Ed David on the Future of Research Support

Edward E. David, Jr., president of Edward E. David, Inc., is known to the mathematical sciences community for chairing the committee that produced the so-called "David Report" in 1984, which was a major influence in the rise in federal funding for mathematical sciences research in subsequent years. David served as science advisor to President Nixon and has been prominent in federal science policy circles. The following is an edited version of remarks he made to the AMS Committee on Science Policy at its meeting in September 1994.

Before joining you here, I looked at some science policy documents, including the AMS National Policy Statement for 1994–1995. This document is very interesting and significant. I reread "Science in the National Interest" from the Clinton Administration. I also went back to my own statements over the past few years, the most recent of which was published in the National Academy of Engineering journal, *The Bridge*.

These documents raise some important issues and tell you what is in people's minds with respect to policy issues. I will discuss some of these in a moment. But let us keep in mind that the identification of issues in policy statements is always a first step in science policy, and only a first step. Policies and issues must be coupled with programs which will achieve the goals selected on the basis of studies of policy issues.

But as of now, in most cases, they are not coupled. In fact, the core of my theme is that the programs and funding of the federal government—and also of some universities and some of the states and industry—are really orthogonal to the policy statements that people put out, read, and give lip service to. I do not think that is news to you. But at least we can say that the Administration's views, put forward in"Science in the National Interest", are full of good intentions. But I am saying that there is much more to achieving goals set by policy than the words and good intentions in which those statements are couched.

First, let us look at a few of the imperatives stated in the Administration's document. Some interconnected strategic goals which the country should be pursuing are identified there: economic growth, responses to citizens' needs, and world leadership in science, mathematics, and engineering. The goals are clear, but what are the mechanisms proposed for achieving those goals? We can think of several possibilities: administration programs and initiatives, Congressional controls and initiatives, as well as industrial activities. But the question before us, as technical people, is, What is the role of the scientific, engineering, and mathematical communities in achieving these goals? This leads immediately to the central question, Who controls the national agenda for research in the future?

That is a principal issue that policy people must discuss and resolve. As nearly as I could tell, this matter was not spoken to directly in the policy document; it was more or less finessed. I remind you that Senator [Barbara] Mikulski [D-MD] and others seem to aspire to the role of setting the research agenda, at least in part. So, the question becomes, Will social or political agendas control the scientific agenda? Or will science control its own agenda and have an impact on these other agendas?

The second thing expressed in this document is a desire to convert defense-related research—that of the Departments of Defense and Energy (DOD and DOE) specifically—to job creation and national strategic ends, whatever those are. There is no doubt that some conversion is needed—the cold war is over—and it is a significant question as to how cold war efforts can be converted into activities that address our current situation.

But again, looking into that more deeply, we find the real question, By whom and by what process will decisions be made as to which programs will be used to implement this conversion? Where are those decisions going to be made and on what kind of advice? So far the conversion has been put into the hands of the Technology Reinvestment Program (TRP) of the DOD, the Advanced Technology Program (ATP) of the Department of Commerce, and to some degree the Small Business Innovation Research (SBIR) activities. SBIR predates the end of the cold war

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by some years, but it is still one of the major government programs to which people look for innovation.

So far what we've seen doesn't generate much confidence. One of the TRP programs provides a typical example: the creation of a flat-panel display industry. My understanding is that $500 million has been committed to creating an industry to manufacture flat-panel displays in the United States—to catch up, as they say, with the Japanese. The interesting thing to note here is that this is not a research and development initiative. It is a commercial business initiative or an international trade initiative, depending on how you look at it. Now, you can say that spinning off new industries has always been a DOD function, because DOD—and DOE, for that matter—regularly provides funding to establish industries which produce the materials and technology needed for its own projects. Indeed, these departments have created industries. However, the results have rarely been commercial and in many cases not even commercializable. Thus neither DOD nor DOE have had any experience with creating commercial industries—and certainly the Department of Commerce hasn't either—so such programs are unlikely to be successful. People are already suggesting what to do with the remnants of the flat-panel display activity when it collapses.

Other declarations in the national policy document are that U.S. policies should promote leadership in science; use fundamental research to achieve national goals; stimulate partnerships for economic development and technology development; produce top-rate scientists, engineers, and mathematicians; and cultivate science and technology literacy for the public. Well, this certainly recognizes an important role for academia and professional societies as well as industry. Furthermore, it recognizes the importance of elite people and international participation in science. All of these are worthy, but there appear to be few if any supporting programs to achieve these ends.

For example, the NDEA, the National Defense Education Act of some years ago, was very important for the cold war outcome. Many people believe that NDEA support of graduate and undergraduate students had a strong influence on the technical community, which was in large measure responsible for that outcome. But at the present time, there are no education programs associated with ATP or TRP or SBIR: no federal programs for financial support of academic facilities or faculties, no easing of technology transfer regulations by the Department of Commerce.

Industry is cutting its research rather sharply—the latest figures show a 1% current-dollar increase in industrial spending on R&D, including federal contributions. That translates into a 2-3% reduction in level of effort, because of inflation. During 1976–1985, U.S. industry increased its funding for R&D 6.7% a year, but since 1986 the increase has been 1.2%, and in 1993 about 0.7%. This is a very real cutback in industrially performed research.

