

ROUNDTABLE: NEW CHALLENGES FOR THE NATIONAL LABS

America's government laboratories are a reservoir of scientific and technological capabilities. They contribute to national defense, scientific discoveries, space exploration, better agriculture and improved health care. Over the past decade, Congress has directed the labs to pass along their research ideas and technological knowhow to commercial companies in an effort to enhance the country's competitiveness in global markets. In an attempt to understand how the national labs can best achieve their new mission while retaining their old strengths, PHYSICS TODAY editors brought together six prominent members of the nation's R&D enterprise to discuss the issues.

The birth of national research laboratories in the US is marked by the founding of the Bureau of Standards at the turn of the 20th century. As the country was about to enter World War I, the government organized the National Advisory Committee for Aeronautics, which actually performed R&D to help the fledgling field of aviation get airborne, and the Naval Consulting Board that quickly fostered the Naval Research Laboratory. Both NACA and NRL were formed to advance the country's defenses. While government labs may have seemed strange in a nation dedicated to free enterprise, the concept of research laboratories was familiar to corporate America. By World War I, research labs were spewing forth new products at General Electric, Westinghouse Electric, DuPont, Eastman Kodak, Corning Glass Works and American Telephone and Telegraph. It was World War II that provided the impetus for a proliferation of government laboratories. One of the earliest was the Radiation Laboratory at MIT, where the British invention of microwave radar was transformed from an engineering curiosity to a practical technology. The Advisory Committee on Uranium, initiated at the urging of prominent physicists in 1939, after nuclear fission was discovered in Germany, led the Army to organize the Manhattan Project in 1943 to produce atomic bombs. The Manhattan Project itself spawned a remarkable network of laboratories to advance nuclear weapons and perform fundamental research: Los Alamos, Oak Ridge, Argonne, Lawrence Radiation Laboratory, Ames, Bettis and Brookhaven. Soon after the war, these labs were designated by Congress as government-owned and contractor-operated, placed under the aegis of the civilian-dominated Atomic Energy Commission and managed by either major universities or industrial firms. Aware of the advantages of using high technology in modern warfare, the armed services had initiated their own laboratories to further their military missions. Some were organized before and during the war, others after the postwar creation of the Defense Department. Six months after the Soviet Union launched its first Sputnik in 1957, NACA was transformed into NASA, which produced another group of national laboratories.

Now, as the US approaches the 21st century, and with the cold war palpably thawed, the purpose and potential of

Roundtable participants

Lew Allen Jr., at the time of the roundtable, director of Caltech's Jet Propulsion Laboratory, since retired; former director of the National Security Agency and former chief of staff of the US Air Force

Solomon J. Buchsbaum, senior vice president, technology systems, AT&T Bell Laboratories; member of President's Council of Advisers for Science and Technology

John H. Gibbons, director of the Office of Technology Assessment, US Congress

Siegfried S. Hecker, director of the Los Alamos National Laboratory

Edward A. Knapp, senior fellow at Los Alamos National Laboratory and director of LAMPF; former director of the National Science Foundation; former president of Universities Research Association (which manages Fermilab and the Superconducting Super Collider Laboratory)

Gerold Yonas, director of laboratory development, Sandia National Laboratories; former chief scientist of the Strategic Defense Initiative Organization

Gloria B. Lubkin, editor, PHYSICS TODAY

Irwin Goodwin, senior associate editor, PHYSICS TODAY

Barbara G. Levi, senior associate editor, PHYSICS TODAY

the national labs are being questioned in meeting the new challenges for military defense, scientific research and economic competitiveness. The size and scope of the labs are being reviewed by the agencies and by Congress. In all, about \$18 billion of the annual Federal budget goes into the care and keeping of some 700 laboratories, ranging from data gathering outposts with three or four people to complex facilities employing several thousand scientists, engineers and other staff. PHYSICS TODAY editors invited several laboratory administrators familiar with the issues to discuss the future of the labs. The discussion, held on 22 October in Albuquerque, New Mexico, was often lively and occasionally contentious.

Lubkin: The reason we're assembled here is because the climate for R&D in America is being rapidly changed by economic, political and military conditions, and we wonder what the role of the national laboratories ought to be in the new climate. With the startling changes in Eastern Europe, some people believe that defense should not cost the country as much as it does. With the crisis in the Middle East, we worry again about oil and speculate on whether to proceed with alternative forms of energy. As a nation we are also concerned with environmental problems, such as waste management and climate change. In addition, there is the issue of international competitiveness. These are all topics that the national labs deal with, more or less, and so we will discuss today the purpose of the labs and how they might be reshaped to meet those goals. To start off, I'm going to ask a hard question: What should the Department of Energy nuclear weapons labs be doing in, say, the next ten years?

Yonas: Considering the developments described in your opening remarks, one might conclude that the nuclear weapons complex, which was organized to turn out large numbers of nuclear weapons, might now be reduced in size or function in the next few years. But it doesn't necessarily follow that, even if you're going to change the nature of the stockpile and the whole production complex, R&D at the labs would be reduced. Large demands might very well be placed on the three principal weapons laboratories—Los Alamos, Lawrence Livermore and Sandia—to engage in work to meet new national requirements. I need only mention environmental and safety requirements, for instance, and new designs and operational procedures for nuclear weapons. If you're going to greatly reduce the number of nuclear weapons, you will probably need to be sure they are safer, more reliable and more flexible than those weapons now in the arsenal. And beating warheads into microchips could mean more rather than less R&D investments in the labs.

Goodwin: Does what you're saying suggest that the nuclear weapons labs should continue competing with each other? After all, Livermore was established to be competitive with Los Alamos—the purpose being that the rivalry would breed greater ingenuity and, therefore, better atomic bombs. Is this competition necessary now, when peace has broken out among the superpowers?

Hecker: That question is being asked in many circles. It's sometimes called a \$1 billion question, since the total budget of each of the three nuclear weapons laboratories is somewhat more or slightly less than \$1 billion. So, couldn't the nation save a billion dollars by shutting down one of the laboratories? To put the question in the right perspective, I should note that where we compete directly in making nuclear weapons—and it was set up that way—we spend roughly the same, around one-fourth of each lab's total budget. In fiscal 1990, it actually came to about \$230 million for nuclear weapons research, development, and testing at each lab. We spent another \$250 million or so for other DOE activities related to defense. That adds up to roughly \$500 million in military programs. We do \$200 million plus for DOD defense activities that are non-nuclear. Another \$250 million goes

for nonmilitary DOE energy technology and basic research. So if you talk about the cost of Los Alamos in competition with Livermore, it's about \$230 million to \$250 million. The point I'm making is that the nuclear weapons labs represent a reasonably small share of the total \$300 billion defense budget. And if the two laboratories are merged, something like \$125 million might be saved out of a \$300 billion defense budget. Is that worth doing away with the competitive nature of our business and, instead, relying on a sole source? I'd like to quote something Harold Brown [Defense secretary in the Carter Presidency] said when a number of defense experts asked him the same question back in 1987. He said DOD is reluctant to sole-source many things much less important than nuclear weapons research and development. He said it doesn't make much sense to close down all but one nuclear weapons lab. Still, Brown said this before the Berlin Wall came tumbling down. My own belief is that there's still plenty of good reason to have the kinds of checks and balances that two competing labs provide.

