Dr. Robert Cooper
1981-1985

Interview: February 23, 2007

Interviewer: Could you tell us your name and describe your tenure at DARPA?
Cooper: I'm Bob Cooper and I was at DARPA during the first term of the Reagan administration, from 1981 until 1985.

I: It was ARPA then, wasn't it?
Cooper: No, it was DARPA by then.

I: What was your path to the directorship of DARPA?
Cooper: Ah well, I guess it was a reasonably long path in the sense that I was on the faculty at MIT in the Electrical Engineering Department, and I consulted at Lincoln Laboratory. And Lincoln was a favorite place for DARPA to get really smart people to work on some of the problems they had and so I learned about DARPA at that time. I was just a young faculty member and thought, "Gee, I like working with these guys. Maybe I'll go work at DARPA someday." And I'd always kept that in the back of my mind.

I became friends, because of my research, with Johnny Foster, who was the Director of Defense Research and Engineering for many years, which was sort of centered around the Nixon administration. At the time I was on the faculty, he was the director of Lawrence Livermore Laboratory, and was doing some work that interested Johnny having to do with the way you heat plasmas and how they come apart when you heat them and so on.

And one day, I got a call from Johnny to come down to visit with him and he suggested I come down and do some time on the Secretary's staff—when Laird was Secretary of Defense and Dave Packard was Deputy Secretary. I managed the high-energy laser program, which was exploding at the time—all the military space programs, and the connection of the research that was going on in the Pentagon with the intelligence community. So, I worked on that stuff for

a few years and was headed back to the campus to pick up my research again, when I got a call from Jim Fletcher, who I had become close friends with because of the space relationship between NASA and the Defense Department.

Jim asked me if I would stay in Washington and manage the Goddard Space Flight Center, and I told him, "no"—I wanted to go back; but he said, "Look, why don't you go out to Goddard and have a look at it and see what you think?"

So, I went out and looked at Goddard and said, "Hey, this really looks like a neat place to do some really wonderful things for space." I was interested in some of the things they were doing scientifically, as well.

So, I did that. I stayed there, and when I finished that tour I committed to four years and on the day that I was getting ready to go back to Boston again, I got a call from Dick De Lauer who was an old friend from TRW. We had worked together on the tracking and data relay satellite system that Goddard built for NASA, and he said, "Look, why don't you come and take over DARPA?"

And I said, "Gee. I've been thinking about that for about 20 years (chuckles), maybe now's the time." So I did. I agreed to go back, and that's how it happened.

Dick was on Cap Weinberger's staff, and I went there shortly after the Reagan administration came to power in 1981, and I agreed to stay for four years. In the middle of 1985, I left and started up my own company with Larry Lynn and Jeff Buffalano, my two deputies at DARPA.

So, that was my tour through the science and engineering activities of the Defense Department over the years.

I: I want to ask you about Johnny Foster. He's been described as a pretty tough character.
Cooper: He's one of the nicest people you will ever, ever know, but when he gets his mind set on doing something, he is tough. And he gets his way—no question about that—with his bosses and with his associates.

I: There was a story I think I read that you had some doubts about space.
Cooper: That's right. I didn't know a lot about the space program when I went to work for Johnny, but basically, in the Defense Department, it was a management problem. That is—the space programs were set largely by the military departments and their desire for certain capabilities, but they never could manage it right. The National Reconnaissance Office was different. They were set aside, and more like DARPA. They could manage things and get things done in a hurry. The Defense Department always had difficulty with COMSATs and with other satellites they needed—the navigation satellites and so on.

So the first big job I had when I got there was getting the Services to work together on the Global Positioning System. The Navy and the Air Force were at loggerheads. Each wanted to build their own system that had a different configuration—a completely different configuration. And no one was in charge in either one of those places who could actually have done the job.

So, I got together with Johnny one day and said, "Look, Johnny, why don't

we have a joint program? I know how the Services hate joint programs, but let's have a joint program with the Army, Navy, and Air Force. The Navy and the Air Force could be co-deputies with an Air Force person as the final decider."

And he said, "That sounds like a good idea." So we set up an arrangement like that. I asked the Air Force to give me five persons' names who they thought could be the manager of this whole enterprise, and interestingly, one of the names they gave me was a former student of mine at MIT. He was a fantastic guy. His name is Brad Parkinson, and he was *just* the person to do the job. He was a colonel in the Air Force, and he was one of the brightest students I had while I was at MIT. We worked together for the full time I was there. He set up the joint operation, and the GPS system is what it is today because of Brad Parkinson. He was able to bring the Services together on that one program. It was a fantastic program.

I: It's kind of neat that you're responsible for GPS.
Cooper: It reinforced my interest in space, generally. There were a lot of other space programs at that time that were kind of interesting to me, as well—principally some classified ones. But I think that's probably what lured me into the Goddard Space Flight Center situation, and some of the things we did at Goddard were fantastic.

The whole structure of cosmology today is based on a satellite we put in orbit while I was at Goddard. It's a cosmic background explorer, and it looked at the cosmic background after the Big Bang. At that time, no one had been able to figure out why there was structure in the universe, why there were stars and planets, and all the major structures, such as galaxies, in the universe. And you could see them form in the data in the infrared from that cosmic background explorer, which completely changed the approach that people took to theoretically trying to understand how the structure began.

And there were a number of programs like that at Goddard that were just absolutely *wonderful* things that I got involved in and really loved. It was a great time for me.

I: So, you maintained your science interest, then.
Cooper: Oh, absolutely.

I: When you became director of DARPA, did you bring that interest and maintain it?
Cooper: Exactly. As a matter of fact, when I arrived, one of my major interests was the basic research that ARPA was doing. Nowadays ARPA doesn't do much basic research, but then it was doing about $300 or $400 million a year. That was one of my major interests to build up the research and to figure out what the Defense Department really needed for the future in the way of breakthroughs in basic research. I wanted to find out what the communities were doing, put more money into it, and use ARPA as a stimulus for that kind of basic research.

