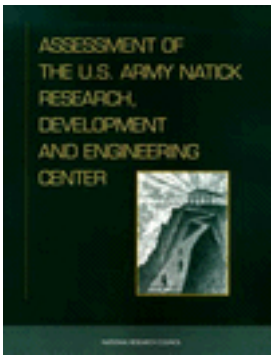

Assessment of the U.S. Army Natick Research, Development, and Engineering Center

Standing Committee on Program and Technical Review of the U.S. Army Natick Research, Development and Engineering Center, National Research Council

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Board on Army Science and Technology
Commission on Engineering and Technical Systems
National Research Council

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Preface

This report is the second in a two-phase response to a request from the technical director of the U.S. Army Natick[1] Research, Development and Engineering Center (RDEC) that the National Research Council (NRC) assess the RDEC relative to its vision of being a world-class organization. The NRC committee I had the pleasure to chair provided the basis for this report in the phase-one NRC report, *World-Class Research and Development*, which was published in September 1996. That report defined the characteristics of a world-class research, development, and engineering organization and the metrics by which an Army RDEC could be assessed. In this second phase of the study, we used those characteristics and their associated metrics to assist us in assessing the Natick RDEC. The results of that assessment are contained in this report.

During the assessment we addressed a wide range of issues, related not only to the Natick RDEC's goal of performing at a world-class level but also to subjects related to the command structure within which the RDEC operates. We are hopeful that this assessment will contribute to the RDEC's ability to confront and resolve complex issues, maintain progress toward reaching its goal, and continue its valuable contributions to our nation's defense, despite the many external pressures currently affecting all U.S. Department of Defense organizations.

In addition, we hope that other Army RDECs and similar organizations within the U.S. Department of Defense or elsewhere will find the results of our assessment valuable, particularly as they demonstrate the application of the characteristics and metrics of world-class organizations. The Natick RDEC's willingness to subject itself to public evaluation speaks volumes about its commitment to excellence. We want this commitment to be recognized, and we hope that other organizations will also benefit from our evaluation.

The committee members included experts in the assessment of research, development, and engineering organizations, as well as in the products and technologies at the RDEC. However, we could not have completed our work without

[1] The Natick RDEC is located west of Boston near the town of Natick, Massachusetts.

the splendid cooperation of the many dedicated personnel at Natick who did their best to explain the intricacies of their operations to us and answer our many questions.

Finally, the committee and I want to recognize the contribution of the NRC staff members who worked so hard to assist us in bringing this study to a successful conclusion.

JOSEPH SOUKUP, CHAIR

STANDING COMMITTEE ON PROGRAM AND TECHNICAL REVIEW OF THE U.S. ARMY NATICK RESEARCH, DEVELOPMENT AND ENGINEERING CENTER

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Acronyms

ASCD	Advanced Systems Concepts Directorate
DOD	U.S. Department of Defense
MobD	Mobility Directorate
NRC	National Research Council
STD	Science and Technology Directorate
SurD	Survivability Directorate
SusD	Sustainability Directorate
R&D	research and development
RD&E	research, development, and engineering
RDEC	research, development, and engineering center

Executive Summary

This report contains the results of the National Research Council (NRC) assessment of the U.S. Army Natick Research, Development and Engineering Center (RDEC). It was prepared by the Standing Committee on Program and Technical Review of the U.S. Army Natick Research, Development and Engineering Center, known as the Natick Standing Committee. The assessment period covered 1996 and the first half of 1997.

BACKGROUND

The Natick RDEC is a major component of the U.S. Army Soldier Systems Command, a subordinate command of the Army Materiel Command. The RDEC's vision is to be a "world-class research, development, and engineering team." The RDEC's mission is to develop products that maximize the soldier's survivability, sustainability, mobility, combat effectiveness, and quality of life.

The committee's work was divided into two phases. In the first phase the committee established assessment criteria. In the second phase the committee applied the criteria. The first-phase report, *World-Class Research and Development* (NRC, 1996) defined the major components of world-class research. As shown in Figure ES-1, these components include five "pillars": Resources and Capabilities, Strategic Vision, Quality Focus, Customer Focus, and Value Creation. These pillars are the supporting elements of an organization's competitive advantages and require a foundation of demonstrated commitment on the part of the management and staff. Each of the pillars of a world-class R&D organization can be assessed by the characteristics listed in Figure ES-2. The metrics for assessing each characteristic are reproduced in Appendix C of this report.

In the second phase of its work, which is the subject of this report, the committee assessed the Natick RDEC against the characteristics and their metrics. The assessment was carried out in response to the statement of task for phase one, which directed that "the metrics derived from the committee's definition will be used as the benchmark by which the business areas and core technologies will be evaluated." The statement of task for phase two established two different stages of

the assessment. The first stage consisted of assessing the RDEC in terms of the five pillars and the associated characteristics and metrics from phase one. The second stage consisted of assessing the RDEC in terms of ten key issues that are related to, but somewhat different from, the pillars and characteristics. The ten key issues and their connection to the "benchmark" for the assessment—the metrics, characteristics, and pillars from phase one —are discussed below.

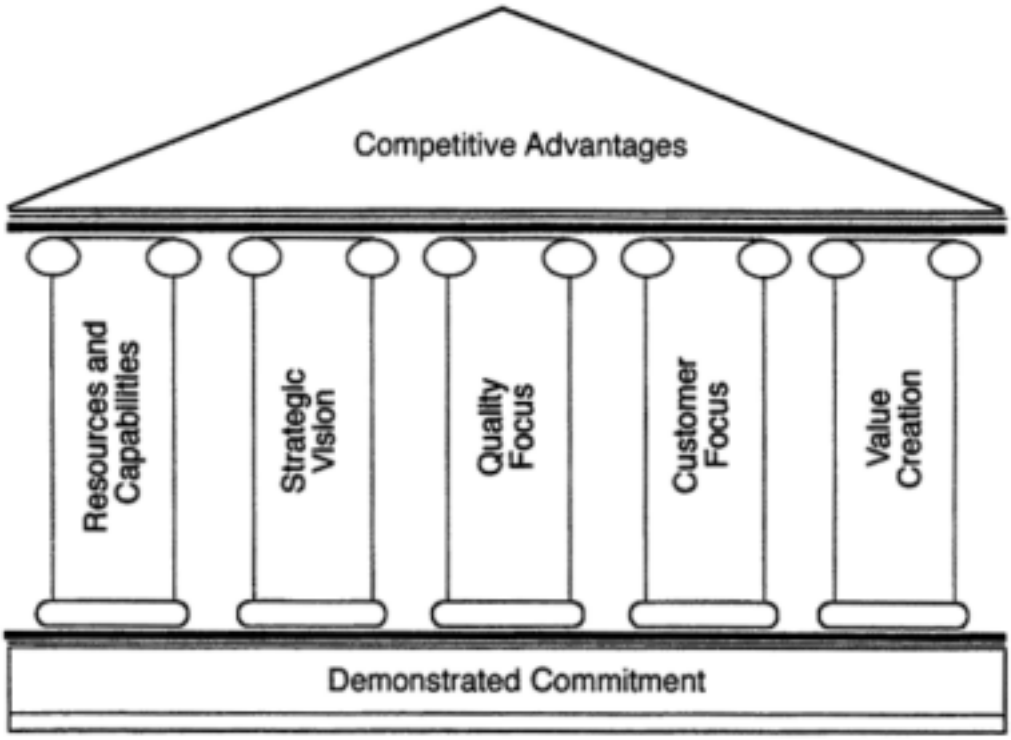

Figure ES-1
The major components of world-class research and development organizations.

The ten key issues, which were derived from the statement of work between the NRC and the Natick RDEC (see Appendix A), involve: (1) funding, personnel, and facilities; (2) organizational structure; (3) new organizational approaches; (4) the effect of the Soldier Systems Command; (5) the RDEC's products and system for measuring their quality; (6) customer satisfaction; (7) the. marketability of the RDEC's products; (8) world-class research and technology; (9) the continuation or elimination of research and technology programs; and (10) models and simulations. As can be seen by a review of the underlying characteristics and metrics, most of these issues cut across the five pillars and were therefore addressed as part of the overall framework developed by the committee in its phase-one report. However, some issues, the most notable being the effect of the Soldier Systems Command, required more direct inquiry and judgment on the part of the committee.

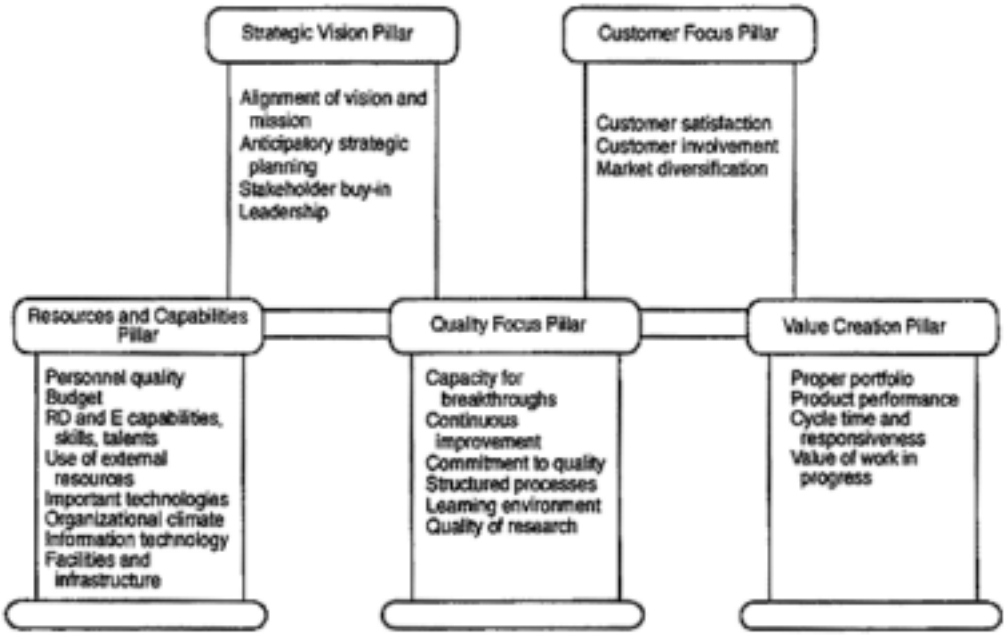

Figure ES-2
The five pillars and 25 characteristics.

APPROACH

The Natick RDEC was organized into five directorates: the Mobility Directorate (MobD), the Survivability Directorate (SurD), the Sustainability Directorate (SusD), the Science and Technology Directorate (STD), and the Advanced Systems Concepts Directorate (ASCD). The first three are called commodity directorates because they are responsible for developing RDEC products, such as rations, food-service equipment, clothing, shelters, and airdrop systems. The last two are called support directorates because they assist the commodity directorates with research (STD) and modeling and simulation (ASCD).

The committee's assessment reflected the RDEC organization. The committee formed three panels, one for each of the commodity directorates. The support directorates were considered primarily in the context of their assistance to the commodity directorates. During the visits of each panel and during the two general discussions (in February 1996 and February 1997), attention was devoted to the support directorates.

Before the panel visits, lengthy questionnaires were sent to and answered by the RDEC management. The questions were designed to illuminate the work of the five directorates in terms of the pillars, characteristics, and metrics of world-class performance and the ten key issues. Additional questions during on-site interviews of managers and staff were framed with these same points in mind. Collectively, the committee had discussions with a broad cross section of RDEC personnel during site visits in February, June, September, and December of 1996 and in February 1997 (see Appendix B).

The credibility of the committee's assessment is based on several factors. First, committee members include experts in the areas that are the subjects of research, development, and engineering at the Natick RDEC (e.g., parachutes, textiles, and food and food processing), as well as experts in the management of research and development (R&D), in the assessment of technical organizations, and in systems engineering and modeling and simulation. Second, the committee used criteria (i.e., pillars, characteristics, and metrics) that were based on the principles of excellence used for the Malcolm Baldrige National Quality Award and by leading organizations in the private sector. Third, the committee learned about the operations of the RDEC through visits, briefings by leaders of the RDEC, reviews of documents, and in-depth interviews of RDEC personnel.

The expertise of committee members, combined with the considerable knowledge gained during the criteria-development and data-gathering portions of the study, gave the committee a comprehensive understanding of the Natick RDEC and its performance. In the end, the soundness of the assessment is based on the application of pillars, characteristics, and metrics, as well as on informed judgments on the ten key issues. The major findings of the assessment are summarized below.

MAJOR FINDINGS

For the commodity directorates overall, three of the pillars were assessed as good (Resources and Capabilities, Customer Focus, and Value Creation), one was assessed as adequate to good (Quality Focus), and one was assessed as poor to adequate (Strategic Vision). A spider diagram that summarizes the assessment results for the commodity directorates is shown in Figure ES-3. Thus, although the assessment did not show the overall performance of the Natick RDEC to be at a world-class level, it did show that the commodity directorates were performing well. The assessment revealed a relatively uniform level of performance for the three commodity directorates.

The Strategic Vision pillar received the most poor or partially poor ratings. Based on a visit to Natick in early 1997, however, the committee was encouraged to see that the situation seemed to be improving because of recent emphasis on real strategic planning and because of the commitment of the RDEC leadership to strategic planning. The committee was concerned, however, that the trend for the Resources and Capabilities pillar appeared to be downward, largely because of the continuing loss of skilled personnel.

Although the committee found some instances in which the support directorates provided effective support for the commodity directorates, the overall support from both directorates was lacking and requires the attention of top management. The STD was of greatest concern because it was not adequately focused on the R&D needs of the commodity directorates, and the relevance of the STD portfolio of projects to those needs was questionable. ASCD, although it performs its internal role well, could play a larger external role for the entire

RDEC by demonstrating, through models and simulations, the utility of RDEC products. However, the committee found that ASCD's models and simulations did not fully address many aspects of soldier-system performance.

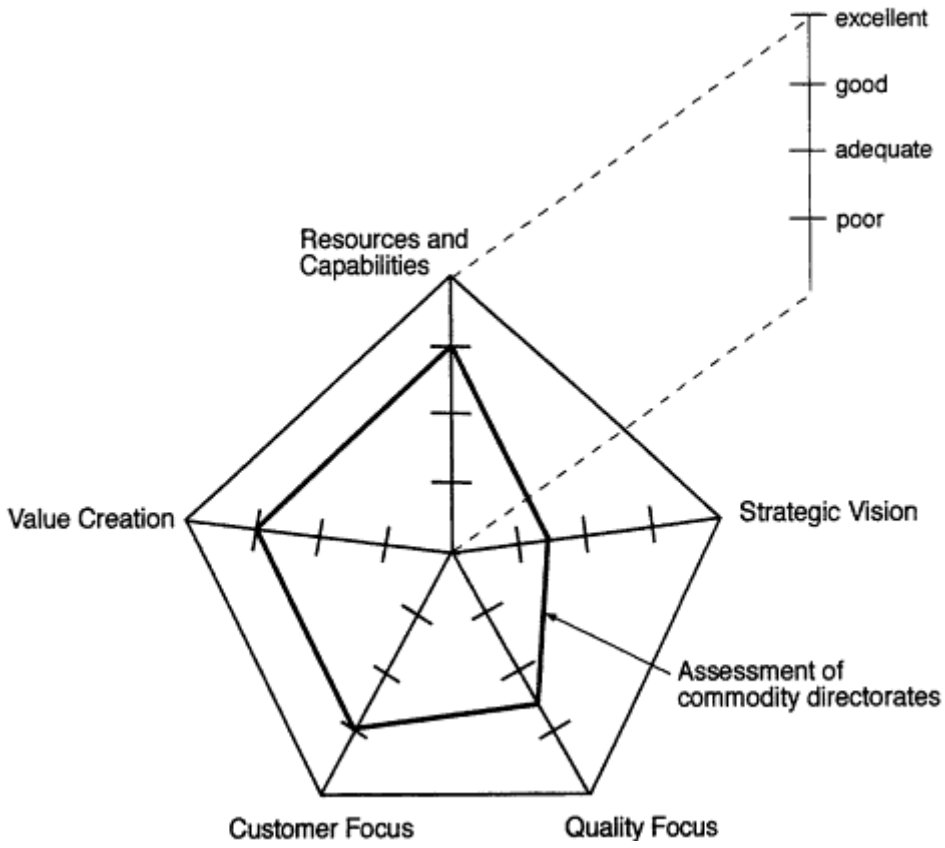

Figure ES-3
Spider diagram for the commodity directorates.

The committee assessed the effect of the establishment of the Soldier Systems Command on the Natick RDEC and found that the positive impact outweighed the increased burdens imposed by the command and the drain on RDEC resources. The new command embodies the soldier system, which is a unifying concept that focuses attention on how the products and services of the entire RDEC could influence the higher-level effectiveness of the soldier system.

MAJOR CONCLUSIONS AND RECOMMENDATIONS

The committee developed its conclusions and recommendations on the basis of the findings described above and the significant body of information assembled in the course of this study. The most important conclusions and recommendations are listed below, accompanied by discussions summarizing the committee's positions.

Commodity Directorates and the Pillars

Conclusion 1. Realizing the strategic vision of the RDEC and facilitating strategic planning require continuous, high-priority attention from top-level management and the involvement of RDEC personnel at all levels.

Recommendation 1. The improvements under way at the Natick RDEC should be solidified and expanded. RDEC management should be especially receptive to adjusting plans and programs to meet new challenges. Senior managers of the RDEC should develop a comprehensive plan to solve the problems associated with the Strategic Vision pillar.

The Strategic Vision pillar is crucial to the RDEC's competitive advantage. Strategic vision, especially strategic planning, requires a strong foundation of demonstrated, steadfast commitment characterized by openness to the exchange of information at all levels of the organization, the involvement of all personnel in goal identification and analysis, and the efficient implementation of plans and programs. The demonstrated commitment of the leadership must be communicated to all levels of the organization in a way that all personnel both understand and accept. If this is done correctly, strategic vision will become a key factor in approaching world-class performance.

The committee found many problems related to strategic vision at the RDEC, including the following: (1) a lack of support for, and sometimes understanding of, the stated visions and missions of the organization; (2) broad strategic visions that exist only on paper because the directorate staffs have not embraced them; (3) some groups that were pursuing their own projects with little cross-fertilization of ideas or interaction with other groups; and (4) upper-level RDEC managers who were devoting too much time to solving near-term problems instead of working with groups and individuals to align their thinking and projects with the overall visions, missions, strategic plans, and programs of the RDEC.

The managers of the RDEC should take to heart the suggestions in the body of this report. In particular, they should examine current and planned work in the directorates to determine if it is in line with vision and mission statements. For example, although terrain traversal and personal augmentation are named as part of the mobility mission, it is not clear how these capabilities fit into the current MobD organization. Either these aspects of mobility should be made vital components of the MobD organization, or MobD should focus solely on airdrop technologies and transfer the other aspects of mobility to another organization.

Conclusion 2. Steps must be taken to stop the steady erosion of scientific and technical talent and experience.

Recommendation 2. Senior managers of the RDEC should develop a plan to stop the erosion of skilled personnel and experience. At a minimum, they should

develop strategies to retain in corporate memory the knowledge of people who retire or depart for other jobs.

Solving this problem is not completely within the control of the RDEC, and the RDEC's struggles to retain resources and capabilities are not unique. The entire U.S. defense establishment is trying to cope with cuts in forces, reduced modernization programs, tight budgets, and the loss of personnel. Furthermore, in the last decade, many corporations have also undergone radical reengineering, which has meant massive reductions in personnel. Recognizing that other organizations have similar problems may be of some help if the RDEC can learn from the experiences of others who have had to adjust to new conditions.

The RDEC must develop strategies for preserving its corporate memory. Given that replacing experienced people will continue to be difficult, the knowledge and expertise of departing staff members must be passed on to remaining personnel. The RDEC must also increase the efficiency of remaining resources and capabilities (e.g., drop programs or functions when a critical mass no longer exists).

Conclusion 3. The Quality Focus pillar was assessed to be at a lower level of performance than three other pillars, but the committee's principal concern was the uncertain trend for the future.

Recommendation 3. Management of the RDEC should take steps to improve RDEC-wide learning and to develop and implement an internal system for assessing quality.

The committee was most uneasy about problems with learning from team to team and the general lack of metrics for tracking quality. The RDEC should have a framework and methodology for measuring quality, measurable objectives for improvements in work processes, measurements for optimizing RD&E processes to deliver value, teams on one project teaching teams assigned to other projects, an organizational climate conducive to organizational learning, and methodologies to measure and evaluate organizational learning.

Support Directorates

Conclusion 4. The Science and Technology Directorate was not adequately focused on its primary customers, the commodity directorates.

The committee determined that the arrangement between STD and the other directorates was not working. An STD that serves only some of the needs of the commodity directorates while pursuing its own agenda, thereby causing the other directorates to establish their own research functions, is not only inefficient, it should be unacceptable.

Recommendation 4a. The RDEC director should take immediate action to consolidate the RDEC's science and technology activities and focus them sharply on the needs of the commodity directorates. If a refocused, centralized Science and Technology Directorate cannot provide the necessary support, the director should consider distributing the entire research function among the other directorates.

Either of these options would eliminate the current arrangement between STD and the other directorates. The first option would consolidate the science and technology activities at the RDEC into a single unit that would serve all of the commodity directorates. The second would do away with a STD at the RDEC and replace it with science and technology traits distributed among the commodity directorates.

The committee favors the first option, primarily because it would concentrate the research talent of the RDEC in one organization, but only if the refocused organization could guarantee requisite support. A refocused STD could facilitate interactions between members of the research staff (e.g., to apply common technological solutions to the problems of various customers) and sharing of scarce research equipment. Nevertheless, concentrating the research talent in a single directorate is less important than contributing meaningfully to the science and technology needs of the RDEC.

If the first option is chosen, the new directorate would not just be a larger STD that operates the way the current STD does. Instead, the new STD would have tight links to each of the commodity directorates and oversight by RDEC senior management and the commodity directorates to ensure that their science and technology needs were being met. In turn, the commodity directorates would also have to specify their needs. Measures of performance for the new directorate that address the research needs of the entire RDEC would be established and monitored.

The new arrangement would be designed to take maximum advantage of outside research, although some in-house work on new technologies would still be done. The RDEC must concentrate its internal resources on maintaining the capability to judge the efficacy of external research and on fulfilling needs unique to the military that the private sector is unlikely to meet.

The committee's preference for a consolidated science and technology directorate should not be determinative on the RDEC management. If after due consideration the director of the RDEC decides that consolidation of the RDEC's science and technology activities cannot overcome the problems associated with the current STD, the STD should be broken up and its functions distributed to the commodity directorates.

Recommendation 4b. The new science and technology operation, consolidated or distributed, should ensure that its research is demonstrably relevant to the RDEC's overall mission.

The RDEC's new research arm, whatever its form, should thoroughly investigate the soldier-system concept and identify the full range of technologies within the RDEC's domain that could improve soldier performance. Then an evaluation should be made, in conjunction with ASCD and the commodity directorates, to determine which technologies offer the highest payoffs for the soldier system. Decisions could then be made on the technologies worthy of pursuit.

Conclusion 5. The Advanced Systems Concepts Directorate is not sufficiently supportive of the commodity directorates (its primary customers) or of the RDEC as a whole.

Recommendation 5a. ASCD must improve its capabilities to develop and use models and simulations in support of the other directorates and the entire RDEC. RDEC management should emphasize to all personnel the importance of (1) adequate modeling and simulations of the soldier system and (2) full cooperation of the other directorates with ASCD.

It is hard to overestimate the benefits to the Natick RDEC of a greatly improved capability to model relevant technologies and simulate the soldier system. The benefits include internal efficiencies and effectiveness, as well as external visibility and appreciation of the contributions of the RDEC to soldier-system performance. The committee firmly believes that RDEC participation in top-level analyses of military forces is necessary for the RDEC to compete successfully for scarce resources. Current constraints at the RDEC will make it difficult to hire new staff for the ASCD. Therefore, it is imperative that people in the other directorates with technical knowledge that is important for models and simulations contribute fully to ASCD.

Recommendation 5b. The RDEC managers should reexamine the other functions of ASCD and either expand them or eliminate them, as appropriate.

Budget Shortfalls

Conclusion 6. The RDEC director and managers face a major challenge in adjusting their priorities to cope with declining budgets.

Recommendation 6. As part of its strategic planning, the RDEC should develop strategies and tactics to cope with budget shortfalls.

Research and Technology Programs

Several research and technology programs at the Natick RDEC are unique, and some have been highly acclaimed. Two considerations should be taken into

account when assessing the mix and emphasis of various programs: (1) circumstances at the time of the assessment and (2) future needs.

Conclusion 7. The mix and emphasis of research and technology programs will have to be adjusted to improve the RDEC's support of the Army and other customers.

The committee considered the RDEC's core technologies and unique capabilities (e.g., in food processing, multicapability protective clothing, and airdrop technologies) in relation to its mission to support the soldier system. In most cases, the connection between what the RDEC was doing (or not doing) and its mission was clear, but in some cases it was not (e.g., some airdrop technology is not supported by the Army's requirements). Some of the areas on the RDEC's list of key technologies did not appear among STD's programs (e.g., airdrop technologies), and some were narrowly focused (e.g., biotechnology).

Recommendation 7. The RDEC should reevaluate its rationale for all in-house research and technology programs in light of the unique needs of the Army or other customers and the availability of sources outside the Army to advance the technology.

The RDEC should reevaluate various technologies to assess their payoffs in terms of improved soldier-system performance. If a program does not show a measurable payoff, the program should be considered suspect. If another agency or the private sector is advancing a technology much faster than the RDEC can with the limited funds available, the RDEC should reevaluate its decision to pursue that technology. Long-range needs for technologies like those associated with airdrop and ground mobility systems should also be reassessed. If the Army is not the customer, the RDEC should seek support from the likely customer (e.g., precision airdrop for the U.S. Air Force) or drop the program. If the Army is the real customer but does not provide adequate support, the effort should also be dropped (e.g., ground mobility).

Opportunities for Reengineering

As part of its assessment, the committee was asked to "identify opportunities for reengineering in areas judged deficient or worthy of improvement." In the committee's opinion, no single recommendation in this report amounts to a recommendation for reengineering, which is usually associated with large-scale corporate reinvention characterized by radical changes. Results of the committee's assessment did not indicate that radical changes were necessary for the Natick RDEC.

However, if the recommendations are taken together, they constitute a prescription for less-than-radical reengineering, a way of doing business that will

require persistent management attention; buy-in from all of the stakeholders, including personnel at the RDEC; and substantial time for implementation. An important component of this less-than-radical reengineering is the establishment of long-range strategies for the RDEC to maintain its competitive advantages. Another component is a demonstrated commitment by management to support those strategies and see that they are carried out.

Conclusion 8. The Natick RDEC is performing well. The RDEC's cycle time and responsiveness to urgent customer needs are particularly impressive. World-class performance, which requires widespread excellence, will be difficult for the RDEC to achieve but remains a worthwhile goal. Less-than-radical reengineering is an appropriate way for the RDEC to move toward that goal.

The RDEC can rightly be proud of its remarkable capabilities and noteworthy accomplishments. The fact that the RDEC had the courage to subject itself to this arduous assessment is indicative of its commitment to strive for world-class performance. The phrase world-class has been used as a description of excellence for all R&D in the U.S. Department of Defense. The Natick RDEC is the first agency, in the committee's knowledge, to bring concrete meaning to that phrase.

The methodology developed in the phase-one report and used in this assessment is sound. Although the characteristics and metrics might be modified to suit specific circumstances, the major components of world-class performance are useful parameters for assessing RD&E organizations. Examples of impressive past performance at the Natick RDEC should suggest ways to correct deficiencies revealed in this assessment. To achieve the goal of widespread excellence, the committee recommends that the Natick RDEC be reengineered in the way described below.

Recommendation 8a. The Natick RDEC should implement a five-step reengineering plan: (1) improve the Strategic Vision pillar to good, reverse the downward trend of the Resources and Capabilities pillar, and upgrade the Quality Focus pillar; (2) correct the problems associated with STD and the research and technology programs; (3) enhance ASCD's capability to support the RDEC; (4) raise selected pillars to the excellent level; and (5) conduct periodic self-assessments using the methods described in the phase-one report.

The committee offers the suggestions below for consideration by management of the Natick RDEC. First, the fact that the committee found significant problems with strategic vision suggests that there has been a shortcoming in management. The committee urges that greater emphasis be put on training to improve the leadership capabilities of the RDEC managers (see Recommendation 8b below). The goal of this training would be to bring about fundamental changes in the RDEC to make it a true learning organization that would develop its own improvement vectors and would produce a cultural change throughout the

workforce. Ideally, the RDEC would then have true leaders instead of just managers. Leaders motivate, empower, and coach continually; they have strategic vision, which they communicate to the workforce at every opportunity. Without this kind of leadership, the organization's vision statements will continue to fall on deaf ears. Appropriate elements of this training would be extended to RDEC team-leaders. The teams themselves should be taught to operate across organizational boundaries and to work toward common goals.

The committee believes that maintaining a highly qualified workforce is possible if management takes a long-term view and attacks the problem creatively. The committee urges that management pay special attention to recruiting high-quality personnel. Successful recruitment is an ongoing process that should begin long before spaces open up or the hiring freeze is lifted. Promising individuals must be targeted long before graduation and nurtured through cooperative projects, summer hiring programs, and temporary jobs sponsored by on-site contractors. Management must be ready to hire expeditiously as soon as a hiring window opens. Also, RDEC management should be aware that good people are attracted by superior facilities, a user-friendly research environment, and rewarding professional relationships.

Implementing this plan will require teamwork among all of the employees at the Natick RDEC, who will have to look beyond the narrow confines of their own programs and encompass the whole organization. The end result should be a cohesive organization that can approach the ideal described in this report.

Recommendation 8b. The Natick RDEC should begin an educational program in leadership development and modem principles of technology management.

In the committee's opinion, many of the problems associated with strategic vision, resources and capabilities, quality focus, and the two support directorates of the Natick RDEC stem from management limitations at the senior level. The committee does not intend to sound simplistic by throwing all of the problems at management and recommending that management fix them. But these problems are similar to the problems that have faced managers of other government and private-sector organizations that had not reengineered themselves to meet the challenges of a rapidly changing world. Problems cannot be excused because managers say they are overburdened or because resources are limited. The RDEC managers must learn and then transmit to all employees the techniques that have made some organizations pacesetters.

The training must be passed from the top down, with people at each level becoming mentors and trainers for people at the level below them. A new culture must be created and maintained through continuous coaching by leaders over a period of months and years. The training should include the many considerations related to the five pillars of a world-class R&D organization contained in the committee's phase-one report. Strong management commitment must be evident to the entire staff at the RDEC. With these improvements, the committee is hopeful that the organization will excel in the future.

ORGANIZATION OF THE REPORT

In Chapter 1, the committee addresses the background, the statement of task, and the approach for the assessment of the Natick RDEC. The committee also provides an overview of the principal features of the organization, including descriptions of the commodity and support directorates.

In Chapter 2, the committee discusses its assessment of the three commodity directorates. The characteristics and metrics developed during phase one are applied to these directorates, followed by the committee's judgments. In Chapter 3, the committee discusses its assessment of the two support directorates. Chapter 4 contains the committee's judgments concerning the ten key issues discussed above, which apply to the entire RDEC. The judgments in this chapter are based on the assessments in Chapters 2 and 3 and the committee's broad expertise. In Chapter 5, the committee presents conclusions and recommendations based on the assessment.

1

Introduction

This report contains the results of the National Research Council[1] (NRC) assessment of the U.S. Army Natick Research, Development and Engineering Center (RDEC). It was prepared by a committee of the NRC known as the Natick Standing Committee, whose formal title is the Standing Committee on Program and Technical Review of the U.S. Army Natick Research, Development and Engineering Center.

In this chapter the committee first discusses the background of the study, including the phased approach. Next, the committee addresses the statement of task that governed the committee's activities during the second phase of the study, explains the study approach, and describes the principal features of the Natick RDEC.

BACKGROUND

The Natick RDEC, located west of Boston near Natick, Massachusetts, is a major component of the U.S. Army Soldier Systems Command, a subordinate command of the U.S. Army Materiel Command. The RDEC's vision is to be the "world-class research, development, and engineering team" (Brandler, 1996) within the U.S. Department of Defense (DOD) that provides customers worldwide with the essentials of life (see Box 1-1). Its mission is to develop products that "maximize the soldier's survivability, sustainability, mobility, combat effectiveness, and quality of life" (Business Plan, 1995).

The objective of being a world-class organization has also been expressed by the Department of the Army, the secretary of defense, and the National Academy of Sciences. The Department of the Army voiced a strong need during 1995 for world-class research. "The Army research mission is to identify and conduct world-class research in areas having a high potential to significantly improve land warfighting capability, to include leveraging the research efforts of other government agencies, academia, and industry" (Army Science and Technology Master Plan, 1995). The secretary of defense, in a strategy statement

[1] The National Research Council is the operating arm of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

of DOD science and technology, established the objective of "maintaining a world-class base of people and facilities." (Defense Science and Technology Strategy, 1996). The Governing Board of the NRC issued a series of policy statements during 1997 on *Preparing for the 21st Century*. One of these documents, *Science and Engineering Research in a Changing World*, stated that "world-class research is critical" (NRC, 1997).

BOX 1-1 ORGANIZATION OF THE NATICK RDEC

The mission is reflected in the organization of the Natick RDEC, which consists of five directorates: the Mobility Directorate (MobD), the Survivability Directorate (SurD), the Sustainability Directorate (SusD), the Science and Technology Directorate (STD), and the Advanced Systems Concepts Directorate (ASCD). The first three are called commodity directorates because they are responsible for RDEC products, such as rations, food-service equipment, clothing, shelters, and airdrop systems. The last two are called support directorates because they assist the commodity directorates with, among other things, scientific and technical support and modeling and simulations (e.g., of the soldier as an integrated system).

The committee's phase-one report, published in 1996, defined world-class research and development (R&D) (NRC, 1996). Drawing on materials from industry, academia, and government (e.g., discussions, literature, and the experiences of organizations in the private sector that have been recognized for excellence with the Malcolm Baldrige National Quality Award), the phase-one report identified the major components of a world-class R&D organization and their interrelationships. It also identified five "pillars" of a world-class R&D organization and established 25 characteristics that further define those pillars. To measure performance (e.g., of an Army research, development, and engineering [RD&E] organization) relative to those pillars and characteristics, detailed tables containing four metrics for each characteristic were developed. (The essential elements are reproduced in Appendix C of this report.)

Over the past several years, the Natick RDEC has often been recognized for superior performance. For example, the RDEC was the Department of the Army Research and Development Organization of the Year in 1993 and the Department of the Army nominee for the President's Quality Award in 1996 (Brandler, 1996). In 1995, Malcolm Baldrige Award winner Motorola contacted the RDEC to benchmark the RDEC's R&D processes (Natick RDEC, 1995). This kind of recognition suggests that the RDEC's vision of being a "world-class RD&E team" is plausible.

The RDEC's ability to realize its vision is not entirely under its control, however. The RDEC must operate effectively and efficiently in the current defense environment, which is characterized by constrained budgets, reductions in force, and numerous uncertainties. These external pressures have presented

challenges for the RDEC, such as upheavals in personnel, hiring and promotion freezes, and difficulties attracting and keeping highly skilled employees.

In 1995, in response to these challenges and in recognition of its goal of becoming a world-class organization, the technical director of the Natick RDEC requested that the NRC assess the RDEC. The project was divided into two phases, the first to establish the assessment criteria and the second to conduct the assessment. The criteria were established in 1996, and the assessment took place during 1996 and the first half of 1997.

STATEMENT OF TASK

The phase-one report, *World-Class Research and Development* (NRC, 1996), provided the foundation for the second (present) report by defining world-class R&D. In response to the statement of task for phase one, which directed that "the metrics derived from the committee's definition will be used as the benchmark by which the business areas and core technologies will be evaluated" (see Appendix A), this second study applies the results of phase one and documents the committee's assessment.

The committee conducted the second study according to the statement of task[2] that follows.

> The Natick Standing Committee will examine the Natick RDEC's directorates and provide assessments and recommendations to the technical director. These assessments and recommendations will assist the RDEC in determining its future corporate strategy, technology thrusts, and related plans. As part of its work, the committee will address the extent to which the Natick RDEC has attained the level of performance of a world-class research, development, and engineering organization.
>
> Committee findings, assessments, and recommendations concerning the directorates will focus on the following three topics: (1) effectiveness and adequacy of organizational structure and resources; (2) quality of, and customer satisfaction with, Natick RDEC products; and (3) adequacy of the research and technology programs. The committee will identify opportunities for reengineering in areas judged deficient or worthy of improvement.

This statement establishes two different stages of the assessment. The first consists of assessing the RDEC in terms of the five pillars and the associated characteristics and metrics established in phase one (NRC, 1996). The second

[2] This approved, abbreviated statement of task was synthesized from (1) the lengthy statements contained in precursory documents (see Appendix A for details) and (2) discussions with the technical director and his staff during the committee meeting at the Natick RDEC on February 25-27, 1996 (see Appendix B). Management of the RDEC particularly wanted the committee to assess the commodity directorates, which are responsible for Natick's key business areas.

consists of assessing the RDEC in terms of ten key issues that are related to, but somewhat different from, the pillars and characteristics. Both stages are discussed below.

Pillars and Characteristics

The pillars and characteristics are described in the phase-one report. (The committee strongly suggests that readers not familiar with the phase-one report review Appendix C, which. contains the executive summary of that report and information on the pillars, characteristics, and metrics.) As shown below, the underlying principle of a world-class R&D organization is demonstrated commitment, which is the foundation of the five pillars, which in turn support the competitive advantages (see Figure 1-1). The five pillars are Resources and Capabilities, Strategic Vision, Quality Focus, Customer Focus, and Value Creation. Based on the phase-one report and knowledge of the Natick RDEC, the committee prepared the following brief description of an ideal world-class RDEC (Box 1-2). The pillars are defined by characteristics, which can be measured by metrics designating poor, adequate, good, or excellent performance. The characteristics are listed in Figure 1-2.

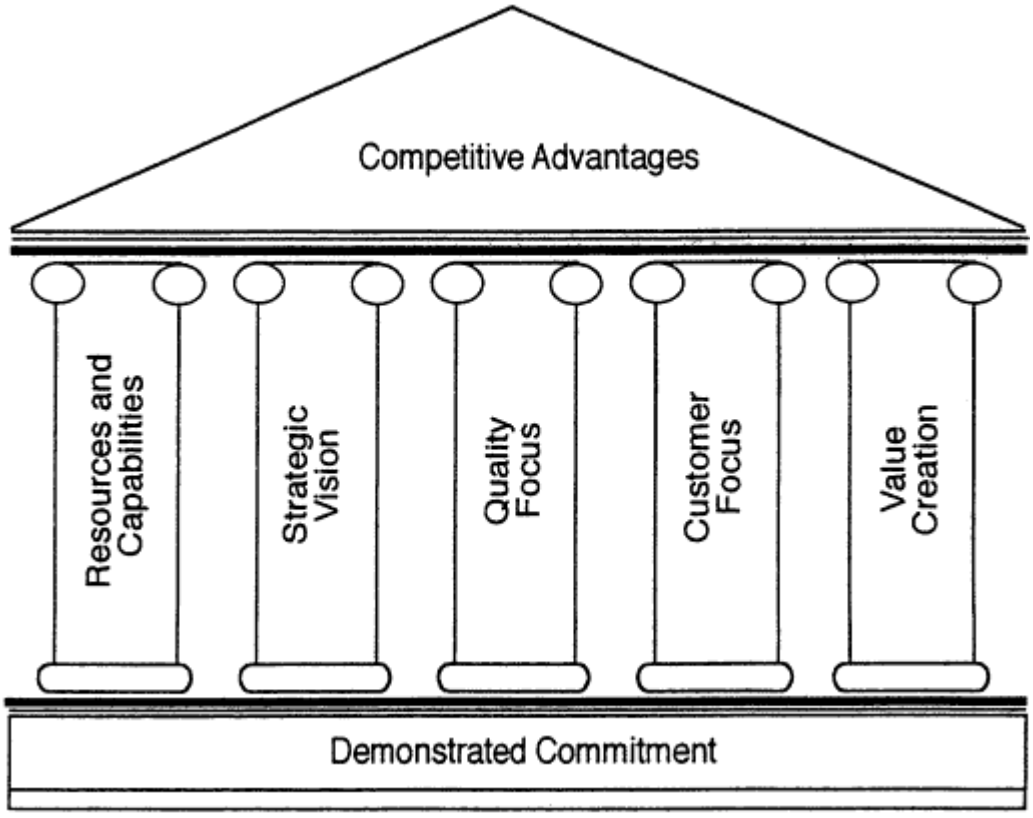

Figure 1-1
The major components of world-class research and development organizations.

BOX 1-2 AN IDEAL WORLD-CLASS RDEC

An ideal world-class RDEC shows clear evidence of (1) demonstrated commitment to being one of the best research, development, and engineering centers in the world; (2) strong performance in each of the major pillars: Resources and Capabilities, Strategic Vision, Quality Focus, Customer Focus, and Value Creation; and (3) development of competitive advantages that put the organization in the forefront of its field. To attain the ideal, special attention must be paid to the five pillars, which are the critical supports of world-class performance.

The Resources and Capabilities pillar reflects the assets and talents with which the RDEC creates value for its customers. This pillar includes the quality of personnel, as measured by both technology-based output and the talents, skills, and abilities of the personnel. A world-class RDEC must focus on developing and retaining its people and its corporate memory. Another key factor is the physical environment, the facilities and infrastructure in which the personnel operate. State-of-the-art machinery and equipment are vital.

The Strategic Vision pillar is management's mental view of the type of organization it wants to create. Realization means aligning the vision, mission, plans, and programs of the enterprise so that everyone in the organization knows what these are and can clearly communicate the links between them. It also means providing charismatic leadership that elicits the strong commitment of personnel to the organization and its goals, so-called stakeholder buy-in.

The Quality Focus pillar is the commitment to quality reflected through actions, such as frequent technological breakthroughs and dedication to continuous improvement. One way to improve quality is by continually measuring the quantity and quality of the organization's products to ensure customer satisfaction. Another is by reviewing and streamlining current operations and eliminating non-value-added activities.

The Customer Focus pillar involves identifying, anticipating, and responding to the current and future needs of the customers receiving RDEC products. There are two important parts to the Customer Focus pillar. One is the careful identification of each customer group and establishment of a comprehensive feedback system for measuring customer satisfaction. A second, related, step is to involve customers in the formulation,design, and implementation of customer-related strategies.

