Performing Collaborative Research with Nontraditional Military Suppliers

RAND

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PREFACE

This report documents the principal findings of a project on the use of collaboration in implementing strategies for developing the management of advanced technologies. This report is the second of two volumes that address this issue. The first volume demonstrates that significant opportunities exist for the Army to more effectively achieve its research and development goals through collaboration with industry. This second volume focuses on how the Army can effectively implement a collaboration policy. The report is an updated and expanded version of a paper presented at an Army conference in November 1995 on Cooperative Research and Development Agreements (CRDAs), grants, Cooperative Agreements (CAs), and Other Transactions (OTs).[1]

The research is being sponsored by Mr. Michael Fisette, Principal Deputy for Technology, AMC Headquarters, and is being conducted within the Arroyo Center's Force Development and Technology Program. The Arroyo Center is a federally funded research and development center sponsored by the United States Army.

The findings should be of interest to Army audiences addressing strategies for developing advanced technology.

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[1]Kenneth P. Horn, "Performing Collaboration to Manage the Development of Advanced Technology," *Proceedings of the Army Conference on CRADAs, Grants, Cooperative Agreements, and Other Transactions,* sponsored by Intellectual Property Law Division, Headquarters, U.S. Army Materiel Command and U.S. Army Domestic Technology Transfer Program Management Office, 2 November 1995.

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INTRODUCTION

Despite conducting substantial research and development, the Army is facing a series of constraints in maintaining its technological edge: (1) future reductions in science and technology (S&T) funding that have averaged 15 percent per year over the past few years; (2) commercial domination of many of the important technological areas for the Army, such as information technologies; (3) growth in international technology capabilities and in competition from European and Japanese companies; and (4) a changing research climate within the government, with a growing ideological shift away from big government involvement in R&D.

At the request of the Army Materiel Command (AMC), the Arroyo Center was asked to study promising options for the Army to consider in conducting collaborative research with nontraditional military suppliers (NTMSs), defined as U.S. profit-making companies that are accepted leaders in their technological fields and that have not historically worked for the Army.

ARE THERE OPPORTUNITIES FOR COLLABORATIONS WITH NTMSs?

To determine how great the opportunities for collaboration were, we started by examining the match between the technologies the Army needs to ensure land supremacy in the future and those technologies suitable for collaboration with NTMSs. Using the list of technologies

WHAT IS THE BEST STRATEGY FOR EXPLOITING OPPORTUNITIES FOR COLLABORATION WITH NTMSs?

Given the potential of the new options, the next step is to conduct a pilot to demonstrate that (1) NTMSs can indeed be attracted, (2) the Army can abide by rules associated with the new way of doing business, and (3) the Army can benefit from research collaborations with NTMSs. RAND is in the process of designing such a pilot. Working with the technology areas deemed most significant earlier in our analysis, we identified Army organizations and specific technologies suitable for collaboration. For example, in the medical technology area, we identified the specific technology of telemedicine and Medical Research and Materiel Command (MRMC) as the Army organization.

The candidates were then assessed against a set of five "screening" criteria (e.g., the technology is important to the Army, and it is appropriate for collaboration). Five candidates passed all the criteria: (1) Natick Research, Development, and Engineering Center (RDEC), in the areas of food, clothing, or biotechnology; (2) Simulation, Training, and Instrumentation Command (STRICOM), in the area of advanced simulators; (3) Director of Information Systems for Command, Control, Communications, and Computers (DISC4), in the area of expert systems; (4) National Automotive Center (NAC), in the area of vehicle technologies; and (5) Army Research Laboratory (ARL), in the area of information warfare. These candidates were then assessed against a set of five "necessary" criteria (e.g., a champion exists within the Army, the technology is central to the organization). Although all the candidates seem promising as pilot programs at this time (especially Natick RDEC and STRICOM), there is still, in some cases, incomplete information for a final evaluation. However, based on our promising findings to date, the Army plans to set up at least one pilot program in fiscal year 1997.

Assuming a pilot collaboration is created, the Army must do three things to ensure it benefits: (1) align its technical objectives with the selected company's strategic goals to ensure that both sides are able to articulate their needs and visualize the desired end products and their intended applications; (2) produce a formal business plan—including such things as development plans, expected windows for technology insertion, and anticipated milestones—and use an initial

version of this plan in the proposal selection process; and (3) plan for success from the outset. This entails such actions as fencing off funding before the formal solicitation process begins, ensuring that the elapsed time from proposal solicitation to research start is short, ensuring that administrative oversight is minimal, making the Army's interest apparent by assigning top-notch personnel who are true believers, and keeping the lines of communication clear and open.

In sum, our research indicates that collaboration should be included in an Army strategy to develop advanced technologies and that for collaboration to be successful, the Army should use CAs and OTs to attract NTMSs for collaborative R&D, should use cost-sharing whenever possible, and must act like a commercial business partner in collaborative R&D efforts with NTMSs.

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The authors wish to thank Lucille Horgan for providing technical assistance on the United States Code, Donna Fossum and Ofra Stauber for running the RaDiUS database, Mike Sickmiller for performing a technology case study on flat-panel displays, Lieutenant Colonel Pat Vye for coordinating our STRICOM interactions, and Barbara Kenny for preparing the tables and figures and typing the manuscript. In addition, we would like to thank Paul Bracken, Eiichi Kamiya, and Richard Wright for reviewing the document. Thanks are also given to various AMC personnel, both at AMC HQ and ARL, for their help in providing technical information. Special thanks go to Michael Fisette, Principal Deputy for Technology, AMC HQ; Saul Elbaum, Assistant Command Counsel for Intellectual Property Law, AMC HQ; Richard Dunn, DARPA General Counsel; and Richard Kuyath, Senior Counsel, Minnesota Mining & Mfg. Company, for their valuable inputs and suggestions.

