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Concerns Over the Continued Health and Quality of the US Basic Research Enterprise

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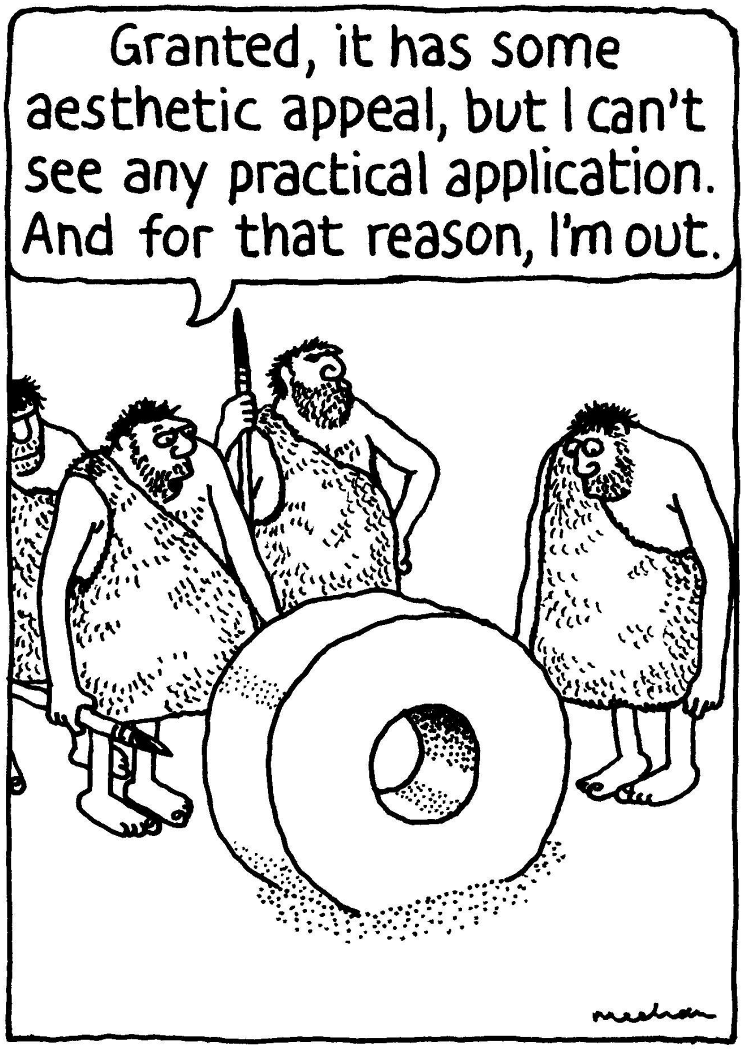
While basic research is the foundation for economic and defense effectiveness, recent trends suggest a decline in the quality of the US basic research enterprise. Drawing from a 2012 Defense Science Board (DSB) report on the Department of Defense (DoD) basic research program, this paper considers the issues of globalization of research, lack of educational competitiveness, and bureaucratic burdens as stressors to the US basic research enterprise. Bolder and more worrisome contentions than found in the DSB report, extrapolated beyond DoD basic research, are posited. Possible responses based on the findings are considered, and a commentary on recommendations to policy changes is provided.

There is a general perception, and considerable evidence, that the quality of basic research conducted by US scientists and engineers is declining. Although US science and technology, particularly at the basic research level, has been heralded as the best in the world for much of the past century, other nations have of late been attempting to raise the quality of their scientific research contributions. While the intention is that fundamental basic research contributes to the world's body of knowledge, and thus is not a competitive endeavor, the reality is that a vigorous and diverse science and technology program leads to economic and national security benefits by virtue of rapid transition of knowledge into capabilities. The industries and defense businesses of the United States have massively benefited from US dominance in basic research and US-driven technology development, particularly in the post-WWII era. Accordingly, there is reason to worry as to whether the rise of other nation's basic research capabilities, and the globalization of research, might lead to a diminution in the quality and effectiveness of US basic research toward national economic and security goals.