The Value Creation pillar is the ability to increase the benefits perceived by customers so they feel that they are getting more value than they expected or received previously. One way to create value is by reducing the cycle time of products in progress and bringing them to market faster. A second way is by creating products that users consider to be better in terms of functionality, ease of use, and reliability.

Ten Key Issues

During the contract negotiations between the Natick RDEC and the NRC that preceded phase one, ten key issues to be addressed by the NRC in the study report were included in the statement of work. These issues were organized under three overarching headings—organization and resources, quality and customer

satisfaction, and research and technology—and are shown in Table 1-1. The ten key issues were addressed in the second stage of the committee's phase-two assessment. Table 1-1 is derived directly from Sections C-3.1a, b, and c of Appendix A, with only minor adjustments by the committee to accommodate its knowledge of the RDEC and its work in the phase-one report. Some of the key issues cover the same ground as the pillars, characteristics, and metrics discussed above. For example, the first issue under the organization and resources topic (see Appendix A, part C-3.1a of section C) is the question of adequate funding and personnel to conduct world-class R&D. In other cases, the key issues are very different (e.g., Appendix A, part C-3.1a: "How has the establishment of Soldier Systems Command affected Natick?").

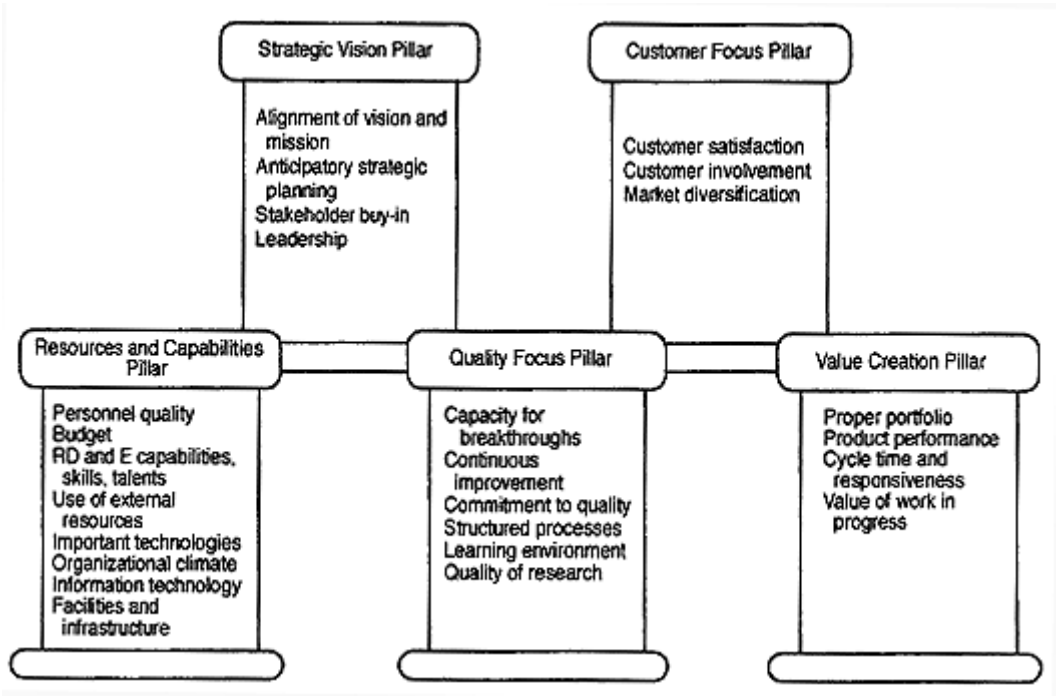

Figure 1-2
The five pillars and 25 characteristics.

STUDY APPROACH

The committee's assessment of the Natick RDEC is a combination of the application of the characteristics and metrics from the phase-one report and judgments on the key issues enumerated in the contract. This approach has several virtues: it is consistent with the phase-one report, it meets contractual requirements, and it satisfies the statement of task. As directed in the statement of task for phase one, the metrics were to be used as "the benchmark" for phase two.

TABLE 1-1 Ten Key Issues Addressed by the Committee in Stage 2 of the Assessment

Organization and Resources	
1. Does the Natick RDEC have adequate funding and personnel (e.g., technical specialties and critical mass) to conduct world-class research, development, and engineering for military products and systems? Are the RDEC's facilities and equipment adequate?	3. What new organizational approaches might be beneficial (include consideration of elements of the federated laboratory concept)?
2. How effective is the current organization structure?	4. How has establishment of the Soldier Systems Command affected the Natick RDEC?
Quality and Customer Satisfaction	
5. Are the Natick RDEC's outputs (e.g., products, systems, and research and development results) deserving of the label world-class? Is the RDEC's system to measure the quality of its outputs adequate?	7. Are the RDEC's outputs marketable to customers outside the Army? Outside the DOD? Is this marketability appropriate and adequate for an RDEC?
6. (i) Do the outputs of the RDEC meet the customers' materiel requirements? (ii) How well does the RDEC support the battle laboratories and its higher-level customers (e.g., Soldier Systems Command, Army Materiel Command, and DOD)? (iii) Is the RDEC's system to determine customer satisfaction adequate?	
Research and Technology	
8. Are the core and supporting research and technology programs world-class (or merely adequate)?	10. Are the models and simulations and other analytic methodologies used by the RDEC appropriate for the commodity areas and research and technology programs?
9. Should all current research and technology programs be continued? If not, which ones should be eliminated? Should any new ones be adopted?	

The extensive literature on what characterizes good R&D supports results of the committee's phase-one report. In phase one the committee consulted with representatives of industry, academia, and government concerning the essential elements of world-class performance and reviewed several leading organizations and their paths to success (three of these organizations were winners of the Malcolm Baldrige National Quality Award). Finally, the committee drew upon the considerable expertise of its members.

An alternative approach would have been for the committee to visit a number (undetermined) of organizations that do work similar to the Natick RDEC. The "world-class" aspects of those organizations could then have been used as benchmarks for phase two. The problem is that this kind of benchmarking requires, first, selecting organizations doing similar work, which would be difficult because the Natick RDEC has a relatively unique mission to serve the U.S. Army. Second, this alternative requires judgments that the organizations being visited are indeed world-class, which implies the application of explicit criteria to all of the organizations selected as candidates. Thus, the committee would have had to assess many organizations to decide which ones exhibit world-class performance in the areas of interest to the RDEC. Next, the committee would have had to assess the RDEC against the benchmarks represented by each of the world-class organizations. Setting aside the controversies that could have arisen in connection with a committee determination that organization A is world-class and worthy of being used as a benchmark for the RDEC whereas organizations B and C are not, the committee notes that its time and resources for this study were limited. The committee found it difficult enough to assess the RDEC as directed (i.e., using the results of phase one as the benchmark). It would not have been possible to do this study using the alternative benchmarking approach.

The committee's fundamental assumption was that one needs to evaluate the work processes of an organization—as is done in major quality award programs (e.g., the Malcolm Baldrige National Quality Award)—to determine if an organization is performing at a world-class level. During the first phase, which was completed in 1996, the committee defined the important work processes (along with some inputs and outputs) from its experience in doing RD&E, its knowledge of the literature, and its discussions with other experts. The committee also found a way to characterize levels of performance. The phase-one report contains the characteristics and metrics that were used as the benchmarks for the committee's assessment in this second phase. (The essence of the phase-one report is elaborated in Appendix C.)

Because the Natick RDEC's main products and principal business areas are embedded within the three commodity directorates, the committee decided to concentrate its attention on them. The support directorates were considered primarily in the context of providing assistance to the commodity directorates. To reflect this focus, the committee formed three panels to review the three commodity directorates. These panels were led by committee members with expertise in the products and technologies of each commodity directorate (e.g., parachutes, textiles, and food and food processing). However, each panel also included members who reflected the broad expertise of the full committee, including expertise in managing and conducting R&D, assessing technical organizations, and systems engineering and modeling and simulation.

Members of the committee participated in fact-finding meetings and in-formation-gathering sessions at the Natick RDEC prior to the assessment. Their familiarity with the organization was bolstered during the assessment by visits to

the Natick RDEC and responses to questions[3] (written and verbal) from Natick personnel during February, June, September, and December of 1996 and February 1997. (See Appendix B for details of these visits.)

The first meeting, in February 1996, was a general discussion with the leaders of the Natick RDEC, who briefed the committee on Natick operations and responsibilities and established ground rules for the study. The panel visits in June, September, and December 1996 focused on the (MobD) mobility, (SurD) survivability, and (SusD) sustainability commodity directorates. Information was also gathered relative to the two support directorates.

The visit in February 1997 focused on gathering follow-up data from the commodity directorates and filling in gaps on the support directorates. In addition, discussions were held with senior managers and strategic planners, primarily to update the committee on changes since the previous panel visits to determine trends suggesting improvements or declines in salient assessment characteristics.

The panel visits in 1996 were preceded by lengthy questionnaires answered by the management of the Natick RDEC and reviewed by the panels before each visit (see footnote 3). The questions reflected the pillars, characteristics, and metrics established in phase one. The questions were also designed to illuminate the ten key issues in the statement of task.

The committee conducted numerous on-site interviews with a broad cross section of personnel at all levels of the organization, including the administrative and professional levels. Among other things, these interviews provided information that the committee used to determine how well the written responses prepared by management corresponded to information from rank-and-file employees.

The assessment by the first panel (MobD) was used as a "pilot run" to ensure that the committee's methodology was sound, that the questions were relevant, and that the time allotted for assessing each commodity directorate was reasonable. This pilot run was closely observed by the other panels so that lessons could be quickly absorbed and applied to the remaining assessments. All three panels employed a standard modus operandi. Specifically, taking into account all of the information received, they used the characteristics and metrics for a world-class organization from the phase-one study supplemented by their expert judgments on the ten key issues. Interactions between the panels were important to the process used by the committee to reach consensus on the assessments of the commodity directorates.

The committee assessed STD and ASCD, the two support directorates, periodically through written responses to questions and as part of the visits to the

[3] The written responses from the commodity directorates are available for review by contacting the Division of Military Science and Technology by phone at (202) 334-3118 or in writing to: National Research Council, HA258, 2101 Constitution Avenue, N.W., Washington D.C. 20418.

commodity directorates. The committee did not believe it was appropriate to subject the support directorates to the full range of inquiry used to assess the commodity directorates. The contributions of the support directorates to the overall performance of the Natick RDEC and its commodity directorates (who are the primary customers of STD and ASCD) were considered most relevant.

BOX 1-3 ASSESSMENT OF CUSTOMER SATISFACTION

The committee assessed customer satisfaction for the Natick RDEC in the following way:

- The committee was briefed on customer satisfaction during the visit to Natick in February 1996 (Faulkner, 1996). The process to determine customer satisfaction was explained, and key performance indicators for RDEC products were described.
- The committee reviewed the RDEC's application for the President's Quality Award (Natick RDEC, 1995), which discussed customer focus and customer satisfaction surveys (e.g., 66 visits to customers at various locations and the collection of data from 40,000 soldiers, sailors, airmen, and marines in the past decade).
- The committee reviewed the written responses to its questions on customer satisfaction.
- The committee interviewed many individuals at the RDEC about customer satisfaction during the site visits.
- The committee are meals-ready-to-eat, packaged food for soldiers in the field. The committee sampled experimental new foods for soldiers, inspected various shelters and feeding facilities for soldiers, and examined displays of clothing to protect soldiers in different environments. The committee was made aware of improvements already completed or being considered by the RDEC in response to feedback from its customers.
- The committee contacted the U.S. Army Science Advisor for the Southern European Task Force deployed to Bosnia and reviewed the results of his findings regarding soldier satisfaction with equipment (see Chapter 2).
- The committee contacted the Program Manager of Soldier Support at the Soldier Systems Command during the February 1997 site visit to Natick (see Chapter 2). This Army official is one of the main clients of the RDEC.
- Against the backdrop of all of the above information, the committee applied the metrics of the Customer Focus pillar, especially the customer satisfaction characteristic (see Appendix C), to assess the commodity directorates. The committee made a summary assessment for the Customer Focus pillar with respect to the support directorates (see Chapters 2 and 3).
- These assessments became a part of the committee's judgments concerning the customer-satisfaction issues in the list of ten key issues (see Chapter 4).

In view of the committee's understanding of customer satisfaction developed above, and in view of the limited time and resources available for this study, the committee decided not to design an independent survey and contact, on its own, individual soldiers or other customers regarding their satisfaction with Natick RDEC products or services.

Once assessments of the individual directorates had been made, the committee extended its judgments to the ten key issues, which spanned a broad range of RDEC operations. Finally, the committee integrated the findings of both stages to produce a comprehensive assessment of the entire Natick RDEC organization. Box 1-3 reflects the committee's overall approach by describing the way customer satisfaction was assessed.

OVERVIEW OF THE NATICK RDEC

This section provides an overview of the Natick RDEC, including how it fits in the Army organizational hierarchy and its mission and responsibilities. The approximate numbers and types of people at the RDEC and its overall budget are also described.

The Army Soldier Systems Command, collocated with the Natick RDEC, provides the organizational environment within which the RDEC operates on a day-to-day basis. The mission of the Soldier Systems Command is to "develop, integrate, acquire, and sustain soldier and related support systems" to improve the soldier's performance and quality of life. The command performs similar functions for other armed services and customers (Brandler, 1996). Figure 1-3 shows how the Soldier Systems Command and the Natick RDEC relate to other components of the Army Materiel Command under the Secretary of the Army.

The mission of the Natick RDEC is to "maximize the individual soldier's survivability, sustainability, mobility, combat effectiveness, and quality of life," which implies "treating the soldier as a system" (Brandler, 1996). The

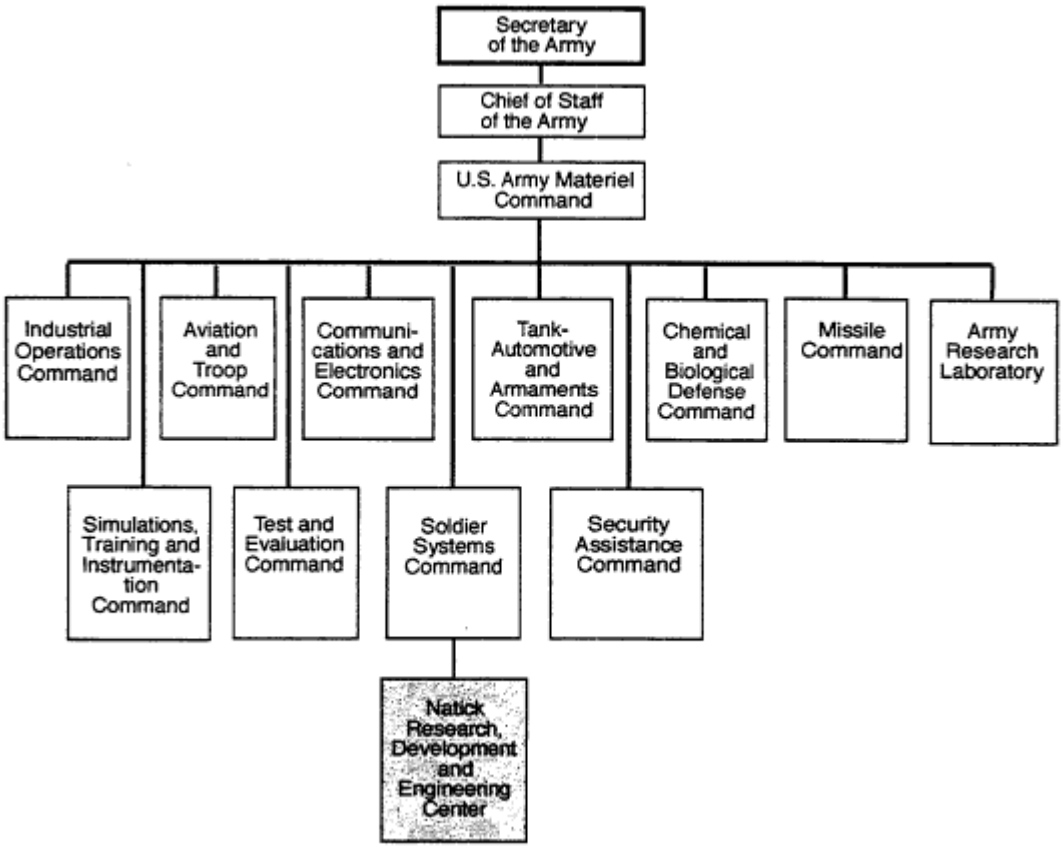

Figure 1-3
Relationship of Soldier Systems Command (and the Natick RDEC) to the Army Materiel Command.

business areas of the RDEC that support the soldier-as-a-system concept include airdrop systems (for personnel and cargo), clothing and individual equipment, combat rations and field feeding, and shelters.[4] The core technologies at the Natick RDEC are: airdrop technology, textile technology, food science, and biotechnology.

The Natick RDEC consists of approximately 500 personnel, the majority of whom are civilian professionals (Brandler, 1996); approximately 65 percent are scientists or engineers, and 30 percent have advanced degrees (10 percent have doctorates). Funding in fiscal year 1996 for the RDEC was slightly more than $110 million, just over $40 million of which was for science and technology. Funding projections shown to the committee suggest that funding for the Natick RDEC will be reduced to about $100 million by fiscal year 1999.

Internal Organizational Structure, Visions, and Missions

This section describes the Natick RDEC's five major organizational units—three commodity directorates and two support directorates—and the role each one plays. Figure 1-4 is a top-level organizational diagram showing the three

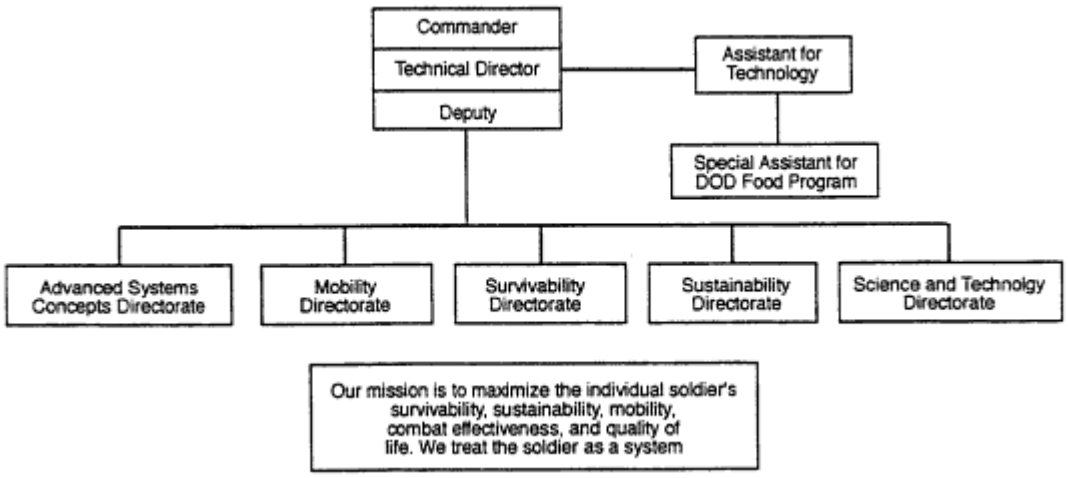

Figure 1-4
Internal organization of the Natick RDEC.

[4] The Words "business areas" might suggest that the Natick RDEC actually manufactures packaged meals or boots for soldiers. These items, of course, are produced by industry according to specifications that result from the R&D done at Natick. Other agencies of government procure the items and provide them to soldiers. The RDEC occasionally produces special-purpose items (e.g., sample meals to obtain opinions on their quality, test fabrics, and airdrop packages). However, the RDEC delivers real value mainly through scientific and technical contributions to the items used by soldiers and technical oversight of improvements to existing products or the initiation of new products. The R&D is guided in part by feedback from soldiers to the Natick RDEC, which maintains. active mechanisms for eliciting and evaluating responses from various "customers."

commodity directorates (MobD, SurD, SusD), which are aligned with key sections of the RDEC mission statement—mobility, survivability, and sustainability—and take the lead in developing items such as parachutes, clothing, and food. Also shown are the two support directorates (STD and ASCD), which provide specialized support in science and technology and advanced systems concepts. Each of the directorates is described below.

Mobility Directorate

The Mobility Directorate (MobD) provides research, development, and engineering to integrate the combat-essential elements known as "mobility" into the soldier system (Business Plan, 1995). Two of the Soldier Systems Command business areas are housed in MobD: (1) aerial delivery and (2) some aspects of clothing and individual equipment. The core technology for airdrop technology is housed solely within MobD.

MobD has the vision of becoming the global leader in meeting military mobility needs (Doucette, 1996). MobD defines the word "mobility" as getting soldiers to the battle safely, efficiently, and combat ready. The mission of MobD is to provide airdrop, terrain traversal, and personal augmentation products and technologies to protect, sustain, and improve the soldier's quality of life under extreme environmental and hazardous conditions. In fiscal year 1996, MobD had a total budget of about $8 million. The budget is projected to remain approximately the same through fiscal year 1999.

In October 1995, MobD adopted a new organizational structure, which had several objectives, including reducing layers of management, improving opportunities for advancement in technical careers, improving support of customer needs, and improving workforce morale and motivation. [5] Figure 1-5 shows the MobD organizational structure. At the top of the organizational hierarchy is a director; below him are four groups, the most important of which are the business management office and the technical management office. Below them are five groups (about 55 people)[6] that report directly to the technical management office. The five groups are: New Ventures, Science and Technology, Product Development, Engineering, and Technical Support. Each group is composed of one to five self-directed work teams. Most work teams are composed of two or three members. The largest team has eight members.

[5] Restatement of these objectives does not necessarily signify that they have been met.

[6] At the time of the assessment, MobD had three people with doctoral degrees and 14 with masters degrees. Key technical disciplines included mechanical and aerospace engineering, operations research, and numerical modeling.

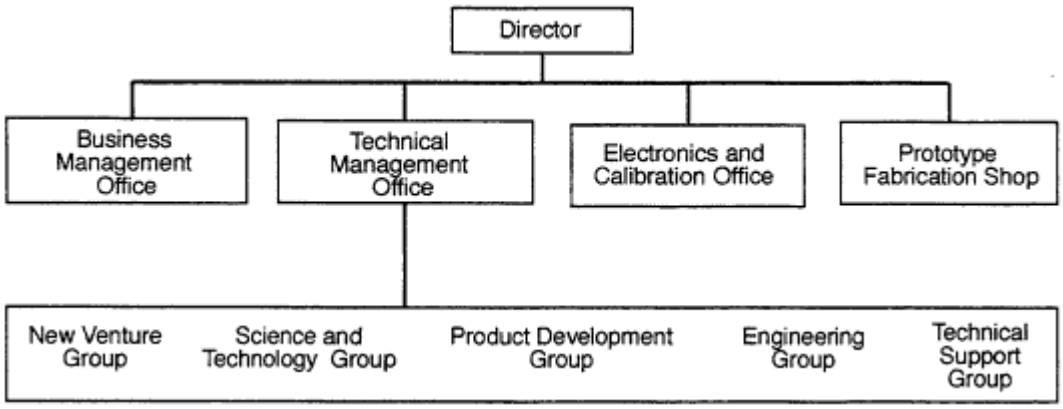

Figure 1-5
Organization of the Mobility Directorate.

Survivability Directorate

The Survivability Directorate (SurD) plays a crucial role in the Natick RDEC. SurD is the organization responsible for clothing, textiles, and individual equipment for the soldier system. The vision of SurD is to become the recognized world leader in survivability technology, products, and systems integration. The mission of the directorate is to plan, organize, and conduct the Army's research, development, and engineering programs for combat and noncombat clothing and individual equipment (Granchelli, 1996). SurD is the system integrator for the following mission areas: chemical and biological protection; ballistic munitions protection; directed energy protection (eye and body); heat stress protection (i.e., cooling equipment); flame protection; environmental protection; visual, thermal, antifratricide camouflage; and dress uniforms.

SurD has a diverse staff of approximately 120 professionals. At the time of the assessment, 11 had doctorates and 36 had master's degrees. Their technical disciplines included chemical, mechanical, electrical, and materials engineering; textile technology; chemistry; physics; and quality assurance. Research facilities in SurD consist of a helmet laboratory; a camouflage evaluation facility; a pilot plant for dyeing, printing, and finishing textiles; a laser laboratory; a rain room; a ballistics laboratory; a scanning electron microscope; and computer-aided-design equipment. The fiscal year 1996 funding for SurD was about $55 million (Granchelli, 1996), which included $30 million from customer orders. [7] Overall funding for SurD is expected to decrease to the range of $47 million to $53 million in fiscal years 1997 to 1999.

[7] A broad range of customers and programs has been identified and served by SurD; these include such diverse organizations as the Bureau of Engraving and Printing, the Army Aviation and Troop Command, the Army Chemical and Biological Defense Command, the U.S. Coast Guard, the Defense Logistics Agency, the National Aeronautics and Space Administration, the U.S. Post Office, and more than 30 others.

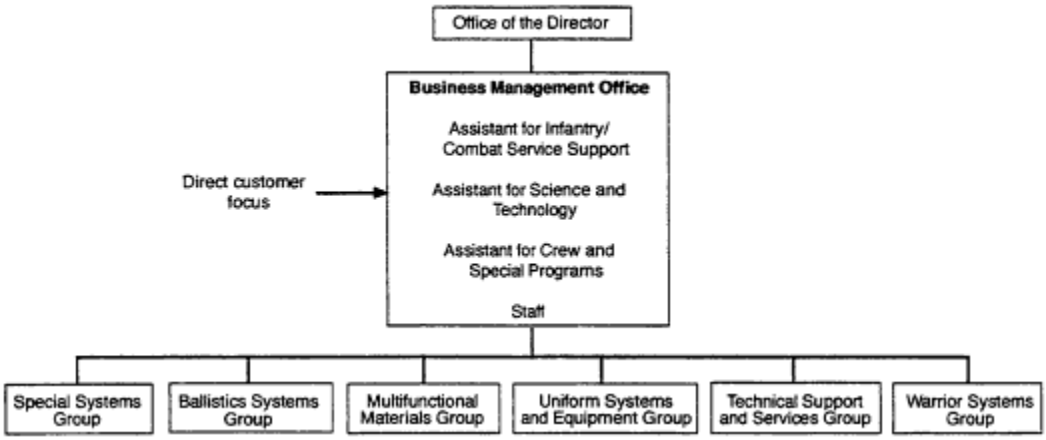

Figure 1-6
Organization of the Survivability Directorate.

The SurD intends to reach world-class status by developing an empowered, well trained, motivated workforce; intensifying leveraging worldwide with academia, industry, and government; and developing well planned, well executed, customer-focused programs. Implementation of these processes began with a major organizational change in October 1995 aimed at replacing the old bureaucratic hierarchy with an empowered workforce, reducing functional divisions to product groups to facilitate technology transition, and intensifying customer focus (i.e., marketing) through the creation of a business management office[8] (Figure 1-6).

Sustainability Directorate

The Sustainability Directorate (SusD) mission is to provide research, development, and engineering for integrating essential elements of sustainability into the soldier system. Three of the Soldier Systems Command business areas are housed in SusD: food and food service equipment; shelters; and unit and organizational equipment. The Soldier Systems Command core technology of food science is housed solely within SusD. SusD's vision is to provide soldiers with timely advancements in food, combat service support equipment, and shelters (Darsch, 1966). Subordinate goals include a rapidly deployable field feeding capability that can sustain and enhance soldier performance across the continuum of military operations; and effective and affordable field support equipment and systems to sustain soldiers, enhance their quality of life, and improve their readiness in all combat situations and operations other than war. Other goals include increasing the availability of aircraft and vehicles for missions by providing mobile maintenance capability in forward areas under all weather conditions; developing highly effective, rapidly deployable, high-performance tents to sustain and improve soldier readiness and performance in combat and

[8] Restatement of these objectives does not necessarily signify that they have been met.

noncombat operations; and becoming the DOD's focal point for tactical rigid-wall shelters. In fiscal year 1996, SusD had a total budget of about $29 million. This level of funding was expected to decline to approximately $21 to $24 million by fiscal year 1999.

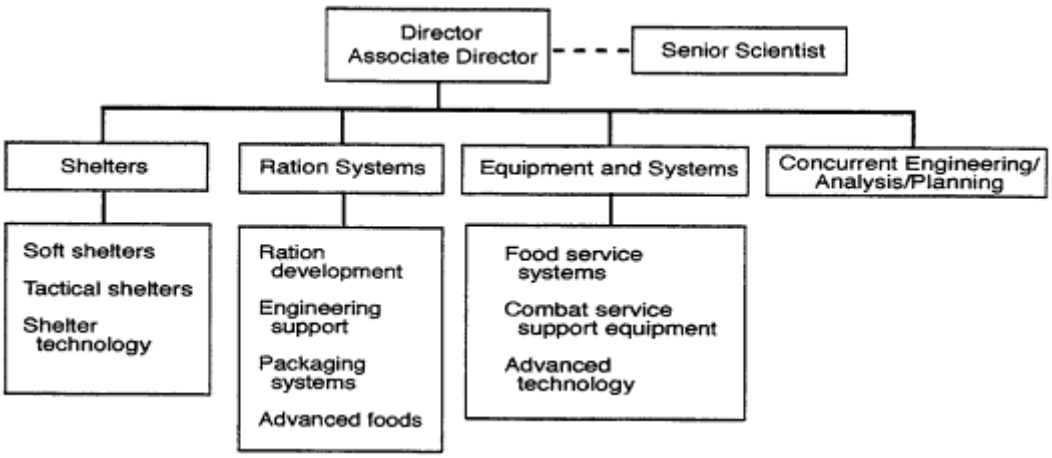

Figure 1-7
Organization of the Sustainability Directorate.

Figure 1-7 shows the SusD organization as it existed during the assessment. At the top of the organizational hierarchy are a director, an associate director, and a senior scientist. Below them, approximately 155 people [9] are divided into four groups. The four groups are: Shelters, Ration Systems, Equipment and Systems, and Concurrent Engineering, Analysis, and Planning.

Support Directorates

The Science and Technology Directorate (STD) and the Advanced Systems Concepts Directorate (ASCD) occupy a unique niche within the Natick RDEC because their purpose is to support the whole range of RDEC programs. STD contributes principally through its focus on research and technology that could be useful to the commodity directorates. ASCD's principal contributions are in integrating programs from each of the commodity directorates and presenting and marketing RDEC commodities (viz., promoting the soldier-system concept).

STD's vision is to be a world-class research organization, and the STD mission is to "provide world-class research, technology, and scientific services; maximize the combat effectiveness of the soldier system through enhanced survivability, sustainability, mobility; leverage outside research programs...[and]

[9] SusD's team of professionals includes 12 people with doctorates and 39 with master's degrees. Key technical disciplines include mechanical, electrical, and bioengineering; food processing and packaging; organic and inorganic chemistry; microbiology and bacteriology; and nutrition.

maintain cutting edge research programs, facilities, and equipment" (Salant, 1996). STD was recently organized around research and scientific services and four so-called "thrust areas": biomolecular processes; materials functionality; ergonomics; and product acceptance (which involves a comprehensive management and technical program to improve total soldier-system performance).

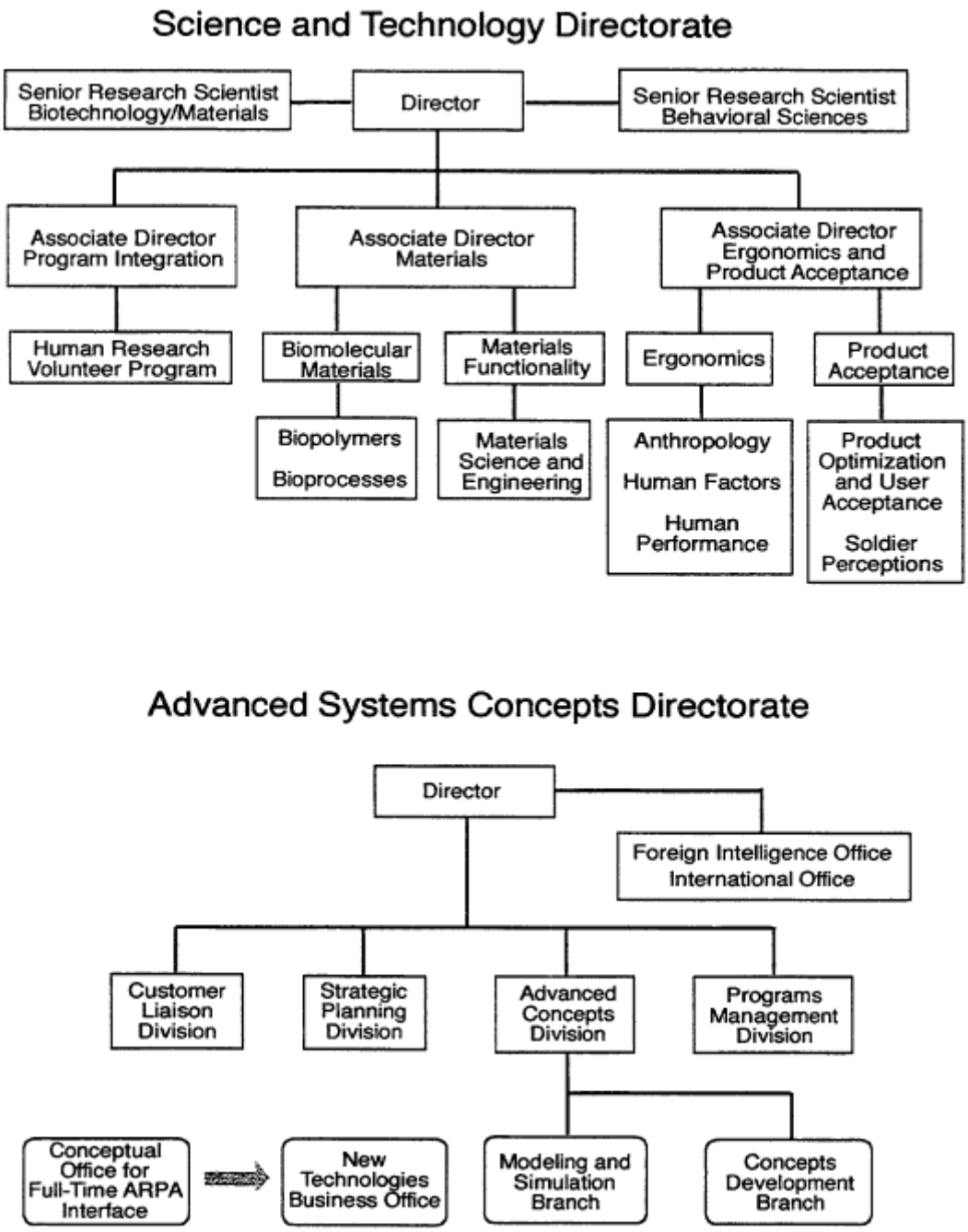

Figure 1-8
Organization of the support directorates. (ARPA: Advanced Research Projects Agency)

STD's team of approximately 60 professionals covers a broad range of technical disciplines (e.g., chemistry, physics, biology, textile science, food science, and psychology) and includes 22 people with doctorates, two with post-doctorate degrees, and 14 with master's degrees. The STD budget for fiscal year 1996 was approximately $6 million. This amount is expected to fall to about $5 million in fiscal years 1997 to 1999.

ASCD's vision is to be the provider of quality services that expedite the transition of technology to development and production. The ASCD's mission is to develop, plan, maintain, and coordinate the overall RD&E program to ensure that the individual soldier's current and future needs are identified, assessed, and appropriately addressed in DOD acquisition of clothing and personal equipment systems, aerial delivery systems, food and food service systems, and field shelters and equipage. ASCD provides analytic and scientific support services to the commodity directorates through its Advanced Concepts Division and other groups that deal with customer liaison, strategic planning, and program management.

Within ASCD, the advanced concepts work encompasses operations research for the entire RDEC and supports higher-level decision making through the development of modeling and simulation tools and the conduct of various analyses (e.g., analyses of cost and operational effectiveness, risk, and other tradeoffs) (Malabarba, 1996). Personnel in ASCD have a wide range of expertise in fields like business administration, mathematics, statistics, economics, computer science, engineering, and physics. Several people have doctorates (including one juris doctorate) and master's degrees. The advanced concepts work, which constitutes the largest funding element in ASCD, had a $12 million budget in fiscal year 1996, about $9 million of which was from customer orders. The modeling and simulation package within advanced concepts is expected to range between $2 million and $3 million in fiscal years 1997 to 1999. Figure 1-8 depicts the internal organizations of the two support directorates as they existed during the assessment. [10]

Summary

Table 1-2 summarizes the key business areas, core competencies, and skill bases of each of Natick's five directorates.

[10] On September 23, 1997, the committee learned from a representative of the Natick RDEC that ASCD was being disestablished and its functions were being distributed to three organizations within the RDEC—two associate directors and the STD (DeCosta, 1997). The former director of ASCD will become the director of STD, and the current director of STD will retire. The committee did not have an opportunity to consider this change as part of its assessment but hopes that the findings of this report will prove useful to the leaders and staff of the organizations that inherit the ASCD functions.

Table 1-2 Major Technical Features of the Directorates of the Natick RDEC

Mobility Directorate	Survivability Directorate	Sustainability Directorate	Science & Technology Directorate	Advanced Systems Concepts Directorate
Business Areas				
Aerial delivery	Combat and noncombat clothing and individual equipment	Food and food service equipment	N/A	N/A
Personal augmentation product and technologies		Shelters		
Terrain traversal		Unit and organizational equipment		
Illustrative Core Competencies				
New parachute concepts	Chemical warfare protection	Targeted nutrient delivery	Biomolecular processes	Modeling and simulation
Advanced soft landing concepts	Ballistic, flame, and surveillance counter-measures	Physical, mechanical, and chemical behavior of materials	Materials functionality	Customer liaison
Gliding wing opening process	Textiles and clothing design	Advanced food preservation and molecular food analysis	Ergonomics	Strategic planning and program management
Computational modeling of parachute and airdrop systems	Systems integration	Encapsulation, coating, and enrobing	Product acceptance	
	Electron microscopy	Self-heating technology and multifuel burners		
	Textile testing and color science	Electromagnetic inhibiting and high strength insulative materials		
Illustrative Skill Base				
Mechanical and aerospace engineering	Anthropometry, biomechanics, and mathematics	Bioengineering, animal science, and bacteriology	Chemistry, physics, and biology/microbiology	Business administration and mathematics

2

Assessment of the Commodity Directorates

This chapter presents the committee's assessment of the three commodity directorates at the Natick RDEC (i.e., the Mobility, Survivability, and Sustain-ability Directorates).[1] The assessment was conducted relative to the five pillars and the associated characteristics and metrics for world-class performance by an Army RD&E organization (refer to Chapter 1 and Appendix C for summaries of the pillars, characteristics, and metrics). Following a discussion of the assessment process, this chapter is organized by pillars and their associated characteristics. Each directorate is discussed in terms of each characteristic. A summary is presented at the end of each pillar, along with an indication of trend (vector).

ASSESSMENT PROCESS

Mobility Directorate

The committee sent a questionnaire to MobD (with related questions for STD and ASCD) in April 1996. The questions were formulated in light of (a) the five pillars and associated characteristics and metrics for a world-class Army RD&E organization from the committee's phase-one report, and (b) the ten key issues shown in Table 1-1. (See Chapter 1, footnote 3, regarding questions and answers.) The answers were reviewed by the committee in preparation for a visit to MobD, which took place on June 3 to 5, 1996. More than half of the personnel in MobD, including the director and his staff in the two management offices, were interviewed. Staff members of all work teams that composed the main elements of the MobD organization were also interviewed.

The visiting members of the committee split into three interview groups, organization and resources, quality and customer satisfaction, and research and technology. During the on-site visit, these groups covered both questions prepared in advance and questions that arose naturally during the interviews. At times, the interviewers presented the metrics for a particular characteristic and asked the

[1] General references for this chapter are Brandler, 1996; Darsch, 1996; Doucette, 1996; and Granchelli, 1996.

interviewees to indicate which one best fit MobD. These self-assessments prompted helpful discussions by MobD personnel. Following the on-site visit, the committee synthesized the written answers provided by RDEC management and the results of the on-site interviews to arrive at the judgments reflected in this assessment.

On February 10 to 13, 1997, the committee revisited the Natick RDEC, at which time a brief follow-up assessment of MobD was conducted for the following reasons. First, at the time of the initial visit, the committee's phase-one report had not yet been published and, consequently, the metrics and processes had not been finalized. Second, MobD was the first directorate to be assessed, and the initial visit was partly used to evaluate and refine the interview process. Third, the committee wanted to be updated on major changes that might have occurred since the earlier visit.

On the second visit (February 1997), the committee was able to interview the MobD director, the associate director, the head of the business management office, and a senior scientist. Although the interviews did not produce a thorough reassessment of MobD, they yielded much useful information. The results of the second visit were not used to alter the earlier assessments but to indicate trends since the earlier visit.

Survivability Directorate

Assessment of SurD proceeded in a manner very similar to the process described above. Specifically, the assessment process included formal written questions submitted in June 1996 that were answered before the visit. The site visit took place on September 25 to 27, 1996, and included laboratory tours and interviews with SurD personnel. The director, members of the business management office, and some management and staff of the main elements within the SurD organization were interviewed.

The committee was given short guided tours of the various laboratories in SurD, as well as of the STD laboratories that support SurD. The interviews were again conducted by three groups (i.e., organization and resources, quality and customer satisfaction, and research and technology) in parallel sessions. Following the on-site visit, the committee synthesized the written answers provided by the RDEC management and the results of the on-site interviews.

Sustainability Directorate

Assessment of SusD followed the pattern described above. The committee sent a set of questions in September 1996 and reviewed the answers prior to the site visit, which took place on December 3 and 4, 1996. Tours of SusD

laboratories were included. The director and his staff were interviewed, as well as management and staff members of each main element of the SusD organization. After the on-site visit, the committee synthesized the information.

RESOURCES AND CAPABILITIES PILLAR

CHARACTERISTICS OF THE RESOURCES AND CAPABILITIES PILLAR

- Personnel Quality
- Budget
- RD&E Capabilities, Skills, Talents
- Use of External Resources
- Important Technologies
- Organizational Climate
- Information Technology
- Facilities and Infrastructure

See the metrics for each of the above characteristics in Table C-2.

This section is organized into subsections presenting the assessment of each commodity directorate for each of the eight characteristics of the Resources and Capabilities Pillar (see accompanying box). An assessment for the entire pillar appears at the end of the section.

