mathematics?

STEIN: Yes. We found that there was really, in mathematics, a great deal of resistance sometimes to giving credit to this kind of work, and also to accepting the theses of our students. They seemed to be willing to accept this kind of material for masters' degrees, but when it came to a doctoral thesis it became quite difficult. While one could be examined in this kind of material as a topic, still a candidate had to take a normal series of examinations covering the kinds of subject matter that people getting degrees in mathematics undergo. That was only natural, and I had to agree with that because those people were getting degrees in mathematics.

ASPRAY: I can understand that very well, too. Were the courses that you mentioned first, numerical analysis and the course that you introduced, offered every year?

TAPE 3/SIDE 2

STEIN: Yes. Those course sequences have been offered every year since 1955, they've always been very well attended, and until recently they've had a high proportion of graduate students. As a matter of fact, particularly in the early days, I was frequently called upon to serve on graduate student committees in a wide variety of fields,

because the graduate school, or at least various graduate group committees, allowed in certain programs that this course could serve as a so-called research technique and could be substituted for a language. Computing and numerical analysis -- computer science, which it wasn't called at that time -- was so new that it was felt that we ought to be on the committees to examine the students. And we did that very frequently for both masters' and doctoral candidates.

ASPRAY: How did these two course sequences change over time?

STEIN: Over time, we took advantage of new things that were discovered or came of interest to the budding group of computer scientists. For example, these courses started before the advent of a language such as Fortran, before the advent of operating systems. We always had an operating system, but at the beginning it was transparent to the users because we were working on an open- shop basis. So if the user thought there was an operating system, that user considered it simply to be the computer itself. But languages, even assembly languages, became much more sophisticated. Operating systems that were mainly software-based rather than hardware-based came into general use, and so we had to provide a theoretical view of systems like that for our students. To a large extent, the course began to deemphasize aspects of hardware organization, aspects possibly of computer architecture, and began to concentrate more on software considerations. We looked at the structure of assemblers, compilers, and operating systems. What we gave up for that was some of the detailed structure and organization of the underlying hardware that we used to teach. For example, we used to spend some time talking about machine arithmetic and the theory of machine arithmetic, which can be approached as very abstract mathematics. But that was deemphasized, and today we have a separate course which runs one quarter and covers that subject and a graduate seminar that is given every other year, maybe sometimes more frequently, that covers the more advanced and abstract aspects of that subject. Today we have a separate course in computer architecture which covers a lot more material beyond what we covered in the beginning.

ASPRAY: Were students encouraged to take both sequences, or did they elect to take both sequences? That is, the

numerical analysis and the other sequence?

STEIN: Yes. Most students elected to take both. That is, most students that came from mathematics, the physical sciences, and engineering elected to take both. Some of the students from the life sciences and social sciences were not so sure that they needed both, so they took the course in the organization and application of computing machinery and software. I think it was mainly that they had some kind of a vocational objective or, in certain cases, they had a thesis topic in mind; I suppose most graduate students at that point learn what they have to learn to complete their research and write their thesis.

ASPRAY: Are there records still available from these courses such as course descriptions or any materials of that sort?

STEIN: I may have some records. I'm sure I have the class record books and so on. But, of course, the catalogs are probably somewhere in the University Archives.

ASPRAY: One can learn a lot more from a syllabus than from a catalog description.

STEIN: Yes. I probably do have some syllabi of mine left over from those days. But, as I was beginning to say, we found it harder and harder to get our graduate students through to degrees. What was very discouraging is that a number of them decided not to go ahead because they felt that they were not really interested in getting their degrees in mathematics, in studying the other subjects that were required. Some of the other subjects were very valuable and interesting, but I'm talking about the complete gamut of subject matter.

ASPRAY: One might think that numerical analysis, logic, combinatorics, and probability all might have some relevance to computing.

STEIN: Yes. But I think what they were talking about is that they really didn't want to prepare for the written preliminary examinations and qualifying examinations over the complete gamut of subject matter. They wanted a course of study directed at their own interests, their own particular kind of research. So, we were losing students to places that had programs.

ASPRAY: Can you tell me which schools those were?