Indeed, storm clouds have appeared. In 2007, and in 2010, the National Academies published “Rising Above the Gathering Storm,” and “Rising Above the Gathering Storm, Revisited,” with scathing warnings of the ominous signs of the lack of competitiveness of US Science, Technology, Engineering, and Mathematics (STEM) education compared to the rest of the world.[1] The 2013 “Global R&D Funding Forecast” from Battelle Corporation is subtitled “The Uncertain State of U.S. R&D,” and demonstrates even greater concern for academic research.[2] US federal government funding of R&D into 2013 was at best flat because of sequestration and a decline in federal research dollars to universities, which fell in 2012 largely due to the end of the American Recovery and Reinvestment Act (ARRA) funds, as well as drops in medicine and biomedical research funding.[3] Since then, funding increases have been anemic. While funding levels do not equate to quality, and the ARRA was always intended to be a temporary funding source, for the past decade there have been reasons to worry about trends in the overall quality of US research.

As a result of concern over defense basic research, the Defense Science Board (DSB) was commissioned in 2010 to study the defense research portfolio, and to provide strategy and management advice. Led by Dr. Craig Fields and Dr. Lydia Thomas, with Executive Secretary Dr. Robin Staffin from the Department of Defense, this high-profile group studied Department of Defense (DoD) basic research planning and management from October of 2010 into spring and summer of 2011. It was then, in January 2012, that the Defense Science Board published the report of its Task Force on Basic Research.[4] According to the DSB report, the DoD operates a sound basic research program, comparable in quality to other Government basic research programs. However, the report notes several areas in need of attention, calling specifically to issues within human resources, global research, technology strategy, and bureaucratic burdens. While the study was a response to the issue of defense basic research, many of the comments apply to the national basic research enterprise, particularly government-sponsored research. The executive summary of the report groups the recommendations in the following areas:

- Reducing bureaucracy and improving efficiency and effectiveness of the basic research enterprise;
- Building stronger relationships between basic researchers and the ultimate users of the outcomes of the research;
- Strategies to develop science-based human resources for basic research;
- Maintaining a vital workforce in the service laboratories;
- Recruitment and hiring new graduates; and
- Ensuring effective and exemplary program management of defense basic research.



The recommendations of the DSB task force build upon findings and recommendations from a 2005 National Academies assessment of basic research, and recommendations from a 2009 Jason study concerning S&T for National Security.[5,6]

All three studies produced astute observations, and the recommendations deserve careful analysis and consideration. Much has changed in the direction and imperatives of the DoD since the study was conducted, and prior studies are even more out of date. While these studies involved subject matter experts, and participants with deep knowledge and understanding of the basic research enterprise, the reviewers are loathe to be critical of an enterprise that has benefited the nation in critical ways. Thus, a critical review of the basic research enterprise might lead to improved prospects for ameliorating the decline.

The tenor of the DSB report is that the status quo is acceptable. This implies that the one should recommend to "stay the course." However, the DSB's recommendations suggest various changes, and certain new investments and activities. These point to problems and issues, which should be confronted head on. Further, many of these issues are not specific to defense portfolio concerns, but rather to the basic research enterprise of the nation. Accordingly, this article takes the DSB report as a harbinger of a more general and broad assessment of basic research quality in the United States.

Issues

The DSB task force identifies a number of problems and issues, which are grouped into three categories:

- Research Globalization: The task force observes that research (in general) is globalizing. That is, not only is more basic research taking place outside of the United States, but that successful basic research projects typically involve collaborations that cross national borders.
- Bureaucratic Burdens: The task force identifies certain bureaucratic burdens that are imposed on basic researchers and the administration of basic research, which they point out subtract from the overall budget and performance of basic research. The implication is that the level of bureaucratic burdens is increasing, and unreasonably so.
- Talents are Unutilized: According to the task force, basic research and researchers are not being leveraged sufficiently. That is, talents are not being utilized, and research results are not being transformed into useful

capabilities rapidly, or at all. Additionally, the task force suggests that the overall level of innovation within DoD is falling.

These are serious issues, yet they are not completely novel. While globalization has especially accelerated in the past few years, science and technology research has long complained of bureaucratic burdens. Transition has also been a problem for decades, as expressed in the famous “valley of death,” for the dearth of investment after obtaining research results.