Personnel Quality

Mobility Directorate

The committee determined that MobD staff members are motivated and committed. MobD personnel were able to highlight several programs where their work had exceeded customer expectations (e.g., the guided parafoil aerial delivery system [light]). MobD offers ample opportunities for personnel to upgrade or acquire new skills, and personnel have good connections with external technical and scientific communities (e.g., the American Institute of Aeronautics and Astronautics, National Parachute Technology Council, and Parachute Industry Association). However, the MobD workforce is aging, and employees with new skills and capabilities are not being brought in. This has serious implications for the future.

Assessment: Good

Survivability Directorate

The committee determined that SurD has an abundance of highly qualified, highly motivated people. Personnel are encouraged to upgrade and acquire new skills and to make effective use of internal and external resources. Some are attending universities full time and working toward advanced degrees. However, many experienced people have been lost through downsizing and cannot be replaced because of the hiring freeze.

Assessment: Good

Sustainability Directorate

The committee determined that the SusD workforce is highly experienced and, for the most part, has a very strong work ethic as reflected in their commitment to their respective areas of expertise. Overall, SusD has expertise in a wide range of disciplines, and, because of the organization's willingness to support training and education, there are continual opportunities to upgrade and maintain expertise. SusD personnel were able to highlight several projects where they had exceeded customer expectations (e.g., shelf-stable bread products). However, the workforce is aging, and people who leave or retire are not being replaced by employees with new skills and capabilities. To some extent, SusD has been able to compensate for the lack of new personnel by aggressively promoting training and education for its workforce.

Assessment: Good

Commodity Directorates

The committee determined that the metrics associated with a good performance level best fit the overall personnel quality of the commodity directorates. Personnel within the directorates could cite examples of exceeding customer expectations, although the committee notes that there appears to be little reward in the Army system for consistently exceeding customer expectations. The RD&E personnel have many opportunities to upgrade their skills or acquire new ones. The Army has recognized the capabilities of its personnel through various RD&E awards, and the personnel are well connected to the scientific and technical communities outside Natick. The committee notes that the Natick RDEC has not been

able to hire employees to provide (or replace) critical skills and capabilities, which limits the assessment of the performance level to good.[2]

Assessment: Good

Budget

Mobility Directorate

Budget cuts over the past several years have greatly reduced airdrop R&D programs. The ground mobility budget has been reduced even more severely, re-suiting in a drop from four full-time-person equivalents to about one in 1996. Projections of future budgets for airdrop R&D programs appear to maintain this level. Funding from nontraditional customers (e.g., the Special Operations Command and the U.S. Marine Corps) have eased the pain of budget cuts, but these sources of funding may not be available in the future.

Assessment: Adequate

Survivability Directorate

Overall funding for SurD has increased in the last three years, mostly from the Force 21 Land Warrior Program and customer orders, mainly from the U.S. Marine Corps. Leveraging has significantly added to SurD's capabilities. Examples of leveraging are programs with the Army Research Laboratory, the Bureau of Printing and Engraving, and industry and academic partners.

Assessment: Good

Sustainability Directorate

Financial allocations for SusD have remained almost flat, although funds for services from outside organizations have increased the budget slightly. Even with outside funds, however, SusD has not been able to increase its areas of expertise, and the organization cannot keep up with inflation. At best, the present

[2] The committee learned that the Army plans to transfer the "troop missions" of Force Provider, shelters and containers, food handling and preparation, refrigeration, and aerial delivery to the Soldier Systems Command/Natick RDEC from another Army command that is being disestablished (ATCOM, 1997). To the extent that these missions bring with them trained personnel, they may help the Natick RDEC. If the move merely adds to the RDEC's workload, however, it could exacerbate the hiring and replacement problems.

budget will allow SusD to maintain a slowly eroding position in terms of performance. Some divisions have adequate funding for projects but do not have enough personnel to perform the work. A high percentage of the SusD budget goes to requirements-driven activities rather than to discretionary science and technology programs.

Assessment: Adequate

Commodity Directorates

The committee determined that the metrics associated with an adequate performance level best fit the assessment for the overall budget of the commodity directorates. Budget cuts over the past few years have jeopardized or eliminated some major programs. Natick has worked hard to find ways to do more with less, especially by leveraging resources with other government agencies and the private sector. This positive factor is offset by indications that the RDEC's longer range budget projections are either flat or decreasing. Uncertainties about year-to-year funding contribute to the adequate performance rating of the commodity directorates.

Assessment: Adequate

RD&E Capabilities, Skills, and Talents

Mobility Directorate

The capabilities of the individuals in MobD are extremely good. Some members of the MobD staff are recognized as masters of their trade (e.g., two individuals were recognized by the Army for their achievements in R&D, and one was recognized by the American Institute of Aeronautics and Astronautics for a lifetime of achievement in parachute development). Many MobD personnel are active in professional societies, such as the American Institute of Aeronautics and Astronautics and the Parachute Industry Association. However, limited budgets and hiring freezes have jeopardized the RD&E skills of MobD. In many areas, the directorate has only one expert, and his or her expertise will be lost upon retirement (e.g., parachute materials). In the past three years, MobD has lost 15 individuals through retirement, attrition, and transfers to other positions in the RDEC or Soldier Systems Command. None of them has been replaced.

Assessment: Good

Survivability Directorate

SurD is a recognized leader in several core capabilities, such as textile technology, chemical and ballistic protective apparel, and countersurveillance. However, continued downsizing coupled with a hiring freeze have significantly reduced the number of highly skilled personnel. Reductions have been partially offset by bringing in technical interns, using outside contractors, and leveraging via partnerships with industry and academia. Interviews and the committee's experience indicate that one disadvantage of using external resources to help maintain RD&E capabilities is that it shifts the workload of current employees from their own research and technology to contract management. Over time, this tendency increases the bureaucratic nature of the organization and dilutes its technical expertise.

Assessment: Good

Sustainability Directorate

The capabilities of the individuals in SusD are extremely good. In addition, most of the people with whom the committee spoke said that they were receiving up to 80 hours of training and development per year (although in some cases they questioned whether the training was particularly relevant to them, e.g., people who were assigned to take a course on U.S. Department of Defense [DOD] acquisition reform). The biggest problem is that the organization is very lean, and there is no one to fill in for anyone who transfers, quits, or retires. Over time, the core capabilities of the enterprise will slowly erode unless the hiring freeze is lifted.

Assessment: Good

Commodity Directorates

The committee determined that the metrics associated with a good performance level best fit the overall RD&E capabilities, skills, and talents of the commodity directorates. In several areas, the members of the research and support staff have been recognized outside Natick for their superb technical skills, and some members of the RDEC staff are recognized masters of their trade. These would indicate an excellent performance rating, but new techniques and skills are not being acquired via new hires, although the Natick RDEC can perhaps maintain its present core capabilities through internal training programs. Personnel are

encouraged to participate in formal continuing education programs and professional societies and to serve on external committees, which are indicators of a good performance level. The committee weighed all of the considerations in this category and determined that the overall performance level was good.

Assessment: Good

Use of External Resources

Mobility Directorate

MobD has formed many liaisons with external organizations to supplement in-house capabilities. Most of these liaisons involve modeling, primarily with the Army Research Laboratory and the Army Research Office or projects they support. The exception is a cooperative R&D agreement with an outside company to investigate gas-injected air bag technologies. A significant portion of the external work is conducted with the High Performance Computing Research Center at the University of Minnesota, which is supported by the Army Research Laboratory and comes at no cost to MobD. The range of external activities is limited, but it does significantly leverage the financial resources available to MobD. (Even if MobD had additional financial resources, it might choose to work with the same outside groups.) These external activities complement internal efforts to fill in gaps in personnel, capabilities, funding, facilities, and time. However, with the exception of the air bag agreement, none of the current external projects is likely to lead to a major breakthrough in airdrop systems in the foreseeable future.

Assessment: Adequate to Good

Survivability Directorate

SurD has developed a wide range of partnerships so work can be done outside the organization. Examples include (1) a technology program annex with the Army Research Laboratory in science and technology (at no cost to the Natick RDEC); (2) a cooperative R&D agreement on high performance fibers (at no cost to the Natick. RDEC); (3) fiber project contract work with the Bureau of Printing and Engraving; (4) a working group with the textile industry to develop performance specifications; (5) a working arrangement with the Northeastern University Center for Electromagnetic Research; (6) serving as the Natick Textile Technology Center of Excellence with Drexel University, Temple University, the Philadelphia College of Textiles and Science, the University of Massachusetts Center for Industry Research on Polymers, and the National Textile Center; and (7) task

order contracts with small businesses to convert detailed specifications to performance specifications. These partnerships and outside contracts account for about 60 percent of SurD's budget. The amount of time individuals spend on outside contracting varies from 25 to 90 percent.

SurD selects outside partnerships and contractors based on the skills and capabilities of the outside organization and on SurD's assessment of the organization's ability to complete the work. SurD uses measures such as best-value contracting, expected costs, and past performance to evaluate potential partners. In general, SurD considers that the results of these liaisons have been valuable, especially with external sources that provide services at little or no cost to SurD (obviously representing an infinite return on investment). The least valuable have been the task order contracts to convert detailed specifications to performance specifications. In hindsight, these contractors were judged not to have the necessary training to perform the job well. As a consequence, these projects occupied an inordinate amount of the project officer's time and expertise. The last example raises questions about the criteria used by SurD to select outside contractors. Nevertheless, using external resources has led to breakthroughs in the development of materials for combat clothing and individual equipment at little or no cost to the RDEC.

Assessment: Good

Sustainability Directorate

SusD does business with a wide range of outside contractors, including business firms, academic institutions, and other government agencies. Sixty percent of the SusD budget is spent on external resources, including joint programs, modeling, and testing. External clients are selectively chosen and provided with carefully developed specifications to ensure high performance. Moreover, the SusD carefully monitors the work of these external organizations. SusD has learned to focus on the outcomes of relationships with contractors and collaborators rather than on the number of relationships.

Assessment: Good to Excellent

Commodity Directorates

The committee determined that the metrics associated with a good performance level best fit the overall use of external resources by the commodity directorates. In general, the Natick RDEC has made good use of external resources. All of the commodity directorates understand the need to be smart buyers of services from other parties, and all have had successful programs with

businesses, universities, and other federal agencies. Some external programs have provided leap-ahead technologies. (The committee notes that recognizing potential breakthroughs by external groups requires residual expertise within the RDEC.) However, not all external programs can be categorized as successes. Sometimes using external resources has been the only option in the face of hiring freezes within Natick, and valuable internal resources have been tied up with managing contracts. The committee's concern with the value of some partnerships limits the assessment to good.

Assessment: Good

Important Technologies

Mobility Directorate

The research funds available to MobD are severely limited (no funds for research to develop fundamental new knowledge and very limited funds for concept exploration). Furthermore, MobD receives no support from the STD. Consequently, MobD has little chance of developing pacing technologies. However, the parachute inflation simulation and the advanced precision airborne delivery system have the potential to be leap-ahead developments in parachute technology provided a sustained, reasonable level of funding is available to support them. The ground mobility mission of MobD, which represents a small fraction of MobD's activity and has no research program, was assessed as poor.

Assessment: Adequate

Survivability Directorate

The core capabilities important for SurD include: chemical warfare protection; ballistic, laser, flame, and surveillance countermeasures; textiles; systems integration; clothing design; textile testing and functional finish formulation; color science and evaluation; specification development; electron microscopy; and system integration. These capabilities rely on the disciplines of anthropometry, biomechanics, mathematics and physics modeling, human engineering, mechanical engineering, and materials engineering. Eighty percent of the SurD's core capabilities are utilized in one of five programs: countermeasures to battlefield sensors; integrated headgear and laser eye protection; ballistic protection; percutaneous chemical protection; and multifunctional protective materials and uniforms. The other 20 percent of the core capabilities resides within the two support directorates in three other programs: enhancing warrior performance and endurance; bioengineered materials; and systems analysis. All eight programs are well defined and have specified qualitative or quantitative objectives.

As a rule, SurD considers the science and technology programs as support technologies for the SurD mission rather than as pacing technologies. Exceptions to this rule are aspects of the Force 21 Land Warrior program and the development of thermal infrared and agile-laser eye protection. Technological improvements developed from the science and technology program that have found their way into products include: advanced ballistic materials; lightweight materials for chemical and biological protection; durable static resistance for battle wear; miniaturized components for microclimate cooling; water resistant, fire resistant, camouflage printed, near-infrared signature reduced, antistatic, high durability, and high strength materials; chemical protective underwear; and reflective technology for laser-protective eye wear.

The core capabilities of SurD are threatened, however, by restrictions on funding and hiring that SurD believes make it impossible to hire well known experts or well trained technologists. Retirements and promotions (primarily to administrative functions for reasons of greater responsibility and higher pay) have translated into a loss of critical expertise in some areas (e.g., color science, shade evaluation, and textile testing). In response to these restrictions, SurD has opted to focus on a limited number of technologies related to countersurveillance, fiber and fabric development, and chemical and physical resistance. SurD intends to obtain other needed capabilities externally (an example being the relatively low value, task-order contracts, which were discussed earlier, that were issued for converting detailed specifications to performance specifications).

Assessment: Adequate to Good

Sustainability Directorate

Core SusD science and technology programs in the rations and equipment and shelters business areas are: combat ration research; preservation, packaging, and stabilization technologies; performance enhancing and nutritional technologies; and equipment and energy technologies. Currently, SusD has no science and technology programs in the unit and organizational equipment portion of the equipment and systems business area or in the shelters business area. However, recent program breakthroughs have led to some science and technology funding for air beams. Development is focused on group, individual, and special purpose rations; veterinary inspection; systems for field, shipboard, and airborne feeding; and organizational equipment. Illustrative pacing technologies are noted below.

Rations. Pacing technologies in rations include: targeted nutrient delivery; molecular level analysis of food matrices; advanced physical methods for food preservation; intrinsic chemical-marker-validation of process effectiveness;

biopolymers as food preservatives; formulation and processing for extending shelf-life in extreme environments; irradiation; and encapsulation, coating, and enrobing.

Equipment and Systems. Pacing technologies in the equipment and systems area include: diesel and JP8 (standard jet aircraft fuel) combustion; heat transfer; integral power generation; heat-driven refrigeration; exothermic, self-heating rations; self-heating technology; multifuel burners; and catalytic conversion of diesel fuels.

Shelters. Pacing technologies in shelters include: physical, mechanical, and chemical behavior of high performance materials; processing of high performance materials; structural mechanics and modeling; advanced textile manufacturing techniques; smart materials with active response to multiple stimuli; electromagnetic inhibiting materials and manufacturing techniques; and high strength, insulative structural elements.

Each SusD program is focused on a targeted set of operational capabilities for a particular area. All programs are initiated in response to the general requirement to provide rations, feeding systems, and shelters that are lighter, easy to use, rapidly deployable with reduced logistic burden, and that can be used for a broad spectrum of military applications. All of the SusD programs appear to be pacing programs, i.e., they are concentrated on basic R&D that will ultimately provide either new or enhanced capabilities. The science and technology program has resulted in several developments that have been incorporated into products. These include the multifuel burner, Hooah bars (high energy snack bars included in field rations), and pouch bread for meals-ready-to-eat.

Assessment: Good

Commodity Directorates

The committee determined that the metrics associated with a good performance level best fit the important technologies of the commodity directorates. The committee found examples of pacing technologies both being developed and already incorporated into products. The committee also found numerous examples of base support technologies that fulfill a technological need but do not lead to dramatic changes in performance. The mix of pacing and base support technologies seems appropriate for the missions of the commodity directorates.

Assessment: Good

Organizational Climate

Mobility Directorate

Most MobD personnel noted during interviews that the new, flat organizational structure has encouraged teams to set goals and seek innovative solutions with less intervention from management. But the committee observed that many MobD staff members (both senior and junior) did not approve of the changes in organization. Typical negative reactions were variations of a reluctance to change. Few complained of being saddled with more work, and, in fact, considering the cuts in the workforce, there was surprisingly little talk about having to work extra hours or taking on new responsibilities. The committee noted that most staff members of MobD display a can-do attitude and that they appreciated the work of the director and technical management office. Staff members were concerned about ongoing reorganization and downsizing within the Department of the Army.

Assessment: Good

Survivability Directorate

The recent reorganization and continued downsizing of SurD have resulted in many new assignments, new bosses, and physical moves. These changes, along with increased workloads, less job security, and less opportunity for advancement, have increased stress and, in many cases, lowered morale. In spite of this atmosphere, job satisfaction in many cases was still high. Most interviewees felt that Natick was a good place to work.

Assessment: Adequate

Sustainability Directorate

Everyone who was interviewed indicated that they liked their jobs; and turnover is extremely low in SusD. The personnel are dedicated and committed to what they are doing. Their primary focus continues to be on their main customer, the soldier, and they will do whatever it takes to meet his or her needs. However, the SusD personnel are anxious about downsizing and future budget cuts, which are causing concerns about more outsourcing as well as the belief that no one will be promoted because there will be no openings. The personnel are also concerned about the lack of communication with management (despite the fact that a communication system known as Straight Talk is available to everyone), and there is a feeling, especially among personnel in the shelters business area, that

management does not pay attention to their concerns. At the same time, some complained that things were being micromanaged.

Assessment: Adequate

Commodity Directorates

The committee determined that the metrics associated with an adequate performance level best fit the overall organizational climate of the commodity directorates. The committee noted that the vast majority of personnel interviewed perceived the work environment as professional and collegial and felt that their work was meaningful. Teamwork and collaborative efforts abound. Some personnel felt that bold, innovative thinking was encouraged and rewarded, but this feeling was not shared by the majority. In general, most people were extremely anxious about ongoing reorganizations and downsizing, and many felt insecure about their jobs. For these reasons, the committee assigned an adequate rating.

Assessment: Adequate

Information Technology

Mobility Directorate

Nearly all MobD employees had personal computers ranging from a 386 processor to a Pentium processor. All personal computers had software for word processing, spread sheets, databases, time management, internet, and e-mail. MobD also had several workstations, all software was state of the art, and e-mail was the standard mode of communication. Information technology had enhanced MobD effectiveness during the external air-transport certification process; answers could be provided in the field by notebook computers. The Soldier Systems Command maintains an information systems plan that covers the MobD as well as other directorates.

Assessment: Good

Survivability Directorate

Nearly all employees had personal computers with capabilities ranging from a 386 processor to Pentium. Virtually everyone was computer literate, and e-mail is now the standard mode of communication. Improved communication has

reduced the amount of time spent in meetings, and information technology has improved cost effectiveness and created high quality marketing and presentation capabilities. Project planning and management have benefited greatly from information technology. An example is the production line analysis system, which has significantly enhanced communication with SurD customers.

Assessment: Good

Sustainability Directorate

Everyone interviewed by the committee noted that they had adequate to superior computer hardware and software. Computers were 486s or Pentiums and had ready access to the internet and e-mail so everyone could gather data easily and keep in contact. Equipment in SusD has been continually updated, and computers are used for making important analyses.

Assessment: Good

Commodity Directorates

The committee determined that the metrics associated with a good performance level best fit the overall information technology of the commodity directorates. The committee also found evidence of an information technology strategy at the Soldier Systems Command level. Most personnel noted that e-mail allowed them to do their jobs more efficiently. Hardware and software were state of the art, and staff members had ample opportunity to attend training programs in the use and application of information technologies. There were indications that information technology had improved effectiveness. Nevertheless, the committee did not find substantial evidence that information technology had reshaped the way RD&E are performed in the commodity directorates (e.g., that directorates use databases to improve their data gathering capabilities or employ rapid prototyping techniques).

Assessment: Good

Facilities and Infrastructure

Mobility Directorate

During the on-site interviews, the staff noted that the facilities were clean and adequate, although they were not all environmentally controlled year round. The lack of air conditioning 24 hours a day made it difficult for employees to

work early, late, or on weekends. The buildings were old, and repairs were sometimes delayed, although some preventive maintenance and service contracts were in place. Safety and regulatory compliance policies were also in place (e.g., frequent notices of asbestos hazards, wheelchair access to all buildings). Overall, the facilities of MobD were judged to be adequate.

Assessment: Adequate

Survivability Directorate

The facilities and much of the equipment at SurD are 20 to 40 years old, and very little has been done to upgrade them in the last several years. For example, the air conditioning system needed updating, especially in the physical testing laboratories where temperature and humidity are critical. Multiyear funding has recently become available so needed improvements are expected.

Assessment: Adequate

Sustainability Directorate

The facilities and infrastructure of SusD were sufficient to get things done, but they were not well maintained. Maintenance contracts existed for some equipment that could not be maintained in-house. Other machinery was repaired on an as-needed basis. Many of the staff members interviewed stated that funds budgeted for facility maintenance and renovation were insufficient. The present situation differs sharply from the past when funds were available for preventive maintenance. Most facilities were sufficient and clean, but many repairs had been put on hold.

Assessment: Adequate

Commodity Directorates

The committee determined that the metrics associated with an adequate performance level best fit the overall facilities and infrastructure of the commodity directorates. Most personnel noted that the Natick facilities were adequate, but few characterized the facilities as spacious or comfortable, and many mentioned ongoing problems with the air conditioning system. There was

periodic maintenance for most equipment and facilities, but major repairs and upgrades were often implemented at a snail's pace because they require multiyear funding. Safety and regulatory compliance policies were in place.

Assessment: Adequate

Overall Assessment of the Resources And Capabilities Pillar

The committee's overall assessment of the resources and capabilities pillar for the three commodity directorates is good (see Table 2-1). However, the committee notes that, in some instances, the vector for the future is pointing down. The most notable examples are in personnel quality and RD&E capabilities, skills, and talents, where the loss of experienced people could have serious long-term implications for the Natick RDEC. Also, facilities could deteriorate if they are not maintained. The commodity directorates are making good use of information technology and, for the most part, of external resources. These can compensate, in part, for the loss of in-house personnel.

STRATEGIC VISION PILLAR

CHARACTERISTICS OF THE STRATEGIC VISION PILLAR

- Alignment of Vision and Mission
- Strategic Planning
- Stakeholder Buy-In
- Leadership

See the metrics for each of the above characteristics in Table C-3.

The committee was discouraged about strategic vision at the Natick RDEC during the site visits in 1996. The committee decided, therefore, to revisit strategic planning in early 1997, and the results were encouraging (see discussion at the end of this section). The assessment below reflects the situation of the commodity directorates as of 1996, a situation that could continue if the improvements that were initiated by early 1997 are not fully implemented.

TABLE 2-1 Resources and Capabilities Pillar

	Mobility Directorate	Survivability Directorate	Sustainability Directorate	All Commodity Directorates
Personnel Quality	Good	Good	Good	Good
Budget	Adequate	Good	Adequate	Adequate
RD&E Capabilities, Skills, Talents	Good	Good	Good	Good
Use of External Resources	Adequate to Good	Good	Good to Excellent	Good
Important Technologies	Adequate	Adequate to Good	Good	Good
Organizational Climate	Good	Adequate	Adequate	Adequate
Information Technology	Good	Good	Good	Good
Facilities and Infrastructure	Adequate	Adequate	Adequate	Adequate
Overall Assessment of Pillar: Good				
Direction of Vector: Down				

Alignment of Vision and Mission3

Mobility Directorate

The MobD vision is to be a global leader in meeting mobility needs (broadly defined). However, personnel within MobD are not fully supportive of their newly defined mission, which includes working on airdrop systems, terrain traversal, and personal augmentation products and technologies to protect, sustain, and improve the quality of life for soldiers. The focus is now primarily on airdrop technology, with limited attention to terrain traversal and personal augmentation. MobD provides support and technology development for airdrop systems across the DOD. Because of the way the RDEC is structured, however, its programs and resources are not truly supportive of the broader airdrop mission.

Because the Natick RDEC is an Army organization, research programs within airdrop are tailored to meet the perceived needs of the Army and are focused on the requirements for individual soldiers. The requirements of associated forces (e.g., the Air Force, which conducts airdrop operations in

[3] Vision and mission statements for the directorates are in Chapter 1.

support of foot soldier missions) are not considered germane to the Army and, consequently, are not funded by the Army. These programs must rely on independent financial assistance from the relevant service. Thus, the funding structure for MobD is inconsistent with its mission.

Members of MobD understand the soldier-as-a-system mission of the Soldier Systems Command, but they do not understand how mobility, and specifically airdrop (which, to MobD means delivery of personnel, supplies, and equipment from aircraft) fits into the mission of the command or even how it fits into the mission of the Natick RDEC. This is of great concern to the staff. Senior-level management has held several town meetings to convey the RDEC mission and vision, but several MobD staff members feel the mission statement is incomprehensible and has been written for public consumption.

Assessment: Poor to Adequate

Survivability Directorate

The SurD mission involves RD&E programs for combat and noncombat clothing and individual equipment, and the directorate's vision is to become the world leader in individual survivability technology. Joint teams of management and staff have formulated vision and mission statements with input from the workforce. The vision and mission have been communicated through town meetings and posters. The members of SurD see the individual soldier as the core of their mission and clearly understand their roles in support of their mission. Somewhat problematical, however, is their link with the broader mission and vision of the RDEC regarding the soldier-as-a-system. Interviews revealed a conspicuous lack of support and understanding within SurD for the soldier-as-a-system concept.

Assessment: Poor to Adequate

Sustainability Directorate

Within SusD, the committee found that there was a dichotomy of responses to the terms vision and mission. Most people were not only aware of the vision but were also able to recite it. However, they did not know (or at least were unable to verbalize) SusD's mission. At the same time, they were aware that their primary objective was to serve soldiers, and they were dedicated to this mission and determined to do whatever was necessary to ensure that soldiers' needs were met. The personnel admitted, however, that they did not feel there was a strong

link between the SusD vision and their mission. They felt the mission statement was long, incomprehensible, and written for public consumption.

Assessment: Poor

Commodity Directorates

The committee found that few people appeared to understand the broader mission and vision of the Soldier Systems Command or how their directorate's vision and mission were linked to those of the command. Surprising as this might seem, the committee suggests the following explanation.

The soldier-as-a-system vision was part of an advanced concept that migrated to the Soldier Systems Command from the Natick RDEC (and elsewhere) when the command was formed. The creative people behind the idea migrated with it, and the remaining RDEC personnel now have a strong "us versus them" attitude about the command. Only a few people are left at the RDEC to convince their colleagues that they are vital to the soldier-as-a-system concept, and managers at the RDEC have not convinced their employees that their work is integral to the concept. As a result, the workforce does not see itself as part of the larger picture called soldier-as-a-system, although workers are very proud of their contributions to the "soldier." In short, the directors have not done a good job of explaining the vision (see later section on Leadership), and the culture of the directorates remains insular and narrow. To correct this situation, leaders must try to communicate vision and coach their workers during every conversation and every meeting.

Assessment: Poor to Adequate

Strategic Planning[4]

Mobility Directorate

No strategic planning process has been implemented at MobD since the formation of the Soldier Systems Command. MobD strategic planning is related to the funding level. Programs at the concept exploration level are proposed on the basis of needs identified by customers and operational capability requirements from the Army battle laboratories. Programs are reviewed and ranked by the Natick RDEC's planning integration team, senior technical staff, and others for technical merit, probability of success, and return on investment. They are funded, in order of rank, until financial resources are depleted. Programs at the advanced

[4] The term "anticipatory strategic planning" has been shortened. The metrics address whether strategic planning is sufficiently anticipatory.

development level are based on the battle laboratories' requirements and the Army Science and Technology Master Plan, proposed as either advanced technology demonstrations or programs to satisfy science and technology objectives; they are ranked and funded through the battle laboratories.

To a significant extent, therefore, strategic initiatives at the Natick RDEC level are dictated by visions communicated from outside the RDEC. For airdrop technology, for example, there appears to be little or no long-term concept development within the Army. This is a direct consequence of the Army's narrow definition of airdrop as serving only individual soldiers. The Natick RDEC has not been able to influence other airdrop requirements, even in direct support of Army activities. Thus, no broad strategic vision for airdrop systems has been communicated downward to the RDEC; and broader mission or vision statements communicated upward from the RDEC have not been taken seriously.

Assessment: Poor

Survivability Directorate

The planning process for SurD's science and technology programs is based on requirements in the Army's Long-Range Research and Development Plan and the RDEC five-year integrated planning process, both of which have a five-year to six-year planning horizon. Proposals for research by individuals are submitted to the planning integration team for assessment. Individuals are encouraged to base submissions on needs and deficiencies identified by customer focus groups or the battle laboratories. Proposals are subject to three evaluations. The planning integration team assesses proposals for technical approach, probability of success, innovation, resource availability, timetable for return, and value to the customer. Senior scientists conduct technical reviews, and another team evaluates them for return on investment. Proposals are ranked by consensus of all three evaluation panels, and funds are distributed accordingly. Unfunded projects are reconsidered as funds become available, and proposals are usually resubmitted in subsequent funding periods.

Contingency planning is reactive, as needed to solve immediate problems. From a strategic perspective, there is little or no internal planning to support long-term objectives or to justify current science and technology projects. Many interviewees noted that work within SurD is subject to priorities set by Washington, and interviewees repeatedly referred to "firefighting" or "crisis management" as the common mode of operation. They measured progress towards achieving goals by program and budget growth and improvements in productivity and product quality, benchmarking against SurD metrics and metrics from the Government Performance and Results Act.

Assessment: Poor to Adequate

Sustainability Directorate

The SusD has a strategic planning process in place and formulates business plans and annual plans. Senior-level management relies on both top management personnel and support staff for assistance. However, most of the personnel who were interviewed felt that the strategic plan had not been communicated to them. In general, the feeling about the nature and scope of these long-range plans was negative. Many of the personnel, especially those in the shelters business area, believe that the R&D expertise of SusD is being allowed to deteriorate. They believe that in the next decade the organization will become a procurer of materials, products, and services and will no longer do any research. Therefore, there is a general lack of trust, even when senior management tries to communicate long-range objectives to personnel. Many employees believe that SusD is going to be eliminated (at least in its current form) and that the strategic plan is not an operational plan but a requirement mandated from above.

Assessment: Adequate

Commodity Directorates

The committee determined that the metrics associated with an adequate performance level best fit strategic planning by the commodity directorates. Some strategic planning processes have recently been implemented for the direction of the research program. Directorate-level business plans, when they exist, have been formulated without broad involvement from the organization. But planning documents are not used to measure progress throughout the year, and contingency or alternative planning is simply reactive.

Assessment: Adequate

Stakeholder Buy-In

Mobility Directorate

MobD's ultimate stakeholders are soldiers, but there are also other stakeholders, including MobD personnel, who recognize their mission only as it relates to airdrop technology and not as it relates to the broader area of ground-mobility requirements. The rationale for incorporating the latter within this directorate is neither understood nor welcomed by many members. Even within the specific focus of research and technology on airdrop systems, not everyone understands how projects support and complement each other. For example,

members of the product development group (in MobD) do not appreciate the potential impact of the modeling groups (in MobD and in ASCD). MobD groups are isolated from each other according to the type of funding they receive.

Assessment: Poor

Survivability Directorate

SurD defines its stakeholders as all internal personnel, the Defense Logistics Agency, Program Manager-Soldier, and all customers. On an ideal level, SurD considers stakeholders' trust and the directorate's continuing relationship with the stakeholders as buy-in to the directorate's vision. On a more pragmatic level, SurD relies upon stakeholders' involvement in the integrated planning process and customer workshops. The committee found no concrete examples of proactive stakeholder buy-in. Interviewees repeatedly said that they wanted to be left alone to perform their research and not be bothered with the bureaucratic and management details of justifying and assimilating their work into the integration team's plans. The committee agrees that implicit trust, ongoing relationships, and ample funding are indicators that stakeholders are supportive of SurD activities but is not convinced that they represent a buy-in to the vision.

Assessment: Poor

Sustainability Directorate

SusD personnel recognize that their ultimate stakeholder is the soldier, and feedback from soldiers is monitored and used for making changes in the design, development, and creation of goods and services. Soldier feedback indicates that they have a fairly strong buy-in. Based on the interviews, however, other major stakeholders (i.e., the in-house SusD personnel) have not bought into the organization's vision and mission. Many do not understand the plan; most cannot explain it. More important, they appear to be indifferent to what top management is doing because they are convinced that, as long as they do their jobs, the ultimate stakeholders, the soldiers, will be well served. The committee believes that another reason for the failure of employees to buy in is that they believe their areas are being downsized and that their core competencies will eventually be outsourced to private firms that can do what they do at a lower price.

Assessment: Poor

Commodity Directorates

The committee determined that the metrics associated with a poor performance level best fit the stakeholder buy-in of the commodity directorates. The commodity directorates have both external and internal stakeholders, but the committee was able to interview only the internal stakeholders.[5] Consequently, their responses weigh heavily in this evaluation. In general, directorate personnel do not understand and, therefore, do not buy into the organization's vision and mission. Their response to the directorates' visions and plans is indifferent, at best.

Assessment: Poor

Leadership

Mobility Directorate

Management of the Natick RDEC has attempted to encourage staff involvement by establishing a planning integration team. Given current budget restraints and the fact that proposals are initiated on the basis of indicators external to the RDEC, the team has become reactive rather than proactive. Although the broad mission of MobD in air and ground mobility has been convincingly communicated to the staff, some suggestions by the team that worked on reorganizing the directorate were not implemented. The staff trusts the current leaders of MobD but also believes they are overworked and, therefore, constantly having to put out brush fires, leaving them no time for mentoring, planning, or implementing plans. On this issue, both staff and upper management agree. The committee believes that the unavailability of upper management is a serious limitation on the effective functioning of MobD.

Assessment: Poor to Adequate

Survivability Directorate

Although there appears to be a good deal of support for the stand-alone mission of the SurD and trust that leadership is doing its best to fulfill that mission, there appears to be little or no understanding of, or support for, the broader mission of the soldier-as-a-system. Many interviewees noted dwindling resources, deteriorating facilities, and the loss of personnel as impediments to

[5] One exception is the committee's interview of an external stakeholder mentioned later in this chapter under the discussion of customer satisfaction and SusD.

meeting their goals. Several interviewees were concerned about the increasing amount of contract management they had to do. In the committee's view, these problems reflect back on SurD leadership.

Assessment: Adequate

Sustainability Directorate

The strategic vision and plan of SusD are not well understood by the staff, and many individuals who were interviewed felt that resources were not being aligned to meet strategic objectives. In addition, the personnel do not seem to have much confidence that senior-level management will implement the strategic plan. In fact, lack of trust in organizational leadership seems to be growing. In many cases, personnel view actions taken by senior leaders as reactive. For example, budgets are not totally allocated at the beginning of a project or fiscal year. Instead, additional funds are often made available as the year wears on. As a result, personnel may initially have to work on a shoestring budget believing that there may not be enough money to complete the project, or at least not enough to do things correctly. After additional funds are allocated, adjustments are made to complete the project within the predetermined guidelines. This budgetary approach is one reason personnel feel that senior-level management does not provide strong, directive leadership.

Assessment: Poor

Commodity Directorates

The committee determined that the metrics associated with a range of poor to adequate performance best fit the leadership of the commodity directorates. The strategic vision of the directorates is not well understood by staff, especially the links between the vision of a directorate and the vision of Soldier Systems Command (see earlier discussion of alignment of vision and mission). The plans in the directorates appear to be mostly reactive, which limits the alignment of resources with the strategic vision. In some directorates, senior leadership is trusted; in others, there is growing distrust. Senior leadership is viewed as receptive to new ideas in some directorates but not in others. The committee believes that the senior leaders of the commodity directorates have a long way to go before they can "create an air of excitement and commitment through the entire laboratory," which is indicative of excellent leadership and a world-class organization.

Assessment: Poor to Adequate

Site Visit In 1997

In February 1997, the committee was informed that the Natick RDEC was developing a new strategic planning process. This process was initiated internally to help position the RDEC for the future and not in response to an Army requirement for planning. It is too early to assess the new planning process, but the committee is optimistic that this is the first step in improving the Natick RDEC's performance level in the Strategic Vision pillar. Perhaps now planning within the directorates will be better aligned with the Natick RDEC and Soldier Systems Command vision, mission, and strategic objectives.

Overall Assessment of the Strategic Vision Pillar

The committee's overall assessment of the Strategic Vision pillar for the commodity directorates is poor to adequate (see Table 2-2). The lack of acceptance of a strategic vision suggests an endemic shortcoming in the management as far as leadership qualities are concerned. The encouraging factor is that, during the February 1997 site visit, the committee learned that strategic planning had been moved from a support directorate to the top levels of the Natick RDEC where it could receive effective management oversight and attention. The committee believes that strategic planning must go well beyond the articulation of vision and mission statements; it must permeate the organization in a participatory way and lead to realistic strategic plans and programs that match the vision and mission of the organization. Leadership must stand firmly behind strategic planning, which is essential for world-class performance. On balance, the committee believes the strategic planning vector is beginning to point upward, but diligence on the part of leadership (i.e., dedicated commitment, which is the foundation of all five pillars [NRC, 1996]) will be needed to keep it pointing that way.

QUALITY FOCUS PILLAR

CHARACTERISTICS OF THE QUALITY FOCUS PILLAR

- Capacity for Breakthroughs
- Continuous Improvement
- Commitment to Quality
- Structured Processes
- Learning Environment
- Quality of Research

See the metrics for each of the above characteristics in Table C-5.

TABLE 2-2 Strategic Vision Pillar

	Mobility Directorate	Survivability Directorate	Sustainability Directorate	All Commodity Directorates
Alignment of Vision and Mission	Poor to Adequate	Poor to Adequate	Poor	Poor to Adequate
Strategic Planning	Poor	Poor to Adequate	Adequate	Adequate
Stakeholder Buy-In	Poor	Poor	Poor	Poor
Leadership	Poor to Adequate	Adequate	Poor	Poor to Adequate
Overall Assessment of Pillar: Poor to Adequate				
Direction of Vector: Up				

Capacity for Breakthroughs

Mobility Directorate

The examples of breakthroughs cited by MobD (the advanced precision airborne delivery system and guided parafoil aerial delivery system [light]) are indeed noteworthy. Still, these airdrop systems use existing technology, parafoils and remote sensors, rather than changing the basic nature of parachutes. The ideas for both systems were picked up by several individuals at the Natick RDEC who are well connected with aeronautical networks, but the ideas originated in the National Aeronautics and Space Administration and probably will not result in patentable properties for the Natick RDEC. Hence, although both programs represent substantial technological improvements, neither is a surprise or a true breakthrough. The management of MobD is trying, however, to create an atmosphere that encourages advances and creates the capacity for breakthroughs. Presently, due in large part to mission requirements, most MobD advances are not revolutionary in character, that is, they build incrementally on existing technologies and capabilities.

Assessment: Adequate

Survivability Directorate

Most programs at SurD are characterized by incremental improvements, but several examples were cited as innovative, including primed Nomex™

(Nomex is the trademark for DuPont's aramid fiber), which has multifunctional capabilities (flame resistance, camouflage, anti-static capabilities, liquid-chemical-agent resistance); Primaloft™ synthetic-down insulation; ChemPak™ LT™, a semipermeable membrane that protects against chemical agents; Kevlar™ KM2 (Kevlar is the trademark of another DuPont aramid fiber, and KM2 is the grade used by the Natick RDEC) and concepts for ballistic protective systems; and nonlinear optic materials to protect eyes from lasers. Most of these breakthroughs were the end products of materials development by outside contractors that were managed by SurD project officers. SurD has little funding for long-term research to develop fundamental, new knowledge that could lead to breakthroughs. In addition, the committee detected an attitude of complacency among the interviewees toward obtaining new and innovative results from research, and they gave few examples of successful, or potentially successful, research. Research was characterized as excellent if the customer was willing to continue or increase funding.

Overall, SurD has been a resourceful integrator of material systems and design concepts to fulfill specific mission requirements. The capacity for breakthroughs has been enhanced through SurD's increased cooperation with industry, academia, and other government agencies.

Assessment: Adequate

Sustainability Directorate

SusD personnel identified their most significant breakthroughs as the development of shelf-stable bread products, the catalytic conversion of diesel fuels (leading to multifuel burners), the flameless ration heater, and high-pressure air beams. The committee agrees that these are significant technological breakthroughs, all of which resulted from joint internal and external projects. The directorate promotes teaming and is attempting to change from a culture that avoids risks to one that takes risks to foster innovation. However, a high percentage of the SusD budget necessarily goes to requirements-driven projects, thus limiting the science and technology resources for research that could lead to breakthroughs.

Assessment: Adequate

Commodity Directorates

The committee determined that the metrics associated with an adequate performance level best fit the capacity for breakthroughs of the commodity

directorates. The RD&E programs are characterized by steady but incremental improvements. Several innovative and leap-ahead improvements have been made, and some directorates are attempting to encourage their staffs to seek innovative, moderate-risk solutions. The committee felt that the adequate performance rating reflects the minimal funding available for anticipating future military requirements, much less for funding moderate-risk or high-risk solutions.

Assessment: Adequate

Continuous Improvement

Mobility Directorate

Virtually everyone in MobD understands the importance of quality, but the committee found no hard evidence of quality projects, changing work processes, or metrics for assessing quality. The number of parachute malfunctions has dropped dramatically, however, from more than 800 per year in 1976 to about three per year today. The quality deficiency reports collected three times a year at Fort Lee are rapidly addressed by MobD and have led to continual improvements in Army parachutes. The committee also recognized that project teams are now a way of life at the Natick RDEC and that the integrated planning process allows input from across the RDEC concerning a project. MobD's response to the Government Performance and Results Act also represents an attempt to formalize quality metrics.

Assessment: Adequate to Good

Survivability Directorate

Some quality systems and measures are in place in SurD, and the directorate can point out several improvements (e.g., SurD was the source of ideas for improving body armor). SurD also has its own plan for responding to the Government Performance and Results Act and uses some customer feedback to support continuous improvement. If an employee has a suggestion, that person can go directly to the project officer, and, for the most part, action will be taken. No report cards or measures, however, are in place to encourage workers in SurD to strive for continuous improvement.

Assessment: Good

Sustainability Directorate

Everyone in SusD understands the importance of quality. Although the process of continuous improvement has not been formalized throughout all SusD divisions, numerous mechanisms support continuous improvement. The committee found that all directorate personnel are exposed to formal training in total quality management practices and continuous improvement processes (e.g., the Continuous Improvement Ration Program). Teams of interviewers visit soldiers in the field and assess their satisfaction with rations. These assessments, as well as unsolicited customer feedback, have led to several cycles of improvement in meals-ready-to-eat. Finally, the President's Quality Award assessments and Government Performance and Results Act process are being used to encourage continuous improvement (e.g., annual reports on the Act are being used to measure process improvements within SusD). SusD is still refining its use of metrics.

