

An Interview with

BRUCE BARNES

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Conducted by William Aspray

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Bruce Barnes Interview
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Abstract

Barnes describes his duties as a program director at the National Science Foundation (NSF). He provides brief overviews and examples of NSF's support of research in theoretical computer science, computer architecture, numerical methods, and software engineering, and the development of networking. He describes NSF's support for the development of computing facilities through the Coordinated Experimental Research Program.

BRUCE BARNES INTERVIEW

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INTERVIEWER: William Aspray

LOCATION: Washington, D.C.

ASPRAY: This interview with Bruce Barnes in his office at the National Science Foundation in Washington is for the National Science Foundation Computing History Project. Let me begin by asking you very briefly to recount your personal career history so we have a context for our discussion - where you were before you came to the Foundation, when you came here, what you have done here.

BARNES: Okay, before coming to the Foundation I was in the computer science department of Pennsylvania State University for 13 years.

ASPRAY: What were the dates?

BARNES: From 1961 to 1974. And with a year's leave of absence in 1969 and 1980 at the University of Iowa. I came to the Foundation in August of 1974.

ASPRAY: In what position?

BARNES: As program director in theoretical computer science.

ASPRAY: What other positions have you held at the Foundation over time?

BARNES: I had that program for two years; then I was made program director for software engineering, which I held until 1986. Okay, in the meantime during that time I was also program director in intelligent systems and program director for coordinated experimental research. I was known as the division's designated hitter and that I would be the one who would fill in whenever there was a vacancy in a position. So I ran most of the programs at one time or another. In 1976 I left the Foundation and joined a company called the Software Productivity Consortium. I was

there until 1988. When I returned to the Foundation as deputy director of the division of information robotics and intelligence systems and as program director for interactive systems. In the fall of 1989 I joined this division as deputy director.

ASPRAY: And when you originally came to the Foundation what was the attraction for you?

BARNES: The usual attractions, I think - a chance to have an impact on the field, a chance to get a new understanding of funding and of research, a chance to look at what was going on in the country; I think the appeal of coming to Washington. I must say, I originally came as a visitor; I came on a two-year appointment. And that's when I was theory. And when they offered me the position in software engineering, that's when I became a permanent NSF employee. Those are mostly the reasons. I had been through a traumatic experience at Penn State and wanted to get away for a few years too.

ASPRAY: How difficult a time did the Foundation have in finding qualified program officers?

BARNES: That's very hard to answer. We never had a lot of candidates, but we always seemed to get very good people. You know, we didn't have a lot of candidates; we didn't have no candidates; we just seemed to have a few, and the ones that we really seemed to want we somehow or other got, so almost all the time we had excellent program directors. Some times we would have a vacancy for a while when somebody hadn't been able to arrange their affairs to come or something of that kind.

ASPRAY: Probably the most important part of this discussion will be about the research areas, but before I turn to that I would like to ask you some questions about the daily life of a program officer. Just to trying to understand what it's like to be here. Maybe the easiest way to ask my question is to start with a statement that had been made by some people who were more attuned to the DARPA community. They said to me that, "You know, those NSF people don't work the way we do. They don't have the same kind of effect on the field that we do, because all they do is they sit in their offices and wait for a set of proposals to come in. They send them out to some reviewers; they get

them back; they're ranked, and they just give as many as they can give money to. And they're not exerting any kind of impact or control on what's going on in the field." Let me let you comment on that.

BARNES: That is both true and false, and it's probably true that they send that. [laugh] I think the impression is one that's true, and there are certain aspects of it that are true. There are certain aspects that aren't. And I think one has to understand somewhat the difference between the missions of the agencies to understand the differences. It is true the Foundation tends to go on what they call "unsolicited proposals." We are very careful not to give undue encouragement to somebody to submit proposals. We try to give everybody who shows any interest and any ability to do any research, we try to encourage them to submit. Unlike DARPA/ONR: they will turn off probably 90% of the people who contact them, just because they don't perceive a military need for the research. Well, we don't have that kind of constraint. We work on a more, what do you want to call it, absolute quality basis. It has been difficult within the Foundation's structure to fund very large projects. And I think in some sense, DARPA, by being able to fund very large projects, has been able to have certain kinds of impact on the field. If one looks, one will find that many of those large projects had their genesis from an NSF grant.