ABBREVIATIONS

ACT II	Advanced Concepts and Technology II program
AI	Artificial Intelligence
AMC	Army Materiel Command
ARL	Army Research Laboratory
ARO	Army Research Office
ARPA	Advanced Research Projects Agency
ATCOM	Aviation and Troop Command
ATP	Advanced Technology Program
C3	Command, Control, Communications
C4	Command, Control, Communications, Computers
CA	Cooperative Agreement
CAD	Computer-aided Design
CAM	Computer-aided Manufacturing
CDMA	Code Division Multiple Access
CECOM	Communications-Electronics Command
CPAR	Construction Productivity Advanced Research
CRDA	Cooperative Research and Development Agreement

DARPA	Defense Advanced Research Projects Agency[2]
DISC4	Director of Information Systems for Command, Control, Communications, and Computers
DFARS	Defense Acquisition Regulation Supplement
DoD	Department of Defense
DoDGARs	Department of Defense Grant and Agreement Regulations
DSSW	Defense Supply Service—Washington
EW	Electronic Warfare
FAR	Federal Acquisition Regulation
GAAP	Generally Accepted Accounting Principles
IDA	Institute for Defense Analyses
IT	Information Technology
LOSAT	Line-of-Sight, Anti-tank
MRMC	Medical Research and Materiel Command
NAC	National Automotive Center
NDI	Nondevelopmental Item
NIST	National Institute of Standards and Technology
NRTC	National Rotorcraft Technology Center
NTMS	Nontraditional Military Supplier
OT	Other Transaction
PLA	Patent Licensing Agreement
RaDiUS	Research and Development in the United States database

[2]The Defense Advanced Research Projects Agency (DARPA) was known as Advanced Research Projects Agency (ARPA) between March 1993 and February 1996.

R&D	Research and Development
RDEC	Research, Development, and Engineering Center
RDT&E	Research, Development, Test, and Evaluation
RFP	Request for Proposal
ROI	Return on Investment
S&T	Science and Technology
SBIR	Small Business Innovation Research program
STRICOM	Simulation, Training, and Instrumentation Command
TACOM	Tank-automotive and Armaments Command
TARDEC	Tank-Automotive Research, Development, and Engineering Center
TRP	Technology Reinvestment Project

Chapter One

INTRODUCTION

BACKGROUND

In an effort to maintain its technological edge, the U.S. Army spent nearly $1.5 billion in fiscal year 1995 in conducting basic research, exploratory development research, and advanced development research—referred to as 6.1, 6.2, and 6.3 science and technology (S&T) research activities, respectively. Despite this outlay of money, the Army is facing a series of constraints in maintaining that technological edge. First, it is facing future reductions in S&T funding, reductions that have averaged 15 percent per year over the past few years. Second, many of the important technological areas for the Army, such as information technologies, are now dominated by commercial firms—firms that have not traditionally done business with the Army. Third, there is a growth in international technology capabilities and in competition from European and Japanese companies. And fourth, there is a changing research climate within the government, with a growing ideological shift away from big government involvement in R&D.[1]

In the face of these constraints, the Army must seek to leverage scarce R&D funds by finding new ways to exploit industry's capabilities, especially in areas where the commercial sector holds the technological edge. In fact, the Army is experimenting with some new ways of conducting business with industry, including the establish-

[1]This topic has been discussed extensively in the press and trade journals. See, for example, Gary Chapman, "The Cold War Has Given Way to War on R&D," *Los Angeles Times*, p. D1, May 6, 1996.

ment of the Federated Laboratory. The Federated Laboratory, which was specifically established to capitalize on the commercial sector's lead in information technologies, has three primary goals: (1) provide the Army with affordable state-of-the-art digitization and communications technology; (2) promote opportunities for industrial/academic partnering with the Army; and (3) forge new cooperative relationships between the private sector and government scientists and engineers. To accomplish these goals, the Army established federated extramural centers in three technical areas of information technology (IT): advanced sensors, advanced displays/interactive systems, and telecommunications/information distribution.

The Federated Laboratory has proved successful in attracting highly capable military contractors—firms that historically have done business with the government. Thirty-one proposals involving over 250 industry/university participants were received in response to the Federated Laboratory Broad Agency Announcement. As a result of site visits, the 31 consortia were reduced to 14, of which three were ultimately selected. The three winning consortia consisted of 27 industry/university participants. Industry participants were mainly traditional military contractors (e.g., Lockheed Sanders; Lockheed Missiles & Space Co., Inc.; Texas Instruments, Incorporated; Rockwell International Corp.), and in each case the lead partner of the consortium was a traditional defense contractor.

Although the Federated Laboratory has been successful in attracting traditional military contractors, it has been less successful in attracting some of the nation's leading-edge commercial companies in the IT area.[2] In particular, only a small number of leading-edge firms that historically have not done business with the government—the so-called nontraditional military suppliers (NTMSs)—participated in the Federal Laboratory competition. In fact, of the 27 industry/university participants in the three winning consortia, only one company was not a traditional defense contractor. In the area of IT

[2]Actually, this is not so much an Army problem as a DoD-wide problem. According to one study, only a very small amount of DoD RDT&E awards in 1994 went to those industry/group leaders listed in *Business Week*'s R&D scorecard of commercial firms that can be considered at the leading edge of technology in their fields. See D. Hornestay, "Try Making 'Other Arrangements,'" *Government Executive,* September 1995, p. 68.

where the commercial sector clearly dominates, one would have hoped for participation from more NTMSs.

Given these trends and the limited ability of efforts like the Federated Laboratory concept to successfully attract leading-edge commercial firms, the Army needs to take a fresh look at various approaches and options to managing the development of Army technologies, especially those in which the commercial sector has a definite lead.

OBJECTIVE AND SCOPE

At the request of the Army Materiel Command (AMC), the Arroyo Center was asked to create a strategy for managing the development of advanced technologies. During the initial phase of this project, we showed that significant opportunities exist for the Army to more effectively achieve its R&D goals through collaboration with industry.[3] In the research described here, we investigated candidate new concepts the Army can use to implement a collaborative R&D policy. In particular, we assessed how effective these concepts were in attracting NTMSs into research collaborations with the Army.

DEFINITIONS

By an NTMS, we mean a U.S. profit-making company that is an accepted leader in its technological field and that has not historically worked for the DoD. NTMSs have not been interested in research collaborations with the Army (except for possibly selling nondevelopmental items, NDIs) because they viewed their operations as incompatible with the Army's way of doing business. By research collaborations, we mean creating formal partnerships, contractual relationships, or sharing arrangements between the Army and industry that advance military technology. Successful collaborations would permit the commercial sector to participate in DoD-funded R&D—gaining access to military developments and new markets through resource sharing—and would enable the Army to reduce its

[3]Carolyn Wong, *An Analysis of Collaboration Opportunities,* Santa Monica, Calif.: RAND, MR-675-A, forthcoming.

research, development, and acquisition costs by incorporating state-of-the-art commercial technologies in future weapon systems.