STEIN: There weren't really very many. Stanford had a program, MIT did and possibly the University of Wisconsin did. Another way we were losing students was the following; as director of the Computer Center, I made it my business to conduct a developmental program. We began with undergraduate students and we put them to work as computer operators. But a part of their duty was to have in-house education, and to take the courses that I have mentioned. These students then progressed from operators: they became consultants, and some ultimately system programmers. This progression went along with their educational development as well. Of course we had attrition. I might appoint twenty students at the beginning of every year, have ten of them survive to their BA's, and of those, maybe five would come to work as graduate research assistants in the Computer Center. We would suddenly discover that they would leave because they were finding it difficult to pursue their graduate degrees along the lines that interested them. Perhaps our biggest competitor was Bell Labs because they would hire the students and then let them go back to some university for a year to get a degree.

ASPRAY: To get a master's degree?

STEIN: Yes. We lost some of our best prospects to Bell Labs, and we weren't getting any Bell Labs students because we didn't have a program. In 1966, this really began to hurt us, because at that time we obtained the CDC 6600, which was the supercomputer of its time and I felt that this put us in a position to assume the leadership in computing and computing science among the universities in the United States. In order to do this, we had to build up our staff properly. As part of the grant from the NSF, we had funds not only for acquiring the equipment, but for

building a staff. Yet I really felt that it would be difficult, if not impossible, to build up the staff properly and to retain the staff without a program, a solid program, in computer science in the university while the students that we had developed were going off to Bell Labs and other places. Some of them, as I recall, went to UCSD. I'm particularly thinking of two of them who did very nice Ph.D. theses out there in mathematics, but with computer science subject matter.

In any event, what I believe I was talking about was our decision that we could not exploit this leap into the future which we potentially could make with the CDC 6600, without having a strong academic program in computer science in the University. Late in 1966, I decided that we should try to go ahead with a graduate program in computer science. The graduate school appointed a committee to study the matter. Up to this point, the only academic program we had was some kind of a concentration or minor in computer science that one could get with a bachelor's degree in mathematics. It was so difficult that I don't know of one student who ever completed that program. I talked to the then Acting Dean of IT, Frank Vebrugge, into appointing a committee to study the problem and it was, if I may say so, a very distinguished committee consisting of N.R. Amundson, who subsequently became a Regents Professor; Lawrence Marcus, who also became a Regents Professor; Warren Cheston, who subsequently became Dean of IT; Hans Weinberger, currently the head of the Mathematics Research Center here; George Collins, who was then the head of Electrical Engineering and has resumed that position after some hiatus just recently; myself; and Bill Munro. The committee came out with a favorable report. I don't have the exact date; the committee report I have is in the archives and so on. It was accepted by the graduate school after discussion by all the group committees and by the executive committee. A program that we called Computer and Information Science was established late in 1967.

ASPRAY: What about hiring a faculty?

STEIN: Hiring a faculty turned out to be a problem. We soon found out that, while we had enough mass to establish a decent program, it would be impossible to maintain that program at any reasonable level for very long, considering how quickly the field was changing, because we had no access to curriculum. We could not introduce any courses

without putting them through the curriculum committee of some department that was not terribly interested in allocating any of its resources to a new program. We couldn't hire faculty. We couldn't hire graduate assistants, except by using funding that was available in the Computer Center. This funding was limited. We did have a small amount of flexibility in this matter because Dean Spilhaus, at my urging, had allocated two positions to this new area, Computer Science. Spilhaus' attitude, "If we have a new horse we have to back it," I considered very commendable on his part, and he gave two positions to the program. The positions, however, were assistant professor positions he felt should be attached to mathematics. The recruiting, however, was to be jointly between the University Computer Center and the Mathematics Department.

ASPRAY: Were the qualifications for the people to take these positions somewhat a mixture, in the sense that mathematics wanted to use these people part-time for their own aims?

STEIN: Yes. The fact is Mathematics wanted to use these people full-time for their own aims. We had difficulty agreeing on the people, although we went out and we tried to recruit people upon whom we did agree. Unfortunately, we didn't succeed in getting them. A couple of the people we were after, young fellows at that time who had just finished their graduate work, subsequently went on to make excellent reputations for themselves. They didn't want to come to a completely new program. We did manage to get some visitors on those positions. One that I can remember was Joseph Gruska working in automata theory and computational complexity. He came from Czechoslovakia, and now he is a rather eminent person in that particular area at the University of Brateslava, I believe.