Goodwin: There's another part to the question about closing the nuclear weapons labs that you haven't talked about: it involves attracting people to be the weapons designers. Without the superpower adversary that once haunted us, is it likely you can attract bright young people to work on nuclear weapons?

Hecker: It's never been terribly popular for a fresh PhD to become a nuclear weapons designer. What we've always had to do—and at Los Alamos we have felt particularly strong about this over the years—is make the whole Los Alamos environment attractive to creative young physicists, chemists and mathematicians. We try to imbue the laboratory with an intellectual stimulus. That means the laboratory must resemble a university campus, with academic people and activities. In a typical year we have 2000 to 3000 faculty visiting our lab. We have roughly 1000 graduate students and 200 postdocs. It turns out that once you get people into the laboratory, the challenges associated with the nuclear weapons programs are so immense that in the past it's not been a terrible problem to bring in good people. But it's going to be much more difficult from now on.

Buchsbaum: I agree with what Sig just said. Whether or not there needs to be competition between Livermore and Los Alamos in weapons design is, it seems to me, a red herring. That's not the issue. The issue is the size and composition of the R&D program that will be needed, given the fact that, even though we no longer have a cold war confronting us, both superpowers are going to sit for the foreseeable future on considerable stockpiles of nuclear weapons. We're not going to disarm ourselves overnight. So, given the world situation, for better or for worse, we do need the R&D to support the nuclear weapons program. To do this, the two laboratories that know how to do this best—the only ones we have—ought to carry on. That doesn't mean that five or ten years from now Livermore and Los Alamos—as well as Sandia—are going to be precisely the places they are today. I daresay they won't be. But in the meantime there's no reason for them not to survive and prosper.

Allen: On the other hand, it seems unrealistic to imagine that Los Alamos and Livermore, and possibly Sandia, will not share to some degree in the general reduction of defense expenditures. So the issue of how best to take those reductions is of intense concern to all three laboratories, as well as to the country as a whole.

Buchsbaum: Spending cuts for military purposes will affect not only the nuclear weapons complex but all DOE and Defense Department laboratories.

Allen: My point is that the same arguments that are made here—that it's essential to maintain a vigorous R&D capability for nuclear weapons, even during a time of downsizing—applies really to almost all other elements of R&D in the national security enterprise. In this connection, one hopes—and would argue—that the R&D portion of the Pentagon's expenditures would decrease less than the overall defense budget.

Hecker: To me the key issue on the question of maintaining two weapons design labs versus one is the natural tendency to decrease the funding of both, so that we wind up with two weak sisters. From the standpoint of reduced funding for research, development and testing of nuclear weapons, what most people don't realize is that at Los Alamos, for instance, we've already made a 25% reduction in the number of people working in the program since 1986, when the first Gramm-Rudman-Hollings axe fell [because Congress was unable to achieve its own deficit-reduction target]. We're going to see more deliberate reductions in defense programs in the years ahead. It's going to be tough for nuclear weapons development, there's absolutely no question about that in my mind.

Buchsbaum: Livermore and Los Alamos will need to help redefine their mission. That mission will be certainly different five to ten years from now from what it is today.

Yonas: One way of redefining our missions is to review all the things we do at the labs and to examine our technology base to find out how we might make the most of our overall technical strengths. If, for instance, one of the major directions is to maintain the nuclear stockpile, with a much smaller weapons production complex, this will probably drive new industrial processes in manufacturing. The kinds of techniques we used in the past, ones that were considered environmentally acceptable when they were applied, are no longer acceptable. So we will do R&D associated with the way we make and test nuclear weapons to meet the new laws and regulations and standards, not unlike the situation that industry faces. There are overlapping needs for the nuclear weapons program and for the commercial industrial sector—in matters involving environment, safety and health and in matters relating to manufacturing technologies. I see our challenges as rather practical, resulting in developing dual-use technologies that have applications in common for nuclear weapons and for commercial products—in process control, say, and in materials science, environmental protection and computer modeling. So I think a strong technology base will help us perform in many defense and civilian programs over the next decade or longer. What is of serious concern, though, is that our tech base has withered over the past several years.

Lubkin: How would you go about converting from defense work to the civilian R&D programs you mention?

Yonas: I fear that the conventional notion of conversion could be applied incorrectly. It would be easy to destroy these labs in the process of converting and to lose vital defense and civilian capabilities with it. That

would result in the nation really losing out on capabilities that it doesn't get any other way. The labs provide a service to the nation by producing a high degree of state-of-the-art technology and by integrating science and engineering in large scale projects. This is difficult to find in other places where research is done. There's a characteristic of these labs that has to do with the broad scope of their activities, as well as their vertical integration that would be difficult to recreate.

Goodwin: You appear to be a one-man cheering section for weapons labs.

Yonas: The other aspect of this relationship with the government and the public has to do with the high level of responsibility imposed on us. A very limited but obviously essential part of this country's technological capability is focused on nuclear weapons activity in which the consequences of a mistake are severe. So it is our responsibility to maintain very high reliability and a high degree of safety. I consider this a special responsibility to the American public.

Allen: I have a little different viewpoint, Gerry. Number one, there are other labs in the country that also have a high national purpose. I would agree that Los Alamos, Livermore and Sandia are very special. They have a degree of competence and a degree of capability that are unmatched. And the reason I think they have this high degree of capability is that they have a unifying purpose, which is understood and which is considered very important and very challenging. I think when the labs have expanded their scope of activities into what one might call peripheral activities, they've had somewhat mixed success. And two, I think they've succeeded when the relationship was very close to their main purpose. In addition, when the synergism and skills developed for their auxiliary purposes are easily recognizable as important to the weapons program, I think that's worked pretty well. When it's been less well coupled, I think Los Alamos and the other labs have not been all that much better than other labs in the country. So, you're correct that they're very special, and possess special capabilities, but I think one wants to be careful not to make the purpose of those labs too diffuse.