ASPRAY: Can you give me a couple of examples?

BARNES: Yes, CM Star at CMU - a big architectural project was... I think it's what called CM2 or something like that (Dan Siewiorek is the PI) - was one very clear case. That's all that comes to mind now. I know there have been others.

ASPRAY: Okay.

BARNES: John Lehmann. I don't know if you are going to talk to John or not. John would be a very good source of that. John seemed to be very good about spotting these small projects that later on turned out to be very big. Dave Kuck at Illinois, another one. I don't know if he is getting DARPA support or not now. I think he is, but again, John supported that for a long time. The other thing, the DARPA ones tend to be more technology-driven.

ASPRAY: And sort of more on the experimental side.

BARNES: Yes, we will get to that issue later. [laugh] You asked what the daily life of a program director is.

ASPRAY: Yes.

BARNES: I am not a program director now, but I was for a long time. [laugh] It was true - I spent a lot of time... Most of the mornings would be spent with what I call "jackets" - proposals. We put them in a jacket. In the fall I would have a big stack of these that needed to be sent out for review. It takes an hour or so to do that, and that, with other things, usually meant I could do two or three in a morning. And then in the spring you would tend to be in a decision-making mode where you are making decisions, writing up your decisions, negotiating budgets, that sort of thing. So I tended to spend the mornings with jackets, the afternoon with the community, and that's when I would be answering correspondence, catching up on my telephone calls, my E-mail - all that sort of thing. And of course you would have your usual meetings.

ASPRAY: Did you travel much?

BARNES: Yes, I used to say I would make about a trip a month, but it probably in reality was about ten trips a year.

ASPRAY: And did you attend most of the major research conferences in the area you were supporting?

BARNES: Right, I would try to attend, in that case, the software engineering ones plus the national ones like the annual Computer Science Conference or IEEE ComCon or one of the major things, and then also do site visits to universities.

ASPRAY: When you went on these trips some of it was just presumably learning what was going on and meeting

some of the new people in the field and continuing your contacts with others?

BARNES: Yes.

ASPRAY: Were you actually suggesting areas that you thought were ones that needed more support or were ones that you were giving the message that the Foundation was ready to support more work in this area or had higher priorities on this area than another?

BARNES: Probably indirectly. If I felt that some issue, some research area was important I would then go out and try to find what I thought were some of the leaders and thinkers in the field and ask them their opinions of that. I was usually right, by their opinion. I think just the act of doing that just sort of stimulates. Or I would say, "We have a dearth of proposals in this area. Why do we have this?" And occasionally (I can't think of an example right now) we might sponsor a workshop or something like that to try to stimulate. That's a standard Foundation way of operating.

ASPRAY: Take me through the review process. What happens in a typical year in a program?

BARNES: A typical program is going to get 100 or so proposals. They usually come in the fall. We get them all year, but the big bulk of them comes in the fall. We send those out for review. We like to get three to four reviews so we send it to six or eight reviewers. That's not an easy job. I will brag a bit; I was excellent at it. You have to sort of match the proposal to the reviewer. You have to make sure you get multiple aspects of the proposal covered. You have to make sure you get a reasonable coverage of the kind of reviewer that you have - not all from one school of thought. In fact, not all from the major schools - from smaller schools, from women, from foreigners - all type of thing to get a right kind of mix. So anyway, you send it out to four to six. It takes quite a while for those to come back. When we send it out to six to eight we will end up with some place between three to six reviews. We rarely make a decision with less than three reviews. So we get three to six reviews, and usually by that time a logical decision comes out - that you should fund it or you shouldn't fund it, and so on. And sort of at what level. Then you have to balance that against your budget to see if you have funds to do it. Lately we haven't had funds to do much. Earlier on it seemed

like we were able to fund more of those that we wanted to than we are able to now.