I asked Chuck Buffalano, one of my associates at Goddard Space Flight

Center, to come and work with us at DARPA to organize the basic research, and Larry Lynn organized the part that was more applied research and system-oriented stuff. So, he was the systems guy and Chuck was the research guy. I worked with Chuck closely on some of the basic research, and some of the things that we did there, I think, really made a difference.

An example is, perhaps, the thrust we had to take to make artificial intelligence available to the Defense Department. The progress that had been made over the preceding 10 or 15 years was not getting into Defense Department systems, and we did a great deal to a make that happen in a major program that we sponsored at DARPA.

I: AI is one of those areas that has come and gone, in and out of directors' focuses, if you will.
Cooper: Right.

I: So, what was the Agency like when you finally became the director?
Cooper: Well, it was divided into several offices: the Strategic Technology Office, and the Tactical Technology Office that worked on more battlefield kinds of programs. The strategic guys were working on things that were interesting to the ballistic missile defense community, to the precursor of the STRATCOM organization and so on.

There was a basic research organization that worked on materials technology, electronics, and that sort of thing. Then there was an organization that was run by Bob Kahn that was oriented toward software and the use of networked computer systems. It was built around these expert folks organized into offices. Each office had maybe about 20 or 30 program managers—very level organization. There was the director, the office director and the program managers, and you could interact as a director directly with the program managers and right down into what they were doing in great detail, which I did, and I think which most directors did.

It's that flat organization and the leadership you can inject into such an organization that I think really makes ARPA a wonderful place to work. Just a great place.

I: So, you wore several hats.
Cooper: Okay. One of the things that Vick De Lauer asked me to do—he said, "Look, I'd like to have you come and run DARPA. I've got some things that you could do for me that would really help." And one of those things was to help him to understand, again, the space programs, because we had worked together on space before. He knew that I had breadth of interest in military research and development programs. He said, "We never have been able to look ahead and make sure that the technology we need for our new systems as they're coming along is mature enough to be able to scale up and as a result we spend a lot of money on in those systems. So, what I'd like to have you do is set up a little office close to me that looks at the military space programs again and gives me advice on those. But also to look broadly at all of our big upcoming system-

development programs and assess whether the technologies that are going to make those possible are really ready, so that we don't get into trouble where we're spending big bucks, but the technology isn't ready, and the program fails."

He gave me two billets (chuckles), which I promptly filled with two long-term associates of mine in the Air Force. One, Don Hammerson, was a one-star general, and the other was a bird colonel I'd worked with in the past. We essentially set up an operation that advised Vick on the question of the maturity of technologies in relationship to big development programs we were planning in the Defense Department over a period of years.

One of the first big jobs that we got was when President Reagan announced he was going to have a big ballistic missile defense activity. We put together the Ballistic Missile Defense Organization, BMDO, the Strategic Defense Initiative, and populated it with people who were going to be major contributors. I then aggregated all of the programs in the Defense Department that were aimed at ballistic missile defense, estimated when the technologies that would support big system developments in that area would be ready, and gave advice to Dr. De Lauer and Cap Weinberger on that.

I: You were almost the "science honesty broker" again?
Cooper: Again, that basically was what I was. I looked at what the Services were doing and what the intelligence community was doing and determined whether the big systems were going to fail as a result of the fact that the technologies weren't ready to be injected into them.

I: The geopolitical climate background you were operating in determined an awful lot of how you structured things.
Cooper: That's right.

I: Tell me a bit about that.
Cooper: Well, back in those days, the whole thrust of the Defense Department was to counter the Soviet Union in the Cold War. And as a matter of fact, one of the things that attracted me to working closely with Vick was that I was given the title of Assistant Secretary of Defense. I was on the secretary's staff then, and a member of the Defense Resources Board, which meant that I could see where all of the money was being apportioned for Defense Research and Engineering firsthand. I could make representations directly to the secretary and to Vick about what I felt was appropriate or not.

And , it gave me such a good overview of what was going on in the Defense Department, that I could steer DARPA much better than I think any former director was able to, just because of the breadth of knowledge I had of what was going on and what was being planned in the Services. I had a complete staff to keep me informed of all of that, so that I could take that information over and use it in the direction that many of the programs at DARPA weren't taking.

The first day I walked into the DRB meeting, Cap Weinberger was there with all the Secretaries of the Services, the military chiefs of staff, the senior staff

members of the secretary's staff, and all of the assistant secretaries. And what I couldn't believe was when Cap stood up and said that the President had decided they were going to double the defense budget within the next three years. Everybody looked around at one another, and I said, "Cap, I've heard that song before, and I don't think the public is going to support doubling the defense budget in the next three years."

Three years later, it was *more* than doubled, and we were spending money like it was going out of style. I mean it was fantastic. We had resources that were really amazing.

So, the view I had of what was going on in the Defense Department, I think, far exceeded the view a typical ARPA Director would have had. And it was because of these other jobs I had; it was seven days a week, 24 hours a day for four years. But it was a lot of fun. A great ride.

I: With all the resources you had available and with reestablishing the basic research, my understanding is that prior to that, relationships that DARPA or ARPA had with the universities had been sort of scaled back

Cooper: That's true.

Well, it had been because of the fact that at that time, there were many proposals to find out if it was feasible to build large systems in DARPA. Typically, that drained money out of the defense-research base and put it into big- system developments and that was what was happening to DARPA. Its budget wasn't expanding. It was before the Reagan initiative to increase the defense budget. For many years before I got there, money was draining out of the basic research programs in DARPA. It went to support things like the Stealth aircraft that were being developed at that time, which were prototypes and very expensive and other things of that sort.

And so, I got there at a time when the budget was expanding, and I could begin to build up the basic research activities. I did so, in materials science, in the computer sciences, in software development, and things of that sort in the artificial intelligence area. We decided to make a major push there, a thing we called the Strategic Defense Initiative. I was able to make a lot of progress, I think, in the basic research activities of DARPA. They could be done selectively and have impacts that were far beyond what you would normally expect.