Assessment: Good

Commodity Directorates

The committee determined that the metrics associated with a good performance level best fit continuous improvement in the commodity directorates. The directorates have taken steps to improve work processes, and quality audits are performed periodically by external reviewers. Some directorates have programs in place to encourage continuous improvement. Product and process improvements have been made in every directorate. Formal internal reports, "report cards," are not issued annually by senior leadership, however, and there are few systematic analyses of R&D and support processes to weed out activities that are of little or no value.

Assessment: Good

Commitment to Quality

Mobility Directorate

MobD staff members seem to want to improve quality. An initiative to improve quality is now under way, and some selected metrics are planned. The leadership recognizes the importance of quality but has not had enough time to devote to this initiative. The Government Performance and Results Act, an externally driven process, is used to measure and assess quality.

Assessment: Adequate

Survivability Directorate

Interviewees described many systems and programs that have already been established to improve quality. With the cooperation of the workforce, SurD is developing appropriate metrics for assessing R&D programs. Several individuals have taken quality training, and the directorate hopes to receive the President's Quality Award. Although some employees do not wave a total-quality-management banner, they are committed to doing quality work, based on the belief that the work of SurD determines life or death for the soldier. Senior management of SurD is a driver for quality work and quality systems. When management asks questions concerning quality, workers know that follow-up actions will be taken. But the committee was told that it had been four months since the last town meeting when the issue of quality had been discussed. Several interviewees rated their own areas as excellent because of their extensive use of standards and other criteria for measuring quality.

Assessment: Adequate to Good

Sustainability Directorate

SusD obtains feedback from soldiers in the field to improve quality. Interviewees cited specific instances where feedback had resulted in improvements, most notably in the combat rations program. The directorate also maintains a file of unsolicited comments from soldiers in the field and circulates these comments. The committee did not observe any formal, internal mechanisms for measuring quality but learned that SusD is studying the metrics listed in the committee's phase-one report and plans to formalize a self-assessment process. Many of the persons interviewed recognized the importance of their work and stressed that quality would be important to them even in the absence of formal quality improvement programs. When the committee asked SusD personnel to assess their commitment to quality on a 1 to 10 scale, with 1 being a low score, most rated the directorate as a 7. This rating reflects the commitment to quality within SusD. Finally, the directorate has actively pursued the President's Quality Award initiative and plans to continue this effort.

Assessment: Adequate

Commodity Directorates

The committee determined that the metrics associated with an adequate performance level best fit the commitment to quality of the commodity directorates. Total quality implementation is a major goal of all three directorates

and their support staff; management has been willing to invest resources in quality training; and personnel are aware of the importance of quality. However, the committee found few formal internal metrics being used to measure or assess quality at the Natick RDEC. The committee did not find established, measurable objectives for improving work processes.

Assessment: Adequate

Structured Processes

Mobility Directorate

Work processes in MobD are well defined, and steps have been taken to simplify development without compromising safety (e.g., simplifying work for Special Operations), but the committee noted a lack of coordination between research, development, and applications. Processes for budgeting and acquiring materials can also be improved. Both the integrated planning process and the planning integration team represent recent attempts to provide structure for the overall planning process, but these programs are too new for the committee to judge their effectiveness. However, they do have the appropriate elements (stakeholder and customer input, team-set objectives, and project monitoring) to be potentially useful, although some fine-tuning may be required after several years of experience. MobD has recently implemented the Government Performance and Results Act, which should help reduce cycle times.

Assessment: Adequate to Good

Survivability Directorate

Work processes at SurD are well documented and highly structured in the development area. The process known as the Total Army Performance Evaluation System is used to monitor individual processes. Work orders are carefully followed and documented, although interviewees suggested that laboratory notebooks may not be as carefully kept as they had been in the past. A structured process has recently been implemented for the submission, review, and funding of proposals. Once funded, projects are reviewed on an annual basis by the planning integration team; costs and schedules are managed by the command finance system and by the Natick RDEC progress and results system (a management-by-objective program). Research and technology projects can be terminated if the goal is determined to be either unachievable or no longer critical to warfighting needs. The termination authority resides with the original approving body. Results of R&D are documented as Natick Technical Reports and through professional

journals, society meetings, and patents. The database of the Defense Technical Information Center provides a vehicle for the broad dissemination of R&D results.

Assessment: Adequate to Good

Sustainability Directorate

SusD uses an integrated planning process to define its science and technology programs. Potential programs, based on needs identified by customers or requirements from the battle laboratories, are submitted by individuals and reviewed for technical merit and return on investment, and funds are allocated based on priority rankings. A list of unfunded projects is maintained for contingency funding. Programs are reviewed annually, and progress towards project goals is tracked by the Natick RDEC progress and results system; costs are tracked by organizational cost reports. Projects can be terminated if the goals are deemed unachievable or no longer relevant. Termination authority resides at the original approval level.

Adjustments in programming are made through the integrated planning process, and program results are documented in Natick Technical Reports, refereed journals, and presentations. Reports and publications are available for general distribution through the Defense Technical Information Center database. The directorate has recently implemented annual reports under the Government Performance and Results Act to assist in program management. However, the committee questions the adequacy of the processes used to quantify each product's contribution to the performance of the soldier system.

Assessment: Adequate to Good

Commodity Directorates

The committee determined that the metrics associated with a range of adequate to good performance best fit the structured processes of the commodity directorates. Work processes and procedures are monitored, and project costs and milestones are closely tracked. Several programs have been put in place recently to improve the quality (possibly more than incrementally) of the R&D program as well as to reduce cycle time. Senior leadership is trying to promote a supportive culture in which leaders can be receptive to ideas for improving work processes. There are no established, measurable objectives for determining the continuous improvement of product quality or work processes.

Assessment: Adequate to Good

Learning Environment

Mobility Directorate

Since the hiring freeze, individuals have been encouraged to keep up their skills or develop new ones (e.g., computer literacy). The committee found a major commitment had been made to improving the MobD learning environment. Even when expenses had been cut drastically, individuals were able to travel to training courses. The committee is concerned, however, about learning across the organization and about the transfer of information, lessons, and skills from team to team and group to group. Networking and interactions among groups should be improved. The committee is also concerned about how MobD can capture the experience of older employees who will retire in the near future. MobD's new "flat" organizational structure may improve organizational learning, but it is too new for the committee to judge its effectiveness.

Assessment: Adequate to Good

Survivability Directorate

Several people interviewed believe that organizational learning in the SurD is poor. They felt that management is too focused on maintaining a "happy family" atmosphere to risk disturbing the status quo with changes or criticism. However, the committee found that managers encourage training courses, development, and continued education, as well as cross training on the job. This encouragement, which should continue, could become part of a strategy for capturing the knowledge of older employees who are ready to retire. Unfortunately, many individuals appear to be too busy to take advantage of the educational opportunities, and use of the library has dwindled. There was some informal networking (e.g., one project officer described lessons learned from a project that had failed because potential manufacturers had not been involved early in the process). This is an effective way to learn across the organization. Lessons could also be learned by sharing experiences in joint-service activities. The committee was told of overkill in some training areas (e.g., the acquisitions course, which elicited one response of "it would boggle your mind what had to be learned by all!").

In SurD, the team concept has replaced the individual, which means there is not as much control at the individual level. Everyone agreed, however, that teaming has helped them get things done more efficiently. Many of the team leaders are new in their positions following restructuring and could learn leadership skills from others. The committee believes the best example of a good learning environment in SurD is the Warrior Systems Group, which meets often

for team training and is very focused because of its involvement with the DOD Infantry School.

Assessment: Good

Sustainability Directorate

On an individual level, SusD workers are encouraged to receive training and develop new skills (e.g., computer literacy, acquisition process training). Even when expenses were being cut, individuals were still able to travel to training courses. When the committee asked SusD staff members to rate the learning environment, most spoke highly of training opportunities. However, the committee is concerned about learning across the organization and the transfer of information, lessons, and learning from team to team and from group to group. During the interview process, many SusD staff members suggested that interactions among groups were weak but improving. Also, many staff members expressed concerns about the ability of the directorate to capture the experience of older employees who will retire in the near future.

For several reasons, the committee is concerned about the adequacy of databases or records of past projects and studies (e.g., laboratory notebooks are maintained in the library for a period of time but are not reduced to microfilm, indexed, or cross-referenced). First, the library staff, including those who had been keeping up the microfilm records, had either been greatly reduced or eliminated; so no help was available to look for information. Second, the project leaders interviewed did not know of any sources, other than themselves or past leaders (if they were still around), who could provide details on the history of projects. Third, project leaders were not making any conscientious attempts to keep records that could be retrieved or comprehended by others. Although the SusD leadership insisted there was a well established policy for project leaders to keep formal records, the interviewees were generally not aware of it.

Assessment: Adequate to Good

Commodity Directorates

The committee determined that the metrics associated with a range of adequate to good performance best fit the learning environment of the commodity directorates. The committee notes that a learning environment can be evaluated on an individual basis or an organizational basis. The commodity directorates could be considered to have good, perhaps even excellent, environments for individual

learning. Individuals have tremendous opportunities to attend courses and seminars. However, at the organizational level, which is the focus of this assessment, no formal processes are in place to ensure that management and staff learn from mistakes or from each other. Team interactions are improving, but teams do not always have a formal way (or sometimes even an informal way) of learning from each other, especially across directorates. The committee notes that management is experimenting with new organizational structures to find ways to promote organizational learning.

Assessment: Adequate to Good

Quality of Research

Mobility Directorate

Using the committee's metrics in a general way, several staff members rated the MobD research as adequate to good. But concerns were raised that research was not correlated well with development, although the situation appeared to be improving. The new integrated planning process gives everyone a vote, which means that research can no longer remain in a vacuum. Several interviewees observed that the modeling and simulation at the Natick RDEC may be the best in the Army, but that capability may not be appreciated outside the RDEC. Certain development capabilities, such as heavy-cargo airdrop, are among the best, if not the best, in the world. The staff members have published papers, attended scientific meetings, and received many awards and patents.

Assessment: Adequate to Good

Survivability Directorate

Twenty years ago, the SurD laboratory's research was widely recognized outside of the RDEC. In fact, researchers came to Natick to do quality research. Considerably less research is done today, and many researchers are being encouraged to complete their projects. Still, some quality work is being done. Current research and technology programs have their genesis in needs defined by the customer and, therefore, are generally aligned with customer requirements. SurD assesses the quality of these programs in the planning-integration process, looking for correlations between research and technology, development, and customers. SurD considers approval of a system technology objective by the user community as affirmation of the quality of the research and technology. Other measures of quality include awards (e.g., a Soldier Systems Command Pin for Development

and Engineering, an Army Science Award), patents (two in the last two years), and publications in peer-reviewed journals (six in the past two years and four in press). SurD offered the committee several examples of aspects of its programs that have been recognized externally.

Assessment: Adequate to Good

Sustainability Directorate

SusD assesses the quality of research and technology in the program-integration process and through evaluations of technical merit and return on investment. External assessments are obtained through DOD and Army reviews, the publication of papers in peer-reviewed journals (30 in the past two years, and 10 in press), patents (five in the past two years), presentations at scientific meetings, and by technical personnel being asked to serve on scientific and technical committees worldwide. Two examples of external assessments are: recognition by DOD of SusD's High Pressure Air Beam Program as an outstanding science and technology program, and the restoration of funds to the DOD Food Program. The directorate has received several awards, most notable among them being the DuPont Award for Innovation in Food Processing and Packaging Technology in 1996.

During the interview process, the committee asked several staff members to characterize the quality of the research program today as compared to the past. Most staff members answered this question by stating that reduced funding and the hiring freeze had resulted in a reduction in the quality of research. The committee is concerned that the business area of shelters and organizational equipment needs better science and technology support to achieve and sustain high quality R&D. The committee was told that more expertise in composite materials was needed in order to achieve world-class performance.

Assessment: Adequate to Good

Commodity Directorates

The committee determined that the metrics associated with a range of adequate to good performance best fit the quality of research of the commodity directorates. The research and technology programs are aligned with customer requirements and needs; the research results are published in technical reports and journal articles; the research staff is invited to participate in scientific meetings and workshops; peers recognize several research and technology programs as being of very high caliber, if not among the best in the world; some patents have

been awarded. Nevertheless, the erosion of research staff and lack of steady funding has lowered the caliber of some research and technology programs so that overall performance is slightly less than good.

Assessment: Adequate to Good

Overall Assessment of the Quality Focus Pillar

The committee's overall assessment of the Quality Focus pillar for the commodity directorates is adequate to good (see Table 2-3). In making this assessment, the committee notes that everyone in MobD and SurD who was asked during interviews to rate quality indicated that, on a scale of 0 to 10, with 10 being the best, the quality today rates from 4 to 6, with some improvement in the past several years. Everyone in SusD who was asked to rate quality indicated that, on a scale of 0 to 10, quality today rates 6 to 8. These judgments tend to substantiate the committee's overall assessment for this pillar.

The committee's assessment reflects two perceptions of most interviewees. First, they perceive a decline in the quality of R&D resulting from retirements without replacements, the shift in technical manpower to higher paying, more visible administrative positions, and the requirement that technical people perform more contract management. Second, they perceive a rise in quality as a result of

TABLE 2-3 Quality Focus Pillar

	Mobility Directorate	Survivability Directorate	Sustainability Directorate	All Commodity Directorates
Capacity for Breakthroughs	Adequate	Adequate	Adequate	Adequate
Continuous Improvement	Adequate to Good	Good	Good	Good
Commitment to Quality	Adequate	Adequate to Good	Adequate	Adequate
Structured Processes	Adequate to Good	Adequate to Good	Adequate to Good	Adequate to Good
Learning Environment	Adequate to Good	Good	Adequate to Good	Adequate to Good
Quality of Research	Adequate to Good	Adequate to Good	Adequate to Good	Adequate to Good

Overall Assessment of Pillar: Adequate to Good

Direction of Vector: Uncertain

improvements in the development and procurement process. Taken together, these perceptions reflect a positive feeling about the RDEC's timeliness and handling of short-term issues, underscored by a concern about the capability of addressing longer-term issues.

The committee is concerned about learning across the organization and the transfer of information and lessons from team to team. As the funding declines and levels off, there is no room for repeating mistakes. The committee applauds the support for individual learning, which appears to be an effective strategy for compensating for dwindling human resources. The committee is concerned, however, that the RDEC does not have internally developed quality metrics for tracking improvement in key areas. The committee is persuaded that internally developed metrics that track real improvements should be considered. Externally imposed quality programs are sometimes seen as necessary busy work.

The committee notes that, in contrast to the Strategic Vision pillar, which had several poor marks, the Quality Focus pillar had several good marks. The committee judged the vector for the future to be uncertain to accommodate positive and negative indications for the long-term.

CUSTOMER FOCUS PILLAR

CHARACTERISTICS OF THE CUSTOMER FOCUS PILLAR

- Customer Satisfaction
- Customer Involvement
- Market Diversification

See the metrics for each of the above characteristics in Table C-1.

Customer Satisfaction

Mobility Directorate

This characteristic is difficult to assess because the list of customers provided by MobD appears to be a mailing list rather than a customer list. The panel notes that MobD was awarded a certificate of achievement for its recent contributions to Operation Provide Promise, indicating customer satisfaction with airdrop products. The guided parafoil aerial delivery system (light) is an example where MobD personnel had reduced product cycle time to the great satisfaction of the customer. The committee observed that soldier involvement and input is

emphasized in MobD. Also, almost by definition, paying customers appear to be satisfied. MobD workers were generally only moderately pleased with the way things are going in science and technology. Their biggest complaint was the lack of understanding of the responsibilities and authority of researchers. There appears to be a good deal of confusion about who the paying customer is for the development programs. The key individual appears to be the officer in charge of the Army's Airborne Airlift Action Office. Turnover in this position has created the appearance, at the MobD level, of a lack of continuity. A strategic plan for the Airborne Airlift Action Office could provide longer-term technical direction, which would assist MobD to develop a strategy for product development and associated research.

Assessment: Adequate to Good

Survivability Directorate

SurD measures customer satisfaction and studies trends. Customers appear to be generally satisfied, except occasionally (e.g., several interviewees indicated there was some dissatisfaction with the body armor used in Somalia and the boots in Desert Storm). After reading a news article concerning soldier dissatisfaction, the committee contacted the U.S. Army Science Advisor for the Southern European Task Force, which was deployed to Bosnia. The science advisor informed the committee that, in concert with Soldier Systems Command/Natick, he had conducted an after-action review of equipment performance. The science advisor stated that results "indicated a high degree of satisfaction with all of the Army equipment provided." The advisor went on to say that the news article "did not convey the full degree of soldier satisfaction with equipment during the deployment." He added that he has "found Natick to be extremely responsive to soldier needs and feedback" (Sprinkle, 1996).

SurD has a process for assessing the satisfaction level of internal customers (i.e., the management and work force of the RDEC). This process uses a rating system (0 to 7) for customer satisfaction, which is normally 5 to 7. Corrective action is taken if there is a rating of 4 or less. If needs are met and customers are pleased, additional funding might be forthcoming, but SurD does not have great incentives for exceeding customers' needs. The Operational Forces Interface Group in the ASCD constantly surveys soldiers and returns feedback on customer satisfaction.[6] SurD also sends project officers out for customer feedback.

Assessment: Adequate to Good

[6] For example, according to Sprinkle (1996), a survey of 196 soldiers who participated in the Bosnia deployment was performed by the Operational Forces Interface Group.

Sustainability Directorate

Everyone in SusD who was interviewed by the committee recognized the importance of customer satisfaction. Most regarded soldiers as their primary customers; however, they also recognized that SusD has many other customers. Project officers frequently go into the field and conduct trials before writing requirements. Several interviewees commented that long development cycle times were a barrier to improving customer satisfaction. The Natick RDEC often shares responsibility for fielding items with other agencies, such as the Defense Personnel Support Center, and delays in procurement elsewhere often cause the customer to have a negative image of the RDEC.

The committee contacted the program manager of Soldier Support at the Soldier Systems Command during the February site visit, who indicated that some organizations within SusD are more responsive than others. The committee notes that program managers are important customers of the RDEC.

Assessment: Adequate to Good

Commodity Directorates

The committee determined that the metrics associated with a range of adequate to good performance best fit the customer satisfaction of the commodity directorates. The committee found that customers generally seemed satisfied with the technical capability and performance of RDEC products, as well as with the technical support for fielded products. Customers were sometimes dissatisfied with product cycle and delivery time, but the committee found that circumstances beyond the RDEC's control often determined cycle time. Because the committee also learned of some indications of dissatisfaction with the products, it would be difficult to conclude that customers were either always very satisfied (required for good performance) or always delighted (required for excellent performance).

Assessment: Adequate to Good

Customer Involvement

Mobility Directorate

The panel saw evidence of extensive involvement by MobD customers in the later stages of development and of continuing customer input. Soldier field

visits are frequently made, and nearly everyone in MobD feels exceptionally concerned about the soldier. However, some personnel in MobD noted they have never formally queried customers as to their level of satisfaction as participants in the development process.

Assessment: Good to Excellent

Survivability Directorate

SurD customers are involved in the development programs, and customer involvement increases as programs progress. Advanced development work involves a great deal of customer input. The planning integration team now brings customers into the shaping of concept exploration and research to develop fundamental new knowledge (e.g., now that the research and concept exploration work is co-located with work on the end item in the ballistic protection group, greater customer interaction is possible). The ballistic armor team is getting ready to undergo review without the presence of the manager in order to encourage good input from the entire directorate. The Program Manager-Soldier also conducts periodic reviews. SurD sponsors workshops involving all the Armed Forces, the Chemical School, and the Infantry School. A survey of durability is now under way and will elicit responses from about 200 soldiers directly from the field.

Assessment: Good to Excellent

Sustainability Directorate

The SusD planning integration team is a good example of customer involvement in the evaluation of proposals for return on investment. SusD also sponsors customer workshops to gain feedback on its programs. The Organizational Equipment Division involves customers through joint working groups. The committee found that customer involvement is much greater during the development phase than the research phase.

Assessment: Good

Commodity Directorates

The committee determined that the metrics associated with a range of good to excellent performance best fit customer involvement of the commodity directorates. Customers are involved in setting program objectives and following their progress. Customers have a major impact on the development phase of

products and services but less impact on the front-end research phase, which limits the committee's assessment to good to excellent.

Assessment: Good to Excellent

Market Diversification

Mobility Directorate

MobD's airdrop capabilities have resulted in products for the Army and other uniformed services, as well as for other federal agencies, such as the National Aeronautics and Space Administration. It may be difficult for MobD to diversify more than it has. Areas to investigate could include other customers who use parachutes. Except for the New Ventures group and individuals in special operations, no one the committee interviewed had ideas on how parachute skills and technology could be used to diversify markets. The committee explored the extent to which MobD had ventured beyond familiar markets and familiar technologies and products and tried to imagine how the technologies of MobD could be applied elsewhere (e.g., to transportation or forest service). The barriers to approaching these markets will probably come from the Army, rather than from Natick. Other government laboratories (through cooperative R&D agreements and advanced technology demonstration programs) may provide models for leveraging and extending the market for MobD's products, services, and technologies.

Assessment: Adequate to Good

Survivability Directorate

SurD primarily supports the clothing and individual equipment needs of DOD, as well as of foreign military operations, including operations by NATO countries. However, SurD also supports customers outside the military (e.g., the Federal Bureau of Printing and Engraving for currency authentication; and the U.S. Postal Service as part of the Uniform Quality Control Program for clothing and footwear). These organizations are long-standing customers of the directorate who depend on the unique qualifications of SurD to develop clothing and individual equipment. SurD also tests textiles, which is more of a service than a technology application. Staff members of SurD indicated that they are attempting to identify new markets in the civilian sector. The lag in developing new markets can, to some extent, be blamed on rules that have prohibited SurD from pursuing, until recently, opportunities in the civilian sector.

Assessment: Good

Sustainability Directorate

The products of SusD are used not only in the military and other government organizations, both in the United States and abroad, but also in the civilian sector. Diversification is especially strong in the food technology area. The shelters business area has limited opportunities to develop products with dual uses in the civilian sector because of the stringent requirements for military shelters (e.g., shielding against electromagnetic fields and resistance to chemical and biological weapons) and the economics of the civilian tent market. SusD has had some success in marketing its services beyond the U.S. Army, however. The directorate has provided services to NATO, benchmarked its products against those of Great Britain, and been asked to analyze rations from 17 countries for United Nations peacekeeping missions. SusD was recently contracted to redesign shipboard kitchens for the U.S. Navy and is responsible for the DOD Food Program.

Assessment: Good to Excellent

Commodity Directorates

The committee's overall assessment of market diversification is good to excellent for those capabilities that lend themselves to market diversification in the private sector. The committee notes that several capabilities of the Natick RDEC are specific to the military (e.g., a large portion of the airdrop program). It is not clear to the committee that devoting a significant amount of the budget to partnerships with industry and academia (part of the metric associated with a good performance level) to encourage market diversification makes sense in these cases. Other programs (e.g., food technology), however, do lend themselves to market diversification, and the RDEC has done a good job of developing external markets in these areas.

Assessment: Good to Excellent

Overall Assessment of the Customer Focus Pillar

The committee believes that, overall, customer focus of the commodity directorates is good (see Table 2-4). Directorate personnel are highly conscious of their primary customers, the soldiers, and are very attentive to feedback from the field. The committee notes that an important aspect of this feedback is the work done by the survey teams within ASCD (see Chapter 3). The committee observed

that less attention was paid to market diversification by MobD and SurD than to the other characteristics in this pillar, which is explainable in part because of the focus within the RDEC on the Army rather than on potential customers outside the Army.

TABLE 2-4 Customer Focus Pillar

	Mobility Directorate	Survivability Directorate	Sustainability Directorate	All Commodity Directorates
Customer Satisfaction	Adequate to Good	Adequate to Good	Adequate to Good	Adequate to Good
Customer Involvement	Good to Excellent	Good to Excellent	Good	Good to Excellent
Market Diversification	Adequate to Good	Good	Good to Excellent	Good to Excellent
Overall Assessment of Pillar: Good				
Direction of Vector: Level				

VALUE CREATION PILLAR

CHARACTERISTICS OF THE VALUE CREATION PILLAR

- Proper Portfolio
- Product Performance
- Cycle Time and Responsiveness
- Value of Work In Progress

See the metrics for each of the above characteristics in Table C-4.

Proper Portfolio

Mobility Directorate

The MobD portfolio reflects primarily funding and history rather than potential payoffs. Because MobD has little or no discretionary money and has not

put forth breakthrough-level concepts, it has had little opportunity to develop a product portfolio different from the traditional one. Historically, science and technology programs go on and on; they are never terminated. Fortunately, MobD has an analytical process to examine its product portfolio, the integrated planning process, which is now in its second year at the Natick RDEC. The committee is hopeful that this process will be used by MobD to evaluate priorities annually and to create a viable portfolio.

Assessment: Adequate

Survivability Directorate

SurD has some control over technology-based programs but little control over engineering development and procurement programs, which are strictly focused on user requirements. Hence, SurD really does not have a portfolio of programs. Severe restrictions on discretionary funds also limit SurD's opportunities for developing a diversified portfolio. Interviewees noted that they feel a sense of urgency because everything they do is important, and therefore, everyone must work on everything. The committee is hopeful that the integrated planning process can help SurD evaluate priorities among program alternatives and help to establish a portfolio.

Assessment: Adequate

Sustainability Directorate

The committee found that SusD customers are involved in portfolio analysis through the planning integration team and the teams that assess proposals for technical merit and return on investment. To some extent, the SusD program portfolio is driven by funding, and not by the potential for payoffs, because of SusD's lack of discretionary funds for unsolicited R&D. The committee found that the products developed by SusD do enjoy significant customer acceptance, particularly the food and combat rations. Continued funding of the DOD Food Program and recognition by customers outside the U.S. military (the United Nations, NATO, Great Britain, and Australia) tend to support this finding.

Assessment: Good

Commodity Directorates

The committee determined that the metrics associated with an adequate performance level best fit the proper portfolio of the commodity directorates. The

committee found some evidence of analytical processes being used to examine portfolios, but the majority of products are developed to meet customer needs. Portfolio analyses have not been part of the strategic planning process (see section on the Strategic Vision pillar).

Assessment: Adequate

Product Performance

Mobility Directorate

The interviews and answers to questions suggested that MobD products almost always meet major performance requirements. The committee noted the great improvement in parachutes over time, which is evidenced by fewer malfunctions. MobD personnel know how to get their products and services out the door, but they do not know how to speed up the DOD acquisition process. A major complaint is DOD's use of performance standards rather than specifications for products. Many staff members expressed concerns about safety, added complexities, more work, and uncertainties associated with this change. The staff believes that the issues and implications of changes like this are not appreciated by those who make them.

Assessment: Good

Survivability Directorate

SurD is now working on most requirements using cost as an independent variable (i.e., cost is taken into account in determining whether a requirement must be met absolutely or whether some relaxation is permissible to lower cost). Because requirements are sometimes unrealistic, SurD now aims at meeting only the most important requirements. When a new project begins, the Army Training and Doctrine Command goes out to a user, such as the Chemical School, and gets the operational requirements. When milestone decisions are made, all players discuss the results. Sometimes SurD exceeds expectations, but there is not much incentive for the directorate to do so.

In general, indications are that SurD products meet established customer requirements. Meeting customer "expectations" is more complicated. With the growth of the recreational clothing industry, soldiers can now compare Army products with commercial products. Soldiers may want some of the features of commercial items, and commercial products can often be adapted to Army needs (e.g., color, durability, and buttons that can be repaired in the field rather than zippers or noisy Velcro). One key issue is that the final user, the soldier, does not

usually pay for the product; thus weighing cost, performance, and customer expectations can be difficult. The committee notes that SurD interviewees provided two examples of customers who had complained about product performance: boots in Desert Storm and body armor in Bosnia. The committee was also told that in some cases the requirements were not well specified. In both instances, SurD was responsive to customer complaints, fixed the problems, and returned products to the field that were perceived as better than the ones they replaced.

Assessment: Good

Sustainability Directorate

The interviews and answers to questions suggested that SusD products almost always meet or exceed customer requirements. A majority of staff members interviewed felt that their products were very good to excellent, particularly at the prototype stage. Some noted that it was more difficult to maintain product quality once an item was turned over to contractors. In recent field tests of improved meals-ready-to-eat, the meals were well accepted by soldiers. Another SusD product, the high-pressure air beam shelter, is considered significantly better than previous shelters.

Assessment: Good to Excellent

Commodity Directorates

The committee determined that the metrics associated with a good performance level best fit the product performance of the commodity directorates. Products appear to meet customer requirements, and the committee did not find any rewards in the Army system for exceeding customer requirements. Most products are perceived as better than the ones they replace. The committee did not find many examples of products that include "some pleasant, unexpected surprises," which is necessary for an excellent rating.

Assessment: Good

Cycle Time and Responsiveness

Mobility Directorate

MobD is very responsive to the soldier's needs in the field when they are well defined. MobD has also demonstrated that it can respond quickly when

motivated by immediate military involvement (e.g., Desert Storm and Bosnia). MobD personnel have looked for ways to speed up the cycle time but, very wisely, have not yielded to pressures that might compromise soldier safety.

Assessment: Good to Excellent

Survivability Directorate

SurD excels in quick responses, as illustrated in the example of boots for use in Macedonia, the soles of which were changed very rapidly; bureaucratic requirements are waived under such circumstances. In other words, evidence suggests that systems are in place at SurD to allow rapid work on emergency items in times of conflict. The committee found that SurD has discovered no "sure fire" way to cut down the time of delivery under normal circumstances. However, SurD has tried to reduce cycle time through low-rate-initial-production procurements, replacing detailed specifications with performance specifications, and eliminating unnecessary field testing. SurD programs are mostly on time and on budget, but the length of the normal acquisition process remains a problem.

The cycle time for clothing and individual items of equipment is two to seven years; product improvements take from one to three years. The directorate considers these response times too long for customer satisfaction. Once customers identify a need, they want it satisfied immediately. The fastest cycle times are for products where a commercial market has an acceptable solution or product available, thus making the directorate's task one of acquisition rather than RD&E. Long cycle times are typical of products unique to the military that have no marketability outside the DOD establishment (e.g., a new uniform for female officers that was delayed for more than seven years).

Assessment: Good to Excellent

Sustainability Directorate

The committee found many instances showing that SusD can respond very rapidly to unforeseen circumstances that affect forces in the field. A prime example is SusD's rapid fielding of sunscreen shelters for Desert Storm. However, some interviewees felt as if they were always "fighting fires." In normal situations, the planning cycle for science and technology is consistent with the five year planning time frame for the RDEC as a whole. Science and technology programs have a slightly shorter cycle time of one to three years. The DOD Food Program is reviewed and renewed on a yearly basis, but most interviewees indicated that they had no incentive to complete a project ahead of schedule. Most

interviewees felt that projects funded for three years should take three years to complete. The committee found no motivation for trying to complete a three-year project in two years.

Assessment: Good to Excellent

Commodity Directorates

The committee determined that the metrics associated with a range of good to excellent performance best fit the cycle time and responsiveness of the commodity directorates. At first glance, one may question this assessment because there are examples of cycle times and responsiveness that appear to be less than good. The committee decided to weigh the "quick fix" portions of the metrics more heavily because the RDEC streamlines processes and allows personnel to perform in a less constrained environment in time of need. In those instances, the committee found the staff to be very responsive to the needs of the troops, and senior management ensures that resources are reprogrammed to fulfill quick-fix requests. The committee also observed several examples of commanders directly and indirectly expressing their gratitude for quick fixes.

Assessment: Good to Excellent

Value of Work in Progress

Mobility Directorate

MobD is attempting to show the benefits of projects (e.g., from cost savings to lives saved) in concrete terms by participating with ASCD in the development of airdrop battlefield simulations. These simulations reflect efforts by the Army to derive hard numbers to demonstrate the value of various RD&E programs. The evaluation and prioritization phase of the integrated planning process is also used to demonstrate the value of MobD projects.

Assessment: Adequate

Survivability Directorate

SurD relies on the Defense Technical Information Center database and the evaluation and prioritization phase of the integrated planning process to evaluate past and current programs. SurD projects are primarily intended to ensure that U.S. soldiers and marines are the best equipped and best protected ground troops

in the world. A secondary goal is the commercial adaptation of SurD technology. Examples are the use of ballistic protection equipment by law enforcement agencies and the use of cold-weather clothing for outdoor equipment. SurD can describe the value of its work, but only in general terms. SurD is still searching for ways to measure the value of its products, estimating the number of lives saved by ballistic protection, for example. Feedback from soldiers through comments to the Operational Forces Interface Group can help.

Assessment: Adequate

Sustainability Directorate

SusD maintains a quarterly database on all projects as part of the RDEC and Soldier Systems Command Planning and Reporting System. In addition, under the Government Performance and Results Act, the directorate recently implemented annual assessments, which document planning, performance accounting, and budgeting for each project. The committee found indications that all divisions of the directorate have developed products with greater value than similar products available in the private sector. Nevertheless, the committee believes that SusD needs to characterize the value of projects in terms of improvements in the performance of soldiers in the field.

Assessment: Adequate

Commodity Directorates

The committee determined that the metrics associated with an adequate performance level best fit value of the work in progress of the commodity directorates. The committee found that customer perception of current RD&E programs appears to be good. Some methodology has been put in place to assess the current RD&E programs with respect to a "value of work in progress." However, across the directorates, there is no database of the primary and secondary effects of past projects that can be used for comparison with current RD&E programs.

Assessment: Adequate

Overall Assessment of the Value Creation Pillar

The committee believes that performance of the commodity directorates is good with respect to the Value Creation pillar (see Table 2-5). The directorates are responsive to soldiers' needs, and product performance is usually good. When

deficiencies surface, the directorates appear to do their utmost to correct them quickly. Better ways to measure the true value of products would be useful to the Natick RDEC.

TABLE 2-5 Value Creation Pillar

	Mobility Directorate	Survivability Directorate	Sustainability Directorate	All Commodity Directorates
Proper Portfolio	Adequate	Adequate	Good	Adequate
Product Performance	Good	Good	Good to Excellent	Good
Cycle Time and Responsiveness	Good to Excellent	Good to Excellent	Good to Excellent	Good to Excellent
Value of Work in Progress	Adequate	Adequate	Adequate	Adequate
Overall Assessment of Pillar: Good				
Direction of Vector: Level				

SUMMARY

The committee's summary of this portion of its assessment is presented in the form of a spider diagram (NRC, 1996). The spider diagram (see Figure 2-1) shows the assessment results for the five performance pillars and indicates that the collective performance of the commodity directorates at the Natick RDEC has been assessed as good for three pillars (Resources and Capabilities, Value Creation, and Customer Focus), adequate to good for one pillar (Quality Focus), and poor to adequate for the remaining pillar (Strategic Vision). Although the assessment did not show the commodity directorates of the Natick RDEC to be performing at a world-class level (i.e., excellent in all five pillars, which is very difficult to achieve), the committee believes they are performing well. Forty percent of the characteristics were assessed as good or good to excellent across the directorates. The characteristics judged to have the best performance overall are customer involvement and cycle time and responsiveness.

Of the two pillars that were assessed as less than good (i.e., Strategic Vision and Quality Focus), the committee is most concerned about Strategic Vision, which was assessed as poor to adequate. Nevertheless, the committee is encouraged that the vector for the future appears to be turning up as the result of the recent emphasis on real strategic planning and the dedicated commitment of RDEC leadership (observed during the committee's final visit in February 1997).

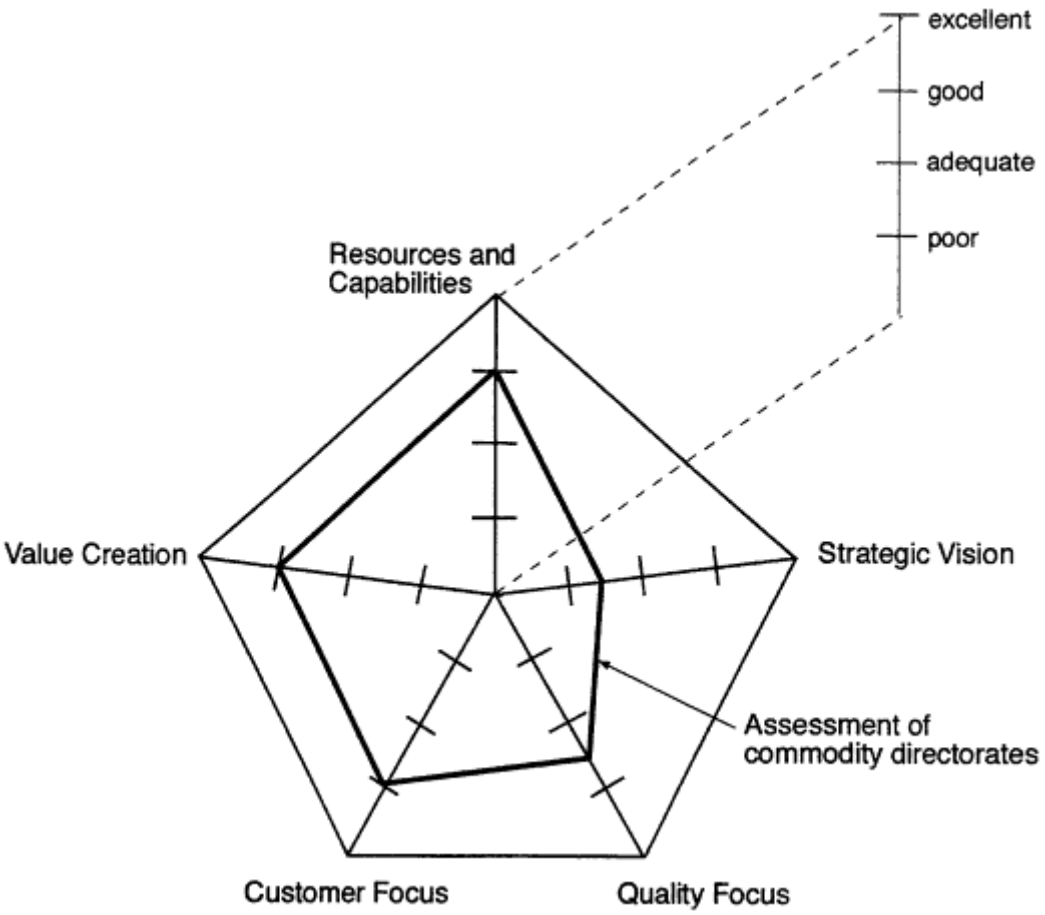

Figure 2-1
Spider diagram for the commodity directorates.

The committee is concerned that the vector for the future of the Quality Focus pillar, which was assessed as adequate to good, is uncertain.

The committee is troubled that the vector for the future appears to be pointing down for the Resources and Capabilities pillar, largely because of the continuing loss of skilled personnel. Unless the direction of this vector is changed, a future assessment could find resources and capabilities at the Natick RDEC to be less than good.

Finally, the committee was struck that the assessment results were very similar across the directorates in all but one characteristic. The exception is the market diversification characteristic in the Customer Focus pillar. Some organizations were able to diversify more easily than others because of the availability of non-Army markets for their products. Not all of the Natick RDEC's products lend themselves to world-class performance in market diversification.

3

Assessment of the Support Directorates

In this chapter the committee focuses on the two support directorates of the Natick RDEC, STD (Science and Technology Directorate) and ASCD (Advanced Systems Concepts Directorate).[1] The committee again used the pillars, characteristics, and metrics established in phase-one for world-class performance. However, the characteristics and metrics were applied in a way that emphasized the supporting roles of these directorates. The assessment results reflect the committee's judgments of the contributions of the support directorates to the performance of the commodity directorates and the RDEC as a whole.

ASSESSMENT PROCESS

The committee decided early on not to subject STD and ASCD to the arduous assessment process undergone by the commodity directorates. The committee submitted fewer pre-visit questions and conducted fewer interviews of personnel in the support directorates. This approach recognized that STD and ASCD were created to complement the commodity directorates and the RDEC by (1) providing research to infuse new technology into the RDEC's products, and (2) by marketing products to external users. Therefore, in applying the characteristics and metrics of a world-class organization, the committee heavily weighted the supporting role of STD and ASCD in relation to the commodity directorates, their primary customers.

The committee gathered data for assessing the support directorates on the same visits to Natick. During the wrap-up session in February 1997, the committee scheduled additional interviews to ensure that sufficient information would be available for assessing the support directorates. The committee also obtained a great deal of information about the support directorates from personnel in the commodity directorates (i.e., the primary customers). However, members of the committee also interviewed people in the support directorates, who made many cogent observations regarding STD's and ASCD's abilities to provide needed support.

[1] General references for this chapter are Malabarba (1996) and Salant (1996).

The committee considered each support directorate in relation to each characteristic of world-class performance. However, the committee believed it had sufficient information only to make summary judgments at the pillar level regarding the performance and major strengths and weaknesses of STD and ASCD. In making these judgments, the committee interpreted the various metrics in light of the relationship between the support directorates and the commodity directorates. Because of the fundamental differences between the support directorates, the committee decided to assess them separately.

SCIENCE AND TECHNOLOGY DIRECTORATE

The Natick RDEC must, at a minimum, maintain a research capability and continue to develop some technology to ensure that the RDEC personnel can make credible scientific and technical judgments. But the research and technology development must be relevant and must offer significant benefits to soldier-system performance. These considerations were important to the committee's assessment of STD's impact on the overall performance of the commodity directorates, the ASCD, and the Natick RDEC as a whole.

Resources and Capabilities Pillar

CHARACTERISTICS OF THE RESOURCES AND CAPABILITIES PILLAR

- Personnel Quality
- Budget
- RD&E Capabilities, Skills, Talents
- Use of External Resources
- Important Technologies
- Organizational Climate
- Information Technology
- Facilities and Infrastructure

Personnel Quality

STD's customers' indicated that their expectations were seldom exceeded by STD. When research tasks were Well defined, their expectations were met; however, if tasks were less well defined, customers felt that the deliverables were either not of high enough quality or were delivered late. These problems may not be entirely attributable to personnel quality, but they indicate a disparity that should be addressed by acquiring skills or training in areas more compatible with customer expectations.

The committee was informed repeatedly that because of the hiring freeze STD had been forced to try to improve personnel quality by training and personnel transfers. The committee was informed about several training activities and programs but found that they were often pursued by employees for personal interests. The committee would have been pleased to see efforts being made to encourage and train current personnel or to obtain transfers of personnel with appropriate expertise to improve support for the commodity directorates. Unfortunately, efforts of this kind were not observed.