ASPRAY: So, then and now, if you had 100 proposals in, how many would you typically fund? What would be the success rate?

BARNES: The success used to run around 35%. It has just dropped down to I think around 25 to 28%. But the success rate is somewhat of a function of what you have. I think there are a lot of things that we are turning down now that we would have funded before.

ASPRAY: At the point you finished your reviewing and you don't have enough money, is there a way to negotiate budgets to try to get some more money in the midst of a year? Stretch it in some way or another?

BARNES: There's various things you can do. We give continuing grants, which means you don't give the money all in one year; you give it in increments. We would do sometimes split funding. If it was numerical methods, we would put part of the money and mathematics would put in part of the money. We would do that. Sometimes we would negotiate with ONR or DARPA to see if they were interested in funding the project, either by transferring funds to us or by just sort of splitting the project. And we did that pretty actively - particularly in numerical methods that was very common.

ASPRAY: How cooperative was mathematics, and I guess engineering would be another likely place where you would have a certain amount of overlap?

BARNES: That depended on the program directors. Generally speaking, the program director in math would be the program director for applied mathematics, and that was a rotating position so that would change every year or every two years. Generally, they were very cooperative - very cooperative - and that worked very well. The other place in engineering was systems engineering and operations research. And again, that was a rotating position. Sometimes that worked very well, and sometimes just sort of so-so depending on who was there.

ASPRAY: Other things about the day-to-day activities of the program officer I should know?

BARNES: I can't think of anything. [laugh] It might come up later.

ASPRAY: What about other kinds of issues in terms of deciding your balance of grants that are given. I mean, I know that the excellence of the proposal is probably the foremost criterion, but there are other things, like whether you want to give extra support to young investigators or to women and minorities, or you wanted geographical distribution of grants, or whether or not you are going to give to researchers in industrial organizations. How do all those things play out in this formula of giving your awards?

BARNES: They would play a very significant role; at least for the programs I ran they did. At that time we had some active programs in industry, university collaborative research where you could get extra funds out of a special pot of money for that kind of thing. So I was rather aggressive in getting some of those going.

ASPRAY: That's something that only lasted for a certain period of time?

BARNES: Yes, and then just disappeared.

ASPRAY: And why was that that it disappeared? Why did it come about in the first place, I guess?

BARNES: It came about in the first place, I think, because it was felt it was important to try to stimulate that kind of work. It went out, I think, because Dr. Balk didn't think we should be giving money to industry, for part of those funds would go into industry. Now, we still do get some collaborative projects, and I think they are still given sort of a little preference of some kind to a small degree. But I think without those funds to induce the industry to participate they haven't done so, except for big players like IBM, Hewlett-Packard, Northern Telecom.

ASPRAY: How do you take care of questions about geographical diversity and a variety of different institutions getting support over a long period of time? Was that a major factor? Was it a problem for you?

BARNES: No, it was never a major factor, but it was always a factor. It's my own inclination. I like a diversity so I was always trying to push some of the smaller school projects and so on through, and likewise for women, minorities, or some of the institutions that don't get a lot of funds. You are talking at the margin. You're not talking big blocks of money; you're talking small amounts. But it would definitely play a role.

ASPRAY: Let me turn to a different question that's likely played out this way. Among all the program officers you have one of the longest lengths of time being around, or at least around in back around here especially of the people around now. So it would be especially interesting for me to hear what you think overall in computing are the areas that the Foundation has had the most impact in - things that we might choose as case studies to look at more carefully: research areas or training programs or facilities programs. If you can identify a few of those that you think are major ones that would be enormously helpful.