Buchsbaum: Let me add something to what Lew just said. Because of the importance and uniqueness of their mission, the nuclear weapons laboratories have been very well supported over the years by their sponsors, the DOE and Congress. They have been allowed a considerable degree of flexibility and freedom in how to invest their resources, unlike almost any other laboratory within the government. This has served the nation very well. One of the most striking features of these laboratories is how much more rapidly the practical applications of nuclear physics came about than was originally thought possible. The money has been well spent.

Knapp: Although it is true what you say about the strong support of the nuclear weapons labs over the years, as budgets for science research became tighter, the technology base was shortchanged and, as a consequence, it is now of less use to the country. I think Vannevar Bush said at the time he formulated the National Science Foundation that applied science drives out basic science when the nation's purse is bare. I think in the government's current fiscal plight we are now witnessing, at these laboratories and at other national labs, an erosion of the ability to expand the technology base. I fear the national labs will lose their unique characteristics if the



Leaders of the R&D enterprise discuss with *PHYSICS TODAY* editors the new missions of the national laboratories to improve the country's industrial competitiveness in world markets. Seated around table, clockwise from top: Gloria Lubkin, John Gibbons, Lew Allen Jr, Irwin Goodwin, Gerold Yonas, Siegfried Hecker, Solomon Buchsbaum, Barbara Levi and Edward Knapp.

technology base isn't strengthened in the next few years.

Hecker: That's an important consideration in our discussion here today—that is, what is special about the laboratories. I certainly agree that we're driven by public service, and so are all the other Federal laboratories, so I don't think that this characteristic is particularly distinguishing. But there is something special in the sense that our primary mission has given us, on one hand, all the things that were mentioned—the flexibility, the freedom, the support, the ability to develop a broadly based scientific program. But, on the other hand, it's also placed strict requirements on us, and that is that we've got to go all the way from generating the idea to worrying about effectiveness of the final product. Such obligations set the weapons labs apart from many other laboratories.

Goodwin: Aren't those characteristics equally true for laboratories within NASA and the National Institutes of Health?

Hecker: Where the real product is there, it tends to drive a very special culture—a kind of vertical integration, from the idea all the way to the application. In cases in which the laboratory is able to take the product right to the customer, as we do with nuclear weapons, I think many of the national laboratories have been very successful. But in the case of the nuclear weapons facilities, when we tried this approach in other projects, as Lew Allen points out, our success has been much more mixed. Is it important that we try to bring our capabilities to bear on civilian applications? The answer to me is a resounding yes. However, to do this, we have to change the way we relate to customers other than the Energy and Defense Departments. We have to make certain that we match up our R&D with commercial users or with other government agencies. If the discovery or the technology is for the government, then we have to be certain the projects are of a size and significance that make our efforts worthwhile. I can think of developments in environmental protection or energy technologies, for instance. If it's energy, we'll have to do it differently in the '90s from the way we did it in the '70s. It didn't work well in the '70s. We were not coupled to the users. If anything emerges from our R&D to improve industrial competitiveness, it's much more diffi-

cult yet, because that coupling to the user is a very tricky affair. Yet I think there are certain things we could do quite well to improve the country's economic competitiveness. I am not going out on a limb when I say that the laboratories are ready to take this approach. I'm convinced it's worthwhile for two reasons: One is it will keep the laboratories healthy, vital and intellectually stimulating so that we can continue with our nuclear weapons mission. And second, I see certain of our capabilities draining away to industry if we don't enlarge our nonmilitary R&D.

Buchsbaum: That's nonsense.

Hecker: It's also true that many industrial companies have already stepped away from longer term research programs. I think the national laboratories, the nondefense facilities as well as the weapons labs, stand ready, willing and able to help industries in civil R&D.

Buchsbaum: Look, let me speak for a moment about the nuclear weapons laboratories. The laboratories did extremely well when their sole mission was nuclear weapons. Over the years that task was diluted from being a sole mission to being what is now called a primary mission. It's still pretty good. Now you say you can apply the expertise, approach and dedication you gave to nuclear weapons to other areas of endeavor, and you mentioned a few possible ones. History shows, as Lew Allen points out, that the record is mixed, although one presumes you learn from those lessons as well. But if you, Sig Hecker, were given a free ticket to convert Los Alamos to whatever Los Alamos management in its wisdom chose to do, what would be its mission ten years from now? Or five years from now?

Hecker: Without doubt, the primary mission would still be the national security umbrella, with the nuclear weapons being the most important part.

Goodwin: Even though weapons work is only a quarter of your budget?

Hecker: It would remain our primary responsibility. Still, from the beginning, we did a certain amount of nonmilitary-related activities within our nuclear weapons program, so that we could have a research environment that would attract and retain the best possible people to also do defense work.

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Solomon J. Buchsbaum



Levi: Let me follow up on something that Gerry said earlier. There are some areas of defense R&D that also would be helpful for industry, such as manufacturing processes. I wonder whether there is much overlap between those technologies that one develops for defense and those that are required by industry. For example, military lasers are developed with the emphasis on power, whereas in industry the emphasis may be on wavelength or monochromaticity.

Yonas: Let me explain: Our nation faces serious environmental issues. If our laboratory has a manufacturing process we use in the nuclear weapons complex, the dominant factor is not the speed of the process or the cost of the process. The dominant factor is the nature of the effluent and the waste from the process. So we are impelled to devise a new technique—for instance, a new solvent. Industry may have the same type of requirement. Another issue has to do with producing a small number of items. We have extensive experience with batch processing. In the past the driving factor was performance before anything else. Cost, flexibility and environment protection were not considered as important. As a direct consequence, there was a greater disparity between the kind of technological challenges we faced and those confronted by American industry. Now, we're seeing a convergence of requirements, which leads us to bring to bear on the things we do the same kinds of thought processes, capabilities and orientation in the weapons labs that exist for those managers, scientists and technicians in commercial manufacturing. So I see an opportunity to provide greater value by working in an alliance with industry. I am reluctant to use the term technology transfer because this new cooperative arrangement will provide an opportunity to learn from each other. So the focus should be on cooperation and not on "transfer," which sounds one-sided—that is, directing research results from the laboratory to industry.

Buchsbaum: I agree totally with Gerry's remarks. I reacted forcefully to Sig's earlier comment, unless I misunderstood what Sig said, about the implication that because industry may be withdrawing from something, the national laboratories can step in.

Hecker: You absolutely misunderstood.

Buchsbaum: If I misunderstood, I apologize. But you implied that industry was withdrawing from research, and therefore . . .

Hecker: I would not fall into the trap of proposing that the national laboratories can make up for US industry's R&D programs.