Budget

The committee was informed that STD is constantly struggling for money. STD's funding comes from two basic sources: the commodity directorates and other government organizations that need the type of research that STD can perform. Both sources require that STD justify those funds. Therefore, budgets are directly related to STD's ability to convince its customers that its research capabilities and services are worth funding.

STD budget shortfalls reflect doubts on the part of the DOD and the Army, as well as customers within the RDEC, about the benefits that will be realized from their investment in research. The committee believes that budget problems will persist. However, conflicts within the RDEC could be reduced by a much closer working relationship between STD and the other directorates and by STD accepting the need to demonstrate the benefits of its work to RDEC projects and soldier-system performance.

RD&E Capabilities, Skills, Talents

This characteristic reflects the broad capabilities of an organization to pursue a viable research program. Several interviewees contributed to the committee's assessment of this characteristic. For example, one person indicated that the hiring freeze is "crippling STD." Another interviewee, well known for his work, predicted that the best people will soon leave the Natick RDEC. The committee agrees that STD will probably incur losses, as most organizations do when budgets and resources are limited. The committee noted the departure of one key scientist from STD whose reasons for leaving included the inability of the organization to hire new people who could bring new capabilities and ideas, which are necessary for a thriving research organization; decreasing funds for equipment and facilities, which limits future work to present technological capabilities; and cutbacks in research by government organizations in favor of research by private industry.

Use of External Resources

STD leverages outside research programs in both academia and private industry. STD has organized its external multidisciplinary research into several technical areas: biodegradable microbiology and chemistry for bioremediation; biotechnology for materials application; biomimetic processing; and functionally tailored textile fabrics. In each of these areas, STD collaborates with one or more academic institutions and one or more research organizations in DOD (e.g., the Army Research Laboratory, the Edgewood RDEC, the Office of Naval Research, and the Air Force Office of Scientific Research). STD also has cooperative agreements with private organizations (e.g., agreements covering various biodegradable materials and synthetic polymers that could mimic the properties of spider silk).

The committee was informed that a lot of work is now being given to outside contractors because of the hiring freeze, thereby establishing connections with external resources. Although the range of external work is impressive, the committee is concerned that there is no master plan showing how external research complements the internal research by STD to fulfill the RDEC's needs.

Important Technologies

Research at the Natick RDEC is divided between the commodity directorates, which conduct research that is uniquely applicable to their programs, and STD. STD maintains oversight of all of the basic research[2] at the RDEC, but the commodity directorates manage the day-to-day activities and progress of the research they conduct. The committee feels that the division of research elements amplifies the perception of a separation between researchers in STD and developers and engineers in the commodity directorates. In fact, information from the interviews implied that STD is preoccupied with its own research and has a tendency to pursue research for its own sake. The committee realizes that STD must focus its efforts on a few select technologies (e.g., the four thrust areas [identified in Chapter 1], as well as external initiatives) in order to achieve critical mass. However, because STD obtains funding from its primary customers—the commodity directorates—it must also ensure that technologies critical to the success of the commodity directorates take precedence. The RDEC's future depends on the maturation of technologies that can be applied to products.

[2] In this report the committee uses the term "basic research" to mean research to develop fundamental new knowledge. The committee believes that basic research usually (but not always) has a long-term orientation. The results of basic research can be used for specific applications in "applied research" programs. In other words, basic research develops new knowledge that can be used in applied research.

The committee observed that STD and the other directorates were reluctant to engage in a frank dialogue about research programs. The commodity directorates need to clarify their research needs that have not been met by STD. Scientists in STD appeared to resent demands that they produce short-term results and argued that long-term results worthy of publication and patents require patience.

The committee accepts the fact that mechanisms like the planning integration team can assess the merits of research proposals and allocate research funding for the RDEC. Nevertheless, in the case of basic research, the committee believes there must be a closer relationship between STD and the commodity directorates. STD management and personnel indicated that important technologies that need to be added include work in materials science, human performance, and modeling and simulation (see discussion under the Value Creation pillar). The committee learned that only one-fourth of the proposals submitted by STD were funded. Better dialogue with the commodity directorates could improve the selection rate.

As the RDEC corporate laboratory, STD should be the center of excellence in understanding as well as in advancing critical technologies for the RDEC and the Soldier Systems Command. To this end, the committee considered ways STD could determine the technologies that are essential to the RDEC's future.

The committee suggests that STD and the commodity directorates agree to a closer working arrangement so important technological needs can be better communicated by the commodity directorates to STD and so STD can make fundamental changes in its approach to selecting technologies that deserve resources. This working arrangement was discussed during committee interviews. For example, one scientist's opinion was that research organizations must have an overall motivation, an overriding goal, and justification for what they do. There has to be accountability along the way (e.g., yearly technical reviews of research programs should be conducted by a team that collects, analyzes, and discusses data and how they fit the long-term goals of the organization). Some fringe ideas that could result in breakthroughs should also be funded. A certain percentage of funding (e.g., 80 percent) should be subject to review and approval by the commodity directorates, and a smaller percentage (e.g., 20 percent) should be provided for the research organization to direct on its own. The committee notes that it does not necessarily endorse this opinion but believes it offers reasonable options.

The committee believes that a formal, periodic review process would ensure that the commodity directorates could clarify technologies important for their needs and would give STD an opportunity to identify beneficial long-term technologies for investment within a small percentage of its budget. STD leadership must clarify which research projects are directly responsive to the

commodity directorates and which have been identified as beneficial by STD and ensure that the STD personnel maintain a balance between the two.

Organizational Climate

Some interviewees indicated that STD is not a part of the big picture; that the Soldier Systems Command does not understand research and supports administrative organizations that do marketing rather than scientific work; that government rules and regulations, which govern the commodity directorates, are different from the approach for performing basic research and force STD people to spend time on shorter-term acquisition rather than furthering a longer-term vision; that the RDEC does too much crisis management; that public relations are often substituted for substance; and that there are few opportunities for advancement. The committee suspects that the organizational climate in which STD is immersed will not improve until STD programs show more relevance to the commodity programs and soldier-system performance.

Information Technology

STD uses modem information technology to support research at the RDEC. Interviewees indicated that there is RDEC-wide cooperation in the use of information technology.

Facilities and Infrastructure

The committee observed that some renovations are being undertaken at Natick. Nevertheless, evidence suggests that the research facilities are barely adequate. For example, although personnel are pleased with the improved work space, they cited several facilities that were in disrepair and instances when necessary facilities or equipment for specific types of research were not available.

Overall Assessment

The general findings related to each of the characteristics and review of the associated metrics led the committee to an overall judgment of adequate for the Resources and Capabilities pillar. Indications are that there is a downward trend in STD's ability to maintain its RD&E capabilities, skills, and talents. This problem is similar to the problems the committee found for the commodity directorates (see Chapter 2).

Strategic Vision Pillar

CHARACTERISTICS OF THE STRATEGIC VISION PILLAR

- Alignment of Vision and Mission
- Strategic Planning
- Stakeholder Buy-In
- Leadership

Alignment of Vision and Mission

STD's mission is to "provide world-class research ... maximize combat effectiveness of [the] soldier system ... leverage outside research programs ... [and] maintain cutting edge research programs, facilities, and equipment" (Salant, 1996). This statement reflects a desire to provide a wide range of scientific expertise in support of the commodity directorates and Soldier Systems Command and is in alignment with the mission and vision of the Natick RDEC. However, interviews conducted by the committee indicated that there is a dichotomy between the understanding and the implementation of this mission by STD personnel.

Although many STD personnel can relate to the vision and mission statements of the Soldier Systems Command and the RDEC, they do not appear to believe the STD's vision and mission statements. Some members of STD consider the commodity directorates to be their customers; others feel that basic research is a mission in and of itself and that the research activities in STD are worthy of support without application, short-term or long-term, to a current program. This difference in opinions about the fundamental role of STD was also reflected in interviews with commodity directorate personnels. Many interviewees in the commodity directorates found it difficult to name technologies developed by STD that have been, or are being, applied to products. They also indicated that key areas were not being researched by STD (e.g., research to assist MobD).

The committee concluded that the vision and mission statements are not helping STD to deliver research that consistently advances the commodity directorate programs or is demonstrably relevant to soldier-system performance. The committee believes that STD and the other directorates must define and focus on the scientific and engineering base critical to the RDEC. STD personnel should understand the areas for which they will be held responsible and identify the technologies for which the commodity directorates expect excellence from the STD.

Strategic Planning

The committee was briefed on recent formal strategic planning by the Scientific and Technical Advisory Council, which is directly under the office of

the RDEC director. This council and the planning integration team are intended to guide STD's planning and research. STD personnel are expected to develop research plans for STD and for the RDEC as a whole. Although some interviewees felt that the new strategic planning process was a significant improvement over the previous process, others felt it was not effective because it does not emphasize longer-term science and technology, for which the return on investment is 10 to 20 years away.

Stakeholder Buy-In

During interviews with members of STD, the committee perceived that the responses of internal stakeholders to the vision and mission of STD were either indifferent or negative. Stakeholders in the other directorates indicated to the committee that the results of STD research do not justify their investments. The committee concluded that either the return on investment in STD research is inadequate or it is not being clearly communicated to the RDEC community by STD.

Leadership

The committee found that STD leaders thoroughly understand the RDEC mission and vision to support the soldier system. They stated clearly that the vision and research plan for the STD should be compatible with those of the RDEC and Soldier Systems Command, and they acknowledged that STD was obligated to justify the contribution of its research to the current commodity directorates. However, some of the researchers expressed their displeasure with having to justify their work on the basis of its relevance to development and engineering projects in the commodity directorates. Several interviewees appeared to be suspicious of, rather than in agreement with, the leadership of STD. The committee concluded that communication between the STD leadership and the staff was inadequate and that senior leadership has not been able to "sell" the vision and mission of STD to rank-and-file members of the directorate.

Overall Assessment

The committee arrived at an overall judgment of poor for the Strategic Vision pillar. Unfortunately, the committee found that STD has been unable to translate its vision and mission into a working philosophy that is accepted, let alone embraced, by the members of STD or the other directorates. The trend for the future was judged to be level.

Quality Focus Pillar

CHARACTERISTICS OF THE QUALITY FOCUS PILLAR

- Capacity for Breakthroughs
- Continuous Improvement
- Commitment to Quality
- Structured Processes
- Learning Environment
- Quality of Research

Capacity for Breakthroughs

Considering that existing research in STD is not well correlated with the commodity directorates' needs, the potential for breakthroughs from STD research is limited. Furthermore, as some interviewees within STD noted, the technologies associated with some commodities (e.g., food and clothing) are already mature, and only incremental advances can be expected in those areas. The most frequently cited example of a "leap-ahead" technology was in the area of biotechnology (the cited project involves developing materials with the properties of spider silk). STD personnel continue to publish papers and make steady, incremental improvements in their knowledge base.

Continuous Improvement

STD personnel interviewed by the committee indicated that STD is not very flexible or capable of change; this inflexibility has contributed to STD's long-standing inward orientation. Interviewees noted, for example, that STD had not taken advantage of the RDEC's being designated as a personnel demonstration, which allows the organization to waive many civil service rules to find a better way of doing business. The quality of work at STD is assessed by STD managers and personnel using the same measures used by the academic community to assess research quality (e.g., number of publications in refereed journals, number of sessions chaired at national and international technical meetings, number of patents granted). But no measures are in place to determine how the output relates to the needs of the commodity directorates. The committee was informed that STD staff recommendations for improvements are considered only within STD, with no feedback from other directorates.

The deep division between STD and other RDEC organizations is of significant concern to the committee. Bringing STD closer to the commodity directorates should bring the research program more in line with the commodity directorates' needs and enhance the value of STD to the entire RDEC.

Commitment to Quality

The committee was convinced in the interviews with STD personnel that they were committed to the highest quality in basic research. However, they judged the merits of their research on a traditional basis and did not consider the effects of their research on the commodity directorates. Several interviewees indicated that their ability to conduct high-quality research had been significantly affected by the hiring freeze, which has made it impossible to hire sufficient support staff and eliminated the influx of fresh ideas. Many interviewees were deeply troubled by the reduction in hands-on research, indicating that they were increasingly being forced to manage and administer external research projects rather than perform or supervise the research themselves. Attempts to offset the hiring freeze by using temporary technical personnel were viewed with skepticism; many felt that hiring temporary personnel compromised the organization's inherent capabilities and made it more difficult to maintain continuity. As a consequence, many interviewees said, the quality of research at the Natick RDEC was declining. Other interviewees, primarily senior scientists, stated that the number of publications and speaking invitations at international seminars indicated that the quality of research was still high.

Structured Processes

STD leaders told the committee that they evaluate projects and personnel according to five performance objectives: well planned and executed research; demonstrations of scientific stature by editing and writing; safe research practices; collaboration; and leveraging technology and securing funding. Overall, research is monitored to control cost and to assess progress toward milestones.

Learning Environment

Funds are available for STD personnel who desire to pursue advanced technical degrees or continuing education courses. However, the committee noted that STD does not have a uniform policy to encourage individuals to pursue opportunities germane to STD's mission, which could amplify and strengthen the current skill base. In addition, successful interactions with the commodity directorates that would motivate cooperative research programs with the remainder of the RDEC are not communicated to the rest of the RDEC. The committee feels that, as a minimum, STD should mount an organized campaign to encourage STD personnel to acquire knowledge in the technologies most important to the commodity directorates.

Quality of Research

The committee has already noted the "disconnect" between STD's chosen areas of research and the commodity directorates' expectations. When STD has been asked to fulfill precise research needs by the commodity directorates, STD has performed well. In the research areas chosen solely by STD, STD's work has been recognized by the greater scientific community. But STD's research and technology programs are only occasionally correlated with the needs of its primary customers. The committee commends STD for maintaining the quality of its research vis-à-vis the community of its peers, but its activities should be relevant to the development and engineering needs of the commodity directorates.

Overall Assessment

The committee arrived at an overall judgment of poor to adequate for the Quality Focus pillar. Improvements will require that STD refocus its activities to support the commodity directorates. The committee is not advocating that STD be relegated to making short-term fixes, but STD should base its long-term programs on issues that are germane to the future needs of the commodity directorates.

Customer Focus Pillar

CHARACTERISTICS OF THE CUSTOMER FOCUS PILLAR

- Customer Satisfaction
- Customer Involvement
- Market Diversification

Customer Satisfaction

The committee was informed by all of the commodity directorates that, with the exception of the support provided by STD's behavioral sciences group to SusD, they do not feel the amount or quality of STD research justifies the cost of supporting an independent STD. To compensate, all of the commodity directorates have mounted their own research projects to provide the information they need to facilitate their development and engineering projects. For example, the shelters area needs information on fabrics and composite materials and has asked STD for support. However, because STD did not start a relevant research program, SusD has initiated its own research in this area.

Based on the interviews, the committee concluded that STD does not initiate research relevant to the commodity directorates' needs. STD has helped only when it was asked for a solution to a specific, well defined problem (e.g., the polymeric tray developed for SusD). Many interviewees in the commodity directorates felt that STD was doing research for its own sake, a view that was confirmed by some STD interviewees. The committee was presented with very few examples of STD research fulfilling a need or making a significant improvement in the technical performance of an RDEC product.

Customer Involvement

The committee found very little evidence that STD proactively involves its primary customers (the commodity directorates) in its activities. The committee sensed that STD personnel had effectively communicated the message that their primary mission is basic research, regardless of their customers' needs. This attitude has created animosity between the commodity directorates and STD. In the committee's view, STD personnel should reorganize, redirect, and refocus their work to satisfy their customers' needs. Frequent participation by the commodity directorates in research planning could help bridge the gap between STD and its internal RDEC customers.

Market Diversification

Although STD's mission and vision statements indicate the need for a broad spectrum of expertise within STD, the focus on four thrust areas significantly narrows the field. Nevertheless, STD personnel did indicate that they had a variety of outside customers (e.g., the Army Corps of Engineers, the Army Research Institute of Environmental Medicine, the Naval Seas and Supply System Commands, the Defense Logistics Agency, and the Canadian Ministry of Defense). It was not clear whether STD was providing feedback to the Natick RDEC directorates concerning relevant research by these customers. This kind of feedback could be very useful to the other directorates.

Overall Assessment

The committee arrived at an overall judgment of poor for the Customer Focus pillar. The committee found no evidence that STD is trying to improve communications with or identify the needs of the commodity directorates. Without this kind of communication, improvement in customer focus cannot be realized.

Value Creation Pillar

CHARACTERISTICS OF THE VALUE CREATION PILLAR

- Proper Portfolio
- Product Performance
- Cycle Time and Responsiveness
- Value of Work In Progress

Proper Portfolio

The current thrust areas within STD are biomolecular processes, materials functionality, ergonomics, and product acceptance. The research in these areas that addresses commodity directorates' needs is described in publications and presentations. STD was criticized during the interviews for not meeting customer needs for research and for publishing results that were not useful. STD personnel indicated, however, that current research programs were pursuing more relevant results.

Several interviewees inside and outside of STD indicated that STD needs more expertise in materials science. STD management indicated that they need technologies that could provide the following capabilities (see further discussion in Chapter 4):

- enhance the soldier's situational awareness and capability of acquiring, comprehending, and transmitting information
- materials that respond automatically, without soldier intervention
- better understanding of the stimuli and environmental factors that influence human performance and behavior
- accurate models and simulations of technical parameters to prepare for operation in the real world.

The committee agrees that STD needs additional technologies. However, in the committee's opinion, STD needs a master plan that integrates the research needs of the other directorates and the STD portfolio of programs. Otherwise, it is difficult to assess what should be added to (or subtracted from) STD's portfolio.

Product Performance

The patents granted to, and publications by, STD personnel are notable and commendable. However, several interviewees from the commodity directorates indicated that these achievements were not relevant to their needs.

Cycle Time and Responsiveness

Assessment of this characteristic with respect to the STD is complicated by the fact that basic research tends to pursue long-term benefits and improvements. The time frame for research results is unpredictable. However, STD does evaluate project times and publishes in a timely fashion.

Value of Work in Progress

The mainstays of STD support are basic-research and technology-development funding, much of it from the commodity directorates, who do not believe they are receiving sufficient benefits from STD in return. Progress by STD tends to be incremental and evolutionary rather than revolutionary (e.g., an assessment of the biodegradability of materials). Interviewees indicated that STD has not done a good job of transferring the technology it has developed. STD has attempted to address this problem by involving researchers in the product teams so that STD's research is fully understood. There were indications that, when people worked on teams during the integrated planning process, for example, they tended to cooperate more. Publications, research plans, and research proposals represent a historical database of research pursued by STD that could be assessed to justify and prioritize research projects.

Overall Assessment

The committee arrived at an overall judgment of poor to adequate for the Value Creation pillar. Improving the directorate's ability to create value for the commodity directorates requires targeting STD's research.

Summary

The results of the committee's assessment of STD are summarized in Table 3-1. The assessment is harsh and suggests that management must act expeditiously to resolve the problems associated with STD's relationship to the RDEC as a whole. The most serious problems seem to stem from the desire of STD personnel to perform research aimed at extending the general body of knowledge in their chosen fields rather than research that supports the needs of the commodity directorates. Striking a balance between the two kinds of research is not a new problem, but it needs to be resolved to reestablish synergistic interactions between STD and the other directorates of the Natick RDEC.

TABLE 3-1 Summary of STD Assessment

Pillar	Assessment	Trend
Resources and Capabilities	Adequate	Down
Strategic Vision	Poor	Level
Quality Focus	Poor to Adequate	Level
Customer Focus	Poor	Level
Value Creation	Poor to Adequate	Level

ADVANCED SYSTEMS CONCEPTS DIRECTORATE

The committee considered two basic questions in assessing ASCD as a supporting directorate: (1) What models and simulations are necessary for evaluating enhancements to the combat effectiveness of the soldier-system? and (2) How should ASCD, as a whole, support the RDEC's efforts to improve soldier-system performance? The second question goes beyond modeling and simulation capabilities and focuses on the ASCD's marketing responsibilities.

A strong, positive image of the Natick RDEC and the Soldier Systems Command can send a persuasive message to external customers and organizations. This image can be developed and presented either by an organization's top management or by an ASCD working closely with top management. The image should reinforce the idea that the soldier system is an integrated, engineered system rather than an assemblage of components and subsystems. Developing the message requires identifying the modeling and simulations that accurately reflect relevant aspects of soldier-system performance and that demonstrate the combat value of Natick RDEC products. In the assessment of the impact of ASCD on the overall performance of its customers—the commodity directorates, STD, and top management of the Natick RDEC—the committee took into account how modeling and simulations were used.

Resources and Capabilities Pillar

CHARACTERISTICS OF THE RESOURCES AND CAPABILITIES PILLAR

- Personnel Quality Budget
- RD&E Capabilities, Skills, Talents
- Use of External Resources
- Important Technologies
- Organizational Climate
- Information Technology
- Facilities and Infrastructure

Personnel Quality

In addition to interviews with personnel from the commodity directorates and STD, the committee interviewed personnel from all levels of ASCD. ASCD personnel were knowledgeable about modeling and decisions. Personnel who were involved with the customer simulation, as well as the analyses needed to support acquisition liaison function interacted with the Army battle laboratories and understood the benefits of operations research to the Army.

The committee learned that ASCD work usually meets, and occasionally exceeds, the expectations of the commodity directorates as well as RDEC management. The workforce has the necessary skills to accomplish assigned tasks and appears to be acquiring new skills as time and resources permit. Some ASCD personnel have participated in the Distributed Interactive Simulation/Synthetic Theater of War modeling and simulations. Now that the RDEC director's office has taken a new interest in strategic planning, ASCD's need for personnel with expertise in strategic planning should be reevaluated.

Budget

The budget for ASCD is included in the budgets of other programs in the RDEC. ASCD has adequate funding to fulfill its current responsibilities. The modeling and simulation function within ASCD appears to have expanded as far as current funding allows. Expanding ASCD's modeling and simulation capabilities will require support from RDEC leadership and justification to higher headquarters. ASCD expends its own resources to interface with the battle laboratories, but based on the interviews and the committee's observations, the RDEC does not receive sufficient requirements definition or user guidelines from the battle laboratories to justify ASCD's expenditures.

RD&E Capabilities, Skills, Talents

The committee believes ASCD's modeling and simulation and customer liaison capabilities can support acquisition decisions by other units of the RDEC. The personnel appeared to be well trained to carry out their tasks. Furthermore, the committee judged the modeling and simulations to be current and up to date. Nevertheless, the commodity directorates do not rely heavily on ASCD. Instead, other RDEC organizations have proceeded on their own in areas such as customer liaison, strategic planning, and obtaining requirements to justify RD&E programs. To bolster its capabilities to support the RDEC, ASCD could consider the following:

- improving tools to guide researchers and engineers through the phases of acquisition and provide feedback on their progress toward meeting the requirements for the next milestone
- improving contacts and working relationships between external customers and the other RDEC directorates (e.g., persuading users to establish requirements against which the RDEC directorates can work)
- increasing support for integrated planning teams to improve their selection of programs and projects for funding.

Use of External Resources

ASCD has established relationships with outside organizations and contractors that have made technological advances in modeling and simulation (e.g., organizations working on the Army helmet mounted display) or have supported modeling of the individual soldier. These outside contacts have enhanced the RDEC's understanding of the soldier-system concept. However, even better modeling and simulation will probably be needed as the DOD depends more and more heavily on information from models and simulations to make acquisition decisions. For example, the committee suggests that modeling the benefits and costs of a wide range of alternatives could influence DOD decisions to acquire the RDEC's products. ASCD can either use external resources to perform these analyses or perform them in-house.

Important Technologies

ASCD is not responsible for finding new technologies but for evaluating the benefits of using various technologies in RDEC products. The better modeling and simulation gets, the better ASCD can evaluate the benefits of a technology. Although the commodity directorates also have the capability to model technologies, ASCD appears to be better equipped to determine in quantitative terms if using a certain technology could improve the combat effectiveness of the soldier system.

The committee observed that when commodity directorates requested ASCD assistance ASCD did incorporate their technologies into advanced models and simulations. However, ASCD management does not believe ASCD has sufficient staff and equipment to train other directorate personnel in using the ASCD facilities to model their own technologies. Therefore, ASCD is unable to take advantage of other directorates' personnel, who are the most qualified and knowledgeable persons to model their technologies. At the same time, the other directorates do not feel welcome to, or see the potential benefits of, their active participation in modeling their technologies, ideas, or products. The committee

believes ASCD should attempt to involve other directorates more in modeling their technologies while ASCD concentrates on integrating various technology models into simulations of a soldier-system archetype.

Organizational Climate

ASCD personnel seemed to be among the most pleased and actively engaged employees of the RDEC. This was evident by the interviewees' genuine expressions of pleasure with their work and their positive outlook for the future. The committee observed that ASCD is a cohesive unit with a productive climate in which innovative ideas are usually tolerated and sometimes encouraged.

Information Technology

ASCD personnel use information technology to support the progress of programs through the acquisition cycle. Generally, as new information technologies are implemented, ASCD's productivity improves. Personnel appear to be well trained, and appropriate hardware and software are available. Access to the internet and e-mail has connected ASCD personnel with internal and external coworkers, contractors, customers, and external information sources. ASCD's active participation in distributed simulations is a strong indication that these connections are up to date.

Facilities and Infrastructure

The tours and demonstrations of the ASCD's facilities revealed that they meet modem standards and can support the current operations, but they may not support significant growth, including implementation of some of the improvements suggested in this report. Given the rapid changes in computer technologies, the committee believes that ASCD's modeling and simulations may soon be out of date. In addition, the facilities cannot accommodate the participation of the other directorates in the modeling activities.

Overall Assessment

The committee arrived at an overall judgment of adequate to good for the Resources and Capabilities pillar. In contrast to other directorates where the committee noted indications of a decline in resources and capabilities, ASCD showed evidence of an upward trend.

Strategic Vision Pillar

CHARACTERISTICS OF THE STRATEGIC VISION PILLAR

- Alignment of Vision and Mission
- Strategic Planning
- Stakeholder Buy-In
- Leadership

Alignment of Vision and Mission

Although many ASCD personnel could not describe the mission and vision statements of their directorate, they did have a good understanding of the RDEC mission and vision statements. ASCD personnel apparently realize that their role is to represent RDEC technologies for the soldier system that are worthy of funding for research, development, and engineering. ASCD helps the RDEC present an integrated, wholly engineered soldier system. ASCD also helps the RDEC demonstrate that its plans and programs contribute meaningfully to the soldier system. Modeling and simulation by ASCD are important to all these endeavors.

The commodity directorates currently take advantage of ASCD's modeling and simulation capabilities only in particular situations. The food program used the modeling and simulation capabilities to examine systems for food delivery. The clothing and individual equipment programs used them to model the combat value of ballistic protection items. MobD has used them to model airdrop delivery systems. In all of these cases, ASCD did the modeling and simulation. The commodity directorates did not send their personnel to ASCD, and ASCD did not have the time to train them to use the models and simulations. Some of the ASCD analyses showed that the systems being modeled had little or no combat value. The commodity directorates could not prove the worth of their systems or disprove ASCD's assessment. Unfortunately, this has discouraged the commodity directorates from using the modeling and simulation capabilities of ASCD.

The committee believes the commodity directorates can make better use of the RDEC's modeling and simulation capabilities. To begin with, there are only a limited number of instantiations of the soldier system to be modeled and simulated: the 21st Century Land Warrior, a multifaceted, high-technology soldier for the most challenging battlefield scenarios; the special-forces soldier, who is responsible for high performance in unique, specialized missions; the infantry soldier, who is expected to fight in more traditional situations; the peacetime soldier, who is deployed for operations other than war; the combat support soldier, who is responsible for battlefield support that requires improved technologies; and any other soldier who uses the products developed at the Natick RDEC.

Although assessing the performance for each version of the soldier system is complex, it is possible to determine a finite set of soldier-system archetypes that represent soldiers in various scenarios. The technologies being developed at the Natick RDEC can be modeled and integrated via simulation to support one or more archetypes. From scenarios and simulations, the benefits of specific RD&E programs can be estimated, and their impact on soldier-system performance can be assessed.

The committee believes that modeling and simulations by ASCD could contribute much more to an all-encompassing vision of the soldier system. This will require a paradigm shift in ASCD's views of modeling and simulation, however, as well as a change in the level of participation by the commodity directorates and STD. The committee believes the commodity directorates and STD could develop models that reflect the performance of their own technologies, and each group should be responsible for supporting its models within the ASCD modeling and simulation center. ASCD would cooperate with the developer of each model to incorporate the models into a soldier-system archetype. If the benefits of a technology could not be described via a model, the technology might offer little or no benefit for the soldier system.

ASCD now has soldier-system models that show the combat worthiness of proposed product-development programs. Some technical performance measures for these models are provided by the other directorates (e.g., information on heat stress and fatigue). However, the committee was told that the scientists and engineers in the other directorates have not provided the full range of technical parameters ASCD needs to model and simulate the performance of products accurately. The committee was astonished at the number of interviewees from the other directorates who could not identify a single technical parameter of the soldier-system their work would influence (although some could speculate). Perhaps the most beneficial aspect of involving other directorates in ASCD's modeling is that scientists and engineers would realize how their work would improve soldier-system performance. In order for an RD&E project to be funded, improving specific technical parameters should be an established goal.

The committee believes that ASCD has the potential to advance the work of the entire RDEC if it can involve the other directorates and help them to understand their technical contributions to the soldier-system. ASCD's modeling and simulation capabilities must reflect the full range of other directorates' visions, missions, plans, and programs. Currently, only select technologies, programs, and projects. are represented in the ASCD cadre of models and simulations. If ASCD can include models from each of the RDEC's programs and projects, it can help integrate the commodity directorates and STD with ASCD and ensure that models and simulations represent the value of RDEC products to soldier-system performance.

Strategic Planning

The question most often raised by interviewees was: What role in RDEC strategic planning should ASCD play? Interviewees explained that the recently established Scientific and Technical Advisory Council, which reports to the RDEC director, had taken on the RDEC's strategic planning role and that ASCD was supposed to furnish support, as requested. The information received by the committee, however, did not show that ASCD was making a valuable contribution to strategic planning. The committee suspects that ASCD was undergoing a change in roles and responsibilities related to strategic planning and that ASCD has much to offer in terms of support for strategic planning, but perhaps in a different way than before. ASCD should use the results of high-level models and simulations to confirm that the RDEC's plans and programs will benefit the soldier system.

Stakeholder Buy-In

ASCD clearly understands the vision and mission of the RDEC, and its personnel are continually developing models and improving simulations. ASCD's part in the overall RDEC mission has been well thought out, but the commodity directorates do not seem to be interested in providing adequate resources for ASCD to implement its mission. As one interviewee told the committee, customers don't always see the value of ASCD's involvement. In the case of the planning process used at the RDEC, however, customers must have recognized the value of ASCD's involvement because the profile of modeling improved greatly after the process went into effect, and funding was increased. Nevertheless, the committee did not see substantial buy-in by all RDEC stakeholders.

Leadership

The committee observed that the leadership of ASCD had empowered its employees more than in other directorates. RDEC leadership must still correct the residual fragmentation of the old policy of emphasizing parts of the soldier system rather than an integrated whole. The new emphasis is on interdependent subsystems and cooperative programs and projects as the soldier-system concept evolves. Some interviewees were concerned that senior leadership had not effectively communicated the vision of ASCD as a separate entity. Given the understanding by ASCD employees of the big picture, the committee was not particularly troubled by this. However, if future changes in the way ASCD supports the other directorates are made (e.g., as a result of this report), ASCD leadership would do well to renew communications with ASCD employees.

Overall Assessment

The committee arrived at an overall judgment of adequate for the Strategic Vision pillar. The committee observed only a modest trend toward improvement in this pillar, primarily because of the empowerment of ASCD employees and their dedication to developing better models and simulations. The committee notes that substantial improvement will require the cooperation of other directorates in the RDEC.

Quality Focus Pillar

CHARACTERISTICS OF THE QUALITY FOCUS PILLAR

- Capacity for Breakthroughs
- Continuous Improvement
- Commitment to Quality
- Structured Processes
- Learning Environment
- Quality of Research

Capacity for Breakthroughs

During the interviews, the committee was told that the problems ASCD tries to solve, with limited resources, do not tend to allow for breakthroughs. The committee understands that breakthroughs in modeling and simulation depend on how robustly the models and simulations are designed, as well as on the potential for the modeling and simulation community to develop new and innovative methods. ASCD is making incremental improvements to models and simulations, as well as in its methods and procedures for supporting the acquisition process over the life cycle of RDEC products. Few if any of the innovations, however, could be called breakthroughs. The committee suggests that the true breakthroughs for ASCD will be (1) persuading the other directorates to participate fully in models and simulations of the soldier system, and (2) using the results to convince higher-level commands and users that the RDEC products add substantial value to the soldier system (assuming, of course, that they do add value).

Continuous Improvement

The committee observed that ASCD has taken some measures to improve the quality of work and the quality of its support to the RDEC (e.g., better

modeling). Nevertheless, more attention could be paid to continuous improvement (e.g., better ways to obtain user requirements).

Commitment to Quality

ASCD demonstrated a commitment to quality through its improved modeling and simulation capabilities that support acquisition decisions. However, the committee did not observe a significant commitment to improving the quality of program management (e.g., better ways to identify, monitor, and manage cost-risk and schedule-risk and better definitions and interpretations of requirements). The committee noted the lack of a requirements database as well as of capabilities for monitoring various acquisition activities. Management has invested some resources in training and implementing quality management, but this has not permeated the organization. Personnel are aware of the need to do a quality job, but measurable objectives for improvement have not been established.

Structured Processes

ASCD models and simulations impose structure, and government procedures mandate structured programs (e.g., requirements must be explicit). The committee was told that ASCD holds regular team meetings to plan approaches to problems, check the status of programs, identify critical resources, develop contingency plans, and assign tasks. However, the committee did not find definitive processes tailored for supporting the modeling and simulation needs of STD and the commodity directorates. Instead of relying on ad hoc interactions between ASCD and other directorates, ASCD should consider establishing structured processes for assisting STD and the other directorates with modeling and simulation.

Learning Environment

The committee observed that the RDEC in general supports continuing education for its employees. Training for ASCD personnel is necessary for them to keep up with changing computer technologies (e.g., distributed simulations). Currently, ASCD does not have the resources to train other RDEC personnel in modeling. Within ASCD, teamwork is apparent among personnel assigned to specific tasks; this encourages learning from mistakes because knowledge is retained and shared. However, RDEC-wide learning could be improved by participation of STD and the commodity directorates in the modeling phases of a program.

Quality of Research

No patents have been awarded in ASCD, and only one program, the head mounted display, has been cited as "very high level." The committee observed, however, that ASCD's activities are generally aligned with internal and external customer needs and that the results of ASCD analyses are often reviewed by the Army for the purpose of making acquisition decisions. ASCD personnel have participated in modeling and simulation meetings and have developed models and simulations to represent the soldier system in distributed interactive exercises. Results of the analyses that ASCD supports have been published. However, the quality of soldier-system models and simulations could be improved by more and better information from the other RDEC directorates. The committee believes that the quality of work elsewhere in the RDEC could profit by close interaction with ASCD.

Overall Assessment

The committee arrived at an overall judgment of adequate for the Quality Focus pillar. The trend was level, but the committee saw the potential for substantial improvement, especially if ASCD and the other directorates can work together more effectively.

Customer Focus Pillar

CHARACTERISTICS OF THE CUSTOMER FOCUS PILLAR

- Customer Satisfaction
- Customer Involvement
- Market Diversification

Customer Satisfaction

ASCD meets customer expectations in many respects. The commodity directorates and RDEC management stated that, for the most part, they were pleased with ASCD support. Modeling and simulation results were provided in a reasonable time with demonstrated technical capabilities for performing operations research. Furthermore, the results were considered useful by the customers. ASCD also received complimentary reviews in the area of liaisons to customers,

although improvements could be made in requirements development and translation to the commodity directorates. However, the fact that the other directorates have had to do some customer surveys on their own and that strategic planning has been moved to another office suggests that satisfaction with ASCD support is not complete. Well satisfied customers would buy in fully to the value added by ASCD models and simulations.

Customer Involvement

Interviewees from the commodity directorates indicated that they do participate in analyses performed by ASCD to support RDEC positions or acquisition decisions by the Soldier Systems Command. Interaction between the commodity directorates and ASCD when an analysis is performed and its results are presented to higher-level commands and other DOD organizations means there must be customer involvement and feedback. However, some ASCD personnel mentioned that ASCD does not have enough time, equipment, or resources to increase the involvement of commodity directorates and STD. The committee also learned that customers are sometimes involved in setting program objectives and monitoring progress.

Market Diversification

The committee judged that diversification in program management assistance, customer liaison, strategic planning, and modeling and simulation can best be measured by the breadth and robustness with which ASCD supports its customers. Many technologies and products at the Natick RDEC need to be modeled and simulated to estimate their combat worth to the soldier system. The committee acknowledges that ASCD's modeling and simulations have supported multifaceted and diverse analyses (e.g., work on head-mounted displays and ASCD's transfer of modeling and simulation improvements to allies, industry, and academia). However, a recurring theme at Natick is that the RDEC can meet customer needs in a crisis but that meeting customer needs under normal conditions seems to be difficult. The commodity directorates do not make full use of ASCD as a resource, especially to facilitate acquisition processes when the bureaucracy gets in the way.

The committee believes that ASCD should strive for its modeling and simulations to serve the entire range of technologies and products at the RDEC. ASCD should also support all RDEC research and technology programs by helping sponsors traverse the acquisition cycle without compromising technical quality.

Overall Assessment

The committee arrived at an overall judgment of adequate for the Customer Focus pillar. The trend appeared level, but the committee noted ample opportunities for improvement.

Value Creation Pillar

CHARACTERISTICS OF THE VALUE CREATION PILLAR

- Proper Portfolio
- Product Performance
- Cycle Time and Responsiveness
- Value of Work in Progress

Proper Portfolio

As a support organization for the entire RDEC, the ASCD portfolio must address the entire range of soldier-system needs and requirements. Although ASCD presented several examples of how it has provided analyses for each of the commodity directorates, in most cases these were special situations (e.g., a commodity directorate recognized a need for a particular analysis to justify a program). Product designs have also been influenced by these analyses. However, the modeling and simulations are not complete enough to treat the soldier-system comprehensively, and modeling and simulations have not been made an integral part of the strategic planning process.

The committee observed that problems throughout the RDEC indicate a need to add substance to the seminal concept of the soldier system. The Army procures individual items, each of which may meet a specific need but adds to the large number of items that could be integrated into the soldier system. One alternative to acquiring individual items is to integrate various components into a subsystem of the soldier system (e.g., the Soldier Integrated Protective Ensemble). The best alternative would be to engineer many technologies and their applications into a single soldier system. This alternative is most closely aligned with the 21st Century Land Warrior concept being developed in SurD.

In support of the ideal of engineering soldier systems (rather than merely acquiring individual items or integrating components into ensembles), the committee believes that ASCD modeling and simulation could be used to perform operations research analyses for entire soldier systems. This approach would be

analogous to the way DOD acquires major weapons systems. However, this approach would require a paradigm shift in the ASCD from individual analyses to multifaceted trade-off studies that combine models of candidate technologies into robust simulations of soldier-system archetypes. These simulations would allow various combinations of parts and components (representing technology applications) to be compared to determine the optimal combination of soldier-system components and subsystems for particular missions. Time lines shown to the committee by ASCD suggest that models and simulations of alternative soldier-system concepts could be available between 1999 and 2003.

Product Performance

ASCD currently satisfies customer needs in many respects. However, current models and simulations must be improved to meet the increasing expectations of DOD. Ultimately, these capabilities should be able to estimate modifications to the soldier system that would best enhance the soldier's combat effectiveness and lead to conclusions in the DOD virtual environment prior to fielding a new subsystem of the soldier system. Development of this analytical capability exceeds the current capabilities of ASCD.

Cycle Time and Responsiveness

Although some interviewees told the committee that ASCD had delivered analyses in a timely manner, several said that there had been problems. The committee was told that projects have been delayed for many reasons, sometimes because of the need to "fight fires" or to respond to a request for a quick fix or urgent support. The committee believes that, except in the case of urgent support, analysis results could be provided on time. ASCD should work on developing more robust modeling and simulation techniques to allow for responses to quick fixes without causing corresponding delays in the delivery of results to other customers.

Value of Work in Progress

Some interviewees told the committee that sponsors of programs request the help of ASCD because of its prior excellent work; requests like these demonstrate the value of ASCD support. ASCD employees explained that they had previously considered the soldier system as a collection of parts, but they now consider that the parts work together with the soldier. In other words, understanding of the soldier-system concept has improved. ASCD now models

squads with small arms and bursts of munitions, does a good deal of work on soldier equipment to support SurD, and has plans to include food in its analyses. All models must be validated, however, and the committee was told that ASCD has not been able to collect sufficient data to validate all of its models.

TABLE 3-2 Summary of ASCD Assessment

Pillar	Assessment	Trend
Resources and Capabilities	Adequate to Good	Improving
Strategic Vision	Adequate	Improving
Quality Focus	Adequate	Level
Customer Focus	Adequate	Level
Value Creation	Adequate	Improving

Overall Assessment

The committee arrived at an overall judgment of adequate for the Value Creation pillar. There were modest indications of an upward trend, particularly in the understanding of the soldier-system concept. ASCD has the potential to add substantial value to the RDEC through advanced modeling and simulation capabilities.

Summary

The results of the committee's assessment of ASCD are summarized in Table 3-2. ASCD was judged adequate for four pillars and adequate to good for one pillar. Several upward trends were noted. As ASCD continues to improve, the committee is hopeful that it will aspire to provide support for the entire cadre of soldier-system archetypes, subsystems, and components. The committee believes that the functions performed by ASCD are vital to the RDEC's realizing much more of its potential. The role of ASCD spans the entire RDEC, from research on new technologies in STD to the development and engineering of products in the commodity directorates, including support of the entire soldier-system concept.

4

The Ten Key Issues

In this chapter the committee addresses the ten key issues (Table 4-1) in the statement of work between the Natick RDEC and the NRC. [1] These issues fall into three major categories (Organization and Resources, Quality and Customer Satisfaction, and Research and Technology), each of which was assessed by a different group of panel members.