We had difficulties. We couldn't reward people very well because we didn't control any budgets to speak of. We couldn't introduce courses. We couldn't hire people. So we would, in a few years, just atrophy. I went to warn Cheston, who by that time had become the Dean of IT. We pointed out the situation to him. After the discussions in which Bill Munro participated, we went back and wrote him a letter summarizing what we had discussed. He agreed to the points that we had made, that without a budget the program would atrophy and without an undergraduate

program it was going to be pretty difficult to get a budget. So we proposed at that time to introduce a department with an undergraduate curriculum to support. He agreed and he appointed a committee consisting of four people: myself, Johannes Nitsche, both of us from Mathematics, and Richard Kain and Bruce Lee, both from Electrical Engineering. We were given a budget and a mandate to define and organize the department and the program.

ASPRAY: This was in what year?

STEIN: This was in the beginning of 1969.

ASPRAY: So, essentially, you tried through 1968 to get the program on its feet without support?

STEIN: Yes. We found some people inside the University who wanted to be associated with the department. Bruce Lee was chairman of the organizing committee. For purposes of recruiting, we thought it would be better to refer to him as Acting Head of the Department. He functioned as chairman under that particular title. We organized the department, defined a curriculum, and went through the various approvals that had to be obtained -- the faculty, the regents, the higher educational coordinating commission, and so on. In the academic year 1970-71, we began functioning as an independent department.

TAPE 4/SIDE 1

STEIN: During this organizational period, we were teaching our courses and trying to function as a department. But, the courses were being offered through Mathematics, and we were in temporary space that had been made available to us in Experimental Engineering by the Computer Center -- by me, as director of the Computer Center really. But, by the 1970-71 year, we were able to move into the area that we now occupy in Lind Hall (not as much of it as we have now, but enough for that day) and to begin functioning as an independent department with its own budget, its own faculty, its own curriculum, its own everything -- including its own troubles, which every independent department

has. At that time, I decided to resign as director of the Computer Center and to transfer my appointment as a professor of mathematics to the new department. I was, in that first year, functioning as acting head of the department.

ASPRAY: Before we go any further, I have a number of questions about these early years. Can you specify for me who the faculty members from the university were who came over to participate in the computing center at the beginning?

STEIN: Yes. Ultimately, I came over. Bill Munro went into this almost at the outset of the organizational days with the title of Associate Department Head, which he still has. And there was Jay Levitt, who was an associate professor.

ASPRAY: In mathematics?

STEIN: His title was Associate Professor of Computer Science. In those days, there was a process where people who were appointed in one department and had most of their responsibilities in another department could obtain promotions, without their titles necessarily reflecting any department, but rather more or less what they were doing. So actually, Jay Levitt and Kris Frankowski were both appointed as assistant professors in mathematics who spent most of their time in the Computer Center and also in teaching the kinds of courses that sprang up from the two sequences that I mentioned at the beginning of our talk. They were promoted to Associate Professors of Computer Science under that special process. Both of them came over to the department when it was organized. Frankowski is still with us, and Levitt is now at SUNY Buffalo, where he is the Director of Academic Computing. We also hired as new assistant professors two of our graduate students who had obtained their Ph.D.'s. The first one was Duane Zimmerman. He was our first Ph.D. student, and he had to remain another year while his wife finished her Ph.D. in mathematics. Both of them, I think, went to a university out in Southern California. Zimmerman joined our faculty, though we knew he would only stay a year. Then, we hired Bill Frante who had been with me since he had been an

undergraduate. He was one of these people whom I had put into our training program, which I discussed previously, and he had become a graduate student and also functioned as Operations Manager for the University Computer Center until he obtained his degree. I was his advisor, and we hired him as an assistant professor. At the time, he didn't think he was going to stay very long. We didn't think it was, in general, a good idea for former students to remain very long; but he went off on a very independent and fruitful line of research and, at the end of last year, he resigned from our faculty with the rank of full professor. I think he's president of a venture capital company in this area at the moment. That was the original department faculty, assembled from among University faculty and former graduate students.

