

Smart Management of R&D in the 21st Century



Strengthening the Army's Science and Technology Capabilities

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To ensure that the Army will meet future defense challenges, the Secretary of the Army and the Army Chief of Staff have articulated a vision for the Army of the 21st century that involves transforming it into an Objective Force that is responsive, deployable, agile, versatile, lethal, survivable, and sustainable.¹ Achieving the Objective Force will require the Army to maintain its superior science and technology (S&T) capability through its research and development (R&D) and procurement efforts. For example, a cornerstone of the Objective Force is the advanced-technology Future Combat System, highlighting how essential it is for the Army to maintain its top-notch S&T capability.

A number of trends over the past decade have made it especially challenging for the Army to maintain the critical S&T element of its transformation. First, the R&D budget has been declining for the past 15 years, and this trend is likely to continue. Second, the Army's civilian workforce, many of whom are the scientists and engineers (S&Es) integral to the Army's R&D capability, has declined in numbers because of acquisition workforce reductions. In addition, increased competition with private industry for highly qualified technical staff has made it difficult for the Army to attract and retain the talented S&Es it needs to ensure a continued superior S&T capability for the coming decades.

Faced with these shortfalls, how should the Army sustain superior S&T capabilities to support the Army transformation? During the past five years, RAND Arroyo Center has worked with the Army to

¹U.S. Army Headquarters, Department of the Army, *U.S. Army Transformation Campaign Plan*, June 15, 2000.



address this question.² Arroyo research has shown that a strategy built on a foundation of three integrated building blocks will enable the Army to be the effective smart buyer and smart provider it must be to achieve the challenging S&T goals required to support the Army transformation. The three building blocks are optimal in-house R&D, expanded collaborative efforts, and smart outsourcing. Figure 1 gives an overview of this strategy.

As seen in the figure, the three basic blocks form the foundation of a successful Army transformation:

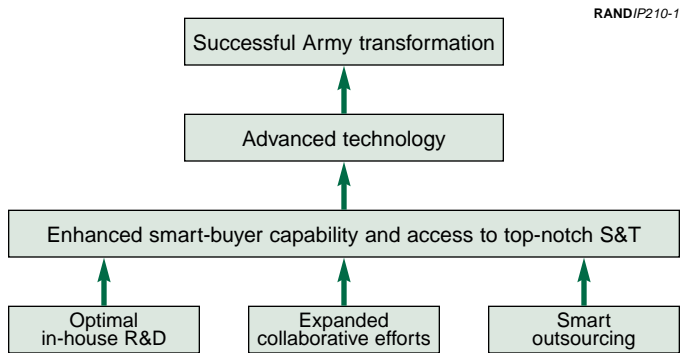


Figure 1—Strategy for a Successful Transformation Through Maintaining and Strengthening S&T Capabilities

²The research described in this issue paper is detailed in a number of publications. See Kenneth P. Horn et al., *Performing Collaborative Research with Nontraditional Military Suppliers*, Santa Monica, CA: RAND, MR-830-A, 1997; Kenneth P. Horn et al., “Conducting Collaborative Research with Nontraditional Suppliers,” *Army RD&A*, November–December 1997, pp. 39–41; Carolyn Wong, *An Analysis of Collaborative Research Opportunities for the Army*, Santa Monica, CA: RAND, MR-675-A, 1998; Carolyn Wong et al., “An Approach for Efficiently Managing DoD Research and Development Portfolios,” *Acquisition Review Quarterly*, Vol. 5, No. 4, Fall 1998, pp. 339–356; Ike Chang et al., *Use of Public-Private Partnerships to Meet Future Army Needs*, Santa Monica, CA: RAND, MR-997-A, 1999; Kenneth P. Horn et al., *Maintaining the Army’s Smart Buying Capability in a Period of Downsizing*, Santa Monica, CA: RAND, WP-120, 1999; and Carolyn Wong et al., “Maintaining the Government’s Ability to Buy Smart,” *Acquisition Review Quarterly*, Vol. 7, No. 3, Summer 2000, pp. 259–274.