I: And an expanded budget helps expand the vision; to better see into the future. It seems there's always been an interesting balance between science and engineering. Had that balance been skewed more towards the engineering?

Cooper: More toward the engineering, because there were a number of really good ideas about large engineering projects that would be useful to the military departments, that should've been funded. And when you look around and try to balance that and find out where the money is, you often will take money out of the basic research programs, which were long-term. Basic research has less certainty in the payback. But, when you have an engineering project that's staring you in the face, and you say, "Boy, if I could just make this one thing and make it work, then we could build a whole bunch of these widgets, and the guys

on out in the field would really have a major advantage," your tendency is to want to do that. It's more certain. It's more near-term. You'll see the results in three-to-five years, at most. So, it's very attractive to shift resources in that direction.

I: That was done probably for political and survival reasons.
Cooper: Sure. Sure.

I: It seems you get fascinated by the idea of SDI and Star Wars. I think you called it a witch's cauldron.
Cooper: Yeah.

I: Talk a little bit about that because, to me, it's visionary.
Cooper: Yeah, it was. There was a lot of debate, I guess you'd call it, within the defense intellectual community during that time about the efficacy of a ballistic missile defense system, and it had largely to do with the scale of a system that could cope with the thousands of ballistic missiles that the Soviet Union had aimed at us by that time. It was difficult to see what technologies to invest in and how long it might take for them to mature to a point where an effective system could be built.

There were studies going on. Jay Keyworth was the scientific advisor to the President at the time, and he had a study going on about whether ballistic missile defense was feasible or not, and I helped to fund that study. Of course, DARPA participated in it because it had many of the advanced technologies that were being worked on for ballistic missile defense right there.

As the study was being completed, the results clearly were negative. They showed that it was going to be many years before technology would be able to cope with anything near what the Soviet Union had arrayed against us. But, when the President made his announcement, the study disappeared in a flash of smoke, and suddenly there was wild enthusiasm in the Office of the Scientific Advisor to the President about a ballistic missile defense, and things moved forward very rapidly after that.

As I mentioned to you before we started this interview, I had spent probably two or three months after the President talked about making ballistic missile technology, basically, discussing the efficacy of ballistic missile defense with Cap Weinberger. I believe Cap understood the long-term nature of the problem and that it would be many, many, many years—maybe many decades—before technology would be available to cope with a force the size that the Soviets had arrayed against us. Yet, we found ways to move forward in developing those technologies without endangering the defense budget, and we were making real progress toward a goal we always admitted was pretty far out there. We weren't doing something that was that was uncalled for, but it was in clear recognition that we had a long road ahead of us to be able to build a system that would be effective.

And we're still working on that today. We're still at the point where we're wondering whether we could deal with a few tens of ballistic missiles from a power like North Korea, as opposed to the thousands that we had to

contend with in the Soviet Union –many of which are still there.

I: I remember the early arguments against ballistic missile defense systems. Was the science basically put in place to support a political poker hand?
Cooper: Well, I think the whole thrust of the President's enlargement of the defense budget was a poker-hand type of operation, and at the time, the Central Intelligence Agency was estimating that the Soviet Union was spending somewhere between 10 and 20 percent of its gross national product on defense measures of one sort or another. It was felt that we should up the ante, both in our spending and in the high-tech content of the programs we were after, and we went after new ballistic missile offensive systems. We did a variety of things with conventional weaponry: making conventional weapons much more lethal by accompanying them with intelligence, surveillance, reconnaissance and precision-guided munitions—things of that sort—which frightened the Soviet military hierarchy tremendously. They wrote books about it and often commented in their secret communications with one another, which we intercepted, about what we were doing.

And so we drove the Soviet Union into bankruptcy, basically, by making them continue to spend more and more of their gross national product on defense. I think that finally they just realize what they were doing, and it caused the system to collapse.

So, in a sense, Reagan was right. He spent them into the ground by the things that he was doing and also by his public pronouncements of the reasons.

And I couldn't believe it. It was certainly counterintuitive to me when I walked into that first DRB meeting and heard Cap say that that was really what was going to go on: "We are going to spend them into the dirt." And four years later, it was done. I mean, it was a *fait accompli*.

I: What slice of the GNP were we spending?
Cooper: Six percent and that was after the build-up.

I: Which we could sustain.
Cooper: Which we could sustain. Our gross national product was enormous then, and, you know, at that time, the Soviet Union was really not a major economic power, so they were spending big bucks just to keep close to what we were spending.

I: Did you go to the Soviet Union after the collapse—or even before? Did it surprise you what you saw over there?
Cooper: I did not go over there, but I did read all of the intelligence reports of people who did go and, in a way, it didn't matter because I was close to the intelligence community for many years. We worked together on programs, and in particular, I had a strong association with the head of Program A at NSA that kept track of the Soviet Union. And they were in bad trouble economically. It was clear that they were not managing their country's economy in a way that would allow them to be a competitor of ours in the long run.

I: What were some of those areas you began to explore that you could look down the road and say, "You know, ten, 15 years down the road, this is going be a pretty neat thing"?
Cooper: Well, a good example is in the Strategic Defense Initiative. We divided the program into a number of goals. One of the goals was to create a technology that would automate much of what goes on in a modern fighter plane, so that the pilot wouldn't be in continuous overload. And, so that much of the kind of thinking that the pilot does could be done with this new technology in artificial intelligence.

It turns out now that the F-22 and the F-35 both have technology in them that grew out of that program and which we knew that we would need, but we didn't know how to do it at the time. And so we set out to have a pilot's associate in that program which would make those fighter planes feasible in terms of the ability of the pilot to control them without having a major overload problem—information overload problem.