ORGANIZATION OF THIS DOCUMENT

Chapter Two examines the Army's research activities to determine whether there is an adequate number of potential opportunities for collaboration with NTMSs—opportunities that are attractive to both the Army and the NTMSs. As part of the attempt to understand how to attract more NTMSs, Chapter Three examines how well the Army has done in attracting them. Chapter Four seeks to identify the prospects for attracting more NTMSs, which involves (1) understanding the potential of using the new contractual mechanisms that are now available to the Army, and (2) talking with NTMSs to get their inputs/suggestions. It also examines what can be done to make sure the Army improves its chances of having successful collaborations with NTMSs. Chapter Five turns to examining possible candidate NTMSs for a pilot study with the Army and some ideas for structuring a pilot demonstration to ensure that it works well. Chapter Six offers some concluding remarks about using the opportunities for Army collaborations with NTMSs as part of an Army strategy for managing the development of advanced technologies.

Chapter Two

ARE THERE OPPORTUNITIES FOR COLLABORATION WITH NTMSs?

As mentioned above, the Army conducted $1.5 billion in S&T research during fiscal year 1995. The first issue for the Army is to determine whether there are opportunities for collaboration with NTMSs in the research it is currently conducting.

This chapter summarizes an approach for determining appropriate candidates for collaboration and shows selected results of applying it to the Army's RDT&E technology programs in the fiscal year 1995 DoD budget request (the so-called "R-1" budget request).[1]

FRAMEWORK FOR DETERMINING THE MOST PROMISING CANDIDATES FOR COLLABORATIONS

To retain land warfare supremacy, the Army must continue to maintain its technological edge in a wide range of technologies. To determine which of these technologies are suitable candidates for collaboration with NTMSs, we devised an approach for assessing the Army's technologies—an approach that is an extension of a methodological approach first developed at RAND for the U.S. Navy to help it prioritize its technologies.[2]

[1]For more detail about this initial phase of research, see Carolyn Wong, *An Analysis of Collaboration Opportunities*, Santa Monica, Calif.: RAND, MR-675-A, forthcoming.

[2]Kenneth V. Saunders et al., *Priority-Setting and Strategic Sourcing in the Naval Research, Development, and Technology Infrastructure*, Santa Monica, Calif.: RAND, MR-588-NAVY/OSD, 1995.

The approach uses two independent criteria that are plotted against each other on orthogonal scales to highlight similarities and differences in the technologies. We selected Army utility as one criterion because it represents a good measure of which technologies are the most important to the Army. The higher the utility, the more important the technology is to the Army. We selected market breadth as the other criterion because it represents a measure of commercial interest and involvement. The more generic the technology, the greater its potential for commercial applications. Figure 2.1 shows the assessment framework used in the analysis. The technologies best suited for collaboration would fall in the shaded area in the upper right-hand corner, where there is high Army utility and high commercial interest.

SELECTED RESULTS

To determine the position on the framework of each of the 6.1 and 6.2 technologies shown in the R-1, each member of the project team

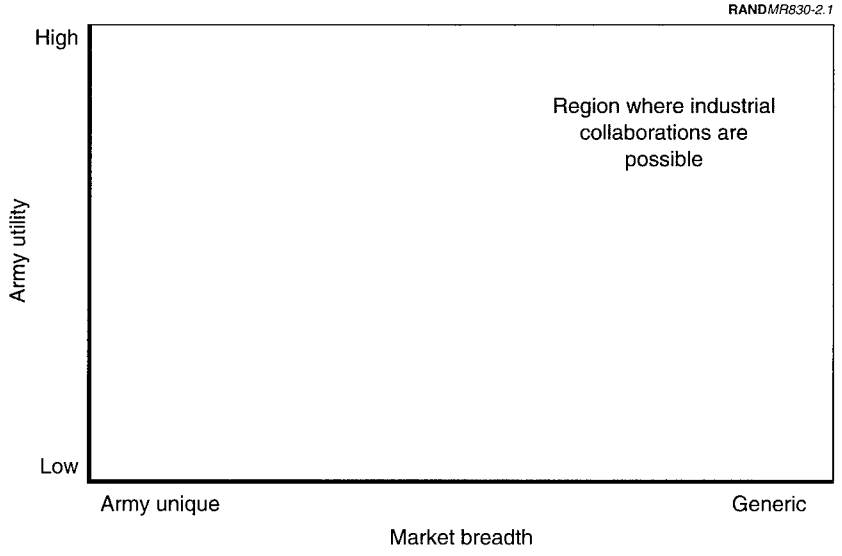

Figure 2.1—Framework for Determining Technology Collaborative Potential

independently placed the technologies into the framework.[3] To determine final placements on the framework, the inputs were averaged after major discrepancies were adjudicated by the group leader following discussions with the project team.

Figure 2.2 shows the results of the placement of 6.1 and 6.2 technologies. As one might have expected, no technologies fall in the lower left-hand corner of the figure (corresponding to low Army utility and Army unique). Also, as expected, many technologies fall in the shaded region in the upper right-hand corner—the region where technologies are best suited for NTMS collaborations (i.e., high Army utility and generic market breadth).

