Attracting and Retaining R&D Talent for Defense

As the defense sector turns the corner on a decade of budget cuts, turmoil, and uncertainty, the outlook for meaningful long-term employment for scientists is brightening.

John F. Holzrichter

Few objectives are more worthy of support than keeping the peace, limiting adversarial actions against our nation and our friends, and allowing democratic forms of government to prosper—the goals of national defense. The large and multifaceted defense sector in the US continues to offer exciting and meaningful work both for technically trained young people and for those more advanced in their careers.

My own career in defense R&D has been rewarding, challenging, and always incredibly interesting. I began my career when there were—compared to today—relatively few academic or civilian-sector employment options for new physicists, and the cold war was proceeding at a high pitch. In addition, the perhaps exaggerated belief existed that yet-to-be-discovered technological breakthroughs would decisively tip the balance of power against our determined adversaries. Ultimately, defense science and technology (S&T) was not "singularly decisive," but it did enable our national leadership and our allies to withstand decades of adversarial assaults until the Soviet Union collapsed from within. The US then took a "peace dividend" and decreased the national debt, in part by reducing the fraction of its gross domestic product (GDP) devoted to defense from 6% to 3%—mainly by cutting back on procurement and R&D.

Since the Soviet Union collapsed in the early 1990s, the US and its allies have had to fashion not only new national security policies but also new defense structures to correspond to those policies. Not surprisingly, this effort has been difficult. Today, US national security policy is still evolving and lacks the consensus it had during the cold war. We face both old and new security commitments in places such as Korea, Iraq, Taiwan, Bosnia, and Kosovo, and in NATO. But today's national security landscape is even more complex than that: There are increased numbers of not only brutal, maniacal political leaders in failed states, but also paramilitary, criminal groups capable of inflicting ever-increasing damage on their victims.

The current uncertainties are influencing the initial and midcareer employment decisions of R&D professionals who typically would have been interested in defense-sector careers but, today, have diverse options in other areas. Yet, the US is faced with a similarly diverse set of evolving defense options and potential adversarial situations, many never before contemplated. Whatever the future brings, national security requires more highly talented and motivated experts than ever before. And it needs experts not only in the traditional S&T disciplines, but also in biology, computer science, and other fields. Equally important are technical experts who can work on common ground with nontechnical experts in social sciences such as diplomacy, policy-making, political science, behavior, economics, and international law, to name a few. Talented people, trained to deal with new knowledge and unknown conditions, are needed to respond to large numbers of unexpected—and sometimes "should have been expected"—situations.

Defense-sector trends

In this article, the defense sector includes institutions that are federally supported to provide for national security. Such institutions include private defense contractors, consulting companies, research labs sponsored by the Department of Defense (DOD), national security labs sponsored by the Department of Energy (DOE), intelligence and reconnaissance organizations, and a large number of universities and colleges where individual researchers work on problems applicable to national security missions. Several common themes run through these myriad institutions.

One important common theme is economics. In 1999, the US GDP was $9.1 trillion, and the US total defense budget was $292 billion, about 3% of the GDP. Of that, 13%, or $38 billion, went to defense R&D, but only $1.1 billion to basic research and $3 billion to applied research (much of which is really developmental work). DOD contractor overhead accounts, for both internally directed R&D (IR&D) and bid and proposal (B&P), together totaled $4.8 billion, but most of those funds were used to win contract competitions;

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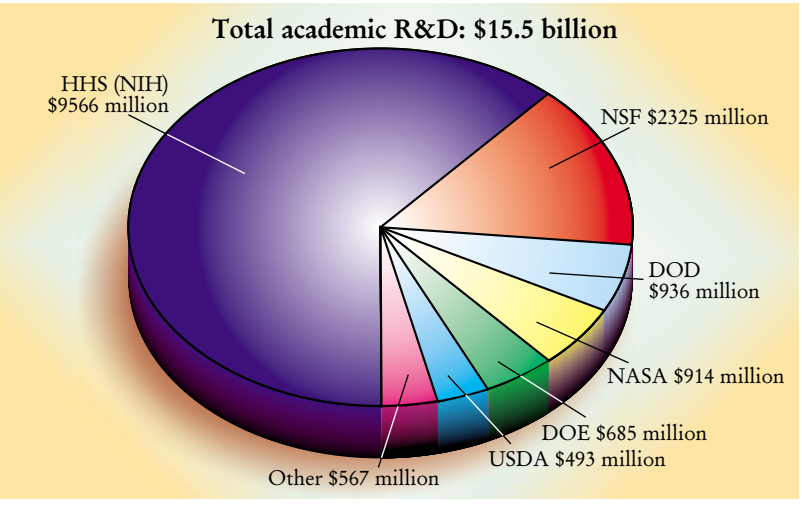