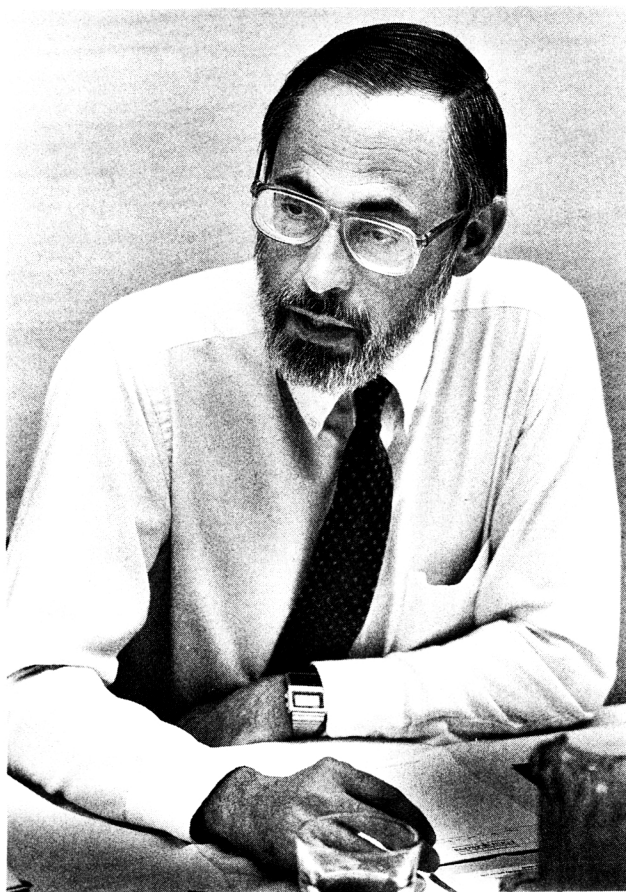
Buchsbaum: What did you mean to say?

Hecker: That if we have a chance to impact on industry, the one thing that I can see us doing is longer term R&D. We could perform a useful role in working with US industry in appropriate R&D alliances, such as in high-temperature superconductivity. What we have set up in the so-called superconductivity pilot centers at Los Alamos, Argonne and Oak Ridge is the ability to form cooperative R&D ventures with US companies and, when appropriate, a university or two. In such a collaboration, with government paying for the participation of the labs

and industry paying its own way, we would set joint purposes and objectives. We've already collaborated with some 40 industrial firms. These ventures provide leverage for American companies to increase their R&D investment in a technology that might have been neglected otherwise. It has happened that these same firms might not have been as inclined to invest their dollars until they participated in a program with our laboratory or one of the other national labs. I think the relationship can be useful in sharing the capabilities of a national laboratory that the private sector wants but can't or won't do on its own.

Buchsbaum: The time has come for greater cooperation between universities, industries and the government laboratories. I resonate with the high-temperature superconductivity endeavor that Los Alamos is in, because we have a similar consortium with IBM, MIT and another government laboratory, Lincoln Labs. In this consortium we organized to develop superconducting electronics, we have a joint program of research managed by a directorate made up of one member from each of the four institutions. It actually conducts research according to a blueprint that was drawn by the directorate. That appears to me an excellent model for proceeding cooperatively with the national labs. It's regrettable that high-temperature superconductivity is the only example of such cooperation. We don't have many examples in other technologies other than perhaps Sematech, in which 14 firms are cooperating, with half the sponsorship provided by the Defense Advanced Research Projects Agency. This country could do with more collaborations like those.

Hecker: As we go into this new regime of alliances, where universities, laboratories and industry work together, it allows a national lab to derive multiple benefits from



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Gerold Yonas

the work it does anyway with only limited benefits.

Buchsbaum: I agree with that. But it requires some very important give and take. Are you ladies and gentlemen aware of the statement on technology policy that recently came out of Allan Bromley's Office of Science and Technology Policy? [See *PHYSICS TODAY*, December 1990, page 54.] Let me read some lines from it on the transfer of government-funded technology. Under the heading of "Improve the transfer of Federal laboratory resources into the private sector" it says "Where appropriate, these laboratories should give greater consideration to potential commercial applications in the planning and conduct of R&D, and these efforts should be guided by input from potential users." To me that's a novel thought—that the most likely users should guide the effort. "To achieve this goal, there must be a closer working relationship among these laboratories, industries and universities. Defense-related laboratories can make major contributions while still providing adequate safeguards for classified information." The notion that government laboratories will give greater consideration to potential commercial applications as they plan and conduct R&D, after discussions with potential users, is a very interesting blueprint for the future. I don't know how one does this, but it seems to me this is an opening that we should enter.

Gibbons: It's easier to think this can be done by the multipurpose labs than by the weapons-related labs.

Buchsbaum: That seems exactly right.

Hecker: Why do you say that? That's not at all obvious to me.

Gibbons: Well, I know that the advisory committee, at Oak Ridge, for instance, is comprised of leaders in the

private sector—CEO's and research directors—who make an input to the lab's mission, activities, priorities, choices of research projects and the like. I would find that difficult to imagine happening at, say, Sandia or Los Alamos or Livermore. I may be wrong.

Buchsbaum: You're wrong.

Gibbons: There are a number of impedimenta that stand in the way between the outer world of commercial enterprise and the classified inner sanctums of the weapons labs.

Yonas: That's just not true. If you'd like to visit, all you have to do is ask. I could assign an escort today and get you in tomorrow.

Gibbons: It's encouraging to me that the nuclear weapons labs emphasize safety, reliability and perhaps new manufacturing methods as high mission priorities. This reaffirms the legitimacy and importance of the weapons labs. What I'm also hearing is that these labs are in the process of examining their specific strengths in terms of staff, equipment and functions as well as evaluating how to match their missions and needs with those of the rest of American society.

Yonas: In November 1989, Congress passed a new law, the National Competitiveness Technology Transfer Act. It was a further elaboration on the Stevenson-Wydler Act of 1980 and another law that modified Stevenson-Wydler in 1986, directing the federal labs to participate in R&D with American businesses. One thing the latest legislation does is enlarge the mission of the weapons labs to include technology transfer. Another thing is that the law requires the DOE to put in place a streamlined and predictable process for doing cooperative R&D arrangements with industry. And third, it provides a way to carry out work in such a way that the intellectual property rights of the participants can be protected for a period of five years. To say the book is written and the labs have been found wanting is wrong. The book is just now being opened.

Gibbons: My point is that you can't just write the book and have it happen. It seems to me that the very environment of the weapons labs is such that you're going to have a much more difficult time than those doing essentially unclassified work in terms of access to staff, use of equipment, joint ventures, all sorts of things, if you're going to adhere to the intentions of Congress.

Knapp: I think you're wrong. I've been working at Los Alamos, on and off, for 30 years, and it seems to me that for research that is not part of the core nuclear weapons program, such as LAMPF and magnetic fusion, there never were any more difficulties in my contacts with people outside the fence, in dealing with the academic community, for instance, than for anyone I knew doing comparable work at the multiprogram laboratories like Brookhaven or Oak Ridge.