ASPRAY: The 1968 curriculum had just appeared at the time. What role did it play in the development of your own curriculum here at the University?

STEIN: To tell you the truth, we were very aware of the developments of the ACM curriculum committee, particularly. But I don't know that what they had set down played a great role in our curriculum development. What did play a great role in curriculum development was something rather more general. For one thing, the Institute of Technology, when I arrived here in 1955, was awarding five-year bachelor's degrees. The five-year programs were abandoned, and departments went over to four-year programs. There was quite a lot of discussion as to what a suitable four-year program was. Dick Jordan, who was head of Mechanical Engineering at that time, and who functioned for several years after his retirement as Associate Dean of IT, chaired a committee to define a four-year degree program in the Institute of Technology. He examined questions regarding its objectives, such as whether to train the professional or to develop somebody who had a broader background and who would then have to become more specialized through a specific employment in the field. He came up with a program whose objective was to train people in a more general way: people who could see the influence of the social sciences on engineering, and so on. These curricula were to have many electives. The electives were quite open, and about that time, the proper liberal arts education for any graduate of the University had been more or less defined. There was a liberal education requirement, and I think the Jordan reports took that very much into consideration as well.

That was the atmosphere in which I was functioning as chairman of our curriculum committee; that was the atmosphere I was working in. We developed a curriculum that did not try all that hard to train people in narrow specialties, but was open and had a lot of electives in it. It was my hope that we could work with what we called the senior elective, which was composed of a number of credits, half of which had to be in comp uter science and half in some related field, usually in IT though not necessarily, but generally in some obvious field of application. In those days, obvious fields were even fields such as political science, economics, and education as well as electrical engineering, math, statistics, and so on. We thought, if we could combine this elective with liberal education, that we could produce at the bachelor's level people who might go on to graduate school in other areas and bring computer science to important applications, or else who would be well qualified to work in government, industry, or business, but primarily in areas of applications of computer science. While I think we were successful, to a large extent we weren't as successful as we had hoped. That is mainly because, in the long run, we didn't know enough about the requirements of the other areas. But I think we still have that philosophy, and it works. Of course, we have students who take all the electives that they can with intense concentration in computer science, and those are the ones, primarily, who are going on to graduate work in computer science.

As far as the specifics of the curriculum, I don't know that we were radically different from those that were proposed, particularly by the ACM, but we didn't really study it that hard. We felt that we knew enough about it, that we had been working in this area long enough, to know what we wanted to do. We already had a start, and courses that were extant, and so we had a certain basis to begin from. I remember we introduced a so-called undergraduate minor in computer science, so we had that to look at. Our product developed from our own experience, that minor, the Jordan report, all of which reflected the needs of the University of Minnesota. Of course, we then compared what we did to the ACM curriculum recommendation.

ASPRAY: Did you look at the curriculum of any other universities very carefully at all? Stanford, or Purdue?

STEIN: Stanford was primarily a graduate program. We may have looked at Wisconsin. The reason I say that is that in the year that I was doing all this, we had retained J. Ben Rosen as a consultant, who at that time, had just retired as head of the Computer Science Department at the University of Wisconsin. So we certainly had his ideas and his input in the process. I remember I would send in the minutes of every curriculum committee meeting, and he would reply with his comments and suggestions. But, I can't say that we were influenced by any place very much.

ASPRAY: What about the number of students you were getting in the early days? Had you had any students participate in the program that ran for just a short period by itself?

STEIN: We had very few students who tried that minor. It was a program that was still reminiscent of the five-year degree. To complete it, one needed well over two hundred credits, whereas the programs developed under the influence of the Jordan report required about a hundred and eighty. While the cost of tuition wasn't that big a consideration in those days, it still was some consideration, and in order to have a minor in computers or computing on their diploma, I don't think students were willing to forego the opportunities that were then available to them in business and industry, just to spend the extra time and money.

ASPRAY: What about the development of the undergraduate program? How long did it take for enrollments to pick up there?