FIGURE 1. FEDERALLY FUNDED academic research and development in the fiscal year 2000 budget. The defense department sponsored about 6% of the total, drastically down from the 20% that it contributed in 1965. (Adapted from ref. 1.)

their buying power for R&D is estimated to have been $1.2 billion. That budget for DOD-sponsored basic research is well below what it should be, considering the rapidly developing new sciences and technologies that offer great promise for defense missions. An undeniable competition for resources has squeezed the defense R&D sector and limited its traditional ability to support basic and applied R&D.

Also, fewer funds are available to support university research in science and engineering. Figure 1 shows today's relatively small presence of defense-supported research on US campuses, relative to other sectors.[1] It was not always so. Although the defense sector's research support has remained fairly constant at about $1.2 billion per year, its portion of campus support has dropped from 20% in 1965 to about 6% today. In addition, much of today's university support is for more applied, shorter-term work than in the past. Today's professors, students, and university administrators are directing their research toward areas that, for the most part, are not immediately useful for national security.

Another common theme is the work environment. Any productive R&D lab is characterized by a sense of exciting, purposeful, and meaningful work assignments, and minimal bureaucratic interference. Such an environment offers a researcher the opportunity to build a solid reputation through accomplishment, speaking, and publishing. In addition to the positive environment, researchers usually receive modest rewards in the form of long-term employment with pay and benefits commensurate with their educational levels. Characteristics of defense-sector R&D programs include articulated sets of common goals, stable funding for basic and applied projects typically over 10-year cycles, excellent facilities, and opportunities to travel and interact with the best scientists, engineers, and corporate leaders in the world. Although several defense R&D institutions today seem to have lost sight of some of these important work-environment factors, many features that attracted me to national defense work still exist, and continue to provide a basis for rewarding careers.

The road to today

A number of recent developments offer a good news–bad news situation for defense R&D. In the years since I began my career, there has been not just an information explosion, but also a knowledge explosion with enormous potential. An unexpected downside, however, is the rise of immensely complicated security and classification policies. More good news is that well-trained people are living longer, healthier lives; they are willing and able to contribute over long, productive careers. Structural changes in our economy, advanced software, and increasingly cost-effective instruments enable gifted people to be exceedingly productive doing much more sophisticated work than had previously been possible. As a result, the venture-capital community has sponsored many initially small but enormously successful new enterprises for both defense and commerce. At the same time, it is increasingly difficult for the US government to mount large, complex projects, because of proliferating bureaucratic structures and pressure groups that lead to ineffective management practices or the pursuit of unscientific conjectures.

Over the decades, US R&D enterprises have evolved into sophisticated organizations, whose output has dramatically affected our present quality of life. Almost everything that we touch on a daily basis is substantially a product of intentional R&D conducted over the past 50 years. Consider latex house paint, most modern plastics, most present breeds of agricultural animals and plants, cell phones, the Web, and satellites for communications and reconnaissance. New defense technologies have been most impressive. The value of R&D cannot be in doubt.

We now know that, during times of rapid change or new discoveries, the larger industrial and governmental R&D laboratories use about 10–15% of the organization's budget for IR&D.[2] Half of that is typically applied to advanced research for meeting mission-related responsibilities; the other 6–8% is commonly directed to stimulate new ideas, fund exploratory work in new risky areas, hire talented people, and support basic or applied research in poorly understood areas of special interest to the institution. These IR&D resources can be used very effectively to keep the labs current in important S&T areas, to attract new people by offering them an opportunity to continue in their specialty as they become integrated into the institution, and to investigate high-risk ideas that are not ready for development into products or procedures.

In contrast, organizations that do not invest in understanding radical new technologies are setting themselves up to go out of business: They will face serious losses when the impacts of new technologies become apparent and their commercial or defense competitors are well prepared. Many defense institutions are guilty of underinvestment in important emerging fields.