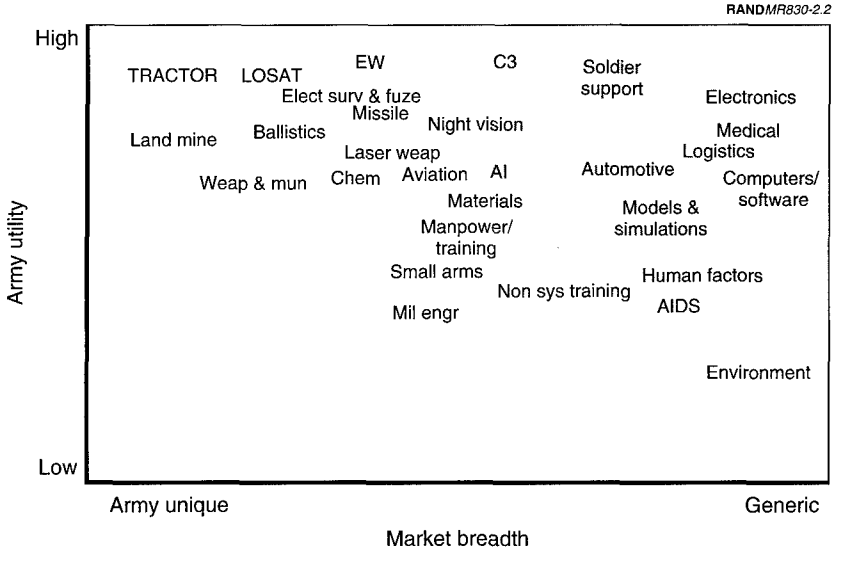

Figure 2.2—Position of 6.1 and 6.2 Technologies on Framework

[3]Project team members were RAND staff with backgrounds in engineering, business management, and the physical sciences. Professional experience ranged from five years to decades of experience in R&D issues. Every team member has worked on Army research development projects for at least several years, and all were familiar with the Army's current R&D program. Some team members also had experience with commercial firms that did business with the Army.

When we look at the nine technology areas in the potential collaboration area—artificial intelligence, electronics/C3 (including computers and software), materials, automotive, medical, logistics, soldier support (including night vision, food, clothing, and individual equipment), human factors, and models and simulation—we discover that the total amount of money the Army devotes to these technologies is significant. In fiscal year 1995, this amounted to approximately $550 million out of the nearly $1.5 billion budgeted to 6.1–6.3 research.

In some of these nine technology areas, the Army already has some collaborative efforts ongoing. For example, in Project Plowshares, Army-generated computer simulations are being used by local government officials in Orange County, Florida, to help in disaster relief. However, this is an example of a "spin-off," and we are interested in collaborative research that leads to "spin-ons" to the Army. The National Automotive Center (NAC) is another case where the Army Tank-automotive and Armaments Command (TACOM) and the "Big Three" auto makers have worked out a collaborative arrangement.

Table 2.1

Examples of NTMSs Associated with Technologies Suitable for Collaboration

Technology	Examples of NTMSs
Artificial intelligence	Expert Software; Network General Corp.
Electronics, C3, computers, and software	Apple Computer, Inc.; QUALCOMM Incorporated
Materials	E. I. DuPont De Nemours & Co.; Minnesota Mining & Mfg. Co.
Automotive	Roush Industries
Medical	Genzyme Corp.; Biogen, Inc.
Logistics	Federal Express Corp.; UAL Corporation
Soldier support (food, clothing, and individual equipment, night vision)	Chemfab Corp.; Opta Food Ingredients, Inc.
Human factors	Cannondale Corp.; The Coleman Co., Inc.
Models and simulations	The Walt Disney Company; Warner Bros, Inc.

In addition, the Federated Laboratory is performing collaborative research on information technologies, as is the Medical Federated Laboratory in medical research. But for many of the other promising technologies, collaborations have not been implemented, and these technology areas are dominated by NTMSs.

Table 2.1 shows examples of NTMSs associated with the nine technology areas. The bottom line is that there are significant opportunities for additional collaborations with industry, especially with NTMSs.

Chapter Three

HOW WELL HAS THE ARMY DONE IN ATTRACTING NTMSs?

As the previous chapter reveals, the Army has significant opportunities for conducting collaborations with industry, especially with NTMSs. The next question is how well the Army has recently done in collaborating with NTMSs.

This chapter examines this question by showing the results of an analysis of Army collaborations with the leading commercial companies in the IT area. This area was selected because, as shown in Chapter Two, it is one of the areas of interest to the Army in which commercial firms dominate. The formation of the Federated Laboratory in this area was a strong indication that the Army is very interested in IT. Also, IT is a good technology to investigate because once the offerors in the Federated Laboratory competition are finally announced, this information can be used to provide an independent check of NTMS participation.[1]

ANALYSIS APPROACH

As a first step in the analysis, we compiled a representative list of 44 leading commercial companies in the IT area, shown in Table 3.1. By "leading," we mean companies that are generally accepted as market leaders in their respective fields. These companies were selected using a variety of sources—relevant business information (e.g., *Busi-*

[1]The information on the unsuccessful offerors in the Federated Laboratory competition is currently considered proprietary. To date, only those selected for awards have been announced.

ness Week's R&D Scoreboard for 1995), various market surveys/analyses (e.g., the Dun & Bradstreet Corporation (DBC) online technology index), and miscellaneous technical assessments/inputs.[2]

The 44 companies cover a wide range of IT areas—from software development, to telecommunication systems, to advanced displays, to advanced sensors. It is important to note that these technology areas closely match the ones being addressed by the Federated Laboratory. While it would be next to impossible to produce the definitive list of "leading IT companies," we believe the list shown here is representative of the leading commercial companies and, as such, was suitable to use as our test sample.

Table 3.1

44 Leading Information Technology Commercial Companies

Adept Technologies, Inc.	Magnetek, Inc.
Adobe Systems, Incorporated	Microsoft Corp.
Advanced Micro Devices, Inc.	Motorola, Inc.
AirTouch Communications	National Semiconductor Corp.
Allied Technology Corporation	Novell, Inc.
Amdahl Corporation	Oracle Corporation
Analog Devices, Inc.	Pacific Telecom, Inc.
Apple Computer, Inc.	Perceptronics, Inc.
Ascend Communications, Inc.	The Perkin-Elmer Corporation
Autodesk, Inc.	Quantum Corp.
Beckman Instruments, Inc.	Read-Rite Corp.
Borland International, Inc.	Sarcos
California Microwave, Inc.	Seagate Technology, Inc.
Cisco Systems, Inc.	Silicon Graphics, Inc.
Conner Peripherals	Stanford Telecommunications, Inc.
Convex Computer Corp.	Storage Technology Corporation
Cypress Semiconductor Corp.	Sun Microsystems, Inc.
Diebold, Incorporated	Teradyne, Inc.
Hewlett-Packard Co.	Minnesota Mining & Mfg. Co.
Intel Corp.	U.S. Robotics Access Corp.
Lotus Development Corp.	Varian Associates
LSI Logic Corporation	Xerox Corp.

[2]We used documents dated from 1993 to 1995.