STEIN: My forecasts were that we would have about 100 students in each year. In about six years, that came to pass. We started in our first year with probably about fifty students. This was with a curriculum in the Institute of Technology. Subsequently, very shortly after that curriculum was approved and functioning, I began talking with people in CLA about a curriculum leading to a Bachelor of Arts degree in Computer Science. (The IT curriculum leads to a Bachelor of Computer Science.) These talks were cordial and were nearly completed by the end of 1970-71. They were well advanced, while I was still chairman of curriculum. Then, I turned this over to a new member of the faculty, Ken Brown. I had hired him while I had been acting as head in the first year. I also hired J. B. Rosen, who

decided to leave Wisconsin. He was to come as the department head. Brown culminated the CLA negotiations. We now also have a CLA curriculum. In the Bachelor of Computer Science program, we now have a total of about six hundred undergraduate majors. I would guess we have another four hundred in CLA who are candidates for a Bachelor of Arts degree in computer science.

ASPRAY: How do the two curricula differ?

STEIN: In terms of the required technical courses, they don't differ at all. The IT program has the senior option, which meets concepts that were suggested in the Jordan report and is therefore akin to a type of what you'll find in other IT curricula. Our senior option differs from the CLA equivalent thing, which is distribution of electives in CLA designed to meet certain college requirements. That is the most significant difference with regard to computer science. Nevertheless, I think that a person in IT who took his senior option with an emphasis in some CLA field would probably end up with about the same number of credits of Computer Science, counting required technical courses and electives, as a student in CLA. The other differences are also at the college level. The CLA students have to study languages, while the IT students have to take physics. As I said, technically there isn't much difference, and I don't see a lot of difference among the students themselves.

ASPRAY: Could you make some comments about the development of the graduate program and about the numbers of graduate students you started to get over time?

STEIN: The graduate program was approved in 1967. The graduate school set up a special group committee for Computer Science, which elected Bill Munro as chairman. The functions of a group committee, in those days, were to appoint faculty, to approve student programs, and things of that nature.

TAPE 4/SIDE 2

STEIN: When Bryce Crawford, the Dean of the Graduate School at that time, wrote the letter approving the program, he pointed out that the executive committee was rather insistent that it be a very interdisciplinary program. Consequently, we appointed people from a wide variety of fields in the university, from the School of Business, Education, Statistics, the Life Sciences, Mathematics, Electrical Engineering. Of course, we appointed all of the people that were in our department, and we were actively recruiting people. This was before the department, but as we became a department, naturally, we appointed all the people that were at the University, that joined the department, and, ultimately, when we had the department, all the people that we recruited; so that we had a pretty good-sized and a relatively active faculty. There was a pent-up demand for this program, and we also managed to recruit a pretty good new class of students. This was due partly to the fact that the Computer Center had a number of assistantships to offer these people. In the first year, we gave the written preliminary examination. I would guess about 25 students took the exam, which I don't think was too bad to get the program underway. I don't know if you wanted me to go into the details.

ASPRAY: I would like to hear more about the development of the curriculum and what kinds of students you wanted to produce.

STEIN: We were interested in what we considered the core area of computer science, and we were primarily interested in producing students for industry, government, and business to work at research laboratories and, to a certain extent, inevitably, there were those who insisted on an academic career in computer science. We were concentrating on students who were really interested in compilers, languages, operating systems, and the generalized applications of computer science.

ASPRAY: Could you elaborate on that for me?

STEIN: What I'm really talking about is where you're not looking at some specific differential equation, but a class of mathematical problems, and how computer science methodology and computing machinery could impinge on the

solution of problems of this nature.

ASPRAY: Can you give me some examples of areas of computer science that the program did not pursue actively?

STEIN: I don't know that we had it in mind to exclude any particular areas. I think if there was one that we didn't pursue actively, it would have been in computer architecture and design; although we always had an intention to maintain a solid interface with that area, particularly in the part that we would call architecture. Design, we had a feeling, was more or less an engineering subject. To the extent we were pursuing it, it was through the members of the graduate faculty who were in Electrical Engineering.