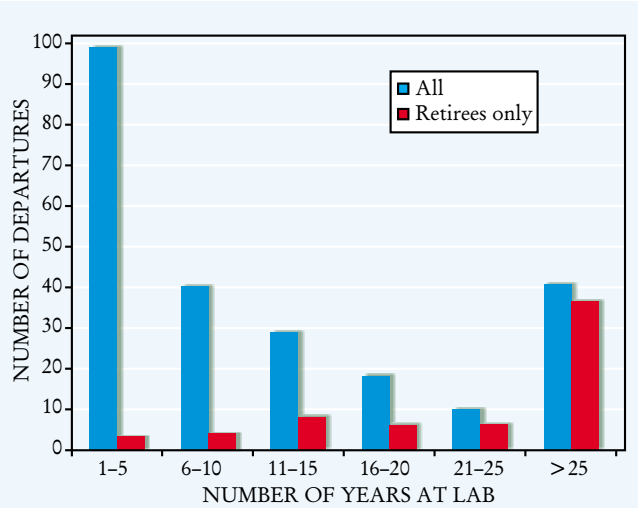

FIGURE 2. ATTRITION AT ONE DOE DEFENSE LAB in a recent two-year period. Almost 100 talented young people left this lab for better opportunities within their first five years. Perhaps more serious, an additional 55 experienced and highly rated midcareer people left, seriously reducing the reservoir of talent and leadership for future projects. Because of their level of talent, I estimate that those 55 departures undo more than five years of efforts in hiring and training.

At present, in a still-strong economy, national expectations are excessively high regarding returns on R&D investments. Venture capitalists and other investors expect greatly multiplied paybacks within a few years. This climate has made it extremely difficult for the private sector to support either long-term or high-risk basic and applied research projects. Defense cannot afford to mimic the private sector. Major national security systems often take decades of R&D effort, followed by another decade to build. The government is widely acknowledged as the proper agent for much of the long-term support in many fundamental areas, such as electronics, materials science, propulsion, and computing. Yet, because of cutbacks and near-term objectives, a funding shortage developed during the 1990s for long-term studies and professional development.

Federal and state governments have done their best to respond effectively. States, with federal assistance, have supported many research universities and educational institutions at the undergraduate and graduate levels. The federal government, of course, has invested heavily in applied research and in national defense technologies, such as satellites, nuclear defense, and undersea defense.

To understand the impacts of today's defense climate on our defense contractors, the Defense Science Board, a prestigious group of talented, experienced individuals, examined the relationships between the US government and the US commercial sector.[3] The board emphasized the need to rethink models for funding contractor IR&D. The study also pointed out that the US government and the defense industry need to work together to properly support the development of new defense systems without draining R&D resources. In addition, because of the merger of many defense contractors into a few large "general contractors," development of these new systems must be nurtured in an environment with less competition than in the past. The board also pointed out the need to develop incentives to attract and retain trained personnel at all technical levels in the defense R&D community, as well as to attract and retain core personnel in design, test, and production organizations and in the increasingly technical military services.

The DOE perspective

Because much of my career has been with DOE, and because physics and physicists are so important to DOE's missions, I now look more closely at that portion of the defense sector. I see a positive climate developing; much exciting work is being supported with excellent facilities, and many problems of the past decade are diminishing. Overall, the three DOE national security laboratories have been effectively accomplishing their scientific and technical tasks in pursuit of their missions. That success stems from relying on highly trained PhD scientists and engineers for technical management and concept development. These organizations have been managed via a government-owned, contractor-operated (GOCO) structure for many years, with the University of California managing Los Alamos (LANL) and Lawrence Livermore (LLNL) National Laboratories, and Lockheed Martin managing Sandia National Laboratories (SNL). The nation has been committed to—and grateful for—their primary mission of nuclear defense.

Over the past decade, the role of the laboratories has changed significantly. The labs are now the stewards of a much-reduced nuclear stockpile that must be maintained without complete testing (see the article by Raymond Jeanloz in PHYSICS TODAY, December 2000, page 44). In addition, the labs' researchers work to reduce the danger of a nuclear mishap through materials surveillance and other nonproliferation activities. The technical and scientific transition from nuclear defense to a mission appropriate for the new millennium appears to be going well, with tremendous achievements in many areas. Accomplishments include work with personnel in the former Soviet Union to reduce the danger of nuclear war or accidents (see the article by Frank von Hippel in PHYSICS TODAY, June 1995, page 26) and the development of the next generation of computer simulations on massively parallel computers that now exceed 10 teraflops operational capability.