After compiling this list, we used it to determine past participation of these companies with the Army. We used three measures of merit: (1) number of contracts awarded, (2) number of Cooperative Research and Development Agreements (CRDAs)[3] and Patent Licensing Agreements (PLAs)[4] generated, and (3) number of informal contacts, or technical discussions, that Army Research Laboratory (ARL) personnel have had with these companies.

Finally, we used the test sample of IT companies to gain insight into past participation of these companies with other government collaborative programs, namely, the Technology Reinvestment Project (TRP)[5] and the Advanced Technology Program (ATP).[6]

ANALYSIS RESULTS

Our results indicate that although the Army has had involvement with about 40 percent of the IT companies (20), most of it is limited to informal contacts. In fact, the Army has contracted with only four of the 44 IT companies in fiscal years 1993 and 1994 (Apple Computer, Inc.; Analog Devices, Inc.; Sarcos; and Varian Associates). The data on awarded contracts was determined using the RaDiUS (Research and Development in the United States) database that re-

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[3]According to AMC, a CRDA is defined as a "legal agreement between a Federal laboratory and a non-federal party to conduct specified research or development efforts that are consistent with the missions of the Federal laboratory." A CRDA is intended to permit intellectual property to be shared. Private organizations can contribute resources to the CRDA, including personnel, services, property and funding, while the government can contribute all these resources, except for funding. See *Cooperative Research and Development Agreements*, AMC Pamphlet No. 27-1, September 14, 1995.

[4]A PLA is an exclusive agreement whereby a license is granted to a company to use a government-generated patent. Like a CRDA, a PLA is another mechanism for transferring technology from the government to industry.

[5]Established by Congress in 1992, the TRP has a goal of developing dual-use (military and commercial) technology. Administered by DARPA, TRP involves six agencies: DoD, the Department of Energy, the Department of Transportation, the National Science Foundation, the National Aeronautics and Space Administration, and the Department of Commerce.

[6]Managed by the Department of Commerce's National Institute of Standards and Technology (NIST), the ATP provides cost-shared funding to support the development by private industry of innovative, high-risk technologies that can yield important, broad-based economic benefits to the United States.

ports all government R&D contractual activities.[7] One limitation of RaDiUS is that it includes only prime contractors.

The Army has not done any better in generating CRDAs/PLAs with the 44 IT companies. In fiscal year 1993 and fiscal year 1994, only four CRDAs/PLAs have been generated (one CRDA with Convex Computer Corp., two CRDAs with Minnesota Mining & Mfg. Co., and one PLA with Hewlett-Packard Co.).

The data on informal contacts are drawn from a survey of ARL personnel.[8] They indicate that approximately a dozen or so of the 44 IT companies have been contacted by ARL personnel. However, the degree of technical discussion has varied greatly—from seeking technical literature to discussing possible CRDAs.

Overall, these data indicate that in fiscal years 1993–1994, the Army did poorly in attracting leaders in the IT area. However, our analysis also indicates that other government agencies have not done any better. Figure 3.1 illustrates that less than 10 percent of the awards from the ATP and the TRP have been granted to firms that are on our list of IT leaders.

It is important to note that our analysis of firm participation in ATP and TRP has been limited to IT projects only. These projects represent only a small portion of the total projects awarded. For example, in the TRP case, there were two and five IT projects in fiscal years 1994 and 1995, respectively; for ATP, the corresponding numbers for fiscal years 1994 and 1995 are seventeen and four. The number of team members (including government, industry, and university) is generally large per project, particularly in the case of TRP, where the two projects in fiscal year 1994 involved 93 team members. This suggests that there was ample opportunity for more of the 44 IT companies to join a team if they so desired.

The ATP and TRP data are also important because they allow us to assess NTMS participation as members of teams. Recall that our analysis of contracts between IT leaders and the Army was limited to prime contractors, because that was the only information in the

[7]RaDiUS database, Critical Technologies Institute, RAND, 1995.

[8]Private communication, Dr. Alan J. Goldman, ARL.

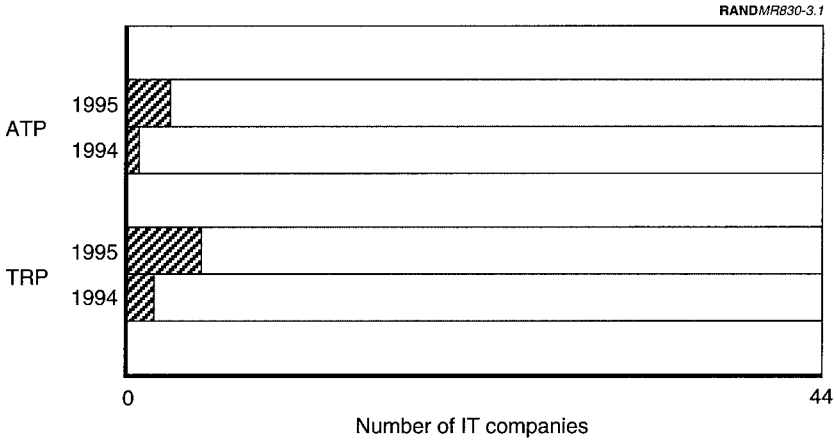

Figure 3.1—Success of ATP and TRP in Attracting IT Companies

RaDiUS database. This left open the possibility of participation as subcontractors or as non-lead-team members. However, the ATP/TRP data, which includes team members, suggests that leading IT firms on our list probably did not participate in any significant role in the collaborations.

The ATP/TRP results support our previous findings: In the IT area, leading firms on our representative list have not rushed to participate in government-initiated collaboration efforts, whether with the Army or with other government agencies.

Chapter Four

OF THE OPTIONS AVAILABLE FOR NTMS COLLABORATION, HOW DO THEY COMPARE?

Given that there are significant opportunities for Army collaboration with NTMSs, why has the Army done so poorly in attracting them? In the previous chapter, the analysis focused on the use of traditional options for attracting NTMSs—contracts, grants, CRDAs and PLAs. However, there are now other collaboration options available—cooperative agreements (CAs) and other transactions (OTs). Are these new options better suited to attracting NTMSs?

This chapter examines that question by, first, discussing the full spectrum of options available and, second, presenting the results of an analysis to determine if the newer options really would attract NTMSs.

OPTIONS AVAILABLE FOR COLLABORATIONS WITH NTMSs

Figure 4.1 shows that the options available to the Army to manage R&D have increased dramatically over the last several decades. Below we discuss the various options.