Gibbons: Were you using equipment especially devoted to weapons work?

Knapp: Well, the research used large-scale computers, which have always been partitioned between weapons program security requirements and the rest of the world. Now, it's unfortunate that we are experiencing some

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Edward A. Knapp

difficulty in recent months as a result of some rulings by DOE's Albuquerque office on who can come and who cannot come from Eastern Bloc countries to do research at Los Alamos. I hope this is a passing problem.

Buchsbaum: You can argue the details till you're blue in the face. The fact of the matter is that because of security restrictions at Sandia, Los Alamos and Livermore, it's harder to get into those places to do research or to do business than it is at unclassified laboratories. This is a fact of life at the national laboratories. That doesn't mean that you can't work with Los Alamos and Sandia. They have open areas as well. It just makes it harder, that's all.

Goodwin: When Jack Gibbons was discussing the way Oak Ridge works with its advisory board, he seemed to be saying in effect that the lab was seeking to develop a little Silicon Valley in the region. Isn't it the case that several small businesses have been set up there by people from Oak Ridge who are now entrepreneurs?

Gibbons: As well as by people who have moved there because of the R&D and its practitioners at the lab.

Goodwin: Has that happened at Los Alamos?

Hecker: Let me address that. Jack's point is valid. He has a perception that, it turns out, is shared by many other people. When we talk to corporations, the first reaction is Jack's reaction—that tech transfer is an opportunity whose time has come at Oak Ridge or Argonne but not at the weapons labs. We have to overcome that perception. Now the fact is that in the world where Ed Knapp has lived he's not had to worry much about that. But it's also true that in the past five years we've put much more of our research capability outside the fence. About 25 small companies have spun off from Los Alamos and remain around the laboratory. It's not a Silicon Valley. In my opinion Oak Ridge has done the best job of any of the DOE laboratories in technology transfer. There isn't another lab like Oak Ridge. Our success rate is probably more like the other DOE multiprogram laboratories. So we have some catching up to do, especially in the perception. But right now the fact of the matter is that the issues you raise, in my opinion, aside from perception, are not at all a major stumbling block in our working with industry. I think literally I've had hundreds of industrial VP's and directors of research in and out of Los Alamos in the last few years. It's not a real problem.

Yonas: Nevertheless, Gibbons is saying something meaningful: Perception is reality. If Sandia is perceived as difficult to get into, requiring 50 days for the approval of US citizens to enter our gates, then that's reality. The problem is, what are we doing to change that perception? There's no way I can see to change that other than to actually carry out cooperative ventures with people from industry. When those people find they can reap real benefits from an association with Sandia, the word will spread rapidly.

Buchsbaum: Sandia did that with its combustion research facility. This facility is outside the fence at Sandia Livermore. So Sandia had to go to great lengths to set up a procedure to enable industry to collaborate.



Yonas: Let me remind you that military secrecy is not the only barrier to collaboration. Proprietary interests within industry can result in even tighter security, even when none of the work carries military implications.

Levi: Could we make the discussion a little more general at this point and examine the opportunities for technology transfer at all the labs and the obstacles that stand in the way of it happening?

Buchsbaum: As I said earlier, we need more cooperative ventures of the sort that already exist in the limited field of high-temperature superconductivity. The Administration, the Congress, the Justice Department, the White House, are opening the way.

Goodwin: Only so far as the precompetitive R&D mode, is that right?

Buchsbaum: Let me read further from the OSTP technology policy statement, which defines for the first time, I believe, what is meant by precompetitive technologies. I quote from a section on Federal R&D responsibilities: "Participate with the private sector in precompetitive research on generic enabling technologies that have the potential to contribute to a broad range of government and commercial applications. In many cases these technologies have evolved from government-funded basic research. The technical uncertainties are not sufficiently reduced to permit assessment of full commercial potential." Now the last sentence represents an opening through which you can drive a trailer truck. The policy paper goes on: "Precompetitive research which occurs prior to development of applications specific to commercial products research results can be shared among potential competitors without reducing the financial incentives to industrial firms to develop and market commercial products and processes based upon the results."

Goodwin: Despite the key phrases, there could conceivably be major hangups in devising practical

working relationships, couldn't there?

Buchsbaum: Sure. We need to sit down, define certain technological areas like high-temperature superconductivity and start spawning partnerships and consortiums to pursue them.

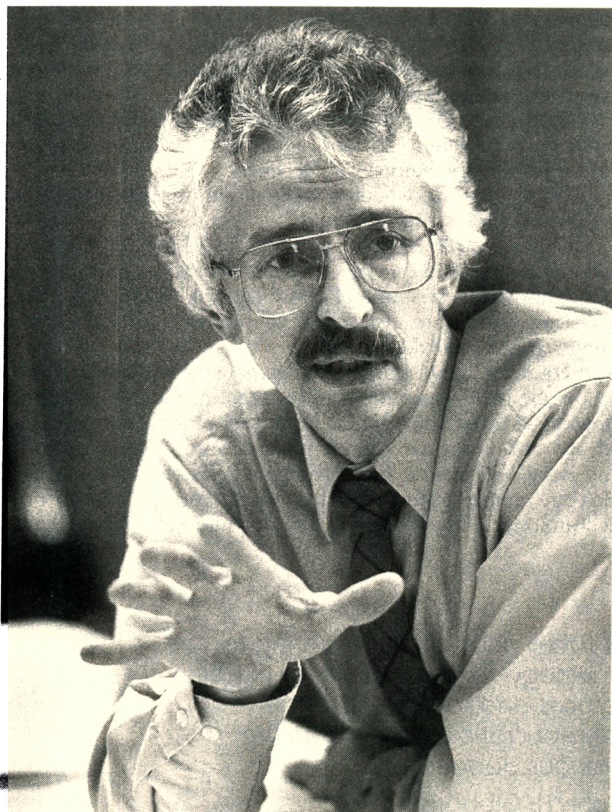
Lubkin: I have heard from people at IBM and at Bell Labs that the reason the superconductivity consortium is successful is because nobody expects commercialization for a long time.

Buchsbaum: That's true. We'll find out whether it's successful or not in a few years if some good stuff comes out of it. Right now we're just working on it. So we can't call it a successful consortium.

Yonas: Let's talk about barriers, all right? For years DOE was not inclined to expedite the technology transfer process. So we would talk to industry, the paperwork would go to DOE and take a very long time before it would come out, and the result wouldn't be predictable. Industry is not about to spend a lot of time on these antics. So many of the things we tried to do before the new law was passed just didn't go anywhere. The second thing is the protection of intellectual property. People may work together and come up with some new process, some new control technique or some new material. They just don't want to see it given to a third party who wasn't involved. And a third issue has to do with the overall structure and convenience of the interaction. The rules have changed.