The work at these laboratories has been demanding, exciting, and of high national importance. These labs have had the flexibility to focus on topics ranging from exploratory research to advanced development, according to mission needs. They have provided an environment conducive to world-renowned research, in which individuals accomplish many things, receive competitive compensation and benefits, and can develop excellent reputations. The labs have also benefited enormously from IR&D flexibility to pursue new ideas and concepts. Also, researchers at LANL and LLNL, being university employees, have been able to give advice and express opinions

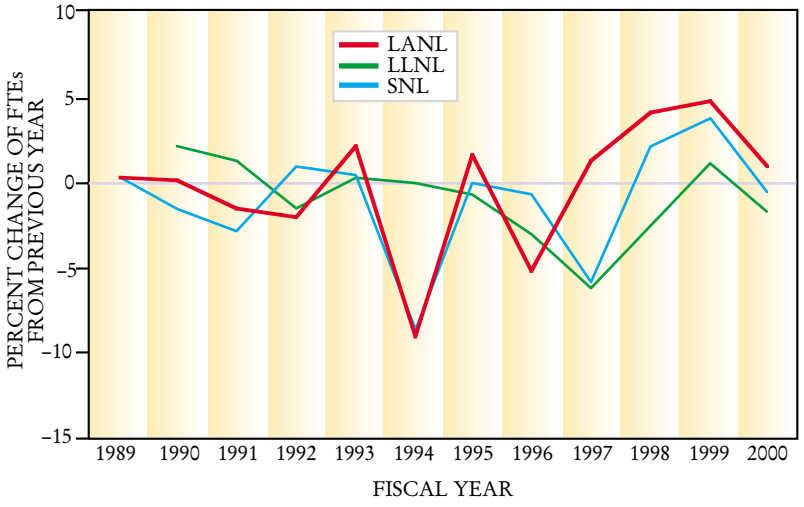

FIGURE 3. LOOMING LEADERSHIP VACUUM. The 5% loss of science and technology full-time-equivalent (FTE) staff in DOE's defense labs, most apparent in 1994, 1996, and 1997, corresponds to a loss of more than 1200 trained people. Such losses lead to a significant reduction of available talent among 25- to 35-year-olds, from which leaders would normally be drawn 10–15 years later.

openly on important topics as responsible individuals (not as laboratory representatives, and to the degree that classification of some topics allows).

But all is not rosy. During the past decade, as the defense climate has changed, many difficulties have faced policy-makers in reaching a consensus on the technical and management roles and responsibilities that these laboratories should have.[4] A great deal of "critical revisionism" has occurred as the labs' remarkable achievements in nuclear defense have become rallying symbols of what was imperfect in the world during the cold war period. In addition, critics have offered a seemingly endless series of allegations of poor procedural performance on issues that include groundwater pollution, sewer problems, safety concerns, workforce diversity, security, and foreign interactions. Furthermore, concerns have been raised regarding the best management structure and funding for the labs. DOE has encouraged industrial collaborations, but difficult questions arise when government funds are involved. How should the skills of these laboratories be made available for state and local problems, particularly considering highly politicized topics such as environmental remediation, transportation, water resources, and nuclear waste storage? What degree of flexibility should these DOE labs (and other defense-sector organizations) have to pursue new ideas? To what degree should the labs work toward resolving major issues such as climate change, water resource definition and allocation, and missile defense? Policy, funding, and technical discussions regarding these and similar topics have inevitably led to controversy. (Also see the article by Sidney Drell in PHYSICS TODAY, December 2000, page 25.)

The technical reputations of the DOE laboratories remain excellent, but the management and procedural structures have required updating. Still, the all-too-frequent and often unreasonable pronouncements of malfeasance expressed in newspaper headlines have been difficult for all of the well-intentioned parties. One (hopefully temporary) outcome has been the reduction of local contractor control (less GOCO-like) and the installation of larger internal and external bureaucracies to "prevent" future problems (more civil service-like). Unfortunately, this management direction is contrary to that evolving in the private sector, where less oversight and more individual responsibility are the norm. It is also contrary to new directions in the public sector, for example at the National Institutes of Health, where new civil service hiring procedures and new management structures are proving to be very effective.