BARNES: I think I could identify more than you could study. [laugh]

ASPRAY: Well, mention a number and if there's any way of giving some sort of priorities to these that would be useful too.

BARNES: Okay, I won't try to give them priorities. Maybe we can prioritize them later. Theoretical computer science; there's been practically no support other than outside of the Foundation, and the development has been absolutely marvelous. We have developed within the field its own set of research paradigms, its own sense of what is considered important and good. This grew out of the math tradition, and up until about the time I came to the Foundation (it wasn't caused by me, but it happened within the field) is about the time it really started switching over into its own kind of research paradigms with its own kind of values of what's important and so on. And we just made marvelous strides. And those marvelous strides have led us to be able to then make major strides in areas like VLSI

design, which is very much dependent on theoretical computer science in terms of image processing, in terms of compilers. There has been a number of areas where having a strong theoretical basis has allowed us to move the technology forward. And that support has almost exclusively come out of the Foundation.

ASPRAY: If you were to name somewhere between two and five people that were important people you have awarded grants to in this area, who would you think of?

BARNES: Yes, it could be more than that. I would say Dick Karp at Berkeley, John Hopcroft and Juris Hartmanis at Cornell. Bob Tarjan at Princeton. There's a number more. If you need more I can come up with some more. I am trying to think of ones that we funded early that have really made major contributions.

ASPRAY: I don't want to lead you, so I don't want to mention any names.

BARNES: Roe Kosaraju at Johns Hopkins, Ron Book at Santa Barbara.

ASPRAY: He was at Harvard for a while, wasn't he?

BARNES: He was at Harvard for a while, then Yale, then Santa Barbara. Paul Young at Purdue and now at the University of Washington. Mike Fisher was at Washington and now at Yale.

ASPRAY: That was the first area - theoretical computer science. What other areas or programs?

BARNES: Architecture, but I really think I would defer the discussion of that to John Lehmann, because he was the program director in computer architecture and computer graphics. Computer graphics, we were about the only ones supporting it and now there's, I don't know, a billion dollar industry - something like that - in computer graphics. And a lot of that has its genesis back into the programs that effectively... like we supported. But John Lehmann was the program director and if you are going to interview him he could probably give you a better perspective than I could

on it. That whole industry in a sense has its roots very much back into NSF support and the DARPA support that Evans and Sutherland got. You can't diminish the building of that part of the industry too. But I don't think they can lay the total claim that because we were supporting a number of other people who later went on to produce more Ph.D. students and that sort of thing to impact the field.

ASPRAY: Architecture and graphics anything else?

BARNES: Numerical methods. Again, that was worth probably in some sense an equal player with the Department of Energy and with the Air Force and ONR. I don't think DARPA ever did much in numerical methods. But the other agencies did. There have been marvelous strides in numerical computation.

ASPRAY: Who were some of the major people the Foundation supported in numerical methods?

BARNES: Oh, Werner Rheinboldt, first at Maryland and now at the University of Pittsburgh, Gene Golub at Stanford. We worked in conjunction with the Department of Energy to fund Toolpak, Eispak, and Linpak - all major efforts. Those are the ones that sort of come to mind right away.

In software engineering I think we had a big impact, especially in the testing area, but also in software metrics area.

ASPRAY: That's one field in computing that I don't know much about, so I don't know what the problems are of testing and metrics.

BARNES: Testing is to try to make sure that your software has no errors in it and it also meets your requirements. A very difficult problem, and probably anywhere from 10 to 75% of the computing budget in the country is spent on that issue. It depends on who you talk to. [laugh] So, financially it's a big issue. And I think the biggest contribution we made is building again a theoretical underpinning to it. And software metrics is any kind of process or activity you would like to be able to measure it in some way.

ASPRAY: Measure in productivity?

BARNES: Yes, if you can measure output then you can somewhat... You can't remeasure productivity unless you can have some way of relating input to output. We are not very good at that. [laugh] But some of the strides we have made have been through the software engineering program.