Hecker: See, we're trying.

Gibbons: I think it's going to take more than a little change.



Buchsbaum: It's going to take a hell of a lot of effort.

Yonas: We have 17 people working hard to make sure that those who want to come in can come in and to make sure they understand our capabilities, providing funds for in-house people to bring technology further along to the point where it is attractive to industry. We weren't doing these things a year and a half ago. Admiral [James D.] Watkins [the Secretary of Energy] has told us in effect, "This is what you're going to do," and Congress has come along and enhanced our mission.

Gibbons: I think you're on the right course. You need the enabling legislation to give the agency the proper message about what it should be doing. You need a secretary like Jim Watkins who can rattle some cages. But it takes a lot of drumbeating for the message to get through to the field offices and to penetrate into the bureaucratic culture that operates within the department.

Buchsbaum: That's necessary but not sufficient.

Gibbons: That's right. Then, it seems to me, on top of changing the attitude, in order to make the attitude change, you have to build it into the reward structure. The managers, the bench guys, the engineers all need to have a sense that if they're really spending time and effort in this line they are going to get some reward. It used to be at Oak Ridge that every time anyone got a patent all the scientist or engineer got was a dollar bill and a little certificate. It has to go farther than that. When people go through their annual performance review, you will need to look not only at the number of papers they've published but also at the number of industrial guys they've met with and tried to help. This requires a cultural change at the labs, and that can't be done overnight.

Buchsbaum: If Alan Schriesheim had been able to be here today, he would have told you that Argonne National Laboratory has set up a reward system as part of its ARCH venture [a not-for-profit organization representing Argonne and the University of Chicago to license inventions to private companies]. Once a year, Schriesheim gets up in front of the whole staff and presents a \$2000 check to some scientist or engineer and \$1000 to another staff member for work that advances a technology or for some invention that could become a commercial application. This is his attempt at establishing an incentive system.

Yonas: We have an incentive system too, and it's based on overall contributions to our strategic mission.

Buchsbaum: Different organizations are doing it differently.

Hecker: Let me make a little different cut at the problem. I think the most important issue is that the laboratories must define, with help from a lot of other quarters, what it is we can contribute to national defense, scientific knowledge and economic security. If we were to

Whether or not to shut down one of the nuclear weapons laboratories is a \$1 billion question

Siegfried S. Hecker

become job shops and to give \$2 for an idea instead of \$1, that would not make the national laboratories more relevant to American society. I testified before Congress in June 1987 that the labs can offer the country what I called "strategic enabling technologies" that are going to be critical to advancing national competitiveness. The list of enabling R&D would include superconductors, semiconductors, laser technologies, biotechnologies, advanced materials processing and synthesis, high-performance computing and so forth. These are all fields in which the laboratories have great expertise. Take lasers, for instance. DOE has invested hundreds of millions of dollars at Los Alamos alone on lasers. Are there things we can do in laser technologies that can make a substantial difference? You bet there are. We're working on free-electron laser photolithography in ultra-short wavelengths as a possible way of doing projection lithography. We're organizing an industrial consortium around this technology along the same lines that we constructed an alliance around high-temperature superconductivity. The way I like to put it is this: What we do well because of our experience in weapons work is our handling of large and complex technological problems in which science makes a difference. The fact that science makes a difference is vital to the work we do at Los Alamos—and I believe this is true for many of the other national laboratories. That's why the government invested in the laboratories. We have no business running a job shop for every fad that happens to come our way.

Allen: Let me pick up a point that Sig made in discussing the capabilities that the laboratories can bring



to a commercial problem. Of all the things we've discussed here, the thing that concerns me the most is the experience that the tech base supporting the weapons activities has dropped by something like 25% over the last few years. I don't believe the primary mission of any national laboratory is technology transfer. I guess it's all right, but it makes me a little nervous, because it's placing carts out in front of horses. So I think it is important to me to maintain the tech base for the purposes that the labs were created, and presumably the purposes for which they will continue. From that strength one can examine the most effective ways to apply the talents and capabilities within the laboratories to other national problems. But without this essential strength, the whole exercise is pointless.

Buchsbaum: Amen.

Lubkin: Let us now broaden our discussion from the weapons labs to DOE's particle physics labs and multipurpose labs, to the labs supported by NASA and to the astronomy observatories and other special facilities sponsored by the National Science Foundation. Should the missions be changed for any or some of those labs? What will happen, for example, to SLAC or Fermilab when the SSC needs \$700 million or \$800 million or more in any single year—much more than the entire high-energy physics program in DOE now gets per year? Do I hear any comments on this dilemma?

Knapp: The single-purpose scientific research labs are really very different from the multi-purpose labs and the weapons labs. Historically, SLAC and Fermilab have avoided any arrangements that diluted their single-mindedness. At SLAC, I happen to know, it was very difficult for people doing nuclear physics to get access to the high-energy accelerator, because it was outside the mission of that laboratory to provide services to the DOE nuclear physics program. Fermilab, for its part, has generated a number of small companies that have produced products from technologies developed at the laboratory, but I don't think the lab has made any concerted effort whatsoever to transfer the results of research into a commercial application as a joint development with a company.

Gibbons: On the other hand, SLAC and Fermilab have trained scientists, engineers and technicians, who contribute to the country's R&D base.

Levi: Has there been a study of where these people go after working at those places?

Gibbons: There is a misperception, I believe, that the labs are nonproductive in terms of the people equation. In fact, they train streams of postdocs and others. But the question is, where do those people go? Is there any downstream record-keeping?

Hecker: I can tell you our experience at Los Alamos, where we have some 200 postdocs each year. Half of them flow back into the science and technology community. Many enter the academic mainstream. Some go into industry and others into other government laboratories. So they populate the entire known universe of science and technology. The same with the graduate students. Actu-

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John H. Gibbons

We spend 1.8% of our GNP on nondefense R&D, while Japan devotes 2.8% of its GNP on this. That's a big difference and it may bear on our competitiveness

Lew Allen Jr

ally, few stay at Los Alamos.

Buchsbaum: Trained people constitute a conspicuous spinoff of the labs. So, too, are new startup companies. This is true for universities as well. Industries spawn new industries also. That's how this country works, and I think that is great. It's necessary but far from sufficient. A large fraction of the government's investment goes into what has come to be known as dual-use technologies for military and defense purposes. Some of this is unique to the Federal government, and that portion of our R&D is going to decline. Instead, what needs to happen is that the government should continue its investment in research people and in dual-use technology, such as superconductivity research and biotechnology, as well as a whole bunch of critical technologies that are synergistic with the country's present and future needs. This speaks to the questions about the future capabilities of NASA labs, DOD labs, DOE labs, NIH labs and NSF labs.