(1) Optimal in-house R&D refers to the pivotal and supportive research performed solely by Army S&Es; (2) expanded collaborative efforts refers to the research that Army personnel carry out in conjunction with scientists and engineers from one or more non-Army organizations; and (3) smart outsourcing refers to the research performed by non-Army personnel with Army oversight. This integrated foundation enables an enhanced Army smart-buyer capability and Army access to top-notch S&T. In this context, smart-buyer capability refers to only the technological aspect of the smart-buyer function that includes the integrated efforts of many disciplines (e.g., technological, engineering, legal, procurement, management, and funding expertise). Hence, smart-buyer capability is the Army's collective technical expertise that helps the concept and materiel developers conceive, formulate, and execute materiel programs. Optimal in-house research combined with collaborative efforts with technological leaders and well-designed, expertly executed outsourcing will also give the

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Army access to top-notch S&T. With these strengths, the Army will be well equipped to acquire the advanced technology it needs for a successful transformation.

In the sections below we discuss the integrated foundation and then detail the roles that the individual building blocks play in establishing an enhanced smart-buyer capability and providing Army access to top-notch S&T.



THE INTEGRATED FOUNDATION

All Army research is performed in one of three ways. It is either performed in-house by Army S&Es, performed collaboratively by Army S&Es and scientists and engineers from organizations outside the Army, or outsourced and performed by scientists and engineers from external organizations with Army oversight. Normally, these three approaches are mutually exclusive in that research performed using one approach is not performed using either of the other two. However, the approaches are also integrated in that they are all mutually supporting components of a whole. Clearly, then, an important decision that faces the Army is to determine which technologies should be researched in-house, which are best suited

Clearly, then, an important decision that faces the Army is to determine which technologies should be researched in-house, which are best suited for collaborative efforts, and which should be outsourced.

for collaborative efforts, and which should be outsourced. To help the Army formulate a strategy for making these decisions, Arroyo Center researchers developed a framework that helps the Army understand the technology knowledge bases both inside and outside of the Army, facilitating informed choices about how to allocate research efforts among

the three approaches. This framework categorizes efforts along two dimensions: Army utility, and appeal to the broader research community outside the Army.

Figure 2 illustrates the use of this framework to categorize the Army's technologies as described in the RDT&E Programs (R-1) section of the DoD budget for fiscal year 1995. Technologies highly specific to the U.S. Army—the leftmost portion in the figure—

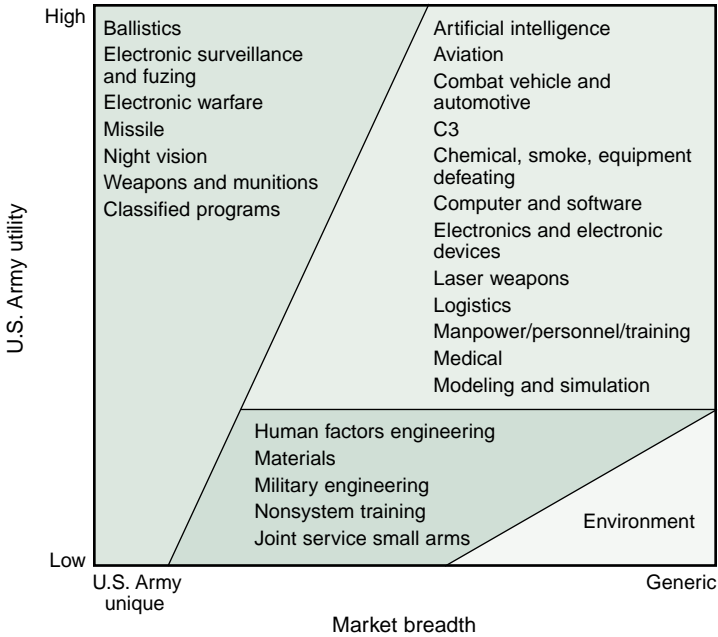


Figure 2—Framework for Determining Appropriate Sources of Technology

are good candidates for doing in-house because they lack sufficient appeal to attract partners from outside the Army and also lack the generic applicability desired by such organizations. Analogously, the technologies in the upper right quadrant—which have high Army utility and high industry appeal (and to a lesser extent those in the middle quadrant, which have more moderate Army utility and industry appeal)—are ideal candidates for collaboration. Similarly, technologies in the lower right quadrant (and some in the middle quadrant) are best suited for outsourcing because their high industry appeal and relatively lower Army utility indicate that the technological leaders in these areas reside in industry.

The framework provides a good starting point for the Army to decide the best approach for each



research effort. However, its only basis for decision is technological factors. For any given research effort, other factors, such as schedule and resources, must also be considered and may in some cases prevail in determining the approach the Army takes.