We could see that the systems required something that just didn't exist, and, yet, there was technology on the campuses that, if matured and brought into the system developments at the right time, could make them happen and could be very salutary and beneficial

I: Did you facilitate liaison between universities and contractors?
Cooper: Absolutely. As a matter of fact, we *required* in many cases that development contracts that were doing prototype developments of these new technologies in systems had to have both an industry and a campus part to them; that they had to come together and do it in a joint program, basically. And that was one of the ways that we got the stuff off the campus, made folks on the campus more sensitive to the fact that they had to get something done in a particular time, at a particular price, which was counter to what (chuckles) you normally find on a university campus.

I: Dealing with universities was a real pain (chuckles)?
Cooper: It *was* a pain, but finally they did come around and there were a lot of relationships that were built up between the defense industry and the campuses that I think still endure.

I: Were there pent-up animosities left over from Vietnam?
Cooper: I don't think that was much of a problem for the science and engineering community on the campuses. Those feelings were more over in the more social science departments and so on. I think it was not difficult to enlist the help of the science and engineering communities on most campuses to help in defense research and engineering.

I: It was probably to their benefit to make the connections with industry. And so the think-tanks kind of got together? Is that how it happened?
Cooper: Well, no. I think the individual researchers got together with the

researchers in the laboratories of some of the major defense contractors, like Northrop Grumman and Lockheed Martin and so on, and created joint programs. There was good research going on at the campuses. In many cases, it was superior to what was going on in the industry. They recognized that, and they took advantage of it. And they *still* do.

I: This constant funny relationship with the Services—talk a little bit about the relationships with the Services.
Cooper: Well, the Services, I think, all view the funding that DARPA gets—and DARPA's funding is substantial, it's several billions of dollars a year as their money. They think it's been taken from them and given to DARPA, and so they resent it to a certain extent. And so every DARPA Director is in a position of having to court the senior members of the various service programs and to essentially get a rapport with them so that DARPA ends up working on things that really count; that really would make a difference for the Services. And in order to do that, of course, you really have to know what their big problems are and in detail.

And so there has always been in DARPA, for every Director, the problem of making sure there was a lot of contact between the program managers and the program managers in the service programs, and that we really did understand in detail, theoretically and practically, what their problems were so that we could take known, potential solutions to those problems, put them together and try to interest them in those solutions. And in many cases, we could actually get the program managers in the Services to manage the programs at DARPA that were being funded by DARPA to produce equipments, concepts and ideas that would help them.

I: Each service, at different stages, offered resistance to the transition of programs?
Cooper: Oh, yes. Oh, yes.

I think one of the biggest successes we had while I was at DARPA involved a major campaign that took many years to get the Services to agree, and this was the moving target indicator radar systems that we put into some aircraft and tested. It finally resulted in the Joint STARS aircraft that has been so effective in doing for ground surveillance what the airborne warning and surveillance aircraft had done for airborne surveillance.

Synthetic aperture radars essentially look at the ground and can identify all the targets that are down there, identify where and what their targeting coordinates are, transfer those to aircraft or other weaponry, and have those weapons attack.

That program had to have the Army and the Air Force and DARPA all agreeing as to what kind of a system needed to be built, what were its capabilities, how would it fit in with the rest of the systems that existed in the Air Force and the Army, and so on. We literally got pushed back from the Services for many years, and finally we built the system, and tested them. They were so effective, that we actually took the developmental aircraft to Iraq during the time

the Iraqis were being forced out of Kuwait. And everybody remembers seeing in the newspapers and elsewhere the highway between Kuwait and Iraq scattered with broken Iraqi equipment, and those were the J-STARS images. The J-STARS targeting was what made it possible to just ravage the forces that were retreating back into Iraq from Kuwait.

And now, the J-STARS aircraft are really some of the most coveted weapons systems the Air Force and Army rely on. They really love those systems now, but they were dead set against them when we were actually developing them.

I: Any other struggles come to mind?
Cooper: Well, the Navy is particularly (chuckles) recalcitrant, I think, with respect to some developments that ARPA has made. We talked briefly before about the development of low-frequency communications with the submarines, and that ARPA had a laser communication system it was developing that made it possible to put blue-green lasers on satellites and to communicate directly with submarines that were many hundreds, even a thousand, feet underwater in areas where the water was reasonably clear. And the Navy just absolutely fought that program tooth and nail, because it was going to be very expensive, but it would've given them instant communication with not only the nuclear weapons-armed submarines, but with the attack submarines, as well.

And I think the reason for that is that submariners just don't like to communicate with anybody onshore. They like to be out there alone, unafraid and fighting their own war out there alone. But, of course, they can clearly be much more effective if they can be part of an overall operation and have communications that are secure and don't give away their location.

But we never were able to convince the Navy to do that, although we did prosecute a program, did a number of experiments that showed that it was quite feasible to do that, but the Navy was just not going to buy that at the price they would have to pay.

I: A couple of paths. Acquisition budgets are one. Tradition is another. Did you run head-on into tradition at all?
Cooper: Well, in a way, this submarine example *is* a tradition. I mean the submariners are known to be very isolated and insulated from the rest of the community. They form a community of their own, basically, and it is traditional for them to operate that way. And systems that require that they somehow become more integrated into a whole are just counter to the tradition of the service.

I guess (chuckles), to a certain extent, all naval vessels are that way. Once they leave land, they are a force unto themselves, and they fight their own battles - although if they can fight in an integrated fashion with other weapons platforms, they can be more effective. But the captain has always been the master of his ship, and he is alone. His decisions are final, and he's almost a god onboard the ship, because he controls the law of the ship and all of the details of what goes on and all of the command structure. And he is pretty much

isolated from things that go on onshore.

I: It suggests the difficulty that I think every Director has had to face with transitioning programs into the field.
Cooper: That's one of ARPA's big problems. It has always been that way, from the time that Herb York started the organization until now. In many ways, it's the way of looking at DARPA. DARPA looks around in the scientific and engineering community at large in the whole United States. It searches for the best ideas and the brightest people and tries to find technologies and techniques that would be useful militarily. Then it tries to create a system of some sort that would be militarily useful and to sell it, or to transition it from a nascent technology to a relatively mature system that can be helpful on the battlefield.