Allen: It seems to me we're going into an era where we've got to ask another question: If defense R&D is reduced in the years ahead, along with whatever benefits and dual-use technologies this is likely to yield, should the government provide a counterbalancing expenditure in nondefense R&D?

Buchsbaum: As a nation, we invest an adequate amount of dollars in R&D. The question is really one of scientific balance and of effective expenditures.

Lubkin: Are you saying the sum of defense and nondefense R&D should be a constant?

Buchsbaum: I'm not saying that at all. It's not a constant. What I'm asking is whether the total number of dollars devoted to all R&D is adequate and whether it is adequately balanced? I submit that as a nation we are investing enough in R&D to be industrially competitive.

Allen: For the Federal side, for the industrial side, or for both?

Buchsbaum: The sum of the two. That doesn't mean we can't spend the dollars more effectively. We can and we should.

Levi: Do you think more dollars should go to the industrial side rather than the Federal side?

Buchsbaum: The balance between industrial investment and government spending has been shifting towards industry for the past decade. Industry already invests more than 50% of the total R&D dollars.

Goodwin: A large portion of our nondefense R&D money, both government and industrial, goes toward health care and into space programs.

Buchsbaum: True.

Goodwin: Are you suggesting a change in the present balance of government support of R&D?

Buchsbaum: Yes, I'm suggesting that we rebalance our investment. But the total amount, when I look at what industry spends for itself and what the government spends for what can be properly labeled as dual-use, leaves me comfortable with our overall investment in R&D. The government will continue doing things uniquely needed by the government, such as nuclear weapons production.

Allen: I'm concerned about our nondefense R&D.



The Science Board numbers show that we spend 1.8% of our GNP on nondefense R&D, while Japan devotes 2.8% of its GNP to this. That's a big difference and it may have a bearing on our competitiveness.

Buchsbaum: In terms of GNP we may not be investing as much as Japan or West Germany, but is that the relevant metric?

Allen: You mean because our GNP is so much larger than the GNP of those countries?

Buchsbaum: Exactly.

Lubkin: Then why are we slipping in industrial competitiveness?

Buchsbaum: That's a good question. We're slipping in competitiveness for all kinds of reasons. But I'm not sure that investment in technology is the crucial reason. I return to the OSTP technology policy paper: "In almost all respects the US science and technology base remains the world's strongest." I think that's an undisputed fact. "The nation's research universities and the ability of its people to innovate remain the envy of the world. Nonetheless, industrial competitiveness depends on many factors besides technology. Our strength in technology and innovation have not prevented an erosion of market share in US companies in many industries." That, too, is undisputed.

Yonas: Market share depends on who is first to get to the market, who is able to satisfy customers, who is able to do that in a way that is cost-effective. These are factors that depend on technology and on the speed of commercialization. If we look at where people are effective in bringing products to market rapidly, it's where they have

been able to break down barriers. We spoke before about bureaucracy and barriers. Technology transfer is mostly a human problem. It's not a problem of technology. It concerns people, institutions and culture. The speed with which you go from an idea, through the process of development, into manufacturing and then out to the marketplace quite often has to do with cultural issues. We may have a great idea, but the ability to take that idea and do something with it quite often has to do with teamwork. How can you put together a team of people who share the ability to think about the idea, develop it rapidly, introduce it into a manufacturing plant? That is a blending of people, institutions and cultures and requires a great deal of teamwork. That's where the US is failing.

Goodwin: You spoke of Sematech a little while ago, Sol, and you said that it was probably a paradigm for labs in the future. Does this suggest to you that perhaps the labs as they're now structured may have to change?

Buchsbaum: I think that's right, because I think we have to break down the kind of barriers—there are many more of the sort that Gerry talked about—for this to work. We simply can't afford to compete at every stage like we have in the past. The fact that industry and the government got together to form Sematech, and that AT&T and IBM and Texas Instruments decided to join forces is something that would have been unheard of ten years ago. Our lawyers would have gone straight through the roof and the Justice Department would have taken us to court. Now, AT&T and Zenith Electronics have a joint venture in high-definition television. So we are witnessing a new way of conducting business in science and in technology. We ought to take advantage of this and build on it.

Goodwin: Does that suggest to you that maybe there should be some sort of department of science and technology or a civilian DARPA, which would function like Japan's Ministry of International Trade and Industry? Such reformulations of the government apparatus are being talked about in Congress—though not very seriously, I must admit.

Buchsbaum: I don't know what organizational structure would be best, but it seems to me that the Federal government does have to play a greater role in helping bring about some changes. The policy statement that has emanated from the White House is the right first step. The government will need to continue to work at being a matchmaker, if you will excuse the term, to get these things going.

Gibbons: I think Sol's right. It seems to me the Federal Coordinating Council on Science, Engineering and Technology, better known as FCCSET [pronounced "fix it"] and other approaches that integrate R&D across the agencies is a productive way to go, because if you try to talk about centering R&D in a department of science and technology, you're removing technological resources from the very mission agencies for which they were created. It's like taking Bell Labs away from Mother Bell and just letting it operate as a laboratory instead of a place that moves ideas all the way from the lab bench to the marketplace. It also seems to me that the confounding nature of thinking about the future of national labs is a reflection of our historic cultural tension between the government and the private sector. What we need, in the labs as well as across government, is more of a sense of

joint venturing between public and private investments, through a variety of flexible arrangements. The national labs could perform the role of regional centers of technological expertise, with very extensive resources, people and equipment. They could continue to be useful not only in the public mission they were originally created for, but they could provide flexible arrangements that benefit both the public and the private sectors. To do this, you have to start, as Gerry Yonas said, with legislation that makes it all possible.

Buchsbaum: A good example of what Jack is talking about is the recent report on high-performance computing by the FCCSET committee under Erich Bloch [when he directed NSF] and Charlie Herzfeld [Director of Defense Research and Engineering]. The committee's report gave structure to a national program dealing with an important technology. Possibly for the first time, all the agencies interested in that particular technology got together and agreed on a common project.