If you consider there to be two faculties, the core area faculty would be primarily the departmental faculty. The graduate faculty includes the departmental faculty, but graduate faculties transcend departmental lines. There were the core areas of computer science, which at that time we could think of as software engineering, compilers, languages, operating systems, and the generalized kinds of applications I mentioned, and then the more peripheral areas, which would be more specific applications and would be dealt with in the components of the graduate faculty that belonged to other departments. I would say the more important components, which possibly at the beginning we considered to be somewhat peripheral, were theory, computer architecture, and design. But we always intended to have, in the graduate faculty, people who were also depart mental faculty, who could serve as an interface to these peripheral areas, so that they weren't out there orphaned with no attention from us. That is the way we've tried to develop. I think some of these peripheral areas have drawn closer to the core as the subject has developed and changed, particularly with the advent of very large scale integration and the rendering of hardware, the least expensive element of a computer system. I believe one can begin to think very much in terms of designing special purpose systems, fit to the application. When that's been made feasible, you won't design a system for some general kind of application, but you'll design really big systems to much more specific kinds of applications.

I believe that pulls the whole spectrum of applications in much closer to the core of computer science. In particular,

you really need the theory, the architecture, and the design aspects. The whole thing has become much more tight-knit. But just how we organize our faculty is an open question being discussed even today.

ASPRAY: How did the strength of having a whole series of high-end line computers affect the program? For a university, you had the best computing equipment that anyone could have.

STEIN: To my mind, it didn't affect it very much. And, unfortunately, I don't think our graduate program affected the Computer Center very much. In the outcome, we didn't take that leap into the future that I'd been hoping for. There were two things that I tried to institute when we started the graduate program, and one was a system by which every graduate student undertook to become an expert in some aspect of the Computer Center's operations, particularly in the software. One would become an expert in Pascal, another in MNF Fortran, another in some part of the operating system, another in something else, and so on... The aim was that these people would serve as resource people in the Department and to the Computer Center. That would establish a special relationship between the Computer Center and the Computer Science program as well. Another thing that I tried, which we had as a requirement, was called the practicum, which said that no student could get an advanced degree in computer science without demonstrating a high level of proficiency in the actual application and use of computing machinery.

ASPRAY: How would that be demonstrated?

STEIN: This would be demonstrated by industrial work, properly certified and documented, by carrying out some special project with a member of the Computer Science graduate faculty, or it could be demonstrated by making some contribution, possibly connected with the idea that I previously mentioned, in the Computer Center. Later, in order to help students with the Internal Revenue Service, because sometimes they were paid for carrying out these projects, and we wanted them to be tax-deductible, we made them a required part of their education. We said that they could do this by teaching, at the appropriate level, the use of computing equipment.

We had that practicum requirement for a while. But one year when I returned from sabbatical, it seemed to have disappeared and I never did find out what happened to it. We began that other scheme, clearly, because the first bunch of graduate students that we had were given appointments in the Computer Center. Those were the new ones, and most of the residue already had appointments in the Center. But I left the Center in June 1970, and the new management really didn't have any interest in pursuing a special relationship with Computer Science. If you want to know the truth, I don't think they had any great interest in taking a supercomputer and developing the potential of that system as a supercomputer and a research tool, which could still be used in an integrated manner to provide for the instructional needs of those times. They didn't pursue it. As a matter of fact, philosophically, they took an entirely different emphasis, which was what I call "Meccizing" the Computer Center, and that is turning it in directions which would be more in accordance with the philosophy of the Minnesota Educational Computing Consortium.

ASPRAY: It's worthwhile to have some of this spelled out.

STEIN: This was a move instituted by state government to coordinate and control all of the computing activities that were supported by the state of Minnesota. It grew out of a study of state computing that was made by a committee appointed by Governor Levander. That committee saw that the University of Minnesota, the state universities, and all education came under this state-supported rubric. A bill was introduced in the legislature, which didn't pass. I probably should consult sources, but I suppose that then they tried for a somewhat more modest success, which would not include everything. Also, they were probably influenced by the passage of the Joint Powers Act. They came up with this organization, The Minnesota Educational Computing Consortium, which would organize computing for the University of Minnesota, the state colleges, the private colleges, the technical and vocational schools, the community colleges, and all of the public schools, K through 12, as the jargon has it. This organization came to be under the auspices of the Joint Powers Act. I was one of the people who was not very much in favor of its coming into existence in the form that it had. Essentially, it was to take control of all the computing equipment and provide computing services to all of these aspects of education. It might not have intended to take physical control

of the existing systems, but it did intend to have its own systems through which it would control.