OPTIMAL IN-HOUSE RESEARCH

In-house R&D is research performed solely by Army personnel. The majority of this research is performed at Army labs by Army S&Es. The Army, of course, has full access to all S&T emanating from its own labs. The S&Es who perform this research are also the Army's smart buyers. Hence, it is evident that the research they perform contributes directly to the Army's smart-buyer capability. The Army can manipulate this capability by optimally choosing the types and amount of research performed in-house. The

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framework described above can elucidate that task. The Army can also ensure the quality of its in-house research by maintaining a cadre of talented and trained S&Es. To do so, the Army must attract talented staff to work in its labs, provide career development opportunities to ensure that this staff has the necessary skills to perform their smart-buyer duties, and create incentives to encourage

the talented staff to stay. Accordingly, our research focused on these three personnel aspects of enhancing the Army's smart-buyer capability. In the subsections below, we describe the current personnel situation and then detail recommended recruitment, training, and retention actions.

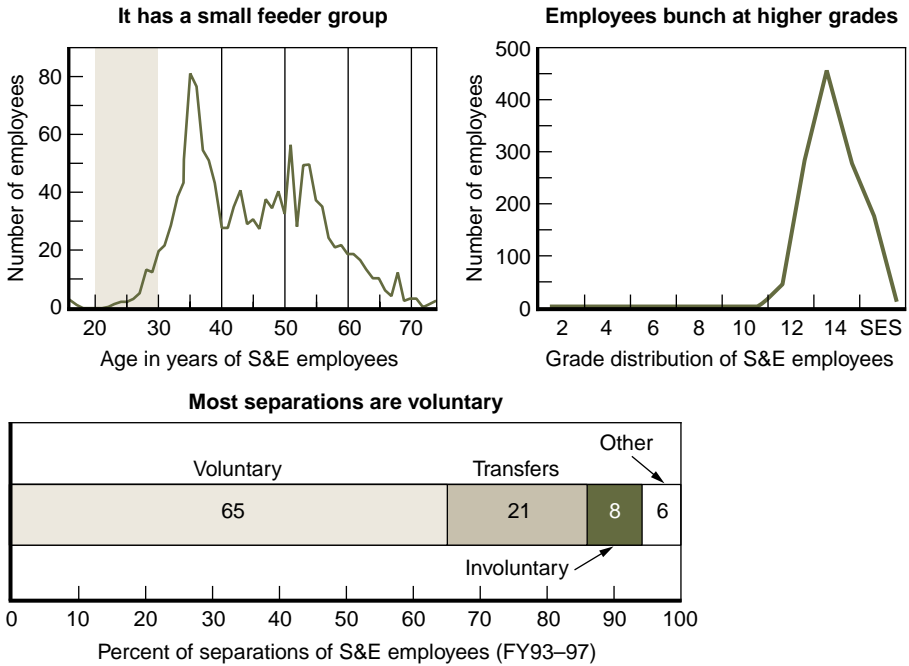


Figure 3—Personnel Challenges at the Army Research Lab

The Current Situation

As we have noted, the Army is losing S&Es—and the smart-buyer capability that goes with them. Outsourcing the smart-buyer capability would be difficult because of the potential conflicts of interest, the need to maintain loyalty to the Army’s interests, the need to maintain corporate memory, and the potential cost involved. Thus, one of the questions Arroyo researchers have addressed is what the Army must do to obtain the smart buyers it needs.

Until recently, civilian personnel policies have tended to undermine hiring and retaining the best and brightest S&Es. For example, as shown by Arroyo Center research on the Army Research Lab (Figure 3), most S&Es are in their mid-30s or mid-



50s. Thus, few recently trained S&Es are being hired, and many senior S&Es will retire within the next five years, creating gaps at the highest and lowest levels of seniority. In addition, the majority of lab scientists who do not wish to leave research for managerial positions face a glass ceiling in promotions and raises. As a result, many researchers have attained the

To enhance its smart-buyer capability, the Army must institute personnel reforms that strengthen its in-house S&T expertise.

highest grade level they can, equivalent to that of a middle manager, a situation that encourages talented S&Es to leave for more rewarding positions in the private sector. Furthermore, most separations are voluntary, which supports the idea that competent

scientists leave the labs for better positions.