The task force also notes the lack of a DoD technology plan. In fact, the Department previously maintained a Defense Technology Area Plan (DTAP), and Joint Warfighting Science and Technology Plan (JWSTP). However, due to the demise of the “Reliance” process of “Technology Area Review and Assessment” (TARA), both DTAP and JWSTP have been neglected.[7] Though the reliance process has been generally viewed as wasteful and ineffective, the publication of a DoD technology strategy is highly desirable.

If we look across the government, we see that basic research is supported in a variety of separate departments other than DoD. For example, Health and Human Services (HHS) accounts for roughly half of all federally-funded basic research.[8] The National Science Foundation funds both individual science research, and also certain “big science” endeavors (which mostly fund science infrastructure development).[9] The executive-branch Office of Science and Technology Policy conducts some cross-cutting coordination, but once again, a national science and technology strategy is lacking.[10]

Given that the DoD task force’s recommendations are directed only to DoD, they do not sufficiently confront all concerns for US basic research. By concluding that the DoD basic research program is comparable in quality to other agencies’ programs, it assumes that DoD is equal to the National Science Foundation (NSF), Department of Energy, or National Institute of Health’s (NIH) basic research programs. This immediately begs certain questions:

- Is “good” good enough? Whether we are talking about DoD research, or NSF, or NIH, what is the absolute quality of the DoD basic research enterprise? If comparisons are in order, how does the work compare to the best program outside of the United States, or the best international collaboration that will provide results to competitors?
- Is the trend positive or negative? Is basic research quality and quantity as funded and/or guided by DoD getting better, or getting worse? Will the trend yield a program that will deliver the body of basic research results that will provide sufficient benefit to DoD in the future? The same issue applies to the entire basic research enterprise in the United States.
- How should DoD basic research investments be distinguished from other agencies’ investments? This is a hard question because basic research is usually conducted without a specific application as an objective. Instead, basic research hopes to discover fundamental principles that can lead to any of a wide range of technologies or capabilities. How should we coordinate basic research across agencies in such a way that preserves unity of effort and strategic goals?

These questions raise difficult issues, but they hold strategic importance. It is well understood that basic research is the foundation for economic and defense effectiveness of the future.[11] Basic research continues to receive strong support from policymakers, and many studies, including the DSB task force report, provide evidence of the benefits of basic research.

Contentions

The DSB Task Force notes that it has not addressed US basic research concerns. To quote from the executive summary:[12]

> “This study did not do full justice to these substantial issues of globalization of science, technology strategy, and the innovation ecology, largely focused as it is on the current DoD basic research program. Nevertheless, the task force considers addressing those issues of considerably greater import than modest refinement of the already very good current DOD basic research program.”

The report does not attempt to provide an absolute, or even a useful comparative assessment. What is needed is a more independent, objective, and bolder study. Based on the DSB task force data, as well as other data, contentions listed below identify what a bolder study might find.

1. The US Basic Research enterprise is rapidly getting worse, squandering a long history of excellence, by virtue of producing less quantity of quality work, and paying less attention to high quality results when they do occur. This is happening despite continued high quality human resources, and an ability to train the best scientists in the world. The decline is exacerbated by the fact that there exists increasing opportunities abroad for temporary US visa-holders who receive graduate degrees in the United States. The “time to market,” or speed of transition of research to application, has become the central issue in maintaining competitiveness. This is due to the globalization of research, and the rapid rise of basic research enterprises throughout the world. The United States has never excelled in transitioning basic research rapidly to capabilities outside of a wartime footing, and the industrial

research and engineering sectors are generally averse to incorporating basic research output. This aversion has greatly increased in the past decade.
2. Certain scientific fields offer game-changing potential, but are inherently high-risk, or have benefits that may exist in the distant future. According to the Office of the Secretary of Defense Basic Research Office, some such fields include synthetic biology, quantum information science, cognitive neuroscience, human behavior modeling, novel engineered materials, and nanoscience. These areas need to be pursued as an insurance policy against technological surprise in defense systems, and to maintain economic competitiveness. Further, a corps of competent young scientists should maintain the level of expertise in these areas to rapidly transition breakthroughs should they occur. Given the trend of greater industrial funding of R&D via Federal largess, these long-term benefit areas are receiving insufficient focus.

While 1) and 2) above are contentions, the DSB Task Force report provides some amount of support for these as findings. For example, page 47 of the task force report states:[13]

> "It is not surprising that, as a result, many of the professionals currently filling academic positions at universities and scientific positions in research laboratories are foreign-born. The task force believes this indicates the United States is losing the technology race for the minds of talented citizens who increasingly have chosen law or finance over science and engineering."