Contracts

For most of the period shown in the figure, the only available mechanism was a standard procurement contract. Although not specifically designed to be instruments for conducting collaborative research, contracts can be used to execute collaborative efforts. However, contracts require adherence to burdensome regulations, such as the Federal Acquisition Regulation (FAR) and the Defense Acquisition Regulation Supplement (DFARS). As a result, in most

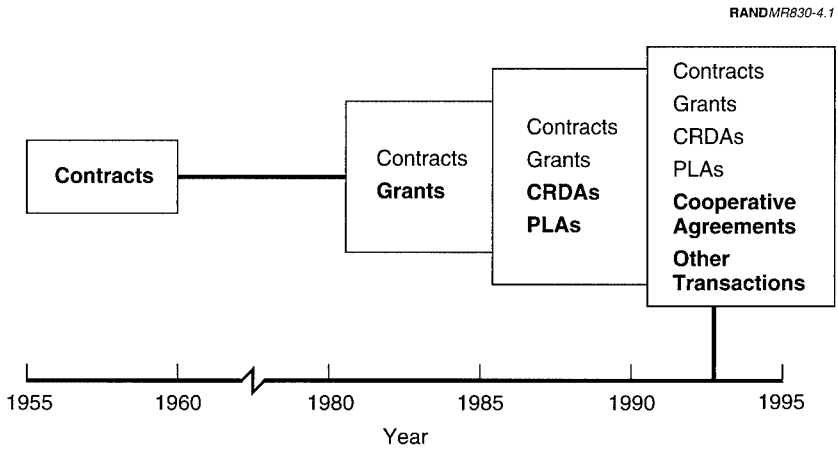

Figure 4.1—Spectrum of Options Available for Collaboration Over Time

instances, contracts have proved too restrictive to attract NTMSs, either because of the management, accounting, and other regulations that apply or because of the high cost to bid.

Grants

In the 1980s, grants were added as another option. Still, grant recipients are usually limited to universities and nonprofit organizations performing basic research. Like contracts, grants require adherence to many burdensome federal acquisition regulations. However, instead of following the FAR/DFARS, grants must adhere to their own set of regulations, the Department of Defense Grant and Agreement Regulations (DoDGARs). The DoDGARs offer some flexibility, but in some cases, such as with intellectual property rights, the awardees are forced to abide by the Bayh-Dole Act, which mandates that the inventing firm has the option of retaining the rights. In general, NTMSs are not interested in this contractual instrument.

CRDAs and PLAs

As a result of the Federal Technology Transfer Act of 1986, federal laboratories were given the authority to establish CRDAs with private

companies, with the public, and with nonprofit organizations; however, CRDAs cannot be used to engage in cost-sharing with the government. More specifically, under a CRDA, the industry partner is allowed to contribute resources such as personnel, services, property, and funding to the effort. The government can contribute all the above, except funding.

In principle, CRDAs permit some freedom in negotiating ownership of intellectual property rights. In practice, however, there appear to be differences in ownership policy between various Army organizations. For example, the AMC CRDA guidance document states that a jointly developed product is jointly owned,[1] while other Army-generated CRDA guidance documents include the appearance of more stringent adherence to Section 3-13 of AR 70-57[2] and state that a jointly developed product is owned by the Army (e.g., the example CRDA included in guidance produced by the U.S. Soldier Systems Command).[3] NTMSs do not like contractual instruments with such ambiguity.

A PLA is an exclusive agreement whereby a license is granted to a company to use a government-generated patent. They have had limited application and success. The Army has accepted approximately 30 PLAs as of the end of fiscal year 1994.

Previous RAND analysis revealed the limitations of using CRDAs as a collaborative mechanism.[4] Details of this analysis are summarized in the appendix.

Part of the problem is that CRDAs and PLAs were specifically created as mechanisms to transfer technology from the government to industry ("spin-off"). They were not created as mechanisms to do the

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[1]"Cooperative Research and Development Agreements," U.S. Army Materiel Command, AMC Pamphlet 27-1, 14 September 1995, p. 3.

[2]"Research, Development and Acquisition Military-Civilian Technology Transfer," Army Regulation 70-57, Headquarters Department of the Army, July 25, 1991, p. 8, Section 3-13.

[3]J. Niro and V. Ranucci, *Cooperative Research and Development Agreement Guidebook,* U.S. Soldier Systems Command, October 1995. Although this document clearly states that each CRDA should be individually negotiated, potential NTMS partners may simply review the example to get an idea of what terms may apply.

[4]RAND unpublished results, 1994.

opposite—efficiently transfer technology from industry to the military ("spin-on"). Therefore, CRDAs can be used as an effective collaborative mechanism only if they are tailored to specific technology areas, thoughtfully conceived (with a "cradle-to-grave" business plan), and closely monitored. The key requirements to generating such CRDAs include: (1) a set of measures to monitor the status of the CRDAs, (2) an adequate dissemination system for sharing information, (3) an incentive structure to sustain commitments, and (4) a flexible interpretation of the intellectual property rights clause.

Cooperative Agreements

In 1989, Congress authorized cooperative agreements (CAs) for use by the military services (and DARPA) as alternative mechanisms for conducting R&D. CAs are authorized by Title 10, Section 2358 of the United States Code (10 U.S.C. §2358). Section 2358 states that the secretary of a military department may engage in basic research, advanced research, applied research, and development using CAs, as well as contracts and grants, on projects that relate to weapon systems and other military needs or of potential interest to the DoD. We have interpreted the "basic, advanced, and applied research and development" phrase as meaning the R&D of generic, not specific, technologies. Others in the Army have told us that they are using a similar interpretation.[5] Section 2358 does not make specific reference to cost-sharing. The Army's Federated Laboratory was established using the program authority stated in Section 2358 (Smith, 1994).

10 U.S.C. §2371 authorizes the inclusion of a recovery-of-funds clause in CAs used to perform basic, applied, or advanced research. For the remainder of this document, we will refer to CAs with a recovery-of-funds clause as 2371 CAs and to CAs without such a clause as 2358 CAs. 2371 CAs require adherence to conditions under 10 U.S.C. §2371 as well as 10 U.S.C. §2358.