I think the new management of the Computer Center was in favor of very close cooperation with MECC, and in order to effect this cooperation, they had to really cut back on the plans that I had had to develop what would certainly be called the Supercomputer Center today. As I said, our name was the Numerical Analysis Center. At that point, we changed to the University Computer Center. I'm sure a lot of the attitudes within the University came right from the top. President Moos felt that this was a way to secure his popularity and standing with the legislature, because the legislature was behind this, or at least he thought they were. As a matter of fact, while initially they had been, by the time it all came to be, there had been a change in the governor and a change in control in the legislature and the legislature actually severely modified MECC in subsequent years. They ultimately changed it to what I thought it should have been in the first place, but by then it was too late.

ASPRAY: Namely, what did it become?

STEIN: It became primarily a consulting organization for K through 12, not worried about maintaining hardware systems or maintaining a lot of control over the use of hardware systems, but one which would work with the public schools and provide applications training to the teachers in using computers effectively. If they had had a broader function, then they might have set up some general standards of cooperation among existing organizations in the state that were already well advanced in computing. There was one area where nobody was really very well advanced, although the University might have had the most experience in it, and that was in communications. They may have provided, even down to the engineering levels, consultation on networking and communications. That's what I thought they should be doing. While they're not doing all of that today, they are concentrating their efforts in the public schools.

ASPRAY: You mentioned University administration a moment ago, which brings me to my next question. How strong was the support from central administration for the development of the Department of Computer Science?

When I look at Minnesota compared to some of the other Big Ten schools, the number of faculty members seems much smaller. Now I understand there are adjuncts and people from other departments that are involved. But, still it seems like the core is extremely small, especially given the large number of students you have coming through.

STEIN: One of the things that I did in the year 1970-71 that I spent as acting head of the Computer Science Department -- which was, as I said, our first year as an independent department -- was making the plan for the development of Computer Science. That plan was made in competition with a number of University departments. We were competing for the right to submit our proposal to an NSF institutional program. NSF restricted submissions to one proposal per university. I wrote the proposal, which was actually a five-year developmental plan for the department. Ours was selected as the most worthy proposal, and I believe that at that point we had the support of the central administration. We certainly had the support of the Dean of IT, who was Warren Cheston, and he told me that even if we were not funded, the personnel part of our proposal could be handled by IT out of deaths, retirements, and resignations.

TAPE 5/SIDE 1

STEIN: This was an oral communication from the dean; he didn't put it in writing. They seldom do. In addition to that, part of our proposal envisaged a computer science laboratory which came to about a million dollars. We were asking the National Science Foundation for half of that. We received the okay from central administration, on the recommendation of consultants they had hired to survey the future of computing in the University of Minnesota. One of these consultants subsequently came to work for the University. He was Peter Patton, the former director of our Computer Center. The other was already hired by the University and that was Peter Rolle. The two Peters then recommended that we receive an item in the University budget, and it went to the legislature. Unfortunately, it wasn't funded. Neither was our NSF proposal, because the NSF decided to kill its institutional program.

ASPRAY: What year was this?

STEIN: 1970. That was a political decision. Institutions weren't supporting the President at the time. In any event, I think I was entitled to the feeling that our program had considerable support. At that time, we had about twelve full-time equivalent faculty members in the program. I had envisaged an expansion to about thirty-one FTE.

ASPRAY: By what time?

STEIN: In roughly five years. I have to step back a little because that also included our graduate students on salary, taking four half-time graduate students as being equivalent to one faculty FTE. Including them, we were expanding from twelve faculty FTE, and a number of graduate students on salary at that time, to thirty-one. This proposal was approved. At least the faculty part of that could presumably have been dealt with out of deaths, retirements, and resignations, if necessary.