- Other support for the finding above comes from multiple sources:
- The fact that multinational corporations establish most of their newest research sites outside of the United States suggests that the basic research enterprise in the United States has become uncompetitive.[14] Most worrisome is the idea that once one falls behind in a scientific field, it is very hard to re-establish a leadership role.
- Further, the demise of corporate basic research labs, exemplified by AT&T Bell Labs and Xerox PARC (among others), means that the basic research ecosystem has changed over the past couple decades.[15] There are fewer job prospects for scientists to remain in basic research throughout their careers in the United States. As well, there are fewer transition points from basic research to applications.
- The past decade has included a focus on rapid acquisition of capability, which has lessened focus on longer-term development of fundamental science. The Department of Defense has emphasized at all levels, including basic research, evaluation of the short-term benefit to current mission operations, and has emphasized "application-driven research."[16] The cues to researchers are sometimes subtle, but often not. Even the evaluation criteria applied to proposals to the National Science Foundation have emphasized "impact," which does not seem to take into account the necessary risk that is a part of basic research.[17]
- University faculty members are highly encouraged and motivated to create companies, which detracts from their mind space for deliberation of fundamentals. Start-up companies have proliferated in academia, encouraged by venture capitalists, universities, and state and federal government policies.[18] While helping create jobs and economic activity through technology transition, it can be argued that they detract from exploratory basic research by diverting the very people who would otherwise be performing it.
- Most importantly, global competition has now been trained and instructed in the business of science and technology innovation, and has sought to mimic American success at innovative technology development and insertion. Foreign-born students and workers that are trained in the United States are encouraged to return home (in the case of China, the returnees are called "sea turtles")[19] through programs that pay competitive salaries and provide easy research funding, and through US temporary-visa policies such as student visas.[20] Notwithstanding the inducements for foreign STEM graduates to return, the large number that do stay suppress salaries (according to the research of Lindsey Lowell), which causes large numbers of talented US-educated scientists and engineers to find careers in other fields.[21] While these supply and demand dynamics are seen primarily in IT support areas, it is not unreasonable to think that similar market distortions are occurring in fields that support basic research. The result is that rather than having the best and brightest enter fields from the pool of available researchers, the incoming body of researchers is instead composed of those willing to work for depressed compensation levels.

Any of these trends could portend a precipitous drop in the relative quality of basic research in the United States. Whether any or all are the root cause of an actual decline, or whether that decline is real or imagined, requires further study.

Contention 1) further states that the transition to market (or, in the case of DoD, to a defense application) is lacking, and indeed is getting worse. The contention is that it is becoming more important to move rapidly from a research result to a fielded system, and DoD does not perform this transition well.

The case for DoD is particularly acute. A decade ago, it was noted that transition from basic research to defense application often took circuitous paths, sometimes involving foreign developers or multinational corporations.[22] DoD has also transitioned basic research into the commercial marketplace prior to adoption for defense needs.[23] For example, DoD developed the networking technology that became the basis for the Internet, and while DoD networks use this technology today, it only became widespread after the adoption in commercial endeavors. The difficulty confronting DoD is that basic research is increasingly globalized, and the fast pace of technology advancement means that slow adoption by DoD will lead to inferior defense capabilities. However, attempts at making basic research results more proprietary to DoD is likely to decrease its ability to leverage commercially driven technology. This conundrum is a key issue for basic research, and requires a sophisticated solution.

For commercial industry, the incentive is to piggy-back on government or foreign research, rather than perform in-house basic research. Ultimately, however, such a policy will "eat the seed-corn" that is needed for timely entry of new systems into market. Instead of being a market leader, industry will be reduced to "fast-following," which typically places one in a competitive catch-up mode.