And it's that transition from the funding that DARPA gives it, to the production funding that the Services have to give to it—that is a real jump. It's a real problem, and it has been a problem for every director.

I: Did you come up with any kind of solutions to that, other than literally door-to-door selling?
Cooper: No (chuckles). I'm afraid there is no general solution to that problem. It's just hard work on a one-on-one basis with the people in the Services at a number of different levels. ARPA has used the technique of getting memorandums of agreement that say at a certain point in the development of a system, the funding will shift from ARPA to the service, and the service will pick up the funding and begin the development for production. The challenge is to get the most okayed, signed, sealed, and delivered by the Assistant Secretary of the Air Force, Army or Navy for R&D. You've got this memorandum of agreement. In truth, it isn't worth the paper that it's written on because it's always subject to the availability of funds, that the service secretary will say, "Sorry. We don't have the funds to do that, and so our memorandum of agreement is null and void." And there is no court you can take that contract to in the government that can force him to live up to his agreement (chuckles). So, those contracts are not contracts in the way that we would understand them in industry.

I: There's a funny budgeting disconnect between the two. ARPA can fund things pretty quickly.
Cooper: That's right.

I: Services can't.
Cooper: That's right.

You know, the reason why DARPA is as great an organization is at is, is a result of three factors. One factor is that it's connected directly to the Secretary of Defense, and so from one point of view, the Secretary is the only one who can say no to DARPA. Secondly, there is a tradition, starting with Herb York, of adequately funding the DARPA budget in the defense budget, and that is a result of the fact that the decision is made by the Secretary, and there is nobody between DARPA and the Secretary to say "no" to the budget. So there's been

adequate budgeting for DARPA's programs. And, third, there is a history of the Congress going along with DARPA programs. They love DARPA. They often will give DARPA more than it asks for certain programs, especially if it's in the programs are being done in the district of some congressman or senator in their state. And so DARPA has had little difficulty in getting funds. And those funds are given in broad categories, as opposed to a program at a time.

That is, typically, DARPA has insisted on funding for major program segments, which means it can move funds around within those program segments to get things done when they needed to be done. And, typically, after the beginning of the budget year, the military departments may have allocated all of their funds for the year with virtually no reserves at all. DARPA may well have allocated its funds adequately over the programs it had, and may have 20, 30, 40 percent of its funds still available for relocation or for new programs during the fiscal year. And that is unusual in government. It doesn't exist in any other program areas that I know of. DARPA has had excellent success in having flexibility for moving funds around and starting new programs, even late in the fiscal year.

I: Dealing with Congress—they can give DARPA too *much* money. Now you were there during a ballooning of the budget.
Cooper: Yes.

I: So, how did you avoid that danger?
Cooper: Well, in essence, there *is* no such thing as too much money, because, typically, R&D money—particularly that in more advanced phases—that is 6-2 and 6-3 funding—is money that can be spent over several years, and so it does go beyond the current fiscal year, so you can save it up and spend it next year.

But having too much money around in basic research programs—basic research programs by and large run out at the end of the year, so if you haven't spent the money by the end of the year, it goes away. But in these other categories, which are more development-oriented, the funding does last several years.

I: There wasn't a ballooning of the bureaucracy because of that?
Cooper: No, you find ways to spend the money (chuckles) with the folks you have.

I: When you walked in and looked around DARPA, were there any tough decisions you had to make concerning maybe personnel or projects?
Cooper: Well, yes. And there were some projects that we did shut down over time, and there is a policy at DARPA that has been extended by virtually every Director, that the personnel turnover at DARPA is managed on a three- or four-year schedule. That is, people can come to DARPA, work there for three or four years, but they have to leave after that. And I think in some sense, DARPA being a 50-year-old agency now, it has not suffered the bureaucratic inroads that many organizations started shortly after the Second World War have had.

Others started during that period of time suffered. DARPA has had new people, new ideas coming into the organization on a regular basis and that keeps it vital. And I think in many ways, DARPA is as vital today as it was 20 years ago when I was there, and maybe even as far back as when it was first brought into being by the Congress in the 1958-59 time period.

I: Was there ever a temptation to get into the business of running labs or things like that, that DARPA has avoided?
Cooper: Yes, that's true. Another policy that DARPA has kept over the years that it doesn't build up any institutions it has to support. And I can't think of a time in any of the directors' tenures I know where there has even been a tendency to do that. I know that DARPA has built some facilities, like the facilities at Kwajalein Atoll, where the ballistic missile radars—instrumentation radars are located. That has been supported by DARPA off and on over the years, but basically that has all shifted to the Ballistic Missile Organizations. Only new instrumentation equipment is the kind of project that DARPA might take on has been put into places like that—Kwajalein being an example. But the policy clearly is you don't get into those and stay in them forever. You get in and get out.

I: I'm curious about the transition into the directorship role—did you communicate with past directors at all?
Cooper: Yeah, there is a tendency for directors to want to put together small groups of former directors for advice and counsel from time to time. We have a small group of people who get together with Tony Tether, the current director, with Johnny Foster (chuckles) interestingly enough from time to time to sort of look at programs and find out what his problems are, give him advice and maybe even try to help him in some ways with particular problems he may have. And I think that has been the case for just about every director. They seek out former directors, people who have had the experiences that they're going through and seeking advice from them.

Finally, I got together with Bob and Vint Cerf, who was one of his colleagues, and those two probably are the people who are most responsible for starting up a small institute where he promoted the ideas of using the Internet to do business, basically. So, I think Bob was there, like, eight years, and Vince there maybe seven years. They also got the Presidential Medal for their work on the Internet.

I: About your relationship with Congress—talk a little bit about that. Did they go along with the President's budget?
Cooper: I think there was broad support in Congress for the requested increase in the defense budget, and that carried over into ARPA's budget as well. So, we had probably as easy a time working with the Congress as any ARPA director either before or since, maybe. And it is true that they had their favorite programs. They did lavishly support those programs.