Despite the best efforts of many people over this past decade, the attractiveness of DOE and other defense-sector institutions to talented individuals has suffered. Meanwhile, the commercial sector is experiencing rapid growth and a changing social contract with its workers, who are increasingly assuming responsibility for their own futures, including retirement. Large starting salaries, stock options, and many alternative opportunities for future employment draw creative scientists and engineers with advanced degrees to the commercial sector. The consequence is that defense-sector R&D organizations have found it harder to recruit highly skilled people: Through 1999, typically 80% or more of initial employment offers were accepted; in 2000, however, the figure dropped to 60%.

Even more serious is the loss of early- and mid-career staff, as shown in figure 2. Still another serious event, depicted in figure 3, occurred in the mid-1990s: Concerns about the future led to far fewer hiring offers being extended. It is very hard for the labs to recover from such a hiring reduction—several hundred per year for several years. What usually evolves is a reduced pool of skilled leaders within the organization 10–15 years later. The resulting leadership vacuum has a negative impact, as middle- and upper-management slots open up but experts familiar with the organization are unavailable.

The recruiting situation

There are many ways to fix the twin problems of recruiting and retaining bright, talented, creative people for defense-related R&D. One of the most effective ways is for our national leadership to more clearly acknowledge the importance of workers' contributions in the defense sector, and in particular the importance of R&D. National security R&D is one of the best collective investments our nation has made.

The laboratories, and many of the organizations that control their funding, procedures, and research topics, are working hard to overcome the difficulties described above. For example, prestigious and well-salaried postdoctoral programs such as the Oppenheimer fellowship at LANL and the Lawrence fellowships at LLNL have been instituted. These highly successful programs encourage talented scientists and engineers to spend several years

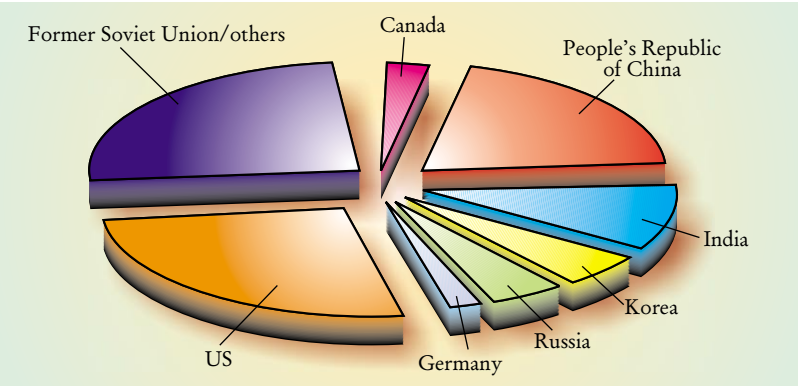

FIGURE 4. DISTRIBUTION BY NATIONALITY of the 470 applicants for the Lawrence Postoctoral Fellowship Program in the latest application cycle. The number of applicants has steadily increased from 398 in 1998. More than half have been foreign nationals. Each year, four fellows are selected, and approximately 15 applicants are hired in some capacity.

using the laboratory's resources to do great science and engineering. Some fellowship applicants have been hired into other positions at LLNL and LANL, or have entered the labs' regular postdoctoral programs, which are also attractive. It seems that many lures of the past—excellent facilities, a positive work environment, an opportunity to do important work, and good salaries and benefits—are still available for young people at these institutions. The retention of these young people will depend on the degree to which the nation develops a longer-term consensus on defense-sector support.

The fellowship programs, however, illustrate another problem for the defense sector: the large number of talented scientists with foreign citizenship who are obtaining advanced degrees at US institutions. (See the article by Kate Kirby, Roman Czujko, and Patrick Mulvey on page 36 of this issue.) Data from the LLNL postdoctoral fellowship program are shown in figure 4. This foreign-national trend is advantageous to the US on the whole, but in much of the defense sector, US citizenship is required for permanent employment. LLNL has benefited both by hiring talented young US citizens and by accommodating exceptional people who expect to become US citizens.