The second contention suggests that we are neglecting the important high-risk high-payoff areas, and increasingly exposing ourselves to technological surprise. The issue particularly concerns maintaining a cadre of scientists through STEM education and fundamental science research. According to President Obama's Federal Science, Technology, Engineering, and Mathematics Education 5-Year Strategic Plan (2013), it is in the nation's interest to increase STEM education, which is critical for national security. President Obama has called for action for an additional 100,000 STEM teachers, who will produce 1 million STEM graduates within the next decade.[24] Additionally, DoD maintains personnel at laboratories and federally-funded R&D centers in order to ensure a continued supply of scientists in a variety of critical fields. However, a common concern is that many of these personnel are ready for retirement, and are unable to keep up with the fields that require upgrades to skills. Moreover, with DoD labs down to 9% PhDs, and competition from startups and multinationals for science talent, there is a real concern that junior scientists will not be enticed to enter careers in government to provide for government-specific needs.[25] In the event that they do, government positions tend to be pedestrian, due to infrequent or nonexistent procurement of specialized technology.

Education is only one aspect of the issue of supply of talent for DoD-specific needs. The supply of specialized talent also depends on satisfying career paths for those selected to become the corps of scientists and engineers. Students recognize the relative lack of job opportunities for graduates of most STEM fields, and instead choose to pursue careers in law, business, health, and banking professions. The specific technologies or areas that should be supported are also uncertain. Most of the topics that are currently considered crucial come from systems that have been procured in the past, and are thought to be essential in the future. Thus, we believe that we need to maintain nuclear weapons experts, and the Department of Energy has labs that maintain those knowledge bases. However, administrators of these labs recognize the need to entice scientists with other challenges and missions. While we would not advocate dropping nuclear weapons knowledge, the right-sizing of past technology capabilities and incorporating experts on new critical government-specific technologies is a challenge that requires an adequate pool of incoming science experts. DoD has set in place STEM programs that are intended to help in achieving these pools. But a detailed analysis has not been conducted of the appropriate levels of supply and the likely demand for scientists and engineers, for the DoD or the nation as a whole. Instead, the National Science Foundation issues annual reports analyzing past supply and demand issues, as "indicators," but without a national strategy, it is hard to know what the future can or will bring.

Some possible responses

How should the nation respond if, as we have contended, the quality of basic research is in decline? Since our future security and competitiveness may be at stake, it is important to develop policies that address these issues.

Of course, there is the issue of resources. Federally-funded research, in particular, basic research, needs to be maintained and managed in a way that strengthens quality and the potential for positive impact. With federal budget controls, we are moving into a regime where private sector expenditures are considered more desirable than discretionary government sector funding, and while basic research has historically been highly dependent on government support, private sources are still possible. For example, university R&D (which is largely – but not entirely – basic research) is funded 62% by Federal government sources; universities self-fund (largely through tuition income) 19%, and other sources supply the remaining 19%.[26] If we discount funding in the health areas, then the non-federal sources are more important to the remaining areas.

For the nation to reinvigorate basic research, it is unrealistic to think that it can be "done on the cheap." Whether public or private funding is involved, the nation will have to expend more on ensuring a vigorous and productive basic research endeavor.

An implementation plan developed in response to the recommendations of the DSB task force on basic research lists five areas of recommendations:

1. Practices that better adapt DoD to the globalization of basic research;
2. Improved policies of basic research personnel in DoD;
3. Improved policies of personnel in DoD labs;
4. Recruitment of more STEM talent;
5. Improved business practices in the management of DoD basic research.

These broad general goals can easily be translated into an action plan for reinvigorating national basic research. However, sufficient resources will be needed, and some policy changes will be required, as opposed to simply perpetuating past practices.

Globalization

Participation in the global network of researchers is critical for success, and the nation will need to increase its connections with the international science and technology community. As previously noted, this is a challenge for DoD, but also applies to national science and engineering.

One approach to increase globalization is to encourage the use of sabbaticals. Promoting international collaborations among university faculty is happening in any case due to pressures on university faculty. The larger issue is finding mechanisms whereby the nation can benefit from these international collaborations.

The Office of Naval Research (ONR) has an intention to increase funding for ONR Global, with discussion of an increase of up to 5% of ONR's total funding.[27] ONR Global, and related operations in DoD, help bridge the government to the international community, while gathering valuable information regarding the directions and intentions of foreign researchers. These efforts provide more direct intelligence into government agencies.

However, these efforts are small steps regarding the more fundamental issue of avoiding technological surprise, and making sure that scientists are fully engaged in cutting-edge basic research by being productive members of an international collaborative community. Bolder efforts would encourage transition of international research to start-ups and small multinational businesses with strong ties to US researchers and opportunities for US workers.