A good example, I think, is the programs that we had in space-based

lasers for ballistic missile defense, a far-out technology, one that is still a long way from being able to be realized with the technologies that we have available to us today. But the story that goes along with the techniques and the technology we were developing—it was so exciting—I think Congress really did overdo itself in supporting that technology.

We built a number of huge lasers—prototype lasers. We put together space experiments to test the optical systems that would be required to support such a system in space. We developed all kinds of materials and machinery that could grind the optics that would be required, materials for the optical systems that would not be destroyed by the very, very high-powered lasers that were being developed and so on. And we would estimate what the cost of creating those things would be and testing them and Congress would invariably increase the dollars in those programs because they were so excited about what was being done, and they wanted to make it come true faster. They would always say, you know, "If we increased your budget by 20 percent or 40 percent in this area, could you do it faster? Could you get it up there this year, rather than next year?" That sort of thing. And that was always the question that was being asked.

I: How were you going to power such a thing?
Cooper: Well, the lasers were all chemical lasers we had in mind, and the chemicals themselves had the energy to be able to create the inverted optical populations and—and they were *enormous* powers. The powers were in many millions of watts of power would come out of the front end of those lasers, and all it had to be was to be focused down on a spot maybe about this size on an object that was traveling three kilometers a second, a thousand miles away—a simple problem (chuckles) .

And, interestingly enough, we're still working on those things. DARPA is not working specifically on that problem, but the Air Force has a program called the Airborne Laser Program, which has a very high-powered laser that fills up the whole inside of a 747. The technology was born in ARPA, and can reach out hundreds, if not thousands, of kilometers and put lethal force on ballistic missiles. And that program is in full swing. It has already spent several billion dollars in the development program, and the aircraft, the laser, and the optical systems are flying now and being tested over the next couple of years.

So, there's still interest in it, it's still being pursued, and probably will be throughout our lifetime and beyond, because the promise is so great, and there is a need to protect from ballistic missile attacks.

I: McNamara apparently really liked the idea.
Cooper: Yeah.

I: He basically, to I think it was Herb York at the time, said, "It's not going to work and here's why" and that was enough for Kennedy to say, "All right. Just kill it."
Cooper: Yeah. Yeah.

Well, DARPA was actually created to prevent surprise from technologies

that might be being built elsewhere, but one of its first and major programs was the Ballistic Missile Defense Program, and it was—it *has* been seeking technologies that could cope with ballistic missiles and destroy them ever since—50 years' work.

Lincoln Laboratory, where I worked for a while, was involved heavily in that program. The program was called Project Defender, and it was a huge program. Only later did the Army become involved in the program and take over the major development activities and testing. But ARPA has continued over the years to be involved in creating new technologies that might be useful in ballistic missile defense.

I: And sometimes inventing whole branches of science. Did that happen? Did that sort of science blossom under SDI?
Cooper: Absolutely. Absolutely.

For instance, it was recognized early on if we were serious about trying to get ballistic missile defense programs that would come to fruition within a few years, there was a major problem in controlling the targeting and the information that was flowing around in that system, and that the technology wasn't there to do it.

And so both new software and hardware had to be sought. New techniques, new ways to do that had to be sought in order to make it even feasible to do it. And in some ways, we're still not there yet, so we had basic research programs in microelectronics that needed to work to be able to cope with some of the electronic problems that would exist in those systems.

So, it's true that whole new approaches to various problems that exist in military problems get created at DARPA. Early on in the Defender program, there were no really satisfactory infrared sensors. We needed infrared sensor systems to be able to look at warm bodies that were traveling through space and to be able to see them and target them. And within a few years, there were major, major programs at DARPA to create new sensors that operated in the infrared, in the short-wave and long-wave infrared, that could accomplish that purpose. We have optical systems that could see these ballistic missiles traveling in space from one continent to another.

I: Processing the amount of information, maybe thousands of different missiles traveling at different arcs and different speeds.
Cooper: Yeah, right.

I: Was that the thinking that determined the existing technology was too slow?
Cooper: Well (chuckles), if you try to design a system that would actually cope with this problem, you would find out that the equipment that was currently available wouldn't work, and speeding up silicon technology was one option, and that option was pursued. What DARPA did was start a completely new technology in gallium arsenide and try to make digital gallium arsenide equipment, since the intrinsic properties of gallium arsenide are about five times faster than the intrinsic properties of silicon. We thought that was a very

promising area, and so we invested an enormous amount of money in that. That naturally went over into the Strategic Defense Initiative, and there are now digital systems that operate on gallium arsenide that are extremely fast.

Since that, of course, silicon technology has gotten faster, too, and so it's still a race.

I: The submarines—an interesting story of why that became an option and how Congress supported that. Tell us that story.

Cooper: Okay.

DARPA worked for a number of years on low-frequency radio techniques. it turns out that very low-frequency radio can penetrate the saltwater in the ocean down to a certain depth—not a great depth, but down to a certain depth—so that it could communicate with a submarine and give it instructions on, perhaps, releasing its ballistic missiles to attack a certain country, or whatever. Very short messages because the penetration was not that great, and it took a good deal of time to get a reasonable-length message to the submarines.

DARPA was working on that technology that had been proposed to the Defense Department and to the Congress to build a sizable antenna that was about 150 miles in length in the state of Michigan. The Michigan delegation didn't like that, because there were people who were saying that the radiation that would come from the radio with this huge antenna in Michigan, could cause people to be medically affected one way or another. We did extensive research and determined that that was not the case, and so we were going ahead with that. And the congressional delegation was, of course, responding to the public sentiment there.

We had another technology that we were working on. It turns out, of course, that seawater is relatively transparent in the blue-green. That's why the ocean is blue-green. And this was a laser technique that would use a blue-green laser—one that was tuned to that transmission region in the ocean. The lasers would be carried on satellites at geosynchronous orbit, and they would be aimed at the ocean to areas where the submarines were known to be patrolling, and they could then transmit messages at reasonably high speeds down through that window in the ocean to the submarine.