While the Army recognizes the importance of the smart-buyer capability, our research also shows that this function is not always truly rewarded. Awards for outstanding smart-buyer performance have not always been forthcoming, and opportunities for ongoing training and development have been limited.

What kinds of measures are needed to overcome these problems? Our research has shown that to enhance its smart-buyer capability, the Army must institute personnel reforms that strengthen its in-house S&T expertise. The Department of Defense is currently exploring a wide range of personnel reform initiatives aimed at increasing the hiring, training, and retention of quality S&Es. We examined these initiatives and concluded that a number appear to have the potential to improve the processes of attracting, developing, and retaining talented S&Es, as discussed below.



Attracting Talented Staff

The Army should exploit the full range of recruiting tools to attract the most promising candidates. For example, intern programs—such as the Career Related Experience Science and Technology Program that provides summer or part-time employment to undergraduate and graduate students, the Student Temporary Employment Program, and the Student Career Experience Program—appear to be successful and should be continued. Other tools, such as recruitment bonuses, are limited by available funds, and some pilot trials with these tools will help establish their role in successful recruitment practices.

The personnel initiatives proposed and introduced thus far represent an important step toward strengthening the Army's cadre of S&Es. But given the strong competition with private industry, these reforms may not be sufficient to ensure adequate S&E capability. An alternative mechanism we have proposed for attracting additional new talent is greater use of temporary or visiting staff such as Intergovernmental Personnel Act workers. Another option that has been proposed is to create a reserve S&E corps that could be called up from the civilian sector in times of critical technological need.

Career Development Opportunities

The Army needs to provide career development opportunities to ensure that its S&Es have the necessary skills to be competent smart buyers. Initiatives aimed at training and development include providing educational fellowships, creating assignments that foster development, and allowing rotation through a



variety of government and private labs. These initiatives are consistent with the four proficiencies that Arroyo Center research has deemed necessary to become a good smart buyer. First, the Army must provide opportunities for S&Es to acquire industry experience, perhaps through industry exchange pro-

The Army needs to provide career development opportunities to ensure that its S&Es have the necessary skills to be competent smart buyers.

grams and well-designed collaborative efforts. Second, S&Es must be able to devote a portion of their time to hands-on research. To ensure ample opportunities to gain this experience, the Army must devise criteria for determining what and how much R&D should be kept in-house. S&Es must also

be able to acquire the required level of education in their fields. The Army and its workers will mutually benefit if the Army encourages and supports education at the nation's top universities. Finally, S&Es need general engineering experience. The Army can ensure that this requirement is met through a well-planned series of work assignments.

Retention

Some of the initiatives aimed at retention include performance-based (rather than seniority-based) promotion and implementation of a special pay scale that would reduce the government-industry pay gap. These reform initiatives will help, but more innovations may be needed to ensure that career advancement opportunities are available to S&Es. In addition, the Army must ensure that tangible recognition of good smart buying reflects the importance placed on this capability. For example, criteria for salary increases, promotions, and awards may have to be



defined, established, or revised to better tie these rewards to outstanding performance of smart buying.

EXPANDED COLLABORATIVE EFFORTS

Despite the Army's best efforts to maintain an adequate number of talented S&Es, downsizing and budgetary decreases, combined with the ever-growing need for cutting-edge technologies, will require the Army to look to other government labs and the commercial sector to meet its technological needs. As Figure 2 shows, we believe that in some cases, it makes the most sense to gain the technological capability by engaging in well-chosen, well-designed collaborative efforts.

The hallmark of a well-designed collaborative effort is that the collaborating parties make mutual contributions for mutual benefits. Collaborative efforts call for the sharing of intellectual and material resources to achieve common research goals. In particular, collaborative research efforts involve hands-on participation by Army S&Es and by scientists from the collaborating organizations in the research activities. This factor distinguishes collaborative efforts from in-house research that is performed solely by Army S&Es

Collaboration offers advantages to both the Army and its partners, such as the opportunity to leverage resources and to broaden in-house expertise.

and from outsourced research that is performed solely by non-Army scientists with Army oversight.

For a variety of reasons, collaboration can be preferable to performing the research in-house or outsourcing it. One reason is that collaboration offers advantages to both the Army and its partners, such as the opportunity to leverage resources and to



broaden in-house expertise. Moreover, collaboration offers the Army the opportunity to access cutting-edge skills, technologies, and products that would otherwise be out of reach.