The committee's judgments on all ten issues are based partly on the characteristics and metrics in the phase-one report and partly on its own expertise. Accordingly, the reader will find some repetition of the assessments in the previous two chapters. Judgments relating to the commodity directorates primarily considered all three directorates together (Chapter 2 showed that the committee did not find major differences in the assessments). The two support directorates are mostly treated individually, however, because of differences between their roles and between the committee's assessments of them (see Chapter 3).

ORGANIZATION AND RESOURCES

Issue 1.

Does the Natick RDEC have adequate funding and personnel (e.g., technical specialties and critical mass) to conduct world-class research, development, and engineering for military products and systems? Are the RDEC's facilities and equipment adequate?

Commodity Directorates

The committee found that the commodity directorates have a highly qualified, highly motivated workforce that is encouraged to upgrade and acquire new skills and to use both internal and external resources to accomplish its objectives. Members of the workforce are well connected to external technical and

[1] General references for this chapter are Brandler, 1996; Darsch, 1996; Doucette, 1996; Granchelli, 1996; Malabarba, 1996; and Salant, 1996.

scientific communities. As a consequence, all three directorates are recognized as leaders in one or more areas of technology. However, their expertise is threatened by the loss of experienced people. The ongoing hiring freeze precludes replenishment of the skill base.

TABLE 4-1 Ten Key Issues Addressed by the Committee in Stage 2 of the Assessment

Organization and Resources	
1. Does the Natick RDEC have adequate funding and personnel (e.g., technical specialties and critical mass) to conduct world-class research, development, and engineering for military products and systems? Are the RDEC's facilities and equipment adequate	3. What new organizational approaches might be beneficial (include consideration of elements of the federated laboratory concept)?
2. How effective is the current organizational structure?	4. How has establishment of the Soldier Systems Command affected the Natick RDEC?
Quality and Customer Satisfaction	
5. Are the Natick RDEC's outputs (e.g., products, systems, and research and development results) deserving of the label world-class? Is the RDEC's system to measure the quality of its outputs adequate?	7. Are the RDEC's outputs marketable to customers outside the Army? Outside the DOD? Is this marketability appropriate and adequate for an RDEC?
6. (i) Do the outputs of the RDEC meet the customers' materiel requirements? (ii) How well does the RDEC support the battle laboratories and its higher-level customers (e.g., Soldier Systems Command, Army Materiel Command, and DOD)? (iii) Is the RDEC's system to determine customer satisfaction adequate?	
Research and Technology	
8. Are the core and supporting research and technology programs world-class (or merely adequate)?	10. Are the models and simulations and other analytic methodologies used by the RDEC appropriate for the commodity areas and research and technology programs?
9. Should all current research and technology programs be continued? If not, which ones should be eliminated? Should any new ones be adopted?	

A significant amount of leveraging via external liaisons (also known as outsourcing) has been done to offset reductions in the on-site workforce and maintain programs and capabilities. Although outsourcing has resulted in some

technological advances at minimal or no cost to the commodity directorates, it also has its downside. An increasing amount of RDEC personnel time is being devoted to contract management rather than to the maintenance, development, and exploitation of the expertise internal to the RDEC.

Interviewees informed the committee that they had all of the computer equipment they needed to do their work properly. And the committee observed an abundance of computer equipment during its visits to Natick. The availability of and familiarity with computer technology has improved communications, as well as the marketing and presentation capabilities, of the RDEC.

Unfortunately, other equipment is not as abundant or up to date. Much of the equipment is aging, and the RDEC has limited resources for preventive maintenance. Some interviewees indicated they have all of the major equipment they need, but others noted that new, sophisticated equipment had not been purchased either because no one at the RDEC had the training or experience to operate it or because not enough people in the group could operate it.[2]

The committee was told that some of the roofs leak and noted many other problems during visits to the site (e.g., some ceilings); most of the facilities showed signs of age. Most, but not all, offices and work spaces were clean. Age, deterioration, and the lack of modem climate controls in the physical testing laboratories could severely impede scientific and technical work.

Some of these problems can be attributed to a lack of funding. In the past several years, most budget increases have come from external customers who have paid directorates to accomplish specific tasks. These monies have been used to address customer needs and have not affected discretionary R&D. The committee recognizes that limited budgets are now a way of life for the military, but the continuity of RDEC programs is being jeopardized, as well as the maintenance of existing facilities and the purchase of new equipment. Funding limitations even threaten the effectiveness of external collaborative programs, which could provide state-of-the-art techniques in key areas.

Support Directorates

Science and Technology Directorate. Downsizing, departures, and the hiring freeze have all contributed to the erosion of basic skills in STD. Employees are encouraged, based on their own motivation and interests, to pursue training and educational opportunities to upgrade their skills and explore new scientific interests, and deficiencies in key technical areas have sometimes been addressed by reassigning personnel from other disciplines. STD has made limited use of

[2] The committee learned during the peer-review process for this report that some laboratories have used creative approaches to obtain equipment and the people to operate it. For example, laboratories have acquired equipment and a person to run it simultaneously by using the new equipment to attract a trained person. An on-site contractor can employ the trained person and operate the equipment under a task order until the hiring freeze is lifted.

external resources, and the committee suggests STD consider leveraging other research organizations and programs.

Based on interviews, the committee found that members of this directorate resent the increasing pressure on them to pursue short-term research goals that might bring in near-term financial support. The committee also found a growing gap between STD and the RD&E needs of the commodity directorates. The committee sensed a reluctance on the part of STD personnel to analyze the relevance of their work to current program needs or to establish closer working relationships with the commodity directorates. Some important technologies (e.g., behavioral sciences and material sciences) could be strengthened within STD to facilitate stronger ties with the commodity directorates. Facilities, including computer-based technologies, appear to be adequate.

Advanced Systems Concepts Directorate. The committee first considered the customer liaison, strategic planning, and program management functions within ASCD. The customer liaison[3] function of assessing customer needs and satisfaction has been taken over, in some instances, by the commodity directorates. The strategic planning function has also been shifted to the new Strategic Planning Office, which reports directly to the RDEC director. The principal program management function of ASCD is to assist with fulfillment of federal rules and regulations and to see that RD&E milestones are met on time and on budget.

Next, the committee considered the modeling and simulation functions of ASCD. Personnel within the ASCD are capable and knowledgeable about the variety of roles modeling, simulation, and operations research can play in support of the RDEC mission. However, the committee questions whether ASCD has the critical mass to lead the RDEC in the use of models and simulations that must demonstrate to external stakeholders how the RDEC commodities can increase overall military effectiveness and efficiency (e.g., how better food translates into more enemy losses). This kind of analysis is likely to become even more important as competition for scarce military RD&E funds intensifies.

The committee believes that ASCD presently has adequate funding to support its program management, strategic planning, and customer liaison responsibilities. Facilities and equipment were also found to be adequate. However, the committee believes that ASCD does not have sufficient resources to help the RDEC fully realize the benefits of modeling and simulation. Additional resources will be needed to improve ASCD's ability to model the payoffs of RDEC programs. For example, it will probably be necessary either to hire additional personnel or to assign knowledgeable staff to train or assist researchers and scientists in modeling and simulation

[3] In February 1997, the committee learned that the customer liaison function is now performed by the Operational Forces Interface Group and the Battle Laboratories Integration Office. ASCD no longer has a separate Customer Liaison Division.

Issue 2.

How effective is the current organizational structure?

Commodity Directorates

Two of the three commodity directorates (MobD and SurD) have been reorganized into a flat structure to encourage teams to set goals and seek innovative solutions with limited intervention from management. However, having all groups report to the associate director and technical management office appears to have overwhelmed the personnel at the top. Upper management in these two directorates is now caught up in day-to-day priorities (putting out brush fires) and existing programs, but managers have little time to focus on strategic planning or implementing strategic plans.

The committee also noted that the new, flatter organizational structure limits communications among the teams. As a consequence, not all segments of the workforce understand each other's roles and how they support and complement each other. For example, members of the product development group in MobD do not seem to appreciate the potential impact of modeling in the science and technology group (MobD has its own science and technology group and does not depend on STD for support).

Although the committee recognizes the potential advantages of flat structures, implementation of the current flat structures does not appear to be effective for the long-term health of MobD and SurD. To improve the situation, staff could be assigned some additional responsibilities to relieve the workload of upper management. In addition, the committee believes that middle managers could communicate the importance and relationship of each group's activities to the overall mission of the directorate and to the missions of other groups.

During the peer-review process for this report, the committee was informed that a similar communications problem in another RDEC was attributed to eliminating the hierarchical "pipeline" that had existed before the formation of a new, flat organization. The problem was solved by recognizing that the old communication link had been broken and then incorporating a new communication strategy in the training programs developed for the teams. Management of the Natick RDEC might wish to consider this remedy.

In contrast to MobD and SurD, SusD has kept its organizational structure intact, which seems to work fairly well for day-to-day operations. The span of control is reasonable, and there is no indication that the personnel are being overworked. All personnel know their jobs and are dedicated to their tasks. The current structure of SusD encourages each group to work autonomously, which fosters the development of highly motivated teams. At the same time, however, the committee observed the same sort of cell mentality as in the flatter structures, i.e., people only work within their particular area or work cell and often feel isolated. Communication tends to flow into pockets and not across the entire

directorate. Groups often interpret things to suit their own interests, teams are entities unto themselves, and the structure does little to support integration between teams. Moreover, top management usually deals with each group as an entity, thereby reinforcing a functionally-driven structure that encourages each group to remain within its own area of expertise and interest. The committee believes that this mentality impedes strategic planning and organizational learning in SusD.

The committee found some evidence that the situation is improving among the Ration Systems and Equipment and Systems groups within SusD, which seem to be communicating and coordinating their activities more often than in the past. But the Shelters group remains an orphan. Interviewees attribute this partly to the fact that senior-level management comes from the food end of the business, and shelters is a relatively new addition to SusD. For the near future at least, the interviewees believe that management will be biased in favor of food. Some organizational efforts have been made to improve teamwork and break down functional barriers, as well as to deal with complaints and concerns. Examples include Straight Talk (an e-mail system) and town meetings.

All of the commodity directorates follow a planning process that is consistent with the Army and the RDEC planning process, but the directorates do little or no long-term planning themselves. In addition, the committee found some antipathy in all of the directorates towards the bureaucratic, management details required by the planning process. Members of the directorates feel that crisis management has become the routine mode of operation, and they have become disenchanted with the amount of contract management they must do with outsourcing. The committee found a strong commitment to the missions of individual directorates and trust in directorate leadership but did not find a strong sense of connection with the broader RDEC soldier-system mission.

Support Directorates

Science and Technology Directorate. The committee assessed the effectiveness of the STD organization by considering how well and how much it contributes to the other directorates' performance and ultimately to the efficacy of the soldier-system concept. The effectiveness of STD's organizational structure is specifically related to the way personnel are grouped into teams to develop or improve specific products and enhance soldier-system performance. The committee found several examples of STD effectiveness (e.g., chemical analysis and research to improve the quality and shelf life of foods; scientific measurement and research into anthropometry of soldiers; physiological and behavioral research to evaluate the effect of environmental conditions and stress on soldiers' performance; and biomechanics for materials development).

STD's support for the commodity directorates varies. STD does little to support MobD but has several programs that support SurD (e.g., materials research and development); the committee was informed that these programs were established principally in response to SurD requests rather than STD initiatives. STD also has several programs that support SusD (e.g., behavioral sciences). The committee was told, however, that SusD has asked many times for support in materials research but has not received it.

Based on interviews, the committee believes that important elements are missing from the STD organization, especially a comprehensive understanding of how technology can ultimately be applied to the soldier system and an understanding of which specific areas of emphasis by STD would have the highest payoff. The basic technologies on which the STD organization concentrates are biomechanics, materials research, behavioral science, and product acceptance. However, there are a host of other technologies that could be researched and engineered into the soldier system. Of course, it would be a mistake for STD to try to cover all areas at once, but it should focus on the areas that offer the highest payoffs. Another missing element is a master plan showing how all of the research at the RDEC, internal and external to STD, supports the needs of the commodity directorates and performance of the soldier system.

The committee suggests that the STD organization investigate the soldier system concept and identify all potential technologies that could be considered as thrust areas. Although only a few can be pursued at any one time, the committee believes the entire STD organization would be more effective if it could articulate the importance of its technology thrusts in comparison to alternatives, all in the context of soldier-system performance. Perhaps the modeling and simulations of ASCD could help in this regard. Also, the new strategic planning process could lead to the development of an RDEC-wide master plan for research that would be very useful to the research-oversight role of STD.

Advanced Systems Concept Directorate. The committee learned that ASCD was originally chartered to facilitate the milestone decision process. This process involves ensuring that funding is in place, that requirements are written, and that the RD&E proceeds in a structured way so the user is ready to accept the final products. The process also involves working with the integrated planning teams of the RDEC to ensure that the highest priority programs and projects are funded and well managed. At the Natick RDEC, ASCD tries to achieve this broad objective through its various organizational units.

The ASCD Operational Forces Interface Group and the Battle Laboratories Integration Office serve as interfaces with customer organizations. The committee believes that RD&E programs that do not have a requirements base to support them should not be pursued until the RDEC (presumably, through ASCD) has established a strong relationship with the appropriate Army or other government customer. To pursue RD&E without a sanctioned customer is often detrimental to the progress of discretionary activities. There were indications in the interviews that ASCD has not always provided the commodity directorates

with necessary information about requirements and potential customers. In those cases, the directorates had to take on some of the customer liaison function themselves.

The committee believes that ASCD should place more emphasis on, perhaps even develop a formal database,[4] correlating customer requirements with the RD&E programs of the RDEC. Management of the RDEC should consider either assigning this function to one of the divisions within ASCD or to incorporating this function into the individual commodity directorates to ensure that all projects are working to meet current, supported, validated Army (or other customer) requirements.

The committee believes that strategic planning in the RDEC director's office has supplanted ASCD's role as strategic planners for the RDEC. Some adjustment or redefinition of roles and responsibilities should be made to ensure that resources formerly devoted to this function at ASCD can either be used to support future strategic planning or can be used to support other activities.

ASCD performs modeling and simulation in support of decisions by the commodity directorates and is an interface between the RDEC and other Army organizations, including organizations that conduct intra-and interservice modeling. The ASCD modeling and simulation capability is used to demonstrate the combat worthiness of products and concepts being developed by the commodity directorates. Modeling and simulation have been used by individual commodity directorates to demonstrate the impact of food delivery systems, clothing and individual equipment, and airdrop delivery systems. However, the committee found that the commodity directorates have relied upon ASCD to conduct the modeling and simulations and that their own personnel did not contribute to (and were not trained in) the use of these capabilities. In addition, individual directorates did not pursue up-front studies to support models by ASCD for evaluating the combat worthiness of their products. An exception is MobD, which has used some modeling and simulation studies to evaluate ideas for airdrop delivery systems.

The committee believes that there is a distinct connection between the level of information available from the individual commodity directorates and the level of information in the models used by ASCD to assess combat worth. This is also true of ASCD's models of overall soldier-system performance, which can show how the introduction of a new technology can significantly improve soldier-system performance. Determining benefits requires identifying the technical performance measures for the technology, modeling the technical parameters to

[4] This marketing-oriented database may or may not relate directly to databases already in existence at the RDEC. The committee is fully aware that the RDEC has surveyed many soldiers for many years and has accumulated a large database of ratings of customer satisfaction. The committee is also aware of RDEC attempts to measure customer satisfaction indirectly (e.g., by increases in direct funding by customers). In 1996, the committee was informed that one of the RDEC's customer-focus initiatives involved the development of a central, integrated customer database (Faulkner, 1996). The committee is not aware of progress on this initiative or exactly what it entails.

represent the technological contribution, and ensuring that the technology is accurately integrated into the soldier-system concept. This will require more direct interaction between the commodity directorate personnel and the modeling and simulation personnel of ASCD.

Issue 3.

What new organizational approaches might be beneficial (include consideration of elements of the federated laboratory concept)?[5]

This subsection begins with some general comments. A major problem facing the RDEC is maintaining and, if possible, improving its current level of performance as the downsizing of the U.S. defense establishment takes its toll. New organizational approaches will probably be among the many alternatives considered by RDEC managers trying to cope with this problem. The committee suggests that new organizational approaches should promote team building, especially between the commodity directorates and the support directorates. For example, people who develop products should work closely with researchers or the developers of simulations. The end result of new organizational approaches should be cohesiveness of the entire RDEC, which will enable the RDEC to marshal scarce resources and focus them on the most significant tasks.

Commodity Directorates

If resources for the military continue to be constrained, as is likely, the military will certainly have less influence on the development of technology. In the future, there may be few alternatives to a federation of laboratories that will have the critical mass to fulfill the RD&E needs of organizations like the Natick RDEC. Federations might also support Air Force and Navy interests. At the directorate level, members of MobD, for example, felt that the federated laboratory concept would be a big plus for their organization, but they were concerned about incurring additional administrative work. The committee suggests that the RDEC investigate how the benefits of the federated laboratory concept could be realized without an excessive administrative burden.

[5] The federated laboratory concept is a new paradigm of operation for the Army Research Laboratory (ARL, 1994). Under this paradigm, the Army laboratory collaborates with external centers that have technical expertise "to forge direct associations with industry and university laboratories with recognized competencies in specific technology areas." Typical features of this arrangement include heavy reliance on the private sector in areas where it has the lead and commitment, the integration of outside work with Army in-house capability to ease the transition to the Army, the maintenance of strong in-house capabilities in Army-unique areas where there is little investment or outside interest, and an "open laboratory" that allows government researchers to work at industrial and academic sites and vice versa.

The examples below highlight areas in which RDEC personnel involved in food processing and packaging could work productively with outside groups.

- By keeping abreast of work being done to eliminate microorganisms or other harmful elements in foods, the Natick RDEC could transfer this knowledge to military rations or feeding systems.
- By keeping track of work on evolving nutritional requirements, RDEC personnel could incorporate these requirements into military rations.
- By monitoring the development of higher performance or lower cost packaging materials, RDEC personnel could take advantage of improvements that could benefit the Army.

Outsourcing will continue to be a necessity in the face of smaller budgets and other directives and restrictions. Outsourcing creates some problems, however, for technical personnel, whose interests and expertise are in technical areas, not in contract management. Many employees complained in the interviews about the many hours they had been made to spend in acquisition training that could have been better spent in outside technical activities. Perhaps the RDEC could find a way to separate the technical and contract management and acquisition functions. This would strengthen the RDEC technical base, which has already been eroded.

The new, flat organizational structures adopted by MobD and SurD and the more traditional structure maintained by SusD both have problems. Perhaps a modified fiat structure that includes middle managers to relieve the workload of upper management and to enhance communication among groups should be considered. In that way, the advantage of flattening the organization could be retained while the empowerment of self-directed work teams could be ensured. Technical excellence may not be the most important criterion for promoting someone to middle management. Individuals who can focus on employee morale and empowerment, enhance communication and teamwork, are concerned with customer satisfaction and quality processes, and who can concentrate on staff career development would be good candidates for middle management positions.

Support Directorates

Science and Technology Directorate. To improve its effectiveness, STD should attempt to identify the full range of technologies (from external as well as internal sources) with the potential to support the ideal soldier system. In the committee's opinion, STD seems to have lost all connection with the R&D needs—both short and long-term—of the commodity directorates. As a result, the commodity directorates have initiated their own research programs, particularly to address short-term requirements.

The weak relationship between STD and the commodity directorates, which is critical to the technological capabilities of the RDEC, is a good reason for the RDEC to reevaluate the roles of basic and applied research (see definitions in Chapter 3) within the mission of the Natick RDEC. This reevaluation could improve the RDEC as a whole.

Advanced Systems Concepts Directorate. Several ways to improve the current organization of the ASCD have already been identified. The functions of strategic planning and customer liaison by ASCD need to be reevaluated so that they more effectively support the RDEC. Most important, ASCD, with the assistance of RDEC management, must enhance the value of modeling and simulations to the commodity directorates and to STD.

Issue 4.

How has establishment of the Soldier Systems Command affected the Natick RDEC?

The committee concluded that the establishment of the Soldier Systems Command has had several negative effects on the Natick RDEC. Most important, the command has drained off many talented people. Since a hiring freeze was imposed on the Army Materiel Command at large, RDEC personnel have only two ways (short of leaving the Natick area or finding a job outside the Army) of increasing their salaries or improving their positions: (1) promotion within the RDEC when someone in a higher-level position is transferred or takes early retirement, or (2) being hired at Soldier Systems Command. When the latter was formed, some of the best personnel in the RDEC were offered jobs, and these people took the opportunity to improve their financial and organizational status. But the RDEC was diminished because the hiring freeze did not allow the RDEC to replace them. The quality and quantity of work within the commodity and support directorates has been directly affected by the loss of personnel to the Soldier Systems Command.

The Soldier Systems Command has created new layers of management that RDEC personnel must respond to on a daily basis. To some extent, this situation has fostered an "us versus them" atmosphere (i.e., the RDEC versus the command). Many interviewees were concerned that the head of Soldier Systems Command (a civilian) is only the *acting* head, although two-star generals are in charge of the commands over other facilities on the same level as the Natick RDEC. The impression, in the minds of the interviewees, is that Natick is not as important to the Army as other facilities, an impression that could have a negative impact on Natick's ability to secure future funding. Finally, many personnel are convinced that the Soldier System Command has caused reductions in the RDEC's budget.

One perceived advantage of the creation of the Soldier Systems Command has been to increase the chances that the RDEC will survive. Many of the interviewees felt that the Natick facility would have been targeted for closure if the Soldier Systems Command had not been created to give the organization greater visibility and a champion to fight for its survival.

In the committee's view, the most important positive effect of the establishment of the Soldier Systems Command is the attention it has brought to the soldier-system concept, which represents an orderly approach to the problems of equipping the men and women who serve in the U.S. military. The committee was gratified to learn that some interviewees also appreciated this positive effect.

QUALITY AND CUSTOMER SATISFACTION

Issue 5.

Are the Natick RDEC's outputs (e.g., products, systems, and research and development results) deserving of the label world-class? Is the RDEC's system to measure the quality of its outputs adequate?

Commodity Directorates

This two-part issue falls under the heading of quality and customer satisfaction. However, the first part requires consideration of all five pillars of world-class performance.

The committee measured quality and customer satisfaction in the commodity directorates according to the Quality Focus, Customer Focus, and Value Creation pillars (see Chapter 2). When the committee applied its metrics to each of these pillars, the overall ratings were adequate to good for the Quality Focus pillar and good for both the Customer Focus and Value Creation pillars. The remaining two pillars, Strategic Vision and Resources and Capabilities, were rated poor to adequate and good, respectively (see Chapter 2). The committee concludes that, although the commodity directorates are performing well in several respects, they are not performing at a world-class level. Indeed, world-class performance is difficult to achieve. The committee recognizes, however, that many noteworthy products have been developed at Natick (e.g., food products, organizational equipment, protective clothing, and airdrop capabilities) and that more are likely to be developed in the future. (A discussion of R&D at the RDEC appears later in this chapter.)

Turning to the second part of the issue, the committee found that several external programs are in place to measure the quality of RDEC outputs (e.g., the President's Quality Award, the Government Performance and Results Act, the

Army Science Award, and biannual quality audits of MobD by the Airborne Airlift Action Office). Internally, management and staff at the RDEC have a positive attitude toward improving quality, and personnel appear to be responsive to quality initiatives at the directorate level.

Measures are being put in place, with input from the workforce, to develop metrics for assessing research and technology programs. Members of MobD have attended Motorola University training sessions, and some quality metrics are being planned. The leadership of SusD is attempting to implement metrics that are more appropriate than the ones used in years past, and SusD staff has been given training in quality processes. At the RDEC level, the integrated planning process has the appropriate elements, stakeholder and customer input, team-set objectives, and project monitoring, to be potentially useful in structuring the planning process. The internal RDEC-level and directorate-level processes, coupled with the external programs, appear to be adequate to measure quality.

Support Directorates

Science and Technology Directorate. Although the committee did not evaluate all of STD's technical publications from the last two years, the committee is confident that this research is commendable. However, the committee feels that the discontinuity between STD research and the needs of the commodity directorates is a significant problem. For this reason, STD products do not meet the highest standards, which include meeting customers' (i.e., the commodity directorates) needs. In addition, the system STD uses to measure the quality of its services has not revealed the source of this problem. To some extent, the STD and the commodity directorates must share the responsibility for identifying and resolving this problem. The commodity directorates should demand the research support they need.

Advanced Systems Concepts Directorate. Although ASCD meets the expectations of its RDEC customers in many respects, other groups within the RDEC have assumed some of ASCD's designated responsibilities (e.g., an office that reports directly to the RDEC director has taken over strategic planning). The committee believes that ASCD needs a structured mechanism for evaluating the quality (and value) of its services. There is no mechanism, for example, for assessing the capabilities of modeling an individual soldier. The committee believes that validating models and simulations should be of primary importance to ASCD as well as establishing quality measurements for modeling soldier-system archetypes.

Issue 6 (i).

Do the outputs of the RDEC meet the customers' materiel requirements?

Commodity Directorates

The committee found many instances when commodity directorates had met customers' materiel requirements. For example, in MobD great strides have been made since 1976 in reducing the number of parachute malfunctions; for this, and for the guided parafoil aerial delivery system (light), MobD was awarded certificates of achievement, which indicate customer satisfaction. SurD has delivered many impressive products and technological improvements to its customers, including advanced ballistic-protection materials; lightweight materials for chemical and biological protection; durable, static-resistant battle wear; water- and fire-resistant, camouflage-printed, near infrared-signature reduced, antistatic, high durability, and high strength materials; and reflective technology for laser-protective eye wear. SusD has completed projects, such as the multifuel burner, the high pressure air beam structure, Force Provider, and meals-ready-to-eat, that meet or exceed customer requirements and, for the most part, could not have been purchased from the private sector. SusD is widely recognized, both within DOD and outside the government, for meeting customer requirements, particularly in the food area. For example, in 1996 SusD received the prestigious DuPont Award for Innovation in Food Processing and Packaging Technology.

Despite these successes, the committee found indicators of existing and potential difficulties in maintaining the RDEC's ability to meet customer requirements. All three commodity directorates have experienced a loss of skilled personnel, a lack of common focus, and a tendency to meet short-term customer requirements at the expense of projects that could meet longer-term requirements. The committee highlights below a long-term problem that the RDEC cannot solve by itself, although the RDEC could influence others to effect a solution. The problem involves establishing customer requirements for advanced technologies. The committee uses airdrop as the example.

MobD's ability to anticipate and meet future materiel requirements is limited by the Army's narrow definition of airdrop technology as serving only the individual soldier. In the operational requirements and the Army Science and Technology Master Plan, little attention is paid to other airdrop requirements, even those that would directly support Army activities. Thus, the Army has not communicated a broad strategic vision for airdrop to MobD. However, the RDEC's increased attention to a wider range of customers (e.g., the Air Force) could lead to the endorsement by the Army or another service of a broader strategic vision, which could include requirements for advanced airdrop technologies from MobD.

Support Directorates

Science and Technology Directorate. The committee consistently heard from interviewees in the commodity directorates that STD products cannot easily

be integrated with their products. Obviously, from their perspective, STD is not satisfying their requirements.

Advanced Systems Concepts Directorate. Based on interviews in the commodity directorates, ASCD modeling and simulation are not sufficient to reveal the higher-level benefits of the commodity directorates' products. Nevertheless, when the interviewees were asked to specify parameters that would improve ASCD modeling, almost none of them could specify technical information that they could supply to the ASCD. The committee is convinced that the commodity directorates need to use modeling and simulation to compare the performance of their products to a baseline and, more importantly, to determine the impact of integrating technologies or products into the cadre of parts, components, and subsystems that make up the soldier system.

The idea of demonstrating through higher-level analyses that a new product or technology has marginal worth may seem a bit idealistic to people who want to keep working on what they know best. But new products or technologies that do not show potential improvements to soldier-system performance should not be pursued. In this era of limited resources for the U.S. military, ASCD's modeling and simulation capabilities must show the benefits of a proposed product or technology before the expensive acquisition phase of a program begins.

Issue 6 (ii).

How well does the RDEC support the battle laboratories and its higher-level customers (e.g., Soldier Systems Command, Army Materiel Command, and DOD)?

Commodity Directorates

The advanced precision airborne delivery system is a good example of MobD's support of the Early Entry Lethality and Survivability Battle Laboratory and the Army Quartermaster School. The guided parafoil aerial delivery system (light) is a good example of acquisition reform by the Army Materiel Command. On the basis of this kind of evidence, the committee believes that MobD adequately supports the battle laboratories and other high-level customers. However, the committee notes that this opinion is based primarily on input from MobD personnel and awards and certificates from the Army. The committee did not have an opportunity to query a range of higher-level customers.

SurD's relationship with and support of the battle laboratories also appear to be strong; the organizations have common goals and have established effective partnerships. SurD's relationships with Soldier Systems Command and higher-level customers are more formal and have many layers, but innovative communications have resulted in positive working relationships with key personnel.

For the most part, information available to the committee indicates that SusD currently does well in supporting the battle laboratories and higher-level customers in the food area. The level of support is also considered quite good in the shelters area. However, based on the committee's interview of one external customer, a program manager, the food group within SusD may be less supportive than the shelters group.[6]

Support Directorates

Science and Technology Directorate. STD has no direct interaction with the battle laboratories. It supports these and other higher-level customers indirectly through its support of the RDEC's mission as executed by the commodity directorates.

STD contributes to the fundamental knowledge base through publications of basic research results and attendance at and participation in conferences and symposia. Some of this may have relevance to higher-level customers. But the committee feels strongly that STD should concentrate on serving the research requirements of the RDEC directorates and Soldier Systems Command, which can still provide opportunities for STD personnel to publish and maintain their external visibility.

Advanced Systems Concepts Directorate. ASCD interacts directly with the battle laboratories and has an individual on site at the Dismounted Battle Space Battle Laboratory to facilitate interaction. ASCD has not established a similar liaison with the Combat Service Support Battle Laboratory, a liaison that would be germane to ASCD's support for SusD and MobD and important for understanding requirements for the commodity directorates.

Issue 6 (iii). Is the RDEC's system to determine customer satisfaction adequate?

Commodity Directorates

The commodity directorates rely largely on processes established within the Army and Natick RDEC for assessing customer satisfaction. The Soldier Systems Command conducts an annual survey of customer satisfaction with the battle laboratories and quartermaster schools. Members of the Operational Forces Interface Group within ASCD, who survey soldiers in the field, use a very general survey that cuts across the various Natick RDEC product lines from food to

[6] Earlier the committee noted that the shelters group is an orphan in SusD. Better communications within SusD could help the other groups learn from the apparent successes of the shelters group with one of its customers.

clothing to shelters. The survey results provide equipment-oriented feedback. Customer satisfaction internal to the RDEC is not directly assessed except through surveys of workforce morale.

The committee was informed that the external surveys are of limited value to a directorate like MobD because the Operational Forces Interface Group rarely has an opportunity to survey an airborne unit. Therefore, to obtain airdrop-related feedback, MobD has developed a survey that emphasizes parachute performance and has administered this survey at airborne-related conferences. The committee learned that SurD also has representatives who obtain customer feedback.

The committee believes that the most difficult information to get is honest feedback from the decision makers in the higher headquarters of the Army. Communications with these groups is very formal, and RDEC personnel perceive that many layers of censorship inhibit positive working relationships with these critical customers.

Overall, the customer focus pillar was assessed as good for the commodity directorates (see Table 2-4). However, the customer satisfaction characteristic received the lowest rating of the three characteristics. Therefore, the committee offers the following suggestions for improving customer satisfaction.

The committee heard of several products that the commodity directorates had delivered that had been met with a high degree of satisfaction by the customer. In addition, some of the units within each of the directorates had established means by which they could qualitatively assess the level of customer satisfaction with their products and services. Nevertheless, the committee did not find regular, rigorous, quantitative measurements of all customers' satisfaction with individual units or the RDEC as a whole. This information would indicate areas that need improvement, as well as demonstrate the RDEC's effectiveness to customers at all levels. Accordingly, the committee suggests that the Natick RDEC consider implementing a regular, rigorous procedure for evaluating customer satisfaction. Elements of such a procedure are described below.

The directorates should obtain specific data on what they have accomplished for their customers, whether these accomplishments satisfied the customers' needs and desires, and whether the customers want new accomplishments. This information would help in the internal planning process and would provide evidence of customer satisfaction that the RDEC could use to describe its accomplishments externally. One of the best ways for the RDEC as a whole to receive information would be for the RDEC director to communicate annually, in writing, with the leaders of the RDEC's major customers. The communication could say, "This is what we accomplished for you in the past year. Did it meet your expectations? If not, why not? If so, how might we improve? What can we do for you next year?" This type of communication would be hard for customers to ignore, and their answers would provide useful insights to managers and the workforce at the Natick RDEC. It would supplement, not replace, the current program of surveying individual soldiers concerning their satisfaction with products from the RDEC.

Support Directorates

The support directorates need to be reminded continually that customer satisfaction is not restricted solely to external customers. Indeed, the communication procedure suggested above for the commodity directorates could be used by the support directorates to obtain feedback on how well the needs of their internal customers (i.e., the other RDEC directorates) are being satisfied by the work of the support directorates

Science and Technology Directorate. STD uses conventional measures to judge external perceptions of the quality of its work (e.g., refereed journal articles, patents, presentations, awards, number of symposia chaired). However, the committee determined that STD has no effective measures by which to judge the satisfaction of its internal customers, the commodity directorates.

Advanced Systems Concepts Directorate. ASCD's current system for determining customer satisfaction—both internally and externally—could be greatly improved. At a minimum, ASCD should solicit candid feedback from higher headquarters and capture in surveys the subjects of interest to each of the commodity directorates so they do not have to conduct their own surveys. (STD may play a role in this because it helps to design the surveys.) ASCD could also assist the RDEC Director and leaders of the commodity directorates by preparing and processing communications (like those described above) to various customers.

Issue 7.

Are the RDEC's outputs marketable to customers outside the Army? Outside the DOD? Is this marketability appropriate and adequate for an RDEC?

Commodity Directorates

For MobD, whose primary output is airdrop products, the Air Force, Special Operations Command, National Aeronautics and Space Administration, Marines, and occasionally the Navy have been and will continue to be customers. These are traditional, appropriate markets for an RDEC. A less traditional market, the private sector, has limited use for MobD parachute systems. However, if one views MobD's product as the design and fabrication of high-performance fabric structures, then it might be attractive to the private sector, for automotive air bags, for example. One can imagine that the fluid and structure simulation being developed by MobD could be applied to the simulation of thin-coating flows over a deformable substrate (e.g., the manufacture of paper or magnetic tape). Technologies produced by the MobD New Ventures group, such as personnel augmentation devices, could easily be adapted for the civilian market. However,

the New Ventures group must become viable before attempting civilian-sector diversification. The committee concluded that the private sector could be an appropriate market for some MobD products.

SurD's products are already being marketed to customers outside the Army and DOD, including the U.S. Postal Service and the North Atlantic Treaty Organization. New markets in the civil sector are also being explored. The associates of the SurD Business Management Office solicit customer input and feedback to generate new business opportunities. An expanded market base appears to be appropriate and necessary, not only to satisfy the needs of external customers, but also for budgetary reasons and for expanding the technology base in the RDEC. However, the committee suggests that the marketing skills of the associates in the Business Management Office should be improved if market diversification becomes a high priority.

SusD, more than any other directorate, has products with significant potential for use by customers outside the Army and even outside the military. Force Provider was initially developed for the Air Force, but other branches of the military also use rigid wall shelters and organizational equipment. The Navy has recently contracted with the RDEC for the development of improved food service kitchens for the future fleet. The food program has historically generated products used in the private sector. In the past, Natick R&D programs in food irradiation and microwave heating have led to applications in the private sector. Currently, SusD has several cooperative R&D agreements with leading food processors for projects dealing with nutritional and performance bars and the microwave sterilization of foods.

The committee considered whether the RDEC should aggressively market its products outside the Army and outside the DOD or should attempt to diversify its products for the private sector. The committee believes it is appropriate, if not essential, for the RDEC, as for other government laboratories (e.g., within the departments of Energy and Commerce), to market its products as broadly as possible. But the committee does not advocate that the RDEC market its products outside DOD at the expense of its military customers. The performance of the RDEC must be measured primarily in terms of its value to the military. In the case of MobD, for example, marketability could require that MobD divert significant attention away from parachute technology. Designing a parachute system is not only science; experience plays a considerable part in the design process. Working on automotive air bags or thin-coating flows might not enhance MobD's simulation tools for parachutes or its capabilities to design and fabricate parachutes. MobD's capabilities can best be leveraged by applying them to the problems of deceleration and soft landings.

In the committee's opinion, the RDEC's current level of dual-use products is adequate and appropriate. This does not mean, however, that additional diversification should not be attempted; in fact, there are good reasons for diversification. But in order to sustain its marketability outside the Army and DOD, the RDEC must first overcome the problems created by the hiring freeze; if

things continue on their present course, the technical capabilities of the RDEC could erode to the point that private sector interest in RDEC products disappears.

Support Directorates

Science and Technology Directorate. To the extent that external researchers consider research by STD to be of high quality and to be applicable to their particular problems, STD's output could be of considerable interest to the scientific community outside of Natick, especially in the fields of behavioral science, biomechanics, and biomaterials. However, STD's first priority should be direct support of the commodity directorates, which have products and services that could be marketed broadly. Therefore, the marketability of STD's output is best indicated by its impact on the marketability of commodity directorate products. However, the links between STD and the commodity directorates are so weak that the committee concluded that even the internal marketability of STD's outputs is questionable.

Advanced Systems Concepts Directorate. ASCD's customer surveys might solicit, or be structured to solicit, information to assist the commodity directorates in developing new markets. STD provides assistance to ASCD in designing surveys and could also play a role in structuring surveys for market development.

RESEARCH AND TECHNOLOGY

Issue 8.

Are the core and supporting research and technology programs world-class (or merely adequate)?

Commodity Directorates

Mobility Directorate. The research in support of aerial delivery systems is not well linked with development, though the situation is improving. The computational analysis and experimental teams are also not linked well. The parachute inflation modeling and simulation may be the best in the Army, but because of limited funding researchers cannot exploit state-of-the-art capabilities in academia, industry, and other federal agencies. The integrated planning process is an opportunity for MobD to evaluate research programs on a yearly basis, which will ensure that research and technology programs are relevant to the MobD and RDEC missions. Certain development capabilities (e.g., in heavy cargo airdrop) are among the best, if not the best, in the world. When asked to rate themselves according to the committee's metrics, most MobD personnel rated the quality of their RD&E programs as adequate to good. Unfortunately, MobD receives virtually no support from STD.

From a broader standpoint, the committee's assessment of all five pillars of a world-class Army RD&E organization indicated that MobD has not achieved excellence in any one of them. Some characteristics considered relevant to research and technology received an assessment of good or good to excellent (e.g., RD&E capabilities, skills, talents; cycle time and responsiveness), but the characteristic of strategic planning, which is also relevant to research and technology, was rated poor. The committee's assessment of research (and development) quality was adequate to good. Thus, based on the committee's definition of world-class performance, the MobD core and supporting research and technology programs cannot be considered world-class, even though pockets of excellence exist.

The achievement of world-class status by MobD is restricted by several factors. First, severe restrictions on research funding prevent MobD from conducting basic research and keep development projects to a minimum. Second, MobD receives no support from STD in identifying and fostering basic research germane to the mobility mission. Third, the one-deep expertise level is jeopardized by near-term retirements and the concomitant loss of valuable expert knowledge. Fourth, MobD as an organization sees only Army-defined objectives even though it is trying to provide armed-forces-wide support. Fifth, the internal perception is that MobD's mission is focused only on airdrop and not on the broader concept of mobility. For all of these reasons, MobD has not been able to implement the long-term, broad-based strategic R&D that would make it world-class.

Survivability Directorate. The majority of core and supporting research and technology programs for SurD reside within the directorate (80 percent); the rest reside within STD (10 percent) and ASCD (10 percent). Most of the research and technology programs are not considered to be pacing. The core capabilities of the directorate are threatened by funding and hiring restrictions; and the core capabilities appear to be shrinking as the workload is shifted from internal research and technology toward contract management. The bureaucratic nature of the organization is increasing while the technical expertise and the focus of the SurD's research and technology organization are being diluted. Although SurD will continue to have ample technical capabilities, its current circumstances inhibit implementation of a robust, long-range R&D program that would put the directorate at the world-class level.

Sustainability Directorate. The committee considers several SusD technologies to be among the best in the world based on their ability to fulfill soldier needs and the broad recognition of their quality. These technologies involve food processing and packaging, multifuel burners, and high-pressure air beams. The Natick RDEC, through SusD and predecessor organizations, has delivered high quality rations that meet the difficult requirements of a military organization. Rations have been formulated to meet the nutritional requirements of troops in the field and are packaged to withstand the rigors of long-term storage

and battlefield use. SusD's packaging has been independently recognized, as evidenced by the prestigious DuPont Award for Innovation in Food Processing and Packaging Technology. The multifuel burner meets and exceeds the requirements of users and offers significant improvements over the safety, performance, and utility of the current version. Finally, the development of high-pressure air beam technology for structures has greatly improved shelter design and utility and greatly reduced the amount of effort needed to erect relatively large shelters.

Nevertheless, the committee's across-the-board assessment of SusD (see Chapter 2) revealed several areas of less than excellent performance in areas relevant to research and technology (e.g., strategic planning and quality of research). Thus, although the committee found examples of excellence, it cannot conclude that the SusD core and supporting research and technology program is at the world-class level.

Support Directorates

Science and Technology Directorate. The examples provided to the committee suggest that the research and technology programs conducted within STD are well respected externally. However, STD's primary customers, the commodity directorates, find it difficult to make use of the STD research publications, patents, and results. Because the primary customers of STD cannot fully use the research and technology products of STD, STD must be judged only as adequate. The committee observes that this is another situation where benefits could accrue if the bonds between STD and the other directorates were strengthened. If STD and the other RDEC organizations worked more closely with one another, STD research and technology would probably become more relevant.

Advanced Systems Concepts Directorate. The committee focused on ASCD's modeling and simulation capabilities, particularly how well they support assessments of the potential effects of RDEC products and technologies on soldier-system performance. ASCD models seem to handle well the gross measures that characterize units and their impact on unit capabilities and performance. But they are not yet at the stage where, without significant manual intervention in the model structure, they can handle fundamental parameters characterizing the individual components related to soldier performance, the details that determine unit performance and overall outcome. As a consequence, the impact of new technologies cannot be easily assessed via these models to provide the commodity directorates with feedback to motivate changes in their products.