CAs should not be confused with CRDAs, even though the words "cooperative" and "agreement" appear in the CRDA phrase. It is also

[5]General counsel personnel at several Army organizations, including HQ AMC and ARL.

important to remember that CAs cannot be used as a substitute for a procurement contract. Therefore, to follow the guidelines for CAs, the research task must be generic and not tied to a specific deliverable. This means that CAs are not suitable for developing all advanced technologies/systems. For example, they are inappropriate for military-specific technologies (such as system-specific land mine technology or weapons/munitions technology, where the commercial sector has limited knowledge/interest) and for system-specific technologies that are not generic. This limitation on system-specific technologies does not apply to DARPA, because it has been granted a special provision to explore R&D prototyping.

Other Transactions

In 1989, Congress also authorized other transactions (OTs) in 10 U.S.C. §2371, which includes the category of "other transactions" as an essentially undefined term. It is interesting to note that within DoD, DARPA has pioneered the use of both CAs and OTs by creatively interpreting Section 2371 (Dunn, 1995).

Since the enactment of Section 2371, DARPA has interpreted it to mean that OTs are a class of transactions outside the procurement and assistance categories (Dunn, 1995). DARPA has signed nearly 100 OTs since 1990. The growth in their use has been especially dramatic in recent years, with 19 signed between 1990 and 1993 and 81 signed between 1994 and 1995.[6] DARPA's interpretation is significant because agreements that are outside the procurement and assistance categories need not adhere to the body of regulations (e.g., FAR, DFARS, DoDGARs, Bayh-Dole Act) that govern such agreements. In short, this means that an OT can follow accepted business practices and negotiate intellectual property rights beyond Bayh-Dole.

Most DARPA OTs have involved partnerships or consortia, either already existing or specifically formed to conduct a particular DARPA-sponsored research or development effort. DARPA OTs have been established with individual commercial firms (e.g., Gazelle Microcir-

[6]For more information, see "ARPA Signs 100 Innovative Agreements Over Five Years," *Army RD&A*, January-February 1996, pp. 26-27.

cuits, Inc.; Cray Research, Inc.; Intel Corp.) and through multiparty arrangements (e.g., Concurrent Superconducting Consortium, Ferrite Development Consortium, Optical Network Consortium). DARPA's success in attracting NTMSs with consortia has been generally good, while efforts conducted under the TRP have been less successful.

DARPA has encouraged the services to use OTs, but even though they have the authority to use OTs, they have made only limited use of this option.[7] In particular, the Army has not generally been the initiator of its OTs. For example, the Army has at least ten OTs that were transferred by DARPA.[8] In each of these cases, the Army is the administrator of the DARPA-funded OT. However, there are indications that the Army is beginning to explore the OT option. For example, the U.S. Army Simulation, Training and Instrumentation Command (STRICOM) has recently solicited commercial companies, universities, or joint ventures interested in CAs and OTs to submit white papers for consideration. Additionally, STRICOM is preparing a pamphlet on CAs and OTs that summarizes their requirements and features.[9]

Comparing Options for Collaboration

Both CAs and OTs are designed to allow the government to more easily conduct collaborative R&D with industry when traditional contractual instruments are neither feasible nor appropriate. And as the above discussion indicates, there are many overlaps between the two options and, consequently, a great deal of confusion.[10] Here, we

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[7]Section 2371 states that an OT (and 2371 CA) can be used only when the use of a standard contract, grant, or cooperative agreement is not feasible or appropriate.

[8]These include one with Defense Supply Service—Washington (DSSW), one with the Army Research Laboratory, one with the Tank Automotive and Armaments Command, six with the Communications-Electronics Command, and one with the Armaments RDEC.

[9]"Cooperative Agreements and Other Transactions POC," *Commerce Business Daily*, February 15, 1996, p. 4.

[10]The General Accounting Office (GAO) has noted that inconsistent selection of a particular instrument and treatment of specific clauses may unnecessarily increase confusion for government and industry users. See U.S. General Accounting Office, GAO/NSIAD-96-11, March 1996.

compare the provisions of contracts, grants, CRDAs, two special programs (ACT II,[11] and SBIR[12]), 2358 CAs, 2371 CAs, and OTs. The eight contractual instruments/programs are also assessed in terms of whether the provisions are favorable from the government's perspective and from that of an NTMS.

Table 4.1 compares available contractual instruments and special programs for collaboration. As the table entries show, contracts are the least flexible, because they require adherence to burdensome regulations and because intellectual property rights are not negotiable. Grants are a little less stringent, because DoDGARs instead of FAR and DFARS apply, and the accounting standards are relaxed. CRDAs appear to be quite flexible with negotiable intellectual property rights, but they also carry a major drawback by forbidding the government to contribute funds to the effort.

In general, CAs are exempt from many bureaucratic rules, regulations, and practices, which makes them attractive to the commercial sector. However, CAs are not the "end-all." Although CAs permit generally accepted accounting principles (GAAP), other burdensome regulations still apply (e.g., DoDGARs and the Bayh-Dole Act). These regulations tend to make CAs unattractive to NTMSs.

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[11]The ACT II program was specifically set up to encourage the application of mature technologies to Army mission needs. The concepts and technologies are solicited annually through a Broad Agency Announcement. This approach is intended to shorten the acquisition cycle and reduce the development costs. The source of this information is the undated Army pamphlet entitled "Army ACT II Program."

[12]The SBIR program, initiated by Congress in 1982, is intended to increase small business involvement in federal R&D. The SBIR objectives are to (1) stimulate technological innovation, (2) increase small business participation, (3) increase private-sector commercialization of technological advances, and (4) increase participation by woman-owned and by socially and economically disadvantaged small businesses. The Army's SBIR budget is more than $80 million. The source of this information is the undated Army pamphlet entitled "Small Business Innovative Research."

The SBIR Fast Track Program, initiated in October 1995, offers venture capital firms, "angel investors," and technology-oriented large companies an opportunity to augment their interests in small technology companies working on R&D projects with defense and commercial applications. An investor that offers to help fund an early-stage technology project at a small company can obtain a match of between one and four dollars in DoD SBIR funds for every dollar it puts in. The source of this information is Section 4.5 of the SBIR solicitation ("Details of the SBIR Fast Track") published by the Office of the Undersecretary of Defense and dated 15 September 1995.