Potential collaborative partners may include other military or civilian government labs, as well as uni-

versity labs, established private corporations, and small start-up and venture capital firms. Each of these potential partners has unique knowledge and skills to share with the Army.

Thus far, with some notable exceptions, the Army has had limited success in attracting and forming collaborations, particularly with nontraditional military

suppliers, the kinds of potential collaborators most likely to be able to supply the innovative cutting-edge technologies the Army will need to realize its new vision. Why has this been the case? Until recently, federal regulations that discouraged collaborative research forced the Army to outsource to traditional contractors any research for which it lacked the technical skills, manpower, or other resources. However, the acquisition reform measures introduced in the 1980s and 1990s have gradually removed these legislative barriers and paved the way for collaborations and other nontraditional arrangements that will mutually benefit the Army and its partners.

The old acquisition structure relied on traditional contracts that had to adhere to the restrictive Federal Acquisition Regulations and their military counterparts, the Defense Federal Acquisition Regulation Supplement (DFARS). These regulations and their

Acquisition reform measures introduced in the 1980s and 1990s have gradually removed these legislative barriers and paved the way for collaborations . . . that will mutually benefit the Army and its partners.



enforcement were believed by many private corporations to foster an atmosphere of mutual mistrust and to be too cumbersome for research collaborations. Newer tools, applicable to research activities, such as Cooperative Research and Development Agreements (CRADAs) and Cooperative Agreements (CAs) removed many government-imposed bureaucratic practices that have discouraged collaborative efforts with commercial entities. CAs allow cost-sharing, hands-on collaborative Army participation in the research, and recovery of funds. Other Transactions (OTs), which are not required to adhere to the burdensome guidelines imposed by the DFARS, allow the military to negotiate terms that are mutually agreeable to itself and its potential research partners. OTs are vital for allowing the military access to many of the advanced technologies offered by firms that will traditionally not do business with the government.

Unfortunately, the Army's initial experience with OTs has been limited. As a result, their potential remains largely untapped. Also hampering research collaborations is the fact that some companies, particularly small, cutting-edge firms, are still hesitant to do business with the Army. Their concerns center on the initial costs of proposal preparation, unpredictable funding cycles, uneven personnel exchange, foreign access limitations, intellectual property rights, and residual fear of burdensome restrictions and controls. To dispel these images, the Army will need to be flexible and establish an atmosphere of trust. In addition, it will need to do its homework and market itself to private firms whose technology is of interest and whose strategic goals match Army needs.



SMART OUTSOURCING

As shown in Figure 2, some technologies lend themselves to in-house research, others are suited for collaborative efforts, and some may best be researched through smart outsourcing. As mentioned above, despite the increased opportunities and mechanisms for collaboration, some Army research does not lend itself to collaboration. In some cases, firms may have attractive technologies but may lack the will or the staffing to collaborate with the Army. In others, the Army lacks the technical competence to participate with a partner on an equal footing. Finally, the Army is a small market with a need for technological competence in some areas that have little or no civilian application. Outsourcing—in particular, smart outsourcing—is the appropriate strategy to supply those needs that cannot be fulfilled in-house or through collaboration. The importance of this building block is exemplified by the Future Combat System, many of whose critical technologies are being attained through outsourcing.

Arroyo Center research in smart outsourcing is ongoing. To date, however, we have identified several innovative and unconventional elements of the smart outsourcing building block. Below we discuss three of these: the Small Business Innovative Research (SBIR) program, the Fast Track SBIR program, and the venture capital concept.

The SBIR is a congressionally mandated program initiated in 1982. The Army has participated in this program for many years. Its purpose is to increase small business involvement in federal R&D. The Army devotes approximately \$100 million annually to the SBIR program. To derive full advantage, the Army has to view SBIR as an integrated part of its



outsourcing plan. SBIR should not be viewed as an adjunct program or as a separate element of Army research. The Army needs to view SBIR as a fixed part of the outsourced research and to exploit its unique properties to attract small businesses that can potentially contribute to achieving the Army's S&T goals. For example, SBIR project funding is provided through contracts with short funding cycles and minimal time lapse between proposal submission and funding decisions. These properties can be very appealing to some small businesses, and the Army

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should use this program to attract and introduce innovative companies with promising technologies to working on Army research. The Army should view the SBIR funding period as a time to evaluate the firm's technologies as well as establish trust and congenial working relationships with firms that may have much to offer in terms of meeting the Army's S&T goals.