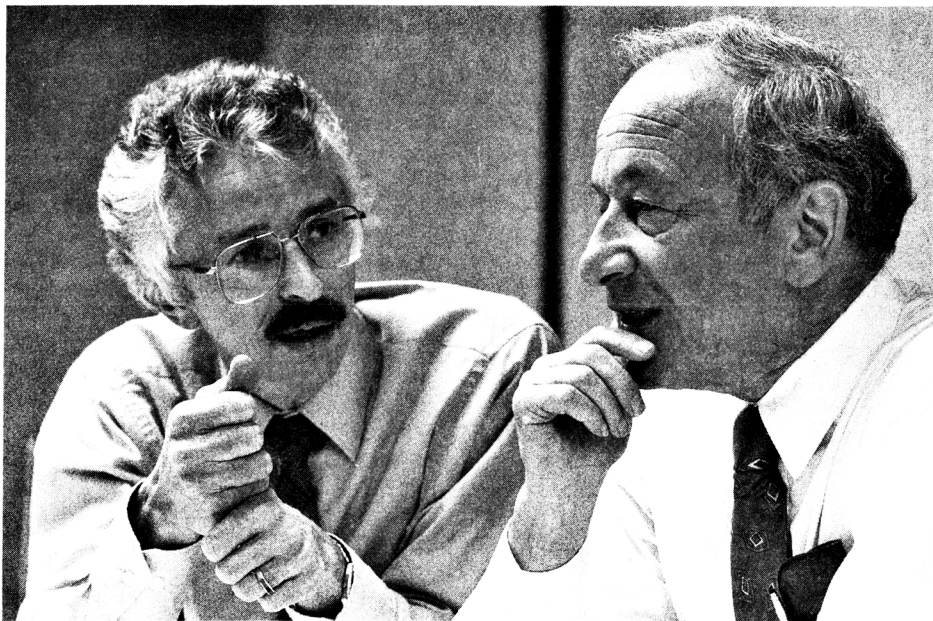
Goodwin: It must be shocking to you that there were no fights over turf?

Buchsbaum: I'm not saying there are no turf wars, but the fact of the matter is they agreed in principle about the part each would play in a truly national program.

Yonas: Can I try to summarize some of the things I think I heard today—and with which I fully agree? Number one, we said a national laboratory has to have a principal mission in order to be healthy. It has to have a reason for being. Then we said after that there need to be arrangements made so that the laboratory, whatever its mission is, can have an increasing role in problems of national importance. Third, there ought to be a streamlined way to make arrangements to lead to teamwork and cooperation in solving important problems and in developing emerging technologies, when possible and justified, with commercial companies and research universities. Did I leave anything out?

Gibbons: That's a good start.

Hecker: Let me use the example of high-performance computing to go a bit farther. It is important to know how the national laboratories are expected to respond to that program. Different agencies will bring different things to the table, and I think that's what we need to optimize. You know, people talk about a civilian DARPA because they see the success that little agency has had in interacting with industry to get new technologies into the industrial sector. DARPA has done this very well. There are a couple of reasons why DARPA has done so well. One is that the customer is the Defense Department. So there is a direct connection between the R&D and the ultimate customer. Another reason for DARPA's success is its selection of bright program managers who approach industrial research people directly. So DARPA is a classic case of technology push and customer pull—the push of technically smart program managers and the pull of the government customer. If you try to translate that into the civilian sector, you find an important component is missing—the government as an eager customer with deep pockets. While DARPA has been significant in promoting massively parallel processing and high-speed computing, the DOE, through its laboratories, has been vital in promulgating high-performance computing for nuclear weapons development, for magnetic fusion research and for global climate modeling, to name a few items in the



Making his point during a break in the roundtable discussion, Hecker (left) engages Buchsbaum.

DOE agenda. The weapons laboratories have worked with vendors as a sophisticated user, pulling for more and better capabilities, always at the top end of high-performance computing. Seymour Cray brought his first Cray computer to Los Alamos in 1976, and he said something like "I don't have an operating system and I don't have any software, but I'm sure that you guys can use this because you're trying to solve big problems that you can't deal with effectively in any other way." We built a good relationship. The added value provided by DOE is the intellectual contribution made to technologies through its laboratories.

Buchsbaum: DARPA and DOE and NSF and Commerce all pulled together with industry and the universities to develop a high-performance computing program. It happened because Allan Bromley knocked some heads together. Allan has the President behind him. Bromley told the agencies that if they want to be funded this is how it's going to be. He put some muscle behind the FCCSER mechanism. FCCSER had existed before Bromley arrived at the White House, but it hadn't been used well. This is one very good example of how the government can put its weight behind a technology. Look, this process is not a panacea. Right now it's a program on paper, but it's a significant new start in the fiscal 1992 budget. It'll take several years to see whether DOE, DARPA, NSF and Commerce can work together. It's a good start.

Lubkin: We haven't yet considered NASA's labs. Are changes in the works for places like JPL, Goddard or Marshall?

Allen: I'll make a couple of comments: Number one, JPL, whose primary mission for NASA is the unmanned spacecraft program to explore the solar system, is relatively stable. That mission will continue for some time, and so JPL is not facing the major changes that are seen in the defense sector or even in other parts of NASA. In fact NASA is at a significant crossroads and is obviously struggling to figure out its future. A committee under the chairmanship of Norman Augustine is examining NASA's future. One aspect of the Augustine review gives me pause to ponder. The Administration is convinced that investment in space activities has very large payoffs to the economy through spinoffs. It uses an analysis dating back to Project Apollo to convince itself that investment in large

space endeavors will do a great deal for technological competitiveness. This is the principal motive behind the President's decision to advocate a Moon base leading eventually to exploration of Mars as the purpose of our civil space program. Until now, few people have rallied around that flag. Congress hasn't rallied around at all. In fact, Congress zeroed out of the fiscal '91 budget all items related to that initiative, including activities ongoing prior to the establishment of the Moon-Mars initiative. So questions about NASA's future and the functions of the agency's laboratories must go unanswered. I think the questions will be revisited over the next two or three years by panels like the Augustine committee and by Congress. I don't really know the answers right now.

Goodwin: What are the implications for Goddard or Marshall or Lewis and the others laboratories if the President's grandiose space plans are rejected by Congress?

Allen: The future is less stressful for Goddard and JPL than for the other centers, because the space science mission is not caught up in this particular issue. But Marshall, Johnson, Kennedy, Stennis, and a portion of Lewis are totally dedicated to NASA's shuttle program and the emerging space station. This particular set of activities is not as robust or as well supported by the Congress as it needs to be for NASA's institutional purposes, and so they raise questions that remain to be answered.

Gibbons: You said that the Administration has claimed that the economic benefits from this space exploration initiative justify the investment. I've never seen any data to support that contention. Is there some basis for that kind of claim or belief?

Allen: Well, my basis is the Administration's statement that says it is. And I don't mean to be facetious about that, because I think such numbers are all hard to derive and I think anyone is entitled to have his own view. But it is a fact that the Administration has a formula that relates to the contribution Apollo made to America's technological progress as a whole, and it extrapolates this to what future space missions could do.

Gibbons: Is that formula available?

Allen: When the tape recorder is turned off, I'll answer that question. ■