Basic research funding policies

Currently, the majority of basic research occurs within universities. The career path for these researchers involves teaching and scholarship, with requirements for receiving sponsored research. With sponsored sources becoming more problematic, there is increasing pressure on university basic researchers to divert their attention to more application-oriented work. Further, relying on university resources (which are largely obtained from tuition dollars, or equivalently, state funds tied to enrollment numbers), is untenable in the long run. It represents a transfer of resources intended for training to long-term research goals. Nonetheless, competition among academic fields, and some level of oversight and management, will help keep quality of basic research at high standards. Thus, the issue is balancing resources against needs. Recent reports suggest that NSF funding has dropped to less than 5% of applications. At this level, most applicants will quickly become discouraged, no matter how much they improve their proposal. On the other hand, if funding were to become a near certainty, quality would suffer. At this point, oversight and management influence has become increasingly intrusive.

Government personnel policies

Of the 35,000 scientists in 67 DoD laboratories across the nation, roughly 9% have doctoral degrees, 26% have master's degrees, and 63% have bachelor's degrees.[28] A percentage of these scientists are engaged in basic research, though nearly all have responsibilities for applied and development work in addition to basic research responsibilities. The quality and caliber of basic research at the laboratories is thus highly dependent on the quality and caliber of laboratory personnel.

Making lab careers attractive is an important goal, but is hard without expenditure of additional resources. There is a critical mass phenomenon: With PhDs dropping to 9% overall, candidates might find insufficient collegial possibilities at the lab. Thus we see a concentration of doctoral talent at a few institutions, such as the Naval Research Lab and the Army Research Lab (and at a number of labs outside of DoD, such as NIST).

According to the DSB task force, government agencies that conduct research depend on a "constant influx of new ideas and fresh perspectives [through] term appointments, visiting researchers, and officer rotations." However, temporary appointments are not about recruiting scientists to a career. A university maintains a constant influx by replacing graduating students with matriculates each year. Since government laboratories are not primarily educational institutions, maintaining vitality and quality is more difficult.

One response to this need is that government laboratories should partner with local universities and create an influx of graduate students and postdocs. This suggests that the labs be transformed, in part, into adjunct universities. For the most part, universities contain a careful and interlocking balance of undergraduate and graduate education and sponsored research, along with incubators and professional development policies. Some laboratories have existing associations with local universities, but effective public-private partnerships that are mutually beneficial are difficult to set up. Further, similar issues and problems exist with respect to Federally-funded research and development centers (FFRDCs), and University-affiliated research centers (UARCs). Fundamentally, the problem is that maintaining a cadre of researchers current in basic research is expensive. Trying to piggyback on other entities' investments is not productive, especially since basic research is under pressure for reduced financial support by non-government sources.

Recruitment of STEM talent

The nation has a number of efforts aimed at STEM education and recruitment of STEM talent. For instance, the Science, Mathematics & Research for Transformation (SMART) program encourages undergraduate and graduate degrees in STEM by awarding full scholarships and the opportunity for employment following degree completion. However, according to the US Department of Education, only 16% of American high school seniors are proficient in mathematics and interested in a STEM career. Even among those who do go on to pursue a college major in the STEM fields, only half choose to work in a related career. Certain international tests purport that the United States is falling behind in terms of young talent, ranking 25th in mathematics and 17th in science among industrialized nations.[29]

We previously mentioned the administration's desire to "...develop, recruit, and retain 100,000 excellent STEM teachers over the next 10 years," and to graduate an additional one million students with STEM majors.[30] This reflects a huge investment and expenditure of opportunity costs. Moreover, the intention is that a large portion of these million added scientists should pursue careers in science and technology (or engineering). If they do not, the opportunity cost of training students in STEM is the money and time that would have been spent training students for something else. The usual enticement is the promise of a career, and thus we are making an implicit commitment of some number of meaningful scientific careers. These might be in the private sector or in the public sector. As we have seen, basic researchers are more likely to require some degree of public funding for their entire careers. If we assume that of these extra million scientists, a quarter will pursue basic research that requires public funding, in today's dollars, we are committing approximately $50 billion per year in additional S&T funding.