At the end of the SBIR funding period, the projects that are still promising can be eased into more long-term arrangements. These arrangements include the CAs and OTs discussed above. Although not all SBIR projects can be expected to be candidates for continued Army interest, viewing the SBIR program as a unified part of the Army's outsource program holds more promise than a piecemeal view that tends to result in missed opportunities. In short, using the SBIR program as an integrated part of the Army's outsourced research translates to smart outsourcing.

The introduction of the Fast Track SBIR in 1995 improved the SBIR program. This variation encour-



ages SBIR awardees to find additional money from sources such as venture capital firms, angel investors, and large companies to augment their interests in small technology companies. The Army should fully exploit the Fast Track SBIR program as a means of leveraging private research dollars. In it, the Army gains financial partners in funding projects at small technology firms. The advantage of exploiting the Fast Track SBIR program is that more Army research gets done without spending more Army research money.

A venture capital investment model to leverage outsourced research funds is another option Arroyo

By avoiding the restrictions of traditional contracts, venture capital investment would allow the Army access to needed commercial technology and would permit it to leverage its own limited R&D resources through cost-sharing.

Center researchers have explored with the Army. Venture capitalists generally invest in start-up companies that have a concept, a potential market, and a business/marketing strategy but lack adequate capital. In addition to financial resources, venture capitalists also provide time, expertise, and experience to help manage and promote the businesses invested in. The advantage for the Army lies

in the ability to influence the technologies early and gain intelligence on technologies being developed. Additionally, revenue generated can be reinvested in Army technologies, and partnerships may be formed with other companies to gain further leverage for Army resources. Venture capital has been used successfully by many of the most inventive companies in the world, is accessed by large corporations with significant internal R&D capabilities to develop new technologies, and is also spreading to the public sec-



tor.³ By avoiding the restrictions of traditional contracts, venture capital investment would allow the Army access to needed commercial technology and would permit it to leverage its own limited R&D resources through cost-sharing. In addition, the Army could enjoy a return on investment for efforts with potential long-term commercial application as well as the potential for reinvestment. Clearly, not all Army technologies would be good candidates to pursue through venture capital efforts. But for those technologies that are suited to this mode of research, the additional benefits in financial leveraging and access to cutting-edge technological advancements justify including venture capital as an option in smart outsourcing.

CONCLUSIONS

The Army has made great strides over the past decade to sustain its superior S&T capability. Recent personnel reforms have widened the Army's options to attract and retain the best and brightest S&Es for its labs and thus optimize its in-house research and directly enhance its smart-buyer capability. By taking advantage of the acquisition reforms of the past two decades, the Army has begun to expand its collaborative efforts—efforts that have played and will continue to play vital roles in helping the Army maintain its tech-

The quality of the S&T that emerges from in-house research, from collaborative efforts, and from the Army's associations with contractors all depends on age-old tenets of open, direct, and unencumbered communications.

³The Central Intelligence Agency's In-Q-Tel is a prime example. See Bruce Held and Ike Chang, *Using Venture Capital to Improve Army Research and Development*, Santa Monica, CA: RAND, IP-199, 2000.



nological edge through access to top-notch S&T and enhancing its smart-buyer capability. In addition, efforts are ongoing to promote smart outsourcing to help ensure that the Army will maximize leverage of its R&D resources and continue to have access to cutting-edge technological advancements. All these efforts should continue, and in a coordinated fashion.

The key to a coordinated reform effort will be effective communication between the concept and materiel developers. This includes communication among strategists, Army S&Es, other executors of the smart-buyer function, program managers, acquisition experts, users, collaborators, and contractors. For example, our surveys show that to retain high-quality S&Es, the Army must give them opportunities to communicate with S&Es in other military and civilian labs as well as in university and industrial labs. S&Es must be able to exchange ideas with others who are performing similar work and monitor the progress in their fields. Without a mechanism for regular communication with others in the same technical area, Army S&Es work in a virtual vacuum. The quality of the S&T that emerges from in-house research, from collaborative efforts, and from the Army's associations with contractors all depends on age-old tenets of open, direct, and unencumbered communications. Toward this end, we encourage the Army to continue streamlining the communications channels among organizations and thus significantly enhance informational exchange among all involved in the research that will ultimately result in the Army's successful transformation.