We briefed that to the armed Services committees in the Congress, and they were wild about it, particularly the delegations from (chuckles) Michigan. They were wild about it, and so they lavished that program with way more dollars than we could spend on the early part of the program, where the technologies were not very mature and we were feeling our way.

But on the other side of that problem, the Navy recognized that building a big space program with four or five, maybe six satellites in geosynchronous orbit with these big lasers on it and putting the receivers on their submarines and so on, would be a very expensive proposition, so they were dead set against it. So we had the Congress on the one hand lavishing funds, and on the other, we had the Navy pushing back on that program. Although we did make a lot of progress on the technology, showing that it was feasible from aircraft to submarines and building equipment on both sides –the lasers and the receivers to do the job—it

never did go anywhere. The Navy just would not pick up the technology and run with it.

And also, the antenna in Michigan didn't go anywhere, either, so the Navy had to settle for a smaller system that's located in another location to communicate with its submarines, and that communication is not all that satisfactory.

I: Back to semaphore.
Cooper: (Chuckles.) Back to semaphore.

I: (Chuckles). Some projects you may have had to eliminate to make room for some of these other projects—were there some that you went, "Boy, I don't need to keep that"?
Cooper: Yeah, there were a couple of those. One thing that I'm reminded of is the fact that Bob Fossum, who was the director just prior to me, had been working on an experimental aircraft that had major parts of the aircraft structure built out of plastic components. And we really didn't know very much about how to design aircraft that had these very light, but very strong, structures on them, and this was an example of an attempt to get control of the design principles that should be applied to that.

The aircraft he was working on before he left DARPA was an aircraft called the X-29, and it had forward-swept wings that, if not designed properly, could peel back and be destroyed just by the maneuvering of the aircraft. But if the design were done properly, it would give the aircraft incredible maneuver capabilities, so that in a dogfight it would be able to turn inside of any known aircraft available to adversaries at that time. So, it looked like a real winner from the standpoint of dogfighting, but you could lose your life if the design principles were not really well founded. So the wings and the other structures that were made out of these materials had to yield.

So I looked at the program, and it turned out that what was happening in the strategic aircraft concept area at that time was that dogfights were going out of style. You just don't want to get close to your enemy. What you want to do is build an aircraft that has radar on it that can see the enemy hundreds of miles away. And you need to have a missile that can travel those hundreds of miles and engage him automatically and kill him before he gets anywhere close to you and anywhere where he could be a serious problem for you.

And so the question was: should we continue with this aircraft that was going to be a magnificent, maneuverable system for dogfighting, or should we yield to what was happening in the world and say non line-of-sight weapons systems in aircraft were the wave of the future?

We said, "Well, look. We may want to build aircraft out of very light materials that are very strong, and we need to get some design capability to do that. So, let's go ahead and build this airplane, and let's build a community of design and aeronautical design engineers who understand how to use these materials so that they can incorporate them into aircraft of the future, because we know that the lighter you make an aircraft, the better it's going to be." The thrust-

to-weight ratio is one of the principal things that you want to control in doing an aircraft design.

So, we did go ahead with that. We did build the aircraft and tested it. We also used the aircraft in a joint program with the Germans to test out the concept of vector thrust, where the thrust vector from the engine is controlled along with other control systems in the aircraft to help maneuver. And that vector thrust is now a standard in some of our operational aircraft, so we did get additional design information for vector thrust out of that program as well. Beautiful airplane, but it came at the wrong time.

I: You've been around DARPA for a long time.
Cooper: Well, I did work on Defender. Right. I did work on that. The research that I did was related to the radars that were down at Kwajalein. I was looking at the plasmas that form around ballistic missiles as they reenter to try and determine which objects that you're looking at are heavy objects that could have bombs in them and which objects are light objects that might be decoys or just debris. And so using radar to look at plasmas around objects in the atmosphere that are traveling at high speed was one of the first things I worked on when I was a young researcher at Lincoln.

I: When you came back and became director, was there anything that surprised you? Were *you* surprised?
Cooper: I don't think I was surprised. What I was pleased about (chuckles) was that it was as much fun as I thought it would be. I believe that being the director of DARPA is probably the best engineering management job you could have anywhere in the world. There is no other organization like it, and the flexibility to create new and wonderful scientific and engineering objects is just outstanding. And if we didn't have a DARPA today, this country would have to develop one, because it needs it badly, and I hope it doesn't do anything to it to change its nature and destroy the capabilities that it is represented by.

I: What kind of a DARPA did you leave behind when you finally left the Agency?
Cooper: Well, let's see. I left behind an organization that was larger in budget, because the buildup had occurred during that period of time. I left an organization that I think had a stronger basic research program and was that doing things in basic research that would benefit the military in the long run.

The staff there was excellent, but I think it has always been that way. One of the reasons why DARPA has been so successful is that it seeks out the best and brightest people in the country and tries to involve them in its programs. And since it has the great flexibility and the resources to do that, it has been highly successful down through the years. I think that that was true both for the in-house staff and for the cadre of research and developers that we had both from industry and academic communities.

I: But you'd slain the dragon. Now what was DARPA going to do?
Cooper: Well, there are always new things for DARPA to do. And maybe some

of the things we were doing were *not* the right things to do. I have some heartburn over that, but subsequent DARPA directors did stop programs I had started, just as I stopped programs others had started. And maybe that's the way it ought to be. New ideas are what make an organization great, and that's what made DARPA great, I believe.

I: Does it have a role to play with an asymmetric enemy like we're facing today?
Cooper: I'm sure it must. The focus we had was entirely on the Cold War, force-on-force, superpower-against-superpower. And some of the problems we attacked were just enormous problems. Now the problems we face are completely different, and they're problems of individuals or small groups of people working against us, but many, many thousands—or, maybe even millions of them—potentially, in the future. I'm sure there are techniques and technologies we can develop to cope with that. Right now, there is a lot of confusion about that.