I recently sent a questionnaire to the fellows of the Fannie and John Hertz Foundation, with which I am affiliated.[5] Each year, the foundation selects about 25 graduate fellows based on their grades, mentor recommendations, and evidence of creativity or entrepreneurship in the physical and biophysical sciences. Those receiving this fellowship are aware of the defense-sector opportunities, and are asked to be available for service in the event of a major national emergency. In the questionnaire, I asked these young people about their career intentions (at a university, in the private sector, or in government service) and factors that might influence their choices. I inquired about their view of opportunities to pursue their own professional specialty, the availability of generous and lasting funding, the breadth of future opportunities for their work, the importance of benefits and salaries, the potential for bureaucratic impediments, and the meaningfulness of the work. For those preferring nondefense careers, high-scoring factors were the availability of more and better opportunities to pursue their specialty and their desire for a low level of bureaucracy. Major factors for those considering defense-sector careers (about 30%) were the opportunity to be well funded, to do exciting and meaningful work, and to work in a stable environment with good benefits. This evidence indicates that the defense sector is still attractive to many gifted individuals, as long as the work environment meets both their personal and the institution's objectives.

Tomorrow's need for today's talent

In my opinion, nothing can be worse than losing a conflict of the magnitude of a world war. Even the so-called winners of past conflicts faced innumerable negative consequences, especially our European allies. Of course, in more recent history, a nuclear exchange would have been a worldwide catastrophe. I firmly believe that the prevention of such conflicts over the past 55 years, using military deterrence, information dominance, and diplomacy, has been the greatest success in America's national security history.

The nation's security leadership now faces an extraordinary set of problems and opportunities. The backdrop of new policies, new technology, and societal change, along with many other factors, strongly influences the employment activities of young and midcareer S&T people.

The consequences of responding unimaginatively to hiring new employees are manifold, and must be resisted at all costs. Government-sponsored laboratories have typically frozen hiring whenever funding looked uncertain, but such inactivity generates a reduction in the talent pool that is difficult to fill (see figure 3). There follows a strong temptation to acquire the missing skills by hiring consultants or short-term contractors. This approach has solved many problems, but the host R&D institution often becomes less capable over time. The opposite approach has been to hire people quickly, to fill "hiring slots" before they vanish. Quick-response actions tend to bring in people of mixed quality and can result in lower workforce effectiveness.

A wise policy, practiced by several farsighted organizations—such as the former Bell Laboratories and the IBM research laboratories—is to hire a few talented individuals each year, no matter what the present operational difficulties. This hiring approach costs very little and ensures some potential for nucleation of future centers of excellence, when the times warrant expansion.

These days, the employment pattern seems to involve a mobile professional sequentially pursuing a varied career path. Young defense R&D professionals, therefore, need to develop external reputations, and will likely move through several jobs (for example, into government, into aerospace, and elsewhere). It is in the nation's best interests to maintain an attractive, high-quality work environment for these professionals.

If I were omnipotent

Many of my observations arose from responses in defense R&D organizations to a progression of federal policies and

executive orders, congressional laws, institutional evolution, societal and bureaucratic change, and so on. Those work environment responses have rapidly multiplied in recent years, almost always with the best of intentions. However, many of the policies have had a systemically negative impact on the health of the national R&D community in general, and the defense community in particular. The following four recommendations, if implemented to any degree, would make a large difference in our national defense posture.

▷ Increase defense R&D and IR&D programs to funding levels that are recognized as being healthy and necessary in today's changing environments. A national security policy that depends on technical advantage is not credible if the nation continues to cut its defense R&D budgets.

▷ Install institutional personnel policies to attract technical leaders from the best educational centers. Add flexibility, indirect benefits, and opportunities for personal and professional growth to work contracts. Make it easier for R&D professionals to get work done, rather than adding bureaucratic layers that make work more expensive and difficult.

▷ Require that the armed forces provide hiring slots (at the general or admiral level) for outstanding technical leaders. It is not credible that our increasingly technical military organizations do not promote technical leaders into the senior management ranks.

▷ Undo old restrictions and build new mechanisms that permit technical experts to rotate into assignments in Washington, DC, and insist that government experts rotate out of Washington for sabbaticals. Conversely, those who wish to spend time in Washington or "in the field" must be rewarded for their efforts by their home institutions.

In short, if I were omnipotent, I would do everything possible to keep talent flowing through the nation's defense R&D laboratories and provide a healthy home for those who choose to stay.

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