Effective feedback requires a three-way interaction between ASCD, the appropriate commodity directorate, and STD to determine and provide the appropriate technical and behavioral parameters that influence performance and

are best suited for the models. The committee believes that several benefits would accrue if management of the RDEC would strengthen bonds among the support directorates and the commodity directorates.

Issue 9.

Should all current research and technology programs be continued? If not, which ones should be eliminated? Should any new ones be adopted?

Commodity Directorates

Mobility Directorate. There are three research and technology programs within MobD: one focused on computational modeling and simulation, one focused on experimental studies, and one focused on technology demonstrations of integrated concepts. The coupled-fluid and structure-interaction simulation shows great promise of reducing the time and costs of full-scale testing. The experimental studies focus on new parachute concepts, advanced soft-landing concepts, and the gliding-wing opening process. The technology demonstration programs in precision offset, high-glide aerial delivery of munitions and equipment (e.g., advanced precision and guided parafoil aerial delivery) have led to designs for hardware, fabrications, and flight tests.

The committee is concerned that these three programs are somewhat disconnected. For example, the experimental studies do not provide data to validate the numerical simulation of canopy inflation. Similarly, the numerical simulation is not sufficiently mature to provide guidance for designing an advanced precision aerial delivery capability, and vice versa; physical insights into parachute flow fields during development of the advanced precision aerial delivery system have not been included in the simulations. The committee also notes that little of the data from these research and technology programs is used by ASCD for cost-effectiveness analyses.

The committee is hesitant to specify which research and technology programs should be eliminated. However, one or more of them must be reduced or eliminated so that an experimental study can be initiated to supply validation data to the simulation study. MobD research and technology plans should include support for ASCD modeling and simulation.

The ground mobility mission appears to have been squeezed into MobD upon reorganization and has not been well received or well funded. A critical decision needs to be made as to the proper home for this group. Either MobD must accept its broader mission of soldier mobility and actively embrace the group, or MobD must drop it entirely. If MobD drops it, the RDEC will have to decide if there is a better location for the ground mobility group elsewhere at Natick or outside of Natick.

The committee notes that both the integrated planning process and the planning integration team have recently been initiated to provide structure to the

overall strategic planning process associated with research and technology at the RDEC. Both methods are too new to judge their effectiveness. However, they have the appropriate elements, stakeholder and customer input, team-set objectives, and project monitoring, to be potentially useful. Some fine tuning may be required after several years of experience, but the new overall strategic planning process should answer MobD's questions concerning the adequacy of existing and future research and technology programs.

Survivability Directorate. In light of budget cuts and downsizing, some SurD research and technology programs will have to be eliminated. The committee is reluctant to recommend that specific programs be dropped because it did not evaluate the worth to the soldier system of each program in SurD. Nevertheless, the committee believes that programs related to protecting the lives of soldiers in future battles are far more important than programs that concern noncombat clothing and involve SurD in bureaucratic battles about uniforms for female officers (see Chapter 2). An atmosphere in which everything must be considered important and everything must be worked on is no longer practical. All programs now require frequent and careful scrutiny to establish priorities. RDEC-unique capabilities and customer input should be included in the assessment of a program's value and in choosing new programs. Leveraging other military and government laboratories and partnerships with industry and academia are important aspects of this process.

Sustainability Directorate. SurD should pay some attention to pursuing science and technology initiatives in relevant areas so that short-term goals can be more easily met and long-range objectives addressed. These initiatives should include, but not necessarily be restricted to, R&D on air beams (which, to the credit of the individuals involved, has been added to the directorate's activities) and new materials for constructing shelters.

Support Directorates

Science and Technology Directorate. STD's basic role is to supply research to support the rest of the organization and to exploit opportunities to expand RDEC support for the soldier system. STD's core science and technology activities were originally chosen because they were believed to have the broadest applications to the RDEC. The committee believes that STD's thrust areas need to be reevaluated for their relevance to the requirements of the commodity directorates. Several committee suggestions are set forth below.

Some restructuring may be warranted (e.g., integration of the current biotechnology program, which focuses on new materials produced by recombinant technology, with a materials science thrust area). Several interviewees cited a need to strengthen the materials science area by adding expertise in basic research and synthesis capabilities. The ultimate goal could be

the development of a leading laboratory and research program for biomechanical and composite materials, a goal that would benefit all of the commodity directorates.

Support of the broad soldier-system mission of the RDEC may require access to several nontraditional technologies. Examples include the following:

- intelligent materials—materials that automatically respond to a situation without forcing the soldier to interrupt other tasks to control or manage the behavior of the materials
- modeling and simulation—the ability to calculate technical parameters that accurately represent the behavior of systems, subsystems, and phenomena in a virtual setting that could help soldiers function in real settings
- human performance and behavior—understanding the stimuli and environmental factors that influence humans and understanding how humans respond to stimuli in various environments
- electronics and computation integral to the soldier system—using microelectronics and computer processing to help soldiers comprehend information obtained autonomously and to enhance their situational awareness and their ability to acquire and transmit information.

The committee notes that these examples might include technologies that are being developed elsewhere in the Army or in the DOD. Clearly, it would be unwise for the Natick RDEC to expend scarce resources to duplicate work being done by others (e.g., in the Army Research Institute, the Army Research Office, the Army Research Laboratory, other RDECs, or other agencies within DOD, such as the Defense Advanced Research Projects Agency). In such cases, the Natick RDEC may be able to negotiate additional support from other organizations within the Army R&D community or within the DOD.

STD should help identify the specifics of new research and technology programs in cooperation with the Soldier Systems Command. Because the soldier-system concept is still evolving, STD needs to understand how technologies can influence the concept. For this purpose, the product acceptance thrust (one of the four STD thrust areas identified in Chapter 1) may be useful for accurately modeling soldier behavior and responses in various scenarios.

The committee believes that STD must inform the rest of the RDEC about technical advances by the R&D community at large that could benefit the soldier system. Technologies like those listed above may not be pursued solely in military R&D programs. In fact, with the military's shrinking influence on technology development, the RDEC will undoubtedly have to turn to outside sources for much of the technology it needs. STD could play a major role in identifying the most promising external developments and the best ways for each directorate of the Natick RDEC to exploit them. In addition to the obvious need for STD research to satisfy unique military requirements, the directorate's

programs should help its personnel maintain the competence to evaluate external research.

The committee points out again the absence of a master plan for research by the Natick RDEC. In the absence of a plan that shows how all the research of the RDEC (internal to STD and the other directorates and external under RDEC sponsorship) fits together, it is difficult to determine what should be added to or subtracted from the RDEC's current research and technology portfolio. A master plan should fulfill the needs of the commodity directorates and indicate how each element contributes to the performance of the soldier system.

Advanced Systems Concepts Directorate. The modeling and simulation capability of ASCD is a key resource that should be expanded to include participation by a broad spectrum of scientists and engineers at the RDEC. A major goal for expanding this capability is the development of higher-level models and simulations that can represent the benefits of the technological enhancements of each funded or proposed program. The committee believes that disciplined analyses of the various RDEC programs could enlighten RDEC decision makers on which programs to initiate, continue, or eliminate. The analyses would also equip the RDEC to convince higher-level commands to support the RDEC's programs.

Issue 10.

Are the models and simulations and other analytic methodologies used by the RDEC appropriate for the commodity areas and research and technology programs?

Commodity Directorates

Mobility Directorate. The numerical simulation of parachutes and airdrop system performance is appropriate research for MobD. Using computer software to model and develop parachutes and airdrop systems will reduce the costs and cycle time of parachute system development. Simulations could also be used to optimize parachute systems and develop novel parachute systems.

The committee noted a lack of communication between the modeling and simulation groups and the development groups, although the relationships have apparently improved recently. These relationships must be strengthened so that modeling and simulation within the MobD can be better integrated with the day-to-day work and planning of the development groups.

Survivability Directorate. Models and simulations are used in several SurD programs to facilitate laboratory testing and to predict the performance of clothing and individual equipment in the field. Some examples are models and simulations of ballistic impacts on fabrics, fibers, and yarns; analysis of ballistic

casualty reduction; and a human thermal physiology model. However, working relationships between SurD and ASCD must be strengthened and better integrated with day-to-day activities and planning processes. One key example of this need is in the modeling of the soldier-system concept.

Sustainability Directorate. Modeling and simulation are not routinely used by SusD to develop and evaluate its products. In the shelters area, for example, there is a recognized need for tools to analyze structures and their properties. But analytical tools have not been used because of the time required to master the techniques and because of the disparity in computational and computer skills among SusD personnel.

Attempts have been made to coordinate efforts with the ASCD modeling program for predicting battlefield outcomes using a variety of performance measures as inputs. Among the performance measures that fall within the domain of SusD are the impacts of eating, sleeping, and other activities on the capabilities of individual soldiers. However, there is a chasm between the microscopic performance parameters measured on the products of SusD and the macroscopic inputs required by the global ASCD models. Closing the gap will be difficult given the complexity of the underlying factors and the requirement that they be reduced to the simplest empirical descriptors. Neither SusD nor ASCD appears to have the personnel or technical skills to meet this challenge.

The committee suggests that SusD and ASCD interface their work with the work of other organizations (e.g., the Army Research Laboratory and the Army Research Institute) in order to take advantage of advances in modeling of the individual soldier. For example, the committee was informed during the peer-review process for this report that substantial research on soldier modeling is being done at the Army Research Laboratory's Human Research and Engineering Directorate (e.g., human modeling and modeling of perceptual, cognitive, and psychomotor performance). In view of the RDEC's limited resources, collaboration between Natick RDEC directorates and other research organizations involved in modeling human activities could be very advantageous.

Support Directorates

Science and Technology Directorate. The committee did not receive much information concerning the use of models by STD. There were indications, however, that STD interacts with and feeds data into a simulation of dismounted infantry. The committee believes that advocates of each technology found to be worthy of research funding should be expected to contribute to the development of a model of the technical parameters that would be influenced by the technology. The model could then be used in conjunction with the ASCD models to estimate the potential value of given research to the soldier system.

Advanced Systems Concept Directorate. Technical measures of the performance of the products of the commodity directorates have not been made available to ASCD. The current modeling and simulation activities should be expanded to include important product parameters, with the long-range objective of building more robust models and simulations. This would require a valid and verified representation of each commodity integrated into the soldier system; a valid and verified representation of soldier responses to pertinent stimuli; and an integrated model or simulation that represents technical and system parameters that reflect the performance of the soldier system with and without each commodity.

5

Conclusions and Recommendations

This chapter contains the top-level conclusions and recommendations based on the committee's assessment, as documented in Chapters 2, 3, and 4. The first three conclusions deal with the Strategic Vision, Resources and Capabilities, and Quality Focus pillars in relation to the commodity directorates. The next two conclusions address the support directorates. The next two focus directly on (1) budget shortfalls and (2) the mix and emphasis of RD&E programs. The last conclusion suggests ways to substantially improve performance through reengineering. The committee has also listed recommendations that follow from each conclusion. Each group of conclusions and recommendations is accompanied by a discussion explaining the committee's positions.

COMMODITY DIRECTORATES AND THE PILLARS

Three of the pillars of a world-class organization (Resources and Capabilities, Customer Focus, and Value Creation) were assessed as good at the Natick RDEC. However, the vector for the future of the Resources and Capabilities pillar was pointing down. Strategic Vision was assessed in the poor to adequate range. Quality Focus was assessed in the adequate to good range. The conclusions and recommendations related to the Strategic Vision, Resources and Capabilities, and Quality Focus pillars follow.

Strategic Vision Pillar

Conclusion 1. The Strategic Vision pillar was assessed as less than good, but there were indications that it is improving. Realizing the strategic vision of the RDEC and facilitating strategic planning require continuous, high-priority attention from top-level management and the involvement of RDEC personnel at all levels.

The Strategic Vision pillar received the most poor or partially poor ratings of any pillar. This may seem surprising to top management of the Natick RDEC because a good deal of time has been spent articulating vision and mission statements. Yet the committee's interviews revealed that many staff members in the RDEC pay little attention to these statements. Also, the strategic planning process that the committee observed during its visits in 1996 seemed to lack substance. For these reasons, the committee devoted considerable time to Strategic Vision during its last visit in February 1997. Based on information presented to the committee at that time (see Chapter 2), the vector now seems to be heading up. If the new strategic planning process continues to receive the dedicated commitment of top-level management and actively involves personnel throughout the RDEC, the committee believes the rating of the Strategic Vision pillar will improve.

The Strategic Vision pillar is crucial to maintaining the RDEC's competitive advantage. Strategic vision, especially strategic planning, requires a strong foundation of demonstrated, steadfast commitment characterized by openness to the exchange of information at all levels of the organization; the involvement (both formal and informal) of all personnel in key organizational processes, such as identifying and analyzing goals and formulating operating methods and procedures; and the efficient implementation of plans and programs. Commitment to a strategic vision often requires that organizations review their current operating procedures and long-range plans and programs and adjust them to meet new challenges. The commitment of Natick's top management to strategic vision must be communicated to personnel at all levels of the organization. The message must be presented in such a way that all personnel understand it and accept it. If this is done correctly, strategic vision will become a key factor in approaching world-class performance.

Recommendation 1. The improvements under way at the Natick RDEC should be solidified and expanded. RDEC management should be especially receptive to adjusting plans and programs to meet new challenges. Senior managers of the RDEC should develop a comprehensive plan to solve the problems associated with the Strategic Vision pillar.

The committee concentrated on defining problems with the strategic vision across the directorates and suggesting ways to solve them. The problems and challenges presented by the Strategic Vision pillar vary by commodity directorate. But rather than singling out a particular directorate, the committee focused on a mosaic of the problems observed across the directorates.

The committee observed a lack of support for, and sometimes a lack of understanding of, the stated visions and missions in the commodity directorates.

This lack of support extends to the broader soldier-system concept. As long as directorate staffs have not embraced broad strategic visions and missions, they will exist only on paper. The committee perceived a general lack of understanding by the directorate personnel of how they should support and complement each other to realize the visions. Some groups were pursuing their own projects with little cross-fertilization of ideas or interaction with other groups. Upper-level RDEC managers devoted too much time to solving near-term problems, leaving them little time or energy to work with groups and individuals to align their thinking and projects with the overall visions, missions, strategic plans, and programs of the RDEC. The committee does not wish to be overly prescriptive by recommending specific changes; however, the managers of the RDEC should consider the following suggestions.

Managers should examine current and planned work in the directorates to determine if it is in line with vision and mission statements. The vision and mission statements represent an ideal, but the operational activities are centered on funding and survival. Managers should be sure visions, missions, plans, and programs are aligned. For example, the basic vision, in spirit at least, should be encapsulated in the mission statement, and the plans and programs should clearly flow from this mission. This back-and-forth alignment is critical to the overall vision-mission-plans-programs linkage.

The new strategic planning initiatives that the committee learned about in February 1997 should help to close the gaps. The new initiatives should consider overall technical direction of the RDEC beyond the tenure of the current leadership. Managers should consider developing technology plans or road maps showing generations of technologies that support the overall goals. In developing these road maps, the five-to-six year integrated planning process (linked to the Army's Long-Range Research and Development Plan) could cover several generations of rapidly advancing technologies. In the committee's experience, time horizons at other organizations have been shortened significantly (to two or three years) and have been complemented with real-time planning (e.g., 12 months) to ensure that technology plans remain viable.

So far, the directorates have done a good job of keeping in contact with soldiers, but managers should also develop strategies for keeping in contact with senior officials who establish higher-level goals for technologies. These contacts would be most effective if they were accompanied by analyses (from models and simulations) that justify the RD&E plans of the directorates in relation to higher-level goals.

Visions, missions, plans, and programs must be aligned in the context of communications throughout the Natick organization, from the Soldier Systems Command to the bottom of the structure. This alignment should take two forms. First, all personnel should be able to clearly enunciate the vision and mission of their organization. Second, the vision and mission should be communicated in a

way that is both understandable and relevant to each person. This would correct the problem for many employees who stated that they were confused by the many vision and mission statements and did not find them inspiring or meaningful. Also, the strategic plans should be presented in a brief, easily understood format. Complicated statements probably will not be read or absorbed by rank-and-file personnel and will probably be looked upon cynically as management busywork.

Communications within the RDEC are good in several respects, but they could also be improved in several respects. Managers should establish better lines of communication with individual staff members regarding how their activities and aspirations contribute to the organization at large. Managers should consider convening more town hall meetings with personnel to discuss the current situation and the overall technical direction of the RDEC. Managers should also consider discussing ways the RDEC might surmount its budgeting problems (see below). Personnel from all the directorates (even some of the most vocal critics) should be included in the strategic planning process.

Managers need time to focus on strategic vision, but they also need time to communicate with employees (e.g., walking the halls). They may have to delegate some of their day-to-day responsibilities to staff or a middle layer of management, which would give them more time to focus on strategies, plans, and communications.

If the suggestions listed above are followed, there may be some organizational fallout. For example, the terrain traversal and personal augmentation programs are now named as part of the mobility mission, but it is not clear how these capabilities fit into the current MobD organization. Either these aspects of mobility should be made vital components of the MobD organization, or MobD should continue to focus solely on airdrop technologies and transfer the other aspects of mobility to another organization.

Resources and Capabilities Pillar

Conclusion 2. Although the Resources and Capabilities pillar was assessed as good for the commodity directorates, steps must be taken to stop the steady erosion of scientific and technical talent and experience.

The committee was alarmed by the continuing drain of RDEC resources and capabilities. Unless steps can be taken to stop the erosion of the base of scientific and technical talent and experience, resources and capabilities will inevitably decline. The committee recognizes that this problem is not under the direct control of the Natick RDEC. For example, a hiring freeze has been imposed from above. Also, the creation of the Soldier Systems Command, despite its good points, has attracted some of the RDEC's most highly skilled personnel to better paying, more promising positions. Nevertheless, the continued decline must somehow be stopped.

Recommendation 2. Senior managers of the RDEC should develop a plan to stop the erosion of skilled personnel and experience. At a minimum, they should develop strategies to retain in corporate memory the knowledge of people who retire or depart for other jobs.

The Natick RDEC's straggles to retain resources and capabilities are not unique. The entire U.S. defense establishment is trying to cope with cuts in forces, reduced modernization programs, tight budgets, and the loss of skilled personnel. Furthermore, in the last decade, many private sector corporations have also undergone radical reengineering, which has often meant massive reductions in personnel. Recognizing that other organizations have similar problems may be of some help if the RDEC can learn from the experiences of others who have had to adjust to new conditions. Several suggestions from the committee are listed below.

Given that replacing experienced people will continue to be difficult, the knowledge and expertise of departing staff members must be passed on to remaining personnel. In other words, the RDEC must develop strategies for preserving its corporate memory. For example, departing experts might be given time to document their expertise (e.g., on video tape or hard copy) or to conduct training sessions. Expert-system software technology could be used to preserve key design processes.

It seems obvious that the RDEC must also increase the efficiency of its remaining resources and capabilities by prioritizing programs and concentrating on the most important ones, dropping programs or functions when a critical mass no longer exists, prolonging the life of remaining programs through conscientious maintenance (of facilities and personnel), and initiating aggressive outreach projects with external organizations. For instance, assignments and training programs should focus on specific ways individuals can optimize their contributions to the organization (e.g., the contractual functions of outsourcing should be performed by people who are already qualified to manage contracts rather than training personnel who are better qualified for technical pursuits).

Quality Focus Pillar

Conclusion 3. The Quality Focus pillar was assessed to be at a lower level of performance than three other pillars, but the committee's principal concern was the uncertain trend for the future.

The committee sets the stage for the following discussion by noting that quality focus at the RDEC was not in bad shape. But because the trend was uncertain, the committee wants to draw attention to this aspect of the assessment so that quality focus does not deteriorate in the years ahead. The committee was

most uneasy about problems with learning from team to team and the general lack of metrics for tracking quality. As resources dwindle, transferring lessons learned across the RDEC is an increasingly important way to improve the efficiency of remaining resources. The repetition of mistakes cannot be tolerated. Metrics to assess the quality of the organization should be developed internally and tailored to measure the quality of unique aspects of the RDEC (e.g., the quality of services from the support directorates).

Recommendation 3. Management of the RDEC should take steps to improve RDEC-wide learning and to develop and implement an internal system for assessing quality.

The committee urges management and staff to review the metrics associated with the characteristics of the Quality Focus pillar called Commitment to Quality and Learning Environment. The RDEC should have a framework and methodology in place for measuring quality, measurable objectives for improvements in work processes, measurements for optimizing RD&E processes to deliver value, teams on one project teaching teams assigned to other projects, an organizational climate conducive to organizational learning, and methodologies to measure and evaluate organizational learning. Of course, all of these must be implemented and backed by the entire RDEC organization, from top management down and across all the directorates.

SUPPORT DIRECTORATES

The support directorates were not subjected to the rigorous assessment techniques used to assess the commodity directorates. The support directorates were assessed principally in terms of their support of the commodity directorates. The committee found that neither directorate provides the support that it should.

Conclusion 4. The Science and Technology Directorate was not adequately focused on its primary customers, the commodity directorates.

Although the committee found some instances when STD provides effective support (e.g., chemical analysis and research to improve the quality and shelf life of foods), and that STD research publications are commendable, the assessment uncovered many problems associated with the support provided by STD. In general, there are many gaps between what STD provides and the R&D needs of the commodity directorates. STD provides virtually no support for MobD, and the committee was informed that SurD and SusD have sometimes

requested support they did not receive (e.g., support in materials research for SusD). The committee consistently heard that the outputs from STD cannot be easily integrated into the products of the commodity directorates. In response to this situation, each commodity directorate now pursues its own science and technology to ensure that at least its near-term needs are met. The committee also believes that STD could contribute to more modeling and simulation by ASCD (e.g., concerning behavioral factors that influence soldier performance). Personnel from STD were unable to articulate persuasively the importance, even the relevance, of STD's portfolio of projects to the soldier system, the ultimate mission of the RDEC.

In short, the committee determined that the arrangement between STD and the other directorates was not working. Perpetuating an STD that serves only some of the needs of the commodity directorates while pursuing its own agenda, thereby causing the other directorates to establish their own research functions, is not only inefficient, it should be unacceptable.

Recommendation 4a. The RDEC director should take immediate action to consolidate the RDEC's science and technology activities and focus them sharply on the needs of the commodity directorates. If a refocused, centralized Science and Technology Directorate cannot provide the necessary support, the director should consider distributing the entire research function among the other directorates.

Either of the options in Recommendation 4a would eliminate the current arrangement between STD and the other directorates. The first option would consolidate the science and technology activities at the RDEC into a single unit that would serve all of the commodity directorates. The second would do away with a centralized science and technology unit (i.e., STD) at the RDEC and replace it with science and technology units distributed among the commodity directorates.

The committee favors the first option, primarily because it would concentrate the research talent of the RDEC in one organization, but only if the refocused organization could guarantee requisite support. Concentration of the research talent could facilitate interactions between members of the research staff (e.g., to apply common technological solutions to the problems of various customers) and sharing of scarce research equipment. Nevertheless, concentrating the research talent in a single directorate is less important than contributing meaningfully to the science and technology needs of the RDEC.

If the first option is chosen, the new directorate would not just be a larger STD that operates the way the current STD does. Instead, the new STD would have tight links to each of the commodity directorates and oversight by senior management of the RDEC and the commodity directorates to ensure that their science and technology needs were being met. The commodity directorates would also have to specify their needs clearly. The new unit would also honor the needs

of ASCD for technical assistance in modeling and simulation. Measures of performance for the new directorate that address the research needs of the entire RDEC would be established and monitored.

Another way to improve the focus and relevance of a centralized science and technology unit would be to rotate staff members between the unit and the other directorates at a pre-planned rate (e.g., 25 percent per year). Consideration could be given to rotating the more experienced researchers to work with the personnel who apply the results of research. The committee was informed during the peer-review process for this report that a rotation strategy in another RDEC is working effectively, especially because promotions were influenced by rotational assignments. Among the benefits were broader vision, improved communications, and a greater willingness on the part of the science and technology unit to pursue research relevant to the customer. Similar benefits were observed in the commodity directorates, where reliance on the research program increased. In short, researchers and the members of the commodity directorates and ASCD need to function as a team (or as several teams).

The new arrangement should be designed to take maximum advantage of outside research, although some in-house work on new technologies should still be done. It is time to recognize that the military's influence on the development of technology is decreasing; the RDEC must keep abreast of technological advances in the private sector that could help satisfy military needs. The RDEC must concentrate its internal resources on maintaining the capability to evaluate external research and on fulfilling needs unique to the military that the private sector is unlikely to meet.

Although the committee favors the formation of a consolidated science and technology unit, the committee does not mean this preference to be determinative on the RDEC management. If after due consideration the director of the RDEC decides that consolidation of the RDEC's science and technology activities can not overcome the problems associated with the current STD, the STD should be broken up and its functions distributed to the commodity directorates.

Recommendation 4b. The new science and technology operation, consolidated or distributed, should ensure that its research is demonstrably relevant to the RDEC's overall mission.

The committee suggests that the RDEC's research arm, whatever its form, should thoroughly investigate the soldier-system concept and identify the full range of technologies within the RDEC's domain that could improve soldier performance. In conjunction with ASCD and the commodity directorates, the science and technology unit should evaluate these technologies and determine which ones offer the highest payoffs for the soldier system. These technologies should then be compared with the technologies already in the military R&D

pipeline or under development in the private sector. Decisions could then be made on candidates that are worthy of pursuit as highly relevant, military-unique, technology-push items.

Conclusion 5. The Advanced Systems Concepts Directorate is not sufficiently supportive of the commodity directorates (its primary customers) or of the RDEC as a whole.

ASCD, through its several divisions, was chartered to provide a variety of support services to the other directorates in the Natick RDEC. These services include customer liaison, strategic planning, and quantitative assistance for evaluations and decision making. Through its operations research and modeling and simulation capabilities, ASCD's purpose is to integrate the programs of the commodity directorates and demonstrate to higher headquarters the utility of the RDEC's products. In other words, ASCD is supposed to have a broad focus across the RDEC and provide support by looking outward as well as inward.

The committee learned of some instances when the commodity directorates had established their own mechanisms for obtaining customer feedback. ASCD could provide more assistance through surveys and by eliciting requirements definitions from customers. However, the commodity directorates must maintain some responsibility for marketing their products and working directly with their customers. Also, strategic planning is no longer the responsibility of ASCD. ASCD's modeling capability does not adequately address many technical aspects of soldier-system components, and the simulation capability does not make use of the entire cadre of models of RDEC products to simulate soldier-system performance. Therefore, the benefits of new technologies from the commodity directorates (or research results from STD) cannot be easily assessed, which limits the RDEC's ability to convince higher headquarters that its programs are worthwhile.

The committee wishes to emphasize that ASCD also needs the cooperation of the other directorates. Personnel in the commodity directorates have little understanding of how their products are represented in the models and simulations that are used to inform higher-level commands in the Army and other potential customers. The commodity directorates and STD must contribute their technical expertise to ASCD, including staying fully aware of what the models do and even developing models for ASCD, if necessary. ASCD must take full responsibility for the simulations, however, and must ensure that the performance of all RDEC commodities and technologies are properly simulated for evaluations of soldier-system combat effectiveness.

Recommendation 5a. ASCD must improve its capabilities to develop and use models and simulations in support of the other directorates and the entire RDEC. RDEC management should emphasize to all personnel the importance of (1)

adequate modeling and simulations of the soldier system and (2) full cooperation of the other directorates with ASCD.

It is hard to overestimate the benefits to the Natick RDEC of a greatly improved capability to model relevant technologies and simulate the soldier system. The benefits include internal efficiencies and effectiveness, as well as external visibility and appreciation of the contributions of the RDEC to soldier-system performance. The committee firmly believes that RDEC participation in top-level analyses of military forces is necessary for the RDEC to compete successfully for resources in the constrained environment facing DOD.

Current constraints at the RDEC will make it difficult to hire new staff for the ASCD to improve modeling and simulations, and personnel within the RDEC who might be reassigned to modeling and simulation projects would probably need additional training. When necessary technical knowledge can be found in another directorate (e.g., behavioral science), full cooperation with ASCD will be vital. Both the commodity directorates and the RDEC's research arm (consolidated or distributed) should share their understanding of how their projects are expected to influence the soldier system and should model the relevant parameters and validate them for use in the ASCD models, which must be as complete as possible. Experts in the various directorates should also support integration of these models with system-level simulations. These contributions will help scientists and technologists appreciate the potential applications of their work to the soldier system. In summary, it is imperative that people in the other directorates with technical knowledge that is important for models and simulations contribute fully to ASCD.

A strategy that might expand the portfolio of models and improve the use of and reliance on models at the RDEC would be to temporarily assign people from the commodity directorates and the science and technology unit to ASCD. The purpose of these temporary assignments would be to embed unique aspects of technologies in existing models or to help ASCD create new models that reflect the needs of a particular directorate. The resulting models would become an important part of the process for assessing the combat value of technologies or products. The strategy might also help to institutionalize the use of models at the RDEC.

ASCD could become a catalyst for closer interaction among the new science and technology unit and the commodity directorates to find areas where new technologies could improve the performance of particular products or the larger soldier system. Closer interaction should include brainstorming, focused by ASCD through models and simulations, on how new technologies can improve performance or lower the costs of a military function. The potential benefits of new technologies should be demonstrated before significant funds are allocated to them. This demonstration could help the commodity directorates explain to the science and technology unit why they need assistance with a particular technology.

Recommendation 5b. The RDEC managers should reexamine the other functions of ASCD and either expand them or eliminate them, as appropriate.

In theory the RDEC could either consolidate all customer liaison work in ASCD or distribute it throughout the RDEC. Consolidation would have the advantage of combining in a single organization all RDEC personnel who design and administer surveys. The major disadvantage of consolidation is that it would separate the scientists and engineers from direct contact with customers. The committee believes that the commodity directorates and ASCD (and the survey designers in STD) must work as a team. ASCD helps but cannot be substituted for direct interaction between the product developers and the users.

The customer liaison function should generate enough customer interest in RDEC products so that customers either establish formal requirements for these products or declare that RDEC products meet their requirements. Surveys should encompass the whole array of potential uses of RDEC products. Comprehensive, marketing-oriented databases could be very useful. Customer liaison is vital to the RDEC both from the marketing-and-requirements standpoint and from the more traditional standpoint of analyzing feedback to determine customer satisfaction. Expansion of the customer liaison function should involve teamwork among ASCD and the other directorates.

The committee learned in February 1997 that the RDEC director's office has taken a new interest in strategic planning, calling into question the merit of having a separate strategic planning function within ASCD. Although strategic planning, per se, by ASCD could be eliminated, the committee believes that the modeling and simulation capability of ASCD is vital to strategic planning for the RDEC. ASCD should remain a strong contributor to strategic planning.

BUDGET SHORTFALLS

Members of the committee probably heard more expressions of distress over the budget woes at the RDEC than over any other problem. Budget cuts are usually followed by limitations on promotions and reductions in personnel, which naturally concern the people who work at the RDEC.

Conclusion 6. The RDEC director and managers face a major challenge in adjusting their priorities to cope with declining budgets.

The committee begins by stating the obvious, that budget shortfalls, and their accompanying constraints on personnel and facilities, are not going to get better. As pressures on the U.S. defense establishment to cut back persist in the years ahead, budget shortfalls at the Natick RDEC are likely to get worse. The

resulting hardships on people and their careers are unfortunate, but they will occur. The RDEC director, managers, and staff must accept this reality and develop ways to cope with it. Lessons can be learned from the private sector, which has also undergone major upheavals as the United States has confronted the need to compete in the global economy. These lessons include the ruthless elimination of inefficiencies, the prioritization of missions to decide which ones to drop, the aggressive marketing of products and services, and the development of new markets.

Recommendation 6. As part of its strategic planning, the RDEC should develop strategies and tactics to cope with budget shortfalls.

The committee recognizes that government operations like the Natick RDEC are limited in what they can do to reduce inefficiencies. Nevertheless, the RDEC has already streamlined organizational structures within the commodity directorates and appointed vigorous leaders. These leaders, other senior managers, and the staff know where the inefficiencies are. Some are addressed in this report. As part of the new strategic planning, the RDEC should reexamine what it does and how it does it, drop activities that are inefficient or unnecessary, and use the remaining resources to concentrate on the sale of services, licenses, and products to government and commercial customers. Good leadership and participatory strategic planning should help to overcome the inevitable resistance to change. The point is not to eliminate jobs but to employ personnel as efficiently as possible.

The committee learned about several attempts to improve marketing at the RDEC; unfortunately, some of these initiatives appeared to be suffering from a lack of expertise and critical mass. The committee learned of instances, for example, of good ideas that had not been sold convincingly to higher headquarters (e.g., Force Provider, air beams, special boots) and had remained dormant until the need became desperate and someone in command, maybe not even in the Army, asked for them.

The committee believes that quantitative cost-benefit analyses would be valuable tools for developing markets. For example, one of the long-range goals of the Air Force is to develop a stand-off delivery capability for air-dropped supplies (AFSAB, 1995). Technology being developed by MobD could help fulfill this need. If cost-benefit analyses show that aircraft would be saved as a function of stand-off-delivery capability, the RDEC could develop a market for this product, even if the market is outside the Army. Other valuable tools include more persuasive communications techniques, strategies for making connections with customers, and techniques for "closing deals." This kind of marketing expertise could be learned from the private sector.

RESEARCH AND TECHNOLOGY PROGRAMS

The committee reviewed the full range of research and technology programs at the Natick RDEC. Several of these programs are unique, and some have been highly acclaimed. The committee believes that two considerations should be taken into account when assessing the mix and emphasis of various programs: (1) circumstances at the time of assessment and (2) future needs.

Conclusion 7. The mix and emphasis of research and technology programs will have to be adjusted to improve the RDEC's support of the Army and other customers.

The committee was told that the core technologies of the RDEC are textile technology, food science, biotechnology, and airdrop technology; the list of underlying technologies included these core technologies, as well as survival technology, materials science, environmental research, and behavioral science (Brandler, 1996). The committee considered some of the RDEC's unique capabilities (e.g., in food processing and packaging, multifuel burners, air beams, multicapability protective clothing, and airdrop technologies) in relation to its mission to support the soldier system. In most cases, the connection between what the RDEC was doing (or not doing) and its mission was clear (e.g., food science to satisfy the unique needs of the military). In some cases, however, the connection was not clear (e.g., some airdrop technology is not supported by the Army's requirements, and the ground mobility mission is not supported by advanced technologies). Some of the RDEC's key technologies were narrowly focused (e.g., biotechnology was limited to developing materials with the properties of spider silk). The committee also noted that STD's main emphasis was not aligned with the RDEC's list of core and underlying technologies (e.g., STD has no airdrop technologies).

Recommendation 7. The RDEC should reevaluate its rationale for all in-house research and technology programs in light of the unique needs of the Army or other customers and the availability of sources outside the Army to advance the technology.

The following suggestions could help the RDEC reevaluate its research and technology programs. First, if any program does not show a measurable payoff in terms of improved soldier-system performance when subjected to benefit and cost analyses, that program should be considered suspect. Second, if another agency or someone in the private sector is advancing a technology much faster than is possible with the limited funds available to the RDEC, the RDEC should consider whether or not to pursue that technology at all. An alternative would be to monitor developments elsewhere and try to influence them to include

features that would benefit the Army. Assessing the status and value of scientific and technical advances by others requires that the RDEC maintain technical competence, which means some ongoing in-house research. Third, the RDEC should reassess the long-range needs for technologies like those associated with airdrop and ground mobility systems. If the Army is not the customer, the RDEC should seek support from likely customers outside the Army (e.g., the Air Force in the case of precision airdrop). If support cannot be guaranteed, the effort should be dropped. If the Army is the customer but does not provide adequate support, the effort should be dropped (e.g., ground mobility). Fourth, the RDEC should consider the merits of suggestions made elsewhere in this report—coordinating experimental and simulation programs within MobD, developing new materials for shelters, and pursuing new areas of research (see, for example, the section on Research and Technology Issues in Chapter 4). However, these suggestions should only be implemented as part of a new master plan for research at the Natick RDEC.

Given the current climate of shrinking resources, Natick should consider negotiating additional support from other organizations within the Army R&D community (e.g., the Army Research Institute, the Army Research Office, the Army Research Laboratory, and other RDECs). The committee was informed during the peer-review process for this report that the Army Research Institute is working on soldier-environment interaction, that the Army Research Office sponsors broad-spectrum research, that the Army Research Laboratory programs include a substantial program and capability in composite materials and in most other Army-relevant materials, and that the Tank-Automotive RDEC has a significant capability in ground mobility. The committee does not mean to suggest that the Natick RDEC is unaware of these organizations or is not coordinating its work with them. However, better collaboration with these organizations might result in more support, which could allow the Natick RDEC to concentrate its scarce resources on Natick-unique capabilities.

Reevaluations should be made in the context of the strategic planning process that was explained to the committee in early 1997. The committee was impressed with the potential of that initiative for making reasonable decisions concerning investments by the RDEC. Whenever possible, models and simulations should be used to help assess the merits of particular technologies in terms of effectiveness and cost.

The committee recognizes that reevaluations and changes will meet with some resistance. From some quarters (e.g., senior scientists), the resistance may be formidable. The leadership skills of senior managers of the RDEC and the participatory strategic planning process should help to overcome such resistance.

OPPORTUNITIES FOR REENGINEERING

The committee was asked to "identify opportunities for reengineering in areas judged deficient or worthy of improvement" (see statement of task, Chapter 1).

In the opinion of the committee, none of the previous recommendations taken individually amounts to a recommendation for reengineering, which is usually associated with large-scale corporate reinvention. Corporate reengineering is usually characterized by radical changes in how an enterprise operates (Davenport, 1993). Results of the committee's assessment did not indicate that radical changes were necessary for the Natick RDEC. Also, the success rate of radical reengineering is reported to be only 25 percent (Landauer, 1995).

However, all of the committee's recommendations taken together do constitute a prescription for less-than-radical reengineering for the Natick RDEC—improving the way of doing business that will require persistent management attention and buy-in from all of the stakeholders (including personnel at the RDEC), as well as substantial time to implement. An important component of this less-than-radical reengineering is the establishment of long-range strategies for the RDEC to maintain its competitive advantages. Another component is a demonstrated commitment by management to support those strategies and see that they are carried out.

Conclusion 8. The Natick RDEC is performing well, and its performance is relatively uniform across most directorates. The RDEC's cycle time and responsiveness to urgent customer needs are particularly impressive. World-class performance, however, which requires widespread excellence, will be difficult for the RDEC to achieve but remains a worthwhile goal. Less-than-radical reengineering is an appropriate way for the RDEC to move toward that goal.

The fact that three of the five pillars of a world-class organization were judged to be good and one more was judged to be in the range of adequate to good indicates to the committee that the Natick RDEC is performing well. Although the assessment did not show world-class performance, the RDEC can tightly be proud of its remarkable capabilities and many noteworthy accomplishments. The fact that the RDEC had the courage to subject itself to this arduous assessment is indicative of its commitment to strive for world-class performance. In general, the RDEC management, directorate leaders, and personnel were extremely cooperative during the assessment, both in preparing answers to the committee's many questions and in participating in the interviews. This was another sign of the RDEC's commitment to its world-class vision. Given this positive environment and the fact that the assessment did not find the RDEC to be broken, the committee believes there is no need for radical surgery.

The phrase world-class has been used as a description of excellence for all R&D in the DOD. The Natick RDEC is the first DOD agency, in the committee's knowledge, to bring concrete meaning to that phrase by sponsoring the committee's studies to define world-class performance and by submitting itself to an assessment of its own performance. Now that there is a reasonable understanding of what constitutes world-class performance, the committee believes it is a worthwhile goal for the RDEC to pursue.

The methodology developed in the phase-one report (NRC, 1996) and used in this assessment is sound. Although the characteristics and metrics might have to be modified to suit specific circumstances, the major components of world-class performance are useful parameters for assessing RD&E organizations like the Natick RDEC. Lessons from the examples of impressive past performance at the Natick RDEC should be used to suggest ways to correct deficiencies revealed in this assessment. To achieve the goal of widespread excellence, the committee recommends that the Natick RDEC be reengineered in the way described below.

Recommendation 8a. The Natick RDEC should implement a five-step reengineering plan: (1) improve the Strategic Vision pillar to good, reverse the downward trend of the Resources and Capabilities pillar, and upgrade the Quality Focus pillar; (2) correct the problems associated with STD and the research and technology programs; (3) enhance ASCD's capability to support the RDEC; (4) raise selected pillars to the excellent level; and (5) conduct periodic self-assessments using the methods described in the phase-one report.

The committee offers the following suggestions for consideration by management of the Natick RDEC. First, the fact that the committee found significant problems with strategic vision suggests that there has been a shortcoming in management. The committee urges that greater emphasis be put on training to improve the leadership capabilities of the RDEC managers (see Recommendation 8b below). The goal of this training would be to bring about fundamental changes in the RDEC to make it a true learning organization that would develop its own improvement vectors and would produce a cultural change throughout the workforce. Ideally, the RDEC would then have true leaders instead of just managers. Leaders motivate, empower, and coach continually; they have strategic vision, which they communicate to the workforce at every opportunity. Without this kind of leadership, the organization's vision statements will continue to fall on deaf ears.

Appropriate elements of leadership training would be extended to members of the RDEC who have team-leader responsibilities. The teams should be taught to operate across organizational boundaries and to work toward common goals. They should strive for a high level of communication and interaction. Team leaders should be trained to motivate, empower, and coach team members by reminding them of the vision and by stressing improved communication with others in the RDEC.

The committee believes that maintaining a highly qualified workforce is possible if management takes a long-term view and attacks the problem creatively. The committee urges that management pay special attention to the recruitment of high-quality personnel. Successful recruitment is an ongoing process that should begin long before spaces open up or the hiring freeze is lifted. Successful hiring of top-quality individuals is the culmination of a recruitment

process that takes place over months or even years. These individuals must be targeted by the most capable scientists and engineers at the RDEC through on-campus interactions—long before graduation. Promising individuals must be nurtured through cooperative projects, summer hiring programs, and temporary jobs sponsored by on-site contractors. Management must be ready to hire expeditiously as soon as a hiring window opens. Also, RDEC management should be aware that good people are attracted by superior facilities, a user-friendly research environment, and rewarding professional relationships.

Implementing this plan will require teamwork among all of the employees at the Natick RDEC, who will have to look beyond the narrow confines of their own programs and encompass the whole organization. The end result should be a cohesive organization, a smoothly functioning RDEC that can approach the ideal of a world-class organization.

Recommendation 8b. The Natick RDEC should begin an educational program in leadership development and modem principles of technology management.