ASPRAY: And again, my same question, who were some of the people that you funded?

BARNES: Oh, Lori Clark at the University of Massachusetts would be certainly one of the key ones. Leon Osterweil, now at Irvine, was at the University of Colorado was one of the ones. Elaine Weyuker at NYU would be another one. Well, that's the sample.

ASPRAY: Other areas, or are those the things you wanted to mention?

BARNES: Well, I guess I am one of these people that thinks everything we did was significant. [laughter] In the programming languages area, again, there's a very rich field of research with a lot of impact that it's had both in our understanding of languages - very much there - but also in the building of commercial compilers. The genesis of those ideas go back to early NSF projects.

ASPRAY: And again to belabor the point, since it's easier to get an overview from you rather than our just looking at the grants and trying to generate those important people, who do you see as the important people here that you funded?

BARNES: Oh, Ralph Griswold at the University of Arizona, John Reynolds at... now I believe he's at CMU, but he was at Syracuse... or was it Syracuse and now at CMU? I can't remember which way it went. [laugh] There's several more. Gary Lindstrom at the University of Utah. You're catching me on a bad day. Usually I can spout out names 90

miles an hour. Who else did we...? That's enough for now.

ASPRAY: What about in the facilities area?

BARNES: Okay, there's another area where NSF has made absolutely fantastic contributions. Two of them: one is in computing facilities. In about 1976 the typical computer science department relied on the computer center at the university for services. It might have had some kind of small machine of some kind to diddle with. There was practically no experimental research going on except at the DARPA schools. The DARPA schools were rich with the stuff.

Well, it was true in 1974 when I came here, but I am saying as each year it became a bigger and bigger problem. It became bigger and bigger in a number of ways. One is that it became sort of a bigger distance and rift between the DARPA schools and the non-DARPA schools. But it also, really more than that, really hindered the development of computer science as a discipline. Without the facilities it was sort of locked into being an analytical type thing - a sort of a mini-math department sort of thing. The first thing we did was establish an equipment program. The equipment program was very successful, in that it scattered a lot of equipment around to universities to get them started into experimental work. Then after that we founded the Coordinated Experimental Research Program, which is now the Infrastructure Program. Most of those programs had their start as an equipment grant. Almost all of them got sort of into the experimental work by getting one or more equipment grants and getting their feet wet and so on and getting an appetite for bigger facilities, then putting in CER program proposals.

ASPRAY: Do I understand correctly that there had been a hiatus between a facilities program and the CER program and for a period of time there wasn't much funding of equipment and facilities?

BARNES: When I first came to the Foundation in 1974 there was practically no funding of equipment. Now, in the early days of NSF - the 1960s - there were major facilities on campuses used frequently with matching funds from IBM and so on. These were for building campus-wide computing facilities. Computer science departments used

those. Computer science departments outgrew those. They had no other source of funding. NSF would have made equipment grants had we gotten requests. The word was out that NSF wasn't funding equipment and nobody requested it. If you ask anybody who was in the field in 1972 or so they will say, "Well, NSF wouldn't fund equipment," which I don't think was true at all. So we came out with the equipment program with a set budget, went into our management, which went into Congress for funds. And I have to say that we got good support from our management in making those requests.

ASPRAY: And this next program was one for equipment for the computer science departments, not for the university as a whole?

BARNES: Right, not for the university. Yes, not to run as a service for research.

ASPRAY: Did that continue until CER?

BARNES: It's still going. Still a very effective program.

ASPRAY: And how does CER differ from that?

BARNES: Those are grants of 20,000 to 200,000 - usually around a hundred thousand dollars. They'll buy you a small system. The CER program are grants of 500,000 to a million. They will buy you a big system, terminals for your station; they'll pay for maintenance and service people. They'll pay for management, some graduate students - that sort of thing. The other one was strictly "Get your computer and it's your problems." Most CER schools, in fact, I can probably say all CER schools, got their start through an equipment grant. It did two things, as did the CER. One is it made equipment more easily available to people, but it also then began to establish a standard for a department, that if the department didn't have a certain level of equipment, it had trouble recruiting. And so there was a lot of equipment by departments saying to their deans, "We have to have this equipment so that we can be a comparable computer science department to our neighbor down the street or whoever they looked at as their competitors in a

sense. And the CER has been very effective in that way in the next level up. You not only had that little machine; you had to computerize the department.