The following year, I went on sabbatical. When I came back, I discovered that there was a crisis, and the University was valiantly trimming budgets. We benefitted to the extent that we didn't get any trim. But from that point on, there was never any commitment to the original program. We had a new dean. The dean who was originally with us, you remember, had been a member of the committee that founded the graduate program. He had left. His successor, while not antipathetic to our program, was not particularly favorable to it. I had predicted to the outgoing dean that he wouldn't be. He had assured me that I was wrong. But, nevertheless, that's the way that it turned out. Dick Swalin never did anything against us, particularly, but he never did anything for us, either. We did receive a few new resources and I think we actually got our faculty up to fourteen or fifteen positions at one time. But in 1980, when I started to write another report -- "Computer Science at the University of Minnesota in the Decade of the '80s" -- I think that we were at that same twelve or thirteen faculty members. While our workload had gone up by a factor of 10, (it certainly exceeded the predictions that I had made for credit hours, etc.), the faculty hadn't gone up at all. Nevertheless, the Gorman report rated us number 4 among undergraduate programs in computer science.

ASPRAY: This was in what year?

STEIN: This was in 1980. This had to be accomplished through the sacrifice and hard work of the faculty that we had. I just want to make one nasty remark while I have the opportunity; we can edit it out later if necessary. I believe in that same period, the School of Chemistry received fourteen positions. They're part of IT. If there had been a will, there would have been a way. I don't say it isn't partly our own fault; we didn't scream and yell. Maybe our department head should have functioned at that level a little better. He didn't, and I think ultimately that's probably why he had to step down as head. That's only an opinion. We didn't get any of these resources. Today I don't think we will ever get the resources, although my last report called for the number thirty as a minimum, and today the central administration is talking thirty in 1994. In 1994, we'll need sixty. However, I will probably be almost retired by then.

ASPRAY: Let me ask you another question. The University postures itself today as an extremely important resource in the growth of high tech industry in Minnesota. From all that I've heard from you, the department and computing center, especially, were oriented towards serving the needs of the University rather than serving the needs of the outside community, with the exception that your programs were oriented towards producing a number of people for industry and business.

STEIN: Yes. That is the greatest service that we can do them.

ASPRAY: I understand that and agree with that. What I wanted to ask -- maybe I didn't start this the right way -- was about any additional University industrial relationships. For example, adjunct faculty positions, funds from outside industry to help with the educational program, any kinds of job placement for practicum experience. Could you comment on those?

STEIN: Yes. Your concept was essentially correct. The institutions that I've developed were oriented toward

serving the university in the most direct sense to produce the students, to support the faculty research, to support instruction, and so on. I think that, in the long run, the best service that the University can do for the business, and the industrial community, the government, or just for the community in general, is to produce the educated people that they need. But we did have direct relations with industry, mainly, and also with state government. We had graduate student positions where students would do work for which they would be paid, that would be recognized by the faculty of our program, under the direction of a person in industry who would have the status of an adjunct faculty member. We had a number of arrangements of that type.

In Computer Center days, we always had arrangements with the manufacturer of the equipment that we bought, and we had particularly with CDC, arrangements for the development of software. They had acquired the rights to a lot of the software that I mentioned to you. We were paid for them essentially, by receiving exceptionally big discounts and, in other similar ways, by receiving some direct grants of actual cash money for the development of software. I remember one was for the development of a Basic compiler that was in the days before microcomputers made Basic a must. I think CDC wanted that compiler as a point in selling equipment to schools. We had research contracts with industry, and we had industrial people here teaching courses as adjunct faculty members. We had some of our faculty leave us and join industry. For instance, Don Boyd left the faculty and he's now with Honeywell Computer Science, where he's manager of quite a large program. We used the adjuncts in those days usually to give special courses in areas of expertise that faculty did not have. In that case the students were mainly advanced. We used the adjuncts also sometimes to give special courses, topics courses, which we encouraged our seniors to attend, especially those who were interested in going to work upon graduation, as a way of easing their transition into the industrial community. My feeling is, again, that our product is the educated people more than specific pieces of hardware or software; yet we have a little mix of the other as well. I think we contributed to high tech. But I think the advent of MECC took away a lot of our ability to do that.

END OF INTERVIEW