"Science in the National Interest" advocates the importance of creating programs which strengthen connections between fundamental research and national goals. This brings us back to the "critical technologies lists" which were formulated by various groups, including the National Science Foundation and the National Academies of Science and Engineering. These lists, it seems, generated some of the TRP and ATP programs. But these statements of policy and the nature of the programs they have so far spawned lead us to ask, Can the departments of government change their roles and missions to match where society wants to go? For example, the NSF estimates that the cost for repairing, renovating, and renewing academic research space is between $7 and $8 billion. Additionally, scientific instrumentation needs another $3 billion according to the NSF. What part of this is going to come from the federal government? We don't know the answer to this, and the outlook for getting that money in finite time is not promising.

Certainly there are good intentions in this document. It is good to have the statement out. But there are trends in the society, in the economy, which are barriers to realizing these intentions. I laid out some of these in my own statement over two years ago at a science policy symposium run by George Washington University, and I've updated it twice since. I'd like to review these very briefly for you. I stated these trends in terms of what the end results would be if they are allowed to proceed to their logical conclusions.

The first of these trends was that corporate research laboratories will be abolished. The reason is that the currently fashionable paradigm in industry is to integrate all activities into teams aimed at specific end results. For example, product development in the automobile industry is now done primarily through "platform teams", including people from what was called the functional departments of these companies: all the way from the design studios and the research and development laboratories to marketing, sales, and support for the vehicles once they're in the field. This pattern is being followed in a number of industries. What results is that the research and development laboratories soon become part of the "big picture" and no longer can work on their own independent R&D.

The next outcome of these trends is that academic research will be completely integrated into the corporate and national strategies. Bell Labs, IBM, the Office of Naval Research, the Air

Force Office of Scientific Research, and DARPA have used this funding paradigm for many years. The idea here is that to be effective, science has to be integrated into an overall plan of corporate or federal action, leaving some room for investigator-initiated research. But proper balance between investigator-initiated research and product-directed team research is difficult to maintain, with support for basic research being slowly but surely eaten away.

The third outcome is that research grants are going to be replaced by contracts with specific deliverables. The ratio of federal R&D contracts to grants has been going up rapidly in the past ten years. There is some thought that this trend will continue and that contracts will replace grants in most cases. Recent concerns about misconduct in science have led to the desire to monitor research more closely. This is reinforcing the trend toward more contracts. The funding agencies and departments are more comfortable monitoring a contract than a grant, because when specific deliverables are specified, the criteria for success are obvious, while with a grant it's not so easy. Furthermore, these misconduct inquiries will result in strict guidelines for research performance, resulting in increased reluctance on the part of independent researchers to be aggressively innovative.

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I have said before that the total national investment in R&D will shrink by about 25% over the next few years. I'm thinking here about level of effort, not about dollars per year. The squeeze on funds at the federal level and in industry will force everyone to live in a much more penurious way. The downsizing you see now in industry hits the technical activities of industry hard; this effect will quickly move into the universities as well. The federal laboratory system will be subject to an even larger reduction. The current budget for those activities is about $25 billion a year. That will go down to half or less in terms of level of effort. I just don't think a structure of that size and scope can be supported when the missions of many of those laboratories have just disappeared. Implementing a policy of turning those laboratories toward commerical, environmental, or any other effort is not going to be feasible.

The oversupply of scientists and engineers will continue to increase, resulting in further downsizing in some of the universities and colleges and industries. In the last few years we have seen many projections of increased personnel needs in science and technology gone awry. Solutions to the overproduction and underemployment of scientists are difficult to find. There have been a number of suggestions, one of the most intriguing being that science, engineering, and mathematics education is one of the best preparations for almost any career, including business and government service. That may very well be true, but the students must believe that, or we won't have any students. And at the moment they don't appear to believe it.

Industrial policy is going to be decided by government. The effort by government to utilize resources to address national needs is going to grow substantially at various levels, but this will not offset the decline in other areas. There will be continued restriction on technology transfer abroad—even today the Commerce Department has put constraints on foreign funding of U.S. research, for fear of foreign ownership of technology.

While there are laudable good intentions articulated on the national scene, the reality seems to be moving in the opposite direction. We in the technical community should insist that programs which make those good intentions into reality should be formulated and funded. Right now we are a very long step away from formulating and funding such programs.

Mathematics is in an especially vulnerable position. Its principal places of performance are in academia, government laboratories, and in a few industries—all at risk in the current situation. The AMS should make a realistic assessment of the available resources for mathematics education and research and include industrial as well as government and university resources. They should also make an assessment of the requirements to satisfy the good intentions of the federal policy statements—that is, keeping the U.S. at the leading edge of mathematics, among other disciplines. There is likely to be a wide gap between the good intentions of the federal policy statements and what can actually be performed given the resources that are available. That's something to be determined, but I expect that gap is big. And then I think the AMS should propose some ways of living within the likely resources while strongly advocating programs to address the more ambitious goals which I think we all have for mathematics.

The next eight or nine years will be a sobering experience. But on the other hand the good intentions of the federal government and some others—state government, in part, and to some degree industry—are comforting. Can they now perform what they have laid out as policy?