OTs, however, essentially eliminate all the cumbersome administrative regulations associated with the FAR, DFARS, and DoDGARs and permit commercial accounting systems that the contracting firms already have in place to be used instead. They also relax many of the restrictions that apply to intellectual property rights, subcontractor relationships, and socioeconomic requirements. The flexibility also extends to solicitation and oversight in terms of length of proposals, frequency of oversight reviews, and required documentation. One drawback of OTs, however, is that 10 U.S.C. §2371 allows OTs (and 2371 CAs) to be used only when use of a standard contract, grant, or cooperative agreement is not feasible or appropriate.[13]

From the government's perspective, the tried and proven instruments, contracts and grants, offer the safest way to conduct R&D, with their numerous regulations and procedures to minimize the possibility of waste, fraud, or abuse. However, these instruments are not compatible with the commercial practices that NTMSs use.

Not surprisingly, from the NTMSs' perspective, the situation is essentially reversed. As shown in Table 4.1, several provisions under contracts, grants, and even CRDAs are inherently unfavorable to NTMSs (e.g., intellectual property rights, DoD regulations, and accounting practices). CAs, and particularly OTs, are the more favorable to NTMSs because they tend to follow commercial practices. The ACT and SBIR programs are not attractive to NTMSs because the contractual instruments used to set up the programs are contracts and grants, respectively.

Other Benefits of NTMS Collaboration Using OTs

In addition to the advantages described above, OTs offer other benefits in NTMS collaborations. Cost-sharing allows the Army and industry to meet their technological goals with less cost. Since saving money is a prime concern to both the Army and industry, cost-sharing can be used to attract NTMSs. In addition, the Army's ability and willingness to negotiate particularly favorable joint effort intellectual property rights might persuade NTMSs to collaborate. Another

[13]Title 10, Section 2371 of the United States Code, (e) (3), found on page 471 of the *United States Code Annotated 1995 Supplementary Pamphlet.*

Table 4.1

Comparison of Available Contractual Instruments and Special Programs from the NTMS Viewpoint

	Contract	ACT II (Contract)	Grant	Fast-track SBIR (Grant)	AMC CRADA	CA 10 USC 2358	CA 10 USC 2371	OT
Intellectual property rights	Bayh-Dole[1]	Bayh-Dole	Bayh-Dole	Bayh-Dole	Specified[2]	Bayh-Dole	Bayh-Dole	Negotiable
DoD regulations	FAR, DFARS	FAR, DFARS	DoDGARs	DoDGARs	AMC Pamphlet 27-1	DoDGARs	DoDGARs	Minimal
Accounting system	Circular A-110	Circular A-110	GAAP	GAAP	Not applicable	GAAP	GAAP	Commercial systems OK
Government involvement?	No	No	No	No	Yes	Yes	Yes	Negotiable
Competition required?	Yes	Yes	Extent practicable	Yes	No	Extent practicable	Extent practicable	Extent practicable
Dispute resolution	Formal claim	Formal claim	Formal claim	Formal claim	Formal claim	Lab director	Lab director	Lab director
Socio-economic requirements	DFW, CRA, etc.	DFW, CRA, etc.	DFW, CRA, etc.	DFW, CRA, etc.	CRA	DFW, CRA, etc.	DFW, CRA, etc.	CRA
R&D phase	All	≥6.3	All	≥6.1	6.1–6.3[3]	All	All	6.1–6.3
Duration of contract	Not limited	12 months	Not limited	30 months	Not limited	Not limited	Not limited	Not limited
Government's cost share	100%	≥$1.5M	100%	≤75% ≤$850K	None[4]	No constraints	≤50% else approvals	≤50% else approvals
Proposal required?	Yes (formal)	Yes (short)	Yes (formal)	Yes (formal)	Yes	Yes	Yes	Yes
Proposal-to-award time	Not specified	16 weeks	Not specified	14 weeks	Not specified	Not specified	Not specified	20 days[5]
Government ROI allowed?[6]	No	No	No	No	Royalties and reim-bursements OK	No	Yes	Yes

Note: Foreign access is subject to all existing federal laws. Army may impose additional restrictions.

[1]Inventor owns intellectual property rights. Government has fully paid-up, nonexclusive license.

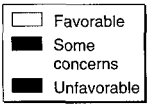
[2]May be negotiable.

[3]Refers to basic (6.1), exploratory (6.2), and advanced (6.3) research and development.

[4]Government may provide in-kind support.

[5]Time period recommended by RAND.

[6]ROI means return on investment.



RAND*MR830-T4.1*

NTMS-friendly feature is that OTs permit the use of fixed-price milestone payments, which greatly reduce the need for extensive financial reporting and government audits. The Army can skillfully use the combination of cost-sharing, negotiable intellectual property rights, and fixed-price milestone payments to make OTs a powerful tool for attracting NTMSs into R&D partnership.

OTs and §2371 CAs also allow return on investment (ROI) for the Army. In fact, much of the language used in Section 2371 is surprisingly similar to that used by the private sector when discussing financial transactions. Hence, industry is likely to be familiar with the Section 2371 ROI notion. For example, Section 2371 authorizes the use of a separate "capital account" for each of the military services at the U.S. Treasury. It entitles the military to require payments to the military as a condition for receiving financial support.

The ROI notion provides the legal authority to demand a claim on assets in exchange for providing military funds. Such claims are not strictly limited to, but could take the form of, a wide variety of transactional approaches employed in the private sector. The code authorizes the military to credit proceeds from past investments toward the Army capital account at the Treasury, rounding out a full cycle for a "revolving fund."

Figure 4.2 conceptually illustrates such a revolving fund, modeled after what occurs in the private sector with venture capitalists. In this case, however, the government plays the role of the venture capitalist. This type of transaction appears to be within the broad guidelines of what is permitted under Section 2371. It works as follows. Both the government (in this case, the Army) and industry initially invest in a new venture at some time (T_0). At some later time (T_1), the venture proves financially successful and an ROI is realized. The Army (as well as industry) receives money in its capital account that has been set up at the Treasury, and the funds are merged with other funds in this account. This revolving fund can be used to support other promising ventures in a similar manner.

This "public venture capital–like" concept may not, after all, be that revolutionary. The state of Maryland has recently created the Maryland Venture Capital Trust as an instrumentality of the state with funds available to invest as a limited partner in venture capital part-