It may change our way of life in some ways, to be able to cope with the threat that is represented by terrorism and non-state actors; how to get at them and how to recognize and deal with them. I can't but imagine that ARPA will not be an organization that will contribute in a major way to dealing with that problem over the years.

It may be a harder problem than we faced with the Soviet Union. It certainly is not clear to me how one would deal with that politically. Ultimately, the collapse of the Soviet Union was a political event. It was dealt with politically by us; and it was done in a way that did not hurt the Soviet Union, nor did it hurt the U.S. Somehow, in the long run, there's going to have to be a political solution to the terrorism problem, but in the meantime, we've got to find a way to fight off the threats that are there, and DARPA will play a role in that. No question about it in my mind.

I: Are there just some areas DARPA can't work in? I mean, the application of scientific thinking always impressed me about the folks at DARPA.
Cooper: I don't know what it is. ARPA has done some things—or, tried to do some things—that are just way out there. They don't get criticized for it because of the fact that many of the things ARPA does turn out to be failures. They are overreaching. They are trying to apply something in an area where it just doesn't apply, or whatever. But it soon learns that, abandons it and goes on to something else.

I can't but believe that it will not get into whatever areas are necessary to deal with these new threats in the future. There is no barrier to it whatsoever. It's a free thinker and has the support, I think, both in the Congress and in the Defense Department to be able to do that.

Now, it's tried some things that have run up against public sentiment about the public's privacy, about information that is required in order to be able to track people throughout the world. We have the technology now, even though there may be four billion people in the world, to keep track of everyone. We can *do* that. We could do that, ultimately, and really know everything that's going on in

everyone's life. The technology is there, just by expanding it, to do that.

Of course, in this country there is no way one would be *allowed* to do it, but there may be some way to do enough of it to be able to place a real barrier in front of the threats the terrorist threats that we have. It's that kind of thing. Information technology is strength of DARPA's, and someday, some way, there may be an acceptable system of those technologies that will provide us with much more security than we have today.

I: Looking back, any regrets?

Cooper: Yeah, there are several, but let me give you the one that makes me the most anxious. And it has to do with space.

When I first got to ARPA, to DARPA, there was a very bright and aggressive, young aeronautical engineer there named Bob Williams, and he had been working with people in industry and in academia, particularly at the Applied Physics Laboratory and some labs in upstate New York on hypersonic flight. And the idea that this group of people had was that supersonic combustion ramjets could be built that would drive flying machines up to orbital speeds, so that you could actually build a ramjet that would operate with hydrogen and oxygen that it got from the air. And it would accelerate a sizable aircraft up to orbital velocity, or, it could fly the object at high altitude, maybe to 110,000 feet to, oh, maybe 200,000 feet, at very high speed—at supersonic speeds. And so it would give you global reach in very short periods of time. It would be almost like a ballistic missile in getting anywhere in the world in half an hour.

So we instituted a program that had all the elements we thought would be required to be conquered in order to have a point-design aid, and a prototype aircraft built and tested. It had the engine development and the materials development because as you fly through the atmosphere, the materials the aircraft would be made of would all get extremely hot, so you had to have new kinds of materials and new design techniques that would keep the aircraft from destroying itself just from the heat of friction as it moved through the atmosphere.

We proceeded along that line for several years—three of the four years I was there—the last three years. And we spent probably during that period of time $700 million or $800 million in relatively fundamental research on all the aspects of it. And it got to the point where it looked like moving forward to a point design could be done over the next three-to-four years, and probably you could build and test an aircraft that would have you along the way toward this goal.

And, well, at that time, it was time for me to leave DARPA. I had been there for four years, and I committed to stay there four years, so I left. During the last year, President Reagan picked up the idea. He called it the "Orient Express" because it could fly you to Japan in a little bit over a half an hour. The point design we had in mind, which was an aircraft about the size of a 737, would fly at 150,000 feet and would go from New York to Japan in, like, 35-40 minutes—a very, very fast ride, and he thought that was great.

And the Congress came back with a lot of money for the first, second and third year. Then I left, and the budget cutters in the Pentagon got to the program. I think it was inattention by the subsequent director. It's probably something I

(chuckles) shouldn't say in this interview. But in any event, Bob Williams ended up writing a personal letter to the President asking for funds to continue the program, and, of course, the letter never did get to the President; it got to the OMB, and the OMB called up the Pentagon and said, "Who *is* this guy? Get him out of there (laughs)."

And so it was Bob Williams' demise and the demise of the program, as well. Whereas, I think with another three or four years of adult supervision, that program probably would be in a position now—which is 20 years later—where we had objects that could fly from an airport into space, or could fly around the world in half an hour, maybe a little bit more.

Everything was sort of in place to keep the spending at around, oh, maybe $400 million -$500 million a year, and that probably would've gotten you all the way in ten years, to a prototype that was flying and being tested.

Now, I wish that would've happened. I do know that both NASA and Boeing Corporation are spending money on this technology now. They're not spending at anywhere like the money DARPA would spend. It's a $4million or $5 million per year kind of thing, rather than $400 million or $500 million per year, but someday it may get there, and I hope I'm there to see it.

That was one of the things that I wished I could've done, or would've transcended my time period at DARPA.

I: Anything else?
Cooper: No, I guess the only thing I would say is that I had a wonderful time at DARPA, and it is a wonderful institution. And if we can keep it going for another 50 years, this nation will be that much better off at the end of that period, as it has been from DARPA's existence in the first 50 years.

I: It's really been the standard bearer for technology globally, hasn't it?
Cooper: That's right. That's right.

I took a jaunt over to Japan and visited our friends at MITI, and they were doing their fifth-generation computer program, and they weren't even close to what we were doing at DARPA. They weren't even close. And it's just marvelous. They looked up to DARPA as if it were a god. They wanted to know everything we were doing, and they wanted to know how they could do better. Yeah.

I: Great. Thank you.
Cooper: This was a lot of fun.