Business practices

The DSB task force identified how little basic research funding actually goes to real basic research. An analysis of the example of AFOSR funding suggests that about 35% of the appropriated basic research funds support research efforts, and that the remainder of the funds go to administrative burden (both within government and industry and university administration). More importantly, it should be understood that research is not bought by the hour, but by the quality and caliber of the researcher. Research productivity increased by having better researchers, and having researchers that are able to devote a larger percentage of their effort to collaboration, research, and dissemination.

As prior studies and reports by industry, universities, and associations indicate, there are "troublesome clauses" in contracts that limit the ability to conduct basic research. Of particular concern, is the International Traffic in Arms Regulations (ITAR) and the notion of "deemed exports."[31] DoD has attempted to provide a "fundamental research" exemption to non-disclosure clauses in contracts as required by the Defense Federal Acquisition Regulations Supplement (DFARS). However, contract officers have not respected these exceptions. The exceptions are not mandatory, but rather subject to the interpretation of agents. Some have suggested that DFARS be amended, but unless there is a mandatory exception for basic research, and an easy-to-interpret specification of when a contract constitutes basic research, defense contract officers will continue to conservatively require non-disclosure, effectively thwarting collaborative and global research.

The DSB Task Force made specific recommendations to reduce bureaucracy that impedes efficiency. Yet who is going to identify inappropriate burdens on basic research conducted for federal or corporate sponsorship, and rule them as inappropriate? For example, who will decide, and measure, when an administrative burden imposes more costs than it saves? Anecdotal evidence suggests that many researchers consider NSF grants to be too burdensome to be worth the proposal effort. Research management is a bureaucracy, and as such it tends to grow over time. Therefore, a full-scale assault is necessary, for example, by an independent commission.

Conclusion

The nation needs a wake-up call, and must understand the consequences of the decline in the quality of its basic research enterprise. In 1957, Sputnik awakened the nation in such a way that succeeding investments in science and technology led to massive economic growth and prosperity. At that time, the nation redoubled efforts to address STEM fields, both in education and in professions. Since then, the perception of the importance of basic research has waned, and the rewards for practitioners have diminished.

The pace of technological innovation has only accelerated, yet federal research funding has dropped from 10% of total government outlays during the space program, to 3% as of 2015.[32] An event constituting a wake-up call could even be too late, if and when it occurs.

Many will view the disputes above as alarmist. Many will deny the contentions in the previous section, and contend that there is not a problem. Indeed, the US has top-rate scientists and remains the envy of the world when it comes to technology development and innovation. Yet such accolades are a lagging indicator, and mask a serious situation involving a major decline. The causes are many, but bureaucratic burdens and uncertainty of career paths are among the main drivers that are discouraging both practitioners and prospective researchers.

As with many things, the nation lacks a strategy. It may also lack the collective will. Perhaps industry will need to take over, using policies that provide incentives to substitute their investments for sponsorship that has historically been made by government. Perhaps the National Science Foundation will find new models and strategies that improve their investment methods and leverage the talents of the nation. New acquisition models for the government may also recognize the uniqueness of research, particularly basic research, and carve out policies that government contracting can find attractive.

As noted, the “Space Race” of the 1960s inspired a generation and provided benefits that went well beyond lunar exploration. Therefore, setting some “grand challenge” goals is useful to set agendas and inspire researchers.[33] Government-developed primers might be established that could be used by graduate students as introductions to fields of particular interest, and provide comprehensive references to the literature. Beyond the educational and journaling aspect, they would be indicative of national topics of interest, and thus leverage a larger talent pool of basic researchers worldwide.

Another expedient might involve the use of national conferences. Rather than discouraging conferences, which is currently the policy, the government could sponsor low-cost conferences, with innovative approaches to attendance on technical topics of interest. By avoiding the conference-oriented associations and event handlers, the government might be able to readily focus on topics relevant to national goals, and again leverage research conducted by the world’s S&T enterprise.

There are undoubtedly many other ideas that could be pursued to restore dominance to the US basic research enterprise, and to take maximum advantage of the nation’s talent pool. It is important to develop these ideas, and to implement them. Maintaining the leadership role that the United States has taken, both in defense applications, and in other branches of science and technology, such as basic research, is critical to ensuring the survivability of the S&T enterprise.

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