The other area where the impact has just been phenomenal is networking. The first networking program was one just for theoretical computer science. I think that's fun that it's turned out that theoretical computer science was the first network; it wasn't one of the other ones. But we put in Theorynet. That was an experiment. It was centered at Wisconsin. So Theorynet was the first, and that proved to be successful - limited, but successful. And then CSnet went in, which has now become NSFnet - now they're building a national backbone, tying all the regional [networks]. It's just changing the whole structure of universities, all out of the theoretical computer science program.

ASPRAY: Now, I haven't looked at this at all...

BARNES: I don't want to take away from ARPAnet; it was there first.

ASPRAY: Sure, but I guess the question was, in the case of ARPAnet there was a lot of money for putting in the facilities, but there was also a fair amount of money spent early on on basic research on networking.

BARNES: We had been doing basic research on networking also.

ASPRAY: Even before Theorynet?

BARNES: Even before Theorynet.

ASPRAY: That continued as part of the CSnet program?

BARNES: No, it's part of the computer system's architecture program.

ASPRAY: It continued to be part of that, even as CSnet was developed?

BARNES: Yes. And of course now, when CISE directorate was formed and everything got reshuffled, all that research got moved up to the division of networking and infrastructure, Networking, Research and Infrastructure, I think it's called - that division.

ASPRAY: All right, one thing we haven't talked about is education. In what ways has the Foundation contributed to computer education? I know that's an ambiguous term. It can either be CAI and the computer as a tool for education or the development of computer science curriculum and such. In either of those ways... [interruption]

BARNES: Okay, the divisions that I have been associated with have not had what I would call major responsibility in education. The early days of computing before I got here, the Office of Computing Activities had, along with research, an educational component. But that got moved off to Education, so I am really not the best person to discuss that. I think that all the time I was in the Foundation the staff has always wanted to do what it could do. And most of what we were able to do was things like trying to continue support for graduate students. I think the equipment program, the CER program very much had as its explicit goal training Ph.D. students. That was laid out as part of the goals of the program-to increase the production of Ph.D. students. But it's always been, I think, the program directors that were here something that they thought was very important. But we did not do much in the way of curriculum or coursework or that sort of thing. Of course, now we are starting to do that again.

ASPRAY: Let me go back to software engineering for just a minute. One of the things we will try to do is to take the work that was supported by NSF and map it onto the whole picture of development in a research area like software engineering. Can you help me paint that picture, make that map? That is, what percentage that was supported by the Foundation was... What percentage of the total work that was going on in software engineering was supported by the Foundation, and was it a leader in developing certain areas? Were there other players developing certain areas?

BARNES: You ask hard questions. [laugh]

ASPRAY: That way, I don't have to try to get out the answer. I can just rely on you. [laugh]

BARNES: In the area of software engineering there is, probably more so than any other fields, probably dual participation in the research field between industrial and academic researchers. You know, in theory it's probably 5% industrial and 95% theory. Architecture probably should be 50/50 but I don't think the architecture people report it. But I think, you know, in the software engineering areas probably there's sort of an equal balance between the efforts. Okay, so then if we get within the academic world the DoD supported a number of large projects. Some of those were directly software engineering. Some of them, since there were large systems building, had a very much of a software engineering component.

ASPRAY: Can you give me an example or two?

BARNES: Probably the Mach system at CMU. That's more of an operating system than a software engineering project. I'm trying to think of some other ones.

ASPRAY: Let's go on.

BARNES: Within the academic world you had sort of those that were supported by NSF and those that were supported by other agencies. Now, if you look at those that were supported by other agencies it broke down into two kinds - those that were being supported by, like, ONR or AFOSR and those that were being supported by an operational unit in the Department of Defense, which is spending billions of dollars on computing. Okay, that which was supported by the operational thing usually was directed towards sort of solving current problems they had, but being good academic researchers they tried to generalize out of it as much insights and so on as they could.

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BARNES: So now if you look at within those agencies funding basic research in the area we were probably an equal player to the sum of the other ones. So, you know, if you're half and half we have maybe supported probably a quarter. I think probably in terms of actual research we have probably supported about a fourth. In terms of dollar amount it was probably only 10%, because some of these other project things had big budgets associated with them.

ASPRAY: What were some of the notable successes out of the NSF funding?

BARNES: The one characteristic of software engineering research that has been frustratingly slow in producing notable results - very slow. I think that the building of a good understanding of testing has been very much of a contribution that the Foundation has made. I think the work of the people that I cited before is certainly part of that. I'm trying to think. I think Toolpak was supported out of software engineering. Are you familiar with Toolpak?

ASPRAY: Yes.

BARNES: Okay, and I think that at least established the viability of programming environments.

ASPRAY: Right. What about failures?

BARNES: Well, I don't think we had any project that was a failure, per se. But we have really failed to push testing research beyond building a sort of fundamental understanding. We have failed to develop what I feel is a really good metric measurement background for the field. We have really failed to develop real research paradigms that would do a good job of evaluating the software process or processes. There has been a lot of research in software engineering and how do you go about building things? What is the process you follow? And just about everybody has their pet way of doing it. And we have been fairly unsuccessful in being able to really evaluate those.

ASPRAY: As a way of closure in the interview, as we go to write this study, what sorts of general themes do you think that we should be emphasizing? What kinds of things would you like to see addressed in the study that you

think are important to the history of NSF computing?

BARNES: I think that the most important contribution that NSF has made to computer science has really been in developing the field as an intellectual equal of its counterparts in the sciences in the university. It has really gone from sort of a technology-driven - a few sort of eccentrics working usually out of a math or physics department or something - into a full-fledged department that's held pretty much in the same regard as other disciplines. And it's done this in a short time. And I know there are some that say we aren't there yet. But we have turned the corner; we certainly have. And I think this has been very much due to NSF, and it's been very much due to NSF program directors maintaining very high standards on the things they have funded. This has not always been true of all agencies. Part of the problem we have faced in computing at times has been the wealth of riches. People would not bother to come to NSF. They could go down to a Navy lab and pick up a hundred thousand dollars for doing practically nothing. That's been a problem somewhat.

ASPRAY: Within the Foundation, how hard has it been to convince others from traditional scientific disciplines of computing as a legitimate scientific discipline?

BARNES: I think we have had very good success. I think we have had phenomenal success.

ASPRAY: Was the reception an easy one?

BARNES: In retrospect, yes. It didn't seem like it, you know, at the time; you're always fighting for more, and so on. It was always, "They don't understand what we are doing," and so on. But over the years I think we have gotten very good success. You know, we went from, when I came in 1974, or let's say 1976, we merged with math, so we went from a section in the math department to a whole directorate, you know, in 14 years. That's amazing support, in retrospect. Bill Bernard, who is executive officer in the math and physical sciences directorate, was the person much of those years writing the budget. And although he was tough on us, I think he was very supportive.

ASPRAY: Sounds like somebody worth talking to.

BARNES: I think it probably would; it's somebody whose name probably wouldn't come up.

ASPRAY: It's the first time I have heard the name. Any other major themes that you think that we should concentrate on, focus on?

BARNES: Well, I think that was the primary one. And far and away I think we have done in instrumentation and what we have done in networking are the other two main things.

ASPRAY: Okay, very good. Thank you.

BARNES: You're welcome.

END OF INTERVIEW