In the committee's opinion, many of the problems associated with strategic vision, resources and capabilities, quality focus, and the two support directorates of the Natick RDEC stem from management limitations at the senior level. The committee does not intend to sound simplistic by throwing all of the problems at management and recommending that management fix them. But these problems are similar to the problems that have faced managers of other government and private-sector organizations that were still functioning partly in the past and had not reengineered themselves to meet the challenges of a rapidly changing world. Problems cannot be excused because managers say they are overburdened or because resources are limited. The RDEC managers must learn and then transmit to all employees the techniques that have made some organizations pacesetters.

The training must be passed from the top down, with people at each level becoming mentors and trainers for people at the level below them. A new culture must be created and maintained through continuous coaching by leaders over a period of months and years. The training should include the many considerations related to the five pillars of a world-class R&D organization contained in the committee's phase-one report (e.g., leadership and stakeholder buy-in under the Strategic Vision pillar and learning environment under the Quality Focus pillar). Strong management commitment must be evident to the entire staff at the RDEC. With these improvements, the committee is hopeful that the organization will be able to excel in the future.

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Appendices

Appendix A

Precursory Documents for the Statement of Task

This appendix contains the texts of the statement of task in the prospectus and the specific requirements in the statement of work in the contract. This lengthy material was a major source of the abbreviated statement of task that the committee synthesized in Chapter 1.

Prospectus
9/12/95

Plan of Action

Statement of Task

The NSC [Natick Standing Committee] will conduct a thorough assessment of the RDEC. The NSC will identify those scientific and engineering R&D programs it perceives as critical, identify those research areas which should be conducted in-house, and identify alternative programs whereby the Technical Director can leverage limited scientific and engineering resources with academic and industrial partners and other Federal laboratories. The NSC will examine the RDEC's basic research/core technology programs in order to evaluate the adequacy of basic research funding, and make recommendations on which technology programs should be retained, eliminated, or transferred to other Army laboratories. To accomplish these objectives, the NSC plans the following reporting activities.

Phase I: *Report on "World-Class" Characteristics*. The NSC will carry out the investigations necessary to prepare a report on the characteristics of a "world-class" research and development organization. The resulting report will:

- define "world-class" research and development, identify the major components that comprise "world-class" research and development, and
- identify the measurable qualitative and quantitative characteristics (metrics) that apply to or are appropriate for an Army RDEC to identify itself as a "world-class" research and development center.

The metrics derived from the committee's definition will be used as the benchmark by which the business areas and core technologies will be evaluated (see below).

Phase II: *Report on Business Areas*. The NSC will review and asses the Natick RDEC's corporate strategy and business plans, scientific and engineering Directorates, and materiel and technology integration offices, and then provide technical and programmatic assessments and recommendations to the RDEC

Technical Director that will enable the RDEC to achieve or maintain the status of a center conducting "world-class" research and development. The NSC will:

- assess the RDEC's organization, structure and adequacy of personnel, funding, equipment, and facilities to develop and produce military products,
- review the basic research programs (core technologies) that support each business area to insure that the technology base will support the applied research and development projects assigned to the center and to assess Natick's success in retaining critical expertise during the RDEC's restructuring so that it can continue to conduct these basic research programs, and
- assess customer satisfaction with the products developed and the commercial marketability of dual-use products.

Contract DAAK60-95-C-2069 between the U.S. Army Soldier Systems Command, Acquisition Directorate, and the National Academy of Sciences (NAS)

Section C
Description/Specifications/Work Statement

C-3. SPECIFIC REQUIREMENTS:

C-3.1. The contractor (NAS) shall examine each of the five Natick business areas in terms of organization, resources, and re-engineering opportunities; research and technology; and product quality and customer satisfaction. Examples of these topics follow:

a. Organization, Resources, and Re-Engineering Opportunities. Does Natick have adequate funding and personnel (technical specialties and critical mass) to conduct World-Class research and development for military products and systems? How effective is the current organizational structure, and what new organizational approaches (e.g., elements of the Federated Lab Concept) might be beneficial to Natick? How has the establishment of SSCOM [Soldier Systems Command] affected Natick?
b. Research and Technology. Are the core and supporting technologies and methodologies appropriate/ adequate? Should all current technologies be continued and should any new ones be adopted? Are appropriate models and simulation used for the technologies and business areas?
c. Product Quality and Customer Satisfaction. How well do business areas support appropriate Battle Labs? Do products/systems meet customers' materiel requirements? Where appropriate, are the research and development and products/systems World-Class? Are Natick's products/systems marketable outside the Army? Outside DoD?

Appendix B

Meetings and Visits

This appendix provides details about committee meetings, site visits, and individuals and organizations contacted during the course of the study.

February 25-27, 1996

Natick, Mass.

Objectives: Introduce and orient new committee members to the National Research Council and the Natick RDEC; discuss the committee's goals and objectives; receive command and business area briefings; review the first draft (including characteristics and metrics) of the phase-one report; review and approve the statement of task for phase two; discuss initial panel visit and work assignments; discuss phase two tailored characteristics.

Presenters:

Robert Lewis, Technical Director, U.S. Army Soldier Systems Command
Colonel Morris Price, Commander, Natick RDEC
Lieutenant Colonel David Faulkner, Deputy Commander, Natick RDEC
Philip Brandler, Technical Director, Natick RDEC
Colleen Cathcart, Office of the Technical Director, Natick RDEC
Gerald Darsch, Sustainability Directorate, Natick RDEC
Edward Doucette, Mobility Directorate, Natick RDEC
Ronald Granchelli, Survivability Directorate, Natick RDEC
Paul Leitch, Advanced Systems Concepts Directorate, Natick RDEC
Dale Malabarba, Advanced Systems Concepts Directorate, Natick RDEC
Abner Salant, Science and Technology Directorate, Natick RDEC

June 2-5, 1996

Natick, Massachusetts

Objectives: Complete preparations for the on-site visit; gather on-site data as part of the assessment of the Mobility Directorate; gather on-site data from the Advanced Systems Concepts Directorate as part of the assessment; prepare rough drafts of relevant sections of the committee's report.

Key Contacts: Philip Brandler, Edward Doucette, Mathew Herz, Dale Malabarba

September 24-28, 1996

Natick, Massachusetts

Objectives: Complete preparations for the on-site visit; gather on-site data as part of the assessment of the Survivability Directorate; gather on-site data from the Science and Technology and Advanced Systems Concepts Directorates as part of the assessment; prepare rough drafts of relevant sections of the committee's report.

Key Contacts: Philip Brandler, Ronald Granchelli, Mathew Herz, Herbert Meiselman, Abner Salant

December 2-6, 1996

Natick, Massachusetts

Objectives: Fulfill administrative requirements for new committee member; complete preparations for the on-site visit; gather on-site data as part of the assessment of the Sustainability Directorate; gather additional on-site data from the Science and Technology and Advanced Systems Concepts Directorates as needed; prepare rough drafts of relevant sections of the committee's report.

Key Contacts: Philip Brandler, Gerald Darsch, Abner Salant, Irwin Taub

February 10-13, 1997

Natick, Massachusetts

Objectives: Gather additional data on the support directorates of the Natick RDEC; gather additional data on management and leadership; gather additional data on strategic planning; accomplish any final data gathering needs on MobD, SusD, and SurD; discuss findings and continue work on chapter drafts.

Key Contacts: Philip Brandler, Colleen Cathcart, Gerald Darsch, Ronald Granchelli, Mathew Herz, David Kaplan, Abner Salant, and James Tierney (Program Manager, Soldier Support, Soldier Systems Command).

May 15-16, 1997

Washington, D.C.

Objectives: Discuss major messages and complete chapter assignments for concurrence draft.

Appendix C

Excerpts from the Phase-One Report

This appendix contains key excerpts from the committee's phase-one report, *World-Class Research and Development, Characteristics for an Army Research, Development, and Engineering Organization.* The excerpts consist of the Executive Summary and the tables (Tables C-1 through C-5), which provide the 25 characteristics and 100 metrics of world-class performance.

Executive Summary

The U.S. Army intends to conduct "world-class" research and pursue advances in technology to maintain superiority in land warfare. This report, which was prepared for an Army sponsor, defines the characteristics of a world-class research, development, and engineering (RD&E) organization.

Background and Approach

The Natick Research, Development and Engineering Center (RDEC) is a major element of the U.S. Army Soldier Systems Command, which, in ram, is a major subordinate command of the U.S. Army Materiel Command. The Natick RDEC vision is to be a world-class RD&E team that provides global customers with the essentials of life. The RDEC is organized into the following five directorates, which reflect the essential elements of its mission: (1) survivability, (2) sustainability, (3) mobility, (4) science and technology, and (5) advanced systems concepts.

The technical director of the Natick RDEC requested the assistance of the National Research Council in shaping the RDEC's future role and direction. A committee of the National Research Council (known as the Natick Standing Committee) was asked to (1) define world-class research, development, and engineering; (2) identify the major components of world-class research, development, and engineering; and (3) identify measurable qualitative and quantitative characteristics (and associated metrics) that must be met in order for an Army RDEC to declare itself world-class. The characteristics and metrics will be used later by the committee for an assessment of the Natick RDEC.

The committee recognized that the phrase world-class is widely used and has different meanings to different people. Although providing a general definition of world-class is relatively easy, defining the term for a research and development organization, particularly an Army RDEC, is more difficult. The committee attempted to develop a definition that takes into account the Army's mission and the RDEC's role in fulfilling that mission. Although an Army RD&E organization has unique features (e.g., it exists principally to serve the Army) that

distinguish it from academic and industry research and development centers, the committee found that research and development centers that are considered world-class share similar, measurable characteristics.

World-Class Research and Development

To define world-class research and development (R&D), the committee drew on material from general discussions with representatives of industry, academia, and government. The committee also examined relevant literature and four examples of widely respected organizations (i.e., Motorola, Milliken & Company, Intel, and FedEx). The committee determined that a world-class R&D organization is one that is recognized by peers and competitors as among the best in the field on an international scale, at least in several key attributes.

The committee observed that world-class R&D organizations maintain performance by creating and sustaining certain critical competitive advantages (e.g., a strategic focus on unique competencies of the organization). These competitive advantages result from excellence in five key attributes, which are often called "pillars." The pillars are (1) customer focus, (2) resources and capabilities, (3) strategic vision, (4) value creation, and (5) quality focus. These pillars are founded, in ram, on a demonstrated commitment to achieving world-class performance.

The major components of a world-class R&D organization are, therefore, demonstrated commitment, the five pillars, and the competitive advantages. Of these, the committee believes that the base—a demonstrated commitment—is the most important. Without it, aspirations to achieve world-class performance will be doomed.

World-Class Army Research, Development, and Engineering

The uniqueness of an Army RD&E organization makes it difficult to find similar peer and competitive organizations on which to base performance comparisons. Therefore, a definition of a world-class Army RD&E organization must also recognize the unique aspects of an organization's vision, mission, and strategy. For example, the Natick RDEC mission, which flows from its vision of becoming a world-class organization, is to (1) maximize the soldier's survivability, sustainability, mobility, combat effectiveness, and quality of life through the research, development, and engineering of items such as rations, clothing, shelters, and airdrop systems; (2) provide the necessary research, development, and engineering to integrate several combat-essential elements (e.g., survivability, sustainability, and mobility) into the soldier system; and (3) perform

similar, related functions for other Department of Defense services and federal agencies (e.g., be the center of excellence for food science and technology). The strategy includes developing highly skilled personnel, acquiring quality equipment and facilities, and establishing consistent and stable funding. However, this strategy —and ultimately the vision—are necessarily influenced by the current environment, which includes shrinking budgets and levels of personnel.

Taking the factors listed above into account, the committee determined that a world-class Army RD&E organization is one that excels in several key attributes by matching core competencies to its mission, thereby fulfilling the needs of soldiers as well as, or better than, similar organizations anywhere in the world. To achieve and maintain world-class performance, an organization must identify and develop the necessary core competencies. For an Army RD&E organization, these include the ability to move quickly from developing to fielding new, applied technologies. The technological capability must encourage continued development of new, superior products.

The committee believes that the pillars of a world-class R&D organization provide the most convenient means of articulating the prominent aspects of world-class performance. The five pillars are also applicable to Army RD&E organizations. The pillars are described below.

- *Customer focus* is the ability to identify, anticipate, and respond to customer needs both now and in the future. The focus is on internal customers as well as external customers.
- *Resources and capabilities* are the assets and talents with which the organization creates value for the customer.
- *Strategic vision* is a mental view of the type of organization that senior-level management would like the enterprise to become. This vision must be communicated indelibly to all personnel and translated into key elements that will make the vision a reality.
- *Value creation* is the ability to produce or increase benefits perceived by customers so they feel they are getting more value than they expected or previously received.
- *Quality focus* is the ability to continue striving for higher quality. The commitment to quality often results in breakthroughs.

Characteristics and Metrics

The characteristics of a world-class RD&E organization are derived from the five pillars. The committee judged that 25 characteristics are most relevant to an Army RD&E organization. These characteristics are discussed below according to the pillar under which they fall.

Customer Focus Pillar

The characteristics of this pillar are customer satisfaction, customer involvement, and market diversification. Both types of customers (e.g., internal product development teams and soldiers external to the RD&E organization) can be surveyed to ascertain how satisfied they are with the technological solutions and products delivered. Customer involvement in setting program objectives and following progress can also be evaluated. Although an Army RDEC must focus on the primary markets it serves, the committee believes that some market diversification is proper for any RD&E organization. Indeed, in the private sector world-class RD&E organizations seek to exploit fully the results of their research and product development. The extent of market diversification by Army RDECs can be determined; but diversification must also be considered carefully because Army RDECs exist primarily to support their Army missions and rely on government funding, which is usually authorized only to satisfy specific needs. Satisfaction, involvement, and the nature of market diversification indicate how well an RDEC is connected with and focused on the long-term and short-term needs of customers.

Resources and Capabilities Pillar

The characteristics of this pillar are the quality of personnel; facilities and infrastructure; budget; RD&E capabilities, skills, and talents; use of external resources; important technologies; information technology; and organizational climate. Internal and external reviews (e.g., by management of the RD&E organization or by higher headquarters) can be conducted to assess the organization's resources and capabilities. These reviews may include analyses of the core technical programs, evaluations of employee morale and the research climate, and assessments of the ability to reach "make versus buy" decisions. The quality and quantity of the human, physical, and financial resources and core capabilities of the RD&E organization indicate the ability and power to achieve world-class results. A positive organizational climate usually correlates with high productivity.

Strategic Vision Pillar

The characteristics of this pillar are alignment of vision and mission, anticipatory strategic planning, stakeholder buy-in, and leadership. Internal and external (e.g., peer) reviews can determine if the strategic vision of the RD&E organization and the mission are aligned and whether anticipatory strategic planning is sufficient to develop future Army and joint service products rapidly. To assess stakeholder buy-in, the stakeholders must first be identified.

Assessments of strategic vision should include the organizational leadership to ensure that the organization's vision is understood by staff and stakeholders alike. The quality of the strategic vision will give a reading of the enduring capability of the organization to plan and achieve world-class results.

Value Creation Pillar

The characteristics of this pillar are a proper portfolio, product performance, cycle time and responsiveness, and the value of work in progress. Value creation is often a perception based on a comparison of previous products (or lack thereof) with current products. Reviews of the breadth of effort (i.e., the portfolio) and other characteristics are important for making a meaningful assessment. Reviews can be conducted using both internal and external evaluations. The extent to which the RD&E organization produces outstanding, meaningful results reflects the impact of the organization.

Quality Focus Pillar

The characteristics of this pillar are the capacity for breakthroughs, continuous improvement, commitment to quality, structured processes, a learning environment, and the quality of research. The capacity for scientific and engineering breakthroughs can be assessed, in part, by reviewing past performance (e.g., how many breakthroughs have already occurred). Continuous improvement and structured processes (i.e., the ability to work in a disciplined and organized fashion) can be assessed by reviewing processes and results. The commitment to quality must be assessed at all levels, from topmost management down. Reviews can determine the ability of the staff and the organization as a whole to learn and use knowledge to achieve outstanding results. Finally, research quality can be assessed by expert review. Measurements of all these characteristics can give an overall assessment of the focus on quality in an Army RD&E organization.

Measuring the Characteristics

Metrics can be developed to measure various aspects of input, processes, output, and outcomes in the past, present, and future. Using the wrong metrics may limit performance or lead to inappropriate results. For an RD&E organization, the metrics should foster improvement and be related to the vision and mission. With these factors in mind, the committee developed a set of metrics that can be used as part of an assessment of the Natick RDEC. Beyond measuring the extent to which the RDEC exhibits world-class performance, the metrics can

also be helpful for self-evaluation or for evaluations of other RD&E organizations by higher-level Army commands.

To describe adequately the many facets of RD&E performance, the committee chose metrics with qualitative descriptors for four levels of performance. These levels are poor, adequate, good, and excellent. The committee believes that a predominance of excellent performance is necessary for an organization to be deemed world-class. The committee also considered the concept of best-in-class, which is the level of performance beyond excellent. This level is not included in the metrics because descriptors would apply to unique situations.

The 100 metrics (i.e., 25 characteristics, with four metrics each) are tabulated in the body of the report according to the characteristics to which they belong. They are sorted by pillar (e.g., there are 12 metrics for the customer focus pillar, four for each of the three characteristics). Assessment results can be summarized in tables or figures, which include overall assessments for each pillar.

It should be noted that the committee has implicitly given equal weight to all five pillars. Under some circumstances, it may be appropriate to assign greater weight to one pillar or another. Other adaptations (e.g., for self-assessment) could also be considered.

Conclusions and Recommendations

Conclusion 1. The phrase "world-class" is widely used to describe products and services. This phrase, however, can reasonably mean different things to different people. Therefore, if the phrase "world-class" is to be useful as a vision, it must be defined, tailored, and characterized in detail.

Conclusion 2. A world-class R&D organization is one that is recognized by peers and competitors as among the best in the field on an international scale, at least in several key attributes.

Conclusion 3. A world-class Army RD&E organization is one that excels in several key attributes by matching core competencies to its mission,-thereby fulfilling the needs of soldiers as well as, or better than, similar organizations anywhere in the world.

Conclusion 4. Efforts to reach or maintain world-class performance require the demonstrated commitment of the full chain of command, from topmost management to the lowest level.

Conclusion 5. World-class R&D organizations are likely to excel in certain fundamental attributes, which are based on demonstrated commitment. These attributes, often called pillars, are customer focus, resources and capabilities, strategic focus, value creation, and quality focus.

Conclusion 6. The five pillars are the basis of 25 Characteristics that the committee believes are most relevant to an Army RD&E organization.

Conclusion 7. Metrics with qualitative descriptors for four levels of performance (i.e., poor, adequate, good, and excellent) of the 25 characteristics are the preferred means of determining the extent to which an RD&E organization has achieved world-class performance.

Conclusion 8. Good or excellent performance for each characteristic, and excellent overall performance for all five pillars, are believed to be necessary for an organization to be judged world-class.

Recommendation 1. The concepts, characteristics, and metrics developed in this study should be used to assist the committee to assess the Natick RDEC.

Recommendation 2. These concepts, characteristics, and metrics should be considered by the Army or outside reviewers for use in assessing other Army RD&E organizations.

Recommendation 3. Army RD&E organizations should consider using these concepts, characteristics, and metrics for self-evaluation.

Recommendation 4. The concepts developed in this study should be considered by RD&E organizations in general for making assessments and self-evaluations. Some tailoring of the characteristics and metrics will probably be needed to suit specific organizations, be they inside or outside the Department of Defense.

Recommendation 5. The concept of a world-class organization should be used principally as an internal focusing mechanism for achieving excellence rather than as an external mechanism for advertising the virtues of an organization.

TABLE C-1 Metrics of the Customer Focus Pillar

Characteristics	Performance Level	Metrics
Customer Satisfaction	Poor	Less than satisfied or dissatisfied with a. strategy used to develop the product or service, appropriateness of the technological solutions, fulfillment of operational capability requirements b. technical capability, quality, and performance of the service or product c. product cycle time and delivery time of the first equipped unit d. technical support for fielded products developed at the RD&E organization e. technical capabilities of the product or service of the RD&E organization
	Adequate	Satisfied with all of a-e (met expectations)
	Good	Very satisfied with a-e (exceeded expectations)
	Excellent	Delighted with a-e (beyond normal expectations)
Customer Involvement	Poor	No consideration was given to involving either internal or external customers in program planning, evaluation, or early "results" (prototype) testing.
	Adequate	Internal or external customers are at times consulted on various aspects of research programs or are involved primarily in program reviews.
	Good	Internal or external customers are from time to time involved in setting program objectives and following progress; there are opportunities for customer feedback.
	Excellent	Customers feel completely involved, almost like partners in the effort; they feel they can and do have a major impact in the life-cycle development of the product or service.
Market Diversification	Poor	Although diversification is addressed in strategic and business plans, senior management has not effectively broadened the customer base; products are developed only for the Army; few joint service RD&E programs are in place.
	Adequate	RD&E programs result in products for the Army and the other uniformed services; the organization provides products to other federal agencies; some of the budget is devoted to developing partnerships with industry and academia.
	Good	The organization is assigned DoD lead on joint programs; a significant amount of the budget is devoted to partnerships with industry and academia; research partnerships yield products that fulfill military needs and fill a void in the needs of other federal agencies.
	Excellent	As a center of excellence, the organization's products serve a wide range of customers, including DoD, other U.S. government organizations, and global allies of the United States; much technology is transferred between the organization and the private sector; industrial and academic partnerships result in the rapid transfer of cutting-edge technology between the organization and its partners; high-quality products are developed, manufactured, and distributed to global customers.

Table C-2 Metrics of the Resources and Capabilities Pillar

Characteristics	Performance Level	Metrics
Personnel Quality	Poor	Work is below standard throughout the organization; there are inadequate technical skills; program planning and management are poor.
	Adequate	Work meets expectations; work force has adequate skills to get results in a timely manner; opportunities to improve and upgrade skills are minimal; few resources are programmed for improving technical skills.
	Good	Work usually exceeds expectations; newly hired employees bring critical new skills and capabilities; present RD&E personnel devote at least a small percentage of their work time to upgrading or acquiring skills, and this training is reflected in annual performance appraisals; the Army gives special recognition to RD&E personnel; personnel are well connected with the scientific and technical community outside the organization.
	Excellent	Work consistently exceeds expectations (of those with major interests in the work of the organization); new skills and capabilities are regularly introduced into the organization; newly hired personnel bring new, state-of-the-art methods into the organization; personnel are encouraged to devote a significant amount of their work week to improving and acquiring technical skills; personnel are recognized for their accomplishments by individuals and organizations outside the Army; career structures support the development of technologists in a wide range of needed disciplines; personnel are noted for effective use of both external and internal resources.
Budget	Poor	Research and program support budgets are constrained; research programs are consistently underfunded; out-year budget projections are flat or decrease; mid-year budget cuts are routine; programs are abandoned, with resulting inefficiencies.
	Adequate	Although budgets are at the recommended levels, major research programs are constantly in jeopardy because of uncertainties about year-to-year funding; no new major construction or programs are funded even though budgets finally prove to be adequate for maintaining ongoing programs.
	Good	The organization consistently finds ways to get more done with less; resources are leveraged with other government agencies; the organization periodically takes the lead in DoD-wide or similar programs; collaborative programs with industry and academic groups are cultivated; some funding is provided to support new research initiatives, acquire new equipment, and construct or renovate laboratory facilities.
	Excellent	The outstanding work of the organization is recognized by prompt funding at desired levels; the organization is asked to accelerate RD&E programs and initiate new missions when additional funding is available; program managers obtain the absolute best value with their budget; resources leveraged with other organizations and agencies are recognized as force multipliers; the organization maintains a backlog of high-quality yet-to-be-funded projects.

Characteristics	Performance Level	Metrics
RD&E Capabilities, Skills, Talents	Poor	Technical skills, capabilities, and talents are inadequate to support current and future customer requirements; few new techniques and skills are acquired via new hires or continuing education and retraining of personnel; personnel cannot fully operate, maintain, or utilize available equipment; continuing education is not promoted, encouraged, or funded.
	Adequate	Plans are developed and funding is provided for maintaining the present core capabilities for the future; personnel are trained to operate and maintain equipment and use equipment as specified by the manufacturer; personnel skills are recognized as current and competent for their technical specialties.
	Good	The organization possesses the skills and talents to fulfill customer requirements for the foreseeable future; new and innovative techniques, skills, and processes are incorporated into the RD&E processes; newly acquired skills result in improved product engineering, manufacturing, or performance; new personnel are recruited to bring state-of-the-art techniques into the organization; personnel are encouraged to participate in formal continuing education programs; members of the research staff are encouraged to participate in professional societies, serve on external committees, etc.; program managers recognize new skills that will benefit their programs, and they plan for the acquisition of these skills and talents.
	Excellent	The research and support staffs are recognized as possessing superb technical and administrative skills and talents; many members of the support staff are recognized as artisans of their trade; research personnel incorporate state-of-the-art techniques into their research and develop pioneering methods of their own; a clearly articulated plan describes how needs and voids in core capabilities are identified and filled; new capabilities that must be developed are also addressed and acted upon; a growing inventory of skills is maintained.
Use of External Resources	Poor	Work is contracted outside the organization on an ad hoe basis with little or no planning; contract managers do not ensure that statements of work are fulfilled on time or on budget; products and services provided by contractors and partners contribute incrementally to the organization's mission.
	Adequate	Partnerships are developed with a wide range of groups to enable work to be done outside the organization; work done by others is contracted primarily based on the other party's willingness to do the work; products and services obtained from external sources fulfill the statement of work; products complement internal research programs.
	Good	The organization is recognized as a "smart buyer" of services and work of other parties; personnel appreciate the quality of the work that is contracted; the extent of leverage (i.e., the ratio of the cost to do the work at the organization to the contracted cost) is appreciated; external research programs enhance internal programs and result in leap-ahead technology.
	Excellent	Partnerships and contracts with organizations recognized as the best in their field complement RD&E programs and result in leap-ahead (and occasional breakthrough) technological advances; skills and abilities of the external organization cannot be duplicated in the organization in a cost-effective manner; the value of partnerships is widely recognized inside and outside the RD&E organization.

Characteristics	Performance Level	Metrics
Important Technologies	Poor	There are no systematic programs or processes for introducing, managing, or assessing research technologies in the research program.
	Adequate	Base technologies being developed or used in the research program are necessary for fulfilling technological needs but offer little differentiation in product performance from other alternatives; important technologies are recognized, developed, and used, but technology development is not advanced.
	Good	Pacing technologies are being developed or used in the research program; these technologies have the potential to change significantly the nature of the research program, but they are not yet embodied in products; incorporation of pacing technologies results in leap-ahead developments.
	Excellent	RD&E programs are anticipatory; development and incorporation of new technology to support RD&E and product development are planned and adequately funded; new areas of research and technology are appreciated, and researchers understand the implications of particular research programs; new scientific discoveries are frequently translated into pacing technologies within the organization.
Organizational Climate	Poor	The work environment is acknowledged by management and staff to be poor; personnel are preoccupied with furloughs, early retirement, and downsizing initiatives; personnel equate reengineering to organizational instability; initiating risky programs is discouraged; management punishes failure by withholding resources.
	Adequate	The work environment is perceived as professional and collegial; personnel enjoy their work and say it is meaningful; responsibilities are clear, and teamwork and collaborative efforts are evident; managers tolerate innovation and occasionally empower their staffs, teams, and groups; personnel are recognized for their contributions; although anxious about reorganization and downsizing, individuals feel relatively secure about their jobs.
	Good	Work and organizational climate is considered good; bold and innovative thinking is encouraged and rewarded; research personnel are fully empowered to set goals and pursue original and innovative solutions, but they do not fear failure; the organization is recognized as possessing a "can do" attitude.
	Excellent	Management and staff perceive the organizational climate as excellent; there is clarity of purpose and vision; the staff is secure; no hint of fear is present, and rewards and recognition motivate individuals and teams to make excellent contributions; management encourages the development of new work environments that result in increased productivity.

Characteristics	Performance Level	Metrics
Information Technology	Poor	Computer hardware and software are not available at every work station; software and hardware are two generations or more out of date; personnel cannot communicate electronically or transfer data internally or externally; personnel are poorly trained and hesitant to learn new applications; funding for information technology and user training is inadequate.
	Adequate	Information technology is used as a tool by research and support personnel, and it increases productivity and ultimately decreases the organization's overhead; acquisition of new hardware and software is adequately funded; training and technical support are available; personnel are comfortable with the available technology and are electronically connected internally and externally.
	Good	An information technology strategy guides program direction; research, support, and administrative systems are integrated; information technology enhances the effectiveness of the RD&E allowing work to be done in entirely new ways; information technology is credited with recent advances in research programs; hardware and software are state-of-the-art; technical support is abundant; the staff is educated in the use and application of the technology.
	Excellent	Information technology enables rethinking how RD&E is done, and technical breakthroughs, previously thought of as being impossible, are within reach; the products include information-technology components.
Facilities and Infrastructure	Poor	Facilities and equipment are inadequate, poorly maintained, and out-of-date; no new investments in equipment and facilities are forecast;. preventive maintenance is seldom performed; safety and regulatory compliance are rarely addressed.
	Adequate	Facilities are judged adequate to meet the needs of the organization; there is a schedule for periodic maintenance and upgrading of equipment; safety and regulatory compliance policies are in place, but audits, inspections, and training are limited.
	Good	Research and support facilities are clean, spacious, and comfortable; facilities are environmentally controlled year round; equipment is upgraded or replaced routinely; preventive maintenance and service contracts are well funded; relatively new technical capabilities are acquired, and user training is provided; there is evidence that safety and regulatory compliance are important (e.g., statistics are maintained, periodic inspections are made versus appropriate standards, and training is emphasized).
	Excellent	Facilities and equipment are exceptional; there is timely access to equipment and facilities, which aid personnel in many unexpected ways (e.g., the latest technologies allow them to look at problems in new ways; specialized analytical equipment opens new horizons; there is sufficient equipment to meet user needs); critical programs are supported with state-of-the-art equipment; there is pride in the installation's records in safety and regulatory compliance, ample resources are devoted to inspections and training, and employees continually strive for better safety and regulatory compliance.

Table C-3 Metrics of the Strategic Vision Pillar

Characteristics	Performance Level	Metrics
Alignment of Vision and Mission	Poor	Vision and mission statements are not articulated well, nor are they linked; senior management has difficulty communicating vision and mission statements through command briefings, annual plans, or business plans to staff members and customers.
	Adequate	Vision and mission statements are articulated and understood by most employees; a research strategy is developed using these statements as a guide; research programs, resources, and management support are aligned, in general, with the research strategy.
	Good	The organization's strategic vision is inspiring, and the vision and mission are in harmony with each other; the vision and mission provide a "guide to action" for all programs; management support and resources are aligned with the research strategy.
	Excellent	The strategic vision and management's translation of this vision into a research strategy yields superior products and services; the alignment of resources with the research strategy is readily apparent.
Anticipatory Strategic Planning	Poor	No strategic planning process is implemented, or the strategic plan is ineffective.
	Adequate	A strategic planning process is in place, and business plans and annual plans are implemented; senior management enlists research and support staff assistance to draft and implement the strategic plan through the business and annual plans; the plans are communicated to the staff.
	Good	A robust planning process is in place, with broad involvement across the organization; the resulting planning document is used to measure progress throughout the year; contingency or alternative plans are developed to accommodate rapid changes in customer needs, the environment, or resources.
	Excellent	Plans for human resources, information technology facilities, budget, and travel are fully integrated into strategic plans; the planning horizon for the strategic plans is sufficient to anticipate major Army and joint service needs; multiple examples demonstrate a high degree of flexibility within the organization, which has reacted rapidly to either major opportunities or critical customer needs.

Characteristics	Performance Level	Metrics
Stakeholder Buy-In	Poor	The strategic vision and research plan either have not been communicated to the RD&E stakeholders or have not been articulated well and are misunderstood; stakeholder response to the vision and research plan is either negative or indifferent.
	Adequate	A strategic vision is spelled out and understood by most stakeholders; the vision makes all major initiatives readily understandable.
	Good	The strategic vision "speaks" to all stakeholders even if they have not been involved in creating it; customers and disinterested parties understand the research plan and advocate providing adequate resources to implement the plan.
	Excellent	The strategic vision is so clearly articulated that stakeholders lobby Army and DoD planners to implement the research plan fully; stakeholder support for the organization's vision and the research plan are so strong that resources are reprogrammed from other accounts to implement the vision.
Leadership	Poor	Commitment of the senior leadership to the strategic vision or research plan is poorly communicated to the staff; administrative and product development managers are not involved in planning the direction of future research or developing the business plan; personnel are suspicious or do not trust the organization's leadership; stakeholders view the senior leadership as ineffectual and reactive.
	Adequate	The strategic vision and research plan are understood by the staff; resources (i.e., time, personnel, and dollars) are aligned to meet these plans; the staff trusts senior leadership and is receptive to new ideas and re-engineering opportunities.
	Good	Management and staff co-develop plans that are understood and embraced by staff and stakeholders alike; ideas flow freely and in both directions between management and staff.
	Excellent	The leadership has created an air of excitement and commitment throughout the entire laboratory; bold and creative ideas are encouraged and funded; RD&E successes are rapidly exploited, and ideas are rewarded; failure is considered an opportunity to learn.

Table C-4 Metrics of the Value Creation Pillar

Characteristics	Performance Level	Metrics
Proper Portfolio	Poor	Products are developed that do not meet customer needs; products have poor customer acceptance; customers perceive that commercial alternatives are cheaper, perform better, and are more durable.
	Adequate	An analytical process to examine the product portfolio is used to design and field products that have greater value and soldier acceptance; results of the analytical process lead to modifications in product design; major changes may be made after fielding the initial product.
	Good	Portfolio analyses of a program are an integral part of the strategic planning process; there is broad and active customer involvement in the portfolio analysis; programs yield products that have significant customer acceptance, meet or exceed customer requirements, and demonstrate increased value compared to current products or commercial alternatives; minor changes in product design occur after initial fielding.
	Excellent	Portfolio analyses result in RD&E processes that yield products and services with excellent value, performance, and customer acceptance.
Product Performance	Poor	Products do not meet customer requirements (e.g., in terms of weight, volume, function, durability, or maintainability); customers complain that product performance does not meet the developer's claims; products are not suitable for use in certain locations or environmental extremes.
	Adequate	Products meet customer requirements, needs, and expectations.
	Good	Products fully meet or exceed customer requirements; products are perceived as better than the ones they replace.
	Excellent	Products not only exceed customer expectations, but product performance includes some pleasant, unexpected surprises (e.g., reduced maintenance requirements, longer shelf life, longer mean time to failure, resource savings).

Characteristics	Performance Level	Metrics
Cycle Time and Responsiveness	Poor	Cycle time for project completion is longer than anticipated; milestones are routinely missed; program delays result in increased end-item cost; research programs do not anticipate customer needs; management and staff are not flexible to modifications of product requirements.
	Adequate	Elapsed time from project initiation to project completion is measured and can be reliably forecasted; research programs are described as being on-time and on-budget.
	Good	RD&E programs are initiated and completed significantly faster than similar government or commercial programs; research staff is responsive to "quick fixes" for troops, and numerous examples are readily available for major products; senior management ensures that adequate resources are reprogrammed to fulfill quick-fix requests.
	Excellent	RD&E programs are initiated and completed substantially (e.g., one third) quicker than similar government or commercial programs; innovative processes and technical solutions reduce typical quick-fix response times by nearly half; the staff monitors foreign and domestic industrial and academic research for solutions to new and unanticipated technical problems; commanders directly and indirectly express gratitude for responsive quick fixes.
Value of Work in Progress	Poor	No evaluations of historical RD&E programs are available for comparison to current programs; no methodology is in place to assess current RD&E programs; customer perception of prior RD&E programs is predominantly critical and negative, and little or no value is placed upon the current programs by the customers.
	Adequate	A database on select historical RD&E programs and all current programs is available; current RD&E programs are vividly described, and these descriptions are used during peer-review discussions to justify programs and prioritize personnel and budget requests; customer perception of prior RD&E programs is generally positive; customer perception of current RD&E programs is positive (i.e., the products and services will generally meet user requirements and be delivered on time and on budget).
	Good	A database is maintained on all past major projects (e.g., for the last decade) and their primary and secondary impacts; the database is used for comparison with current RD&E programs; leadership creates a scale to rate continuously the potential value of current programs compared with previous programs and show improvements; customers rate RD&E programs as very good (i.e., products are expected to fully meet or exceed customer requirements; products are perceived as likely to be better than the ones they replace).
	Excellent	A complete historical database and evaluation methodology are used to demonstrate the value of the organization's products and services; data are used to justify and defend program expenditures; customers rate products and services as excellent (e.g., product performance exceeds customer expectations); product performance exceeds anything projected to be available from domestic and foreign sources for at least several years.

Table C-5 Metrics of the Quality Focus Pillar

Characteristics	Performance Level	Metrics
Capacity for Breakthroughs	Poor	RD&E programs are routine and unimaginative; there is no evidence of imaginative or innovative solutions being applied to RD&E tasks; resources are directed to meeting specific customer requirements only.
	Adequate	RD&E programs are characterized by steady but incremental improvement; several innovative solutions can be pointed out; minimal funding is available for programs that anticipate future military requirements.
	Good	Although most programs are characterized by incremental improvements in technology, the organization has demonstrated several leap-ahead improvements; the organization encourages and funds opportunities to seek truly innovative, moderate-risk solutions.
	Excellent	Unexpected innovation based on breakthroughs in technology occur fairly regularly among internal and external (cooperative) RD&E programs; moderate- and high-risk research that offers high return receives stable funding; numerous examples of breakthrough research are cited from the previous five to ten years.
Continuous Improvement	Poor	There is no tangible evidence of senior management commitment to continuous improvement; the need and ability to focus on continuous improvement are recognized, but not funded; products and services show incremental changes; innovations are not rewarded; solutions from industry and academia are discounted as "not invented here."
	Adequate	Quality of the work is discussed and several measures of quality are used routinely; innovative solutions are encouraged; staff members frequently make suggestions for improvement; several changes are made (and documented) each month for improving the work and the output of the organization.
	Good	The organization takes steps to improve work processes and RD&E results significantly; quality audits are performed periodically by internal and external review groups; numerous improvements can be pointed out; productivity is an important topic of discussion; report cards are issued annually by senior leadership; senior managers have the resources to enact recommendations.
	Excellent	Greater productivity, enhanced research and product quality, improved customer involvement and satisfaction, and continuing education of the work force are areas of primary interest to senior management; the concepts of continuous improvement and excellent product value are embedded in the goals of each RD&E and support function; there is a systematic analysis of research and support processes to eliminate non-value-added activities; research personnel are renowned for finding innovative solutions to technically difficult problems.

Characteristics	Performance Level	Metrics
Commitment to Quality	Poor	Management espouses a commitment to quality, but no formal process to review and evaluate quality is in place; some quality-related results are managed by exception; the quality of products and services varies between RD&E units in the organization.
	Adequate	Management is investing resources for total quality training and implementation; the variability of products and services is being measured and tracked; personnel are aware of the importance of quality.
	Good	Total quality implementation is a major goal in the organization's strategic plans; a framework and methodology for measuring and assessing total quality is in place; measurable objectives for work-process improvement are established; there are methods (e.g., statistical process controls) to improve effectiveness and product quality with existing resources.
	Excellent	The commitment to total quality is inherent and pervasive throughout the organization; the focus of all measurements is on optimizing the RD&E processes to deliver value; frameworks, such as ISO 9000/2 (international quality standards), Baldrige criteria, or locally developed systems, are used for assessment; recommendations to improve quality are immediately funded and implemented.
Structured Processes	Poor	Work processes and procedures are understood and milestones are established, but there is no system of internal or external review; project management results in products or services that are delivered late and over budget; delays result in termination of projects; disciplined approaches to defining problems and the scientific method are rarely used.
	Adequate	Work processes and procedures are monitored; project costs and milestones are closely tracked; processes are established to improve quality incrementally, contain or reduce RD&E cost, and reduce product cycle time; disciplined approaches and the scientific method are used most of the time.
	Good	Program managers are flexible and adaptive; senior leadership and staff are receptive to innovative ideas for improving work processes and procedures; product quality and customer focus mean continuous improvement; disciplined approaches and the scientific method are used consistently.
	Excellent	The senior leadership strives to identify and incorporate best business practices into the organization; processes are considered flexible and not overly restrictive, prescriptive, or bureaucratic; management is focused on achieving superior performance and product quality; emphasis on cross-project management ensures timeliness and the proper allocation of resources; disciplined approaches to problem solving include an extensive network linked to Army technological resources worldwide; the scientific method is strictly followed.

Characteristics	Performance Level	Metrics
Learning Environment	Poor	Senior leadership is characterized as reactive; little if any learning takes place on an organizational basis; some managers and staff learn from mistakes.
	Adequate	Senior leadership recognizes and communicates the importance of organizational learning; management and staff learn from mistakes and from others; personnel are well networked both inside and outside the organization; teams on one project teach teams assigned to other projects; new skills and techniques are acquired through new hires and continuing professional education.
	Good	Organizational learning is characterized as adaptive; the organizational climate is conducive to learning; personnel are rewarded and encouraged for taking risks and entrepreneurial initiatives despite occasional mistakes; personnel learn from others and by doing; management experiments with new organizational concepts to discover new ways of doing things.
	Excellent	Organizational learning is adaptive and anticipatory; research and technical capabilities continually expand, and management anticipates change; traditional and innovative methodologies are used to measure and evaluate organizational learning.
Quality of Research	Poor	Research and technology programs are not generally aligned with customer requirements and needs; records of research methodology and results are poor; although recorded in technical reports, data are not published in peer-reviewed journals or cited by other scientists in academia or industry; research results cannot be replicated by scientists and engineers outside the organization.
	Adequate	Research and technology programs are aligned with customer requirements and needs; research methodology and results are peer-reviewed and published as both technical reports and journal articles; the research staff is invited to participate in scientific meetings and workshops; research results are easily replicated by other laboratories.
	Good	The research and technology programs are recognized by peers as being of very high caliber; several programs are among the best in the federal government and are described as innovative and original; some patents are awarded.
	Excellent	The quality of the research and technology programs is considered to be among the best in the world; basic research not only fulfills customer needs, but also anticipates future requirements, thus reducing cycle time for new products; research and technology programs are innovative and state-of-the-art; new procedures, processes, and materials are developed by personnel; numerous patents are issued for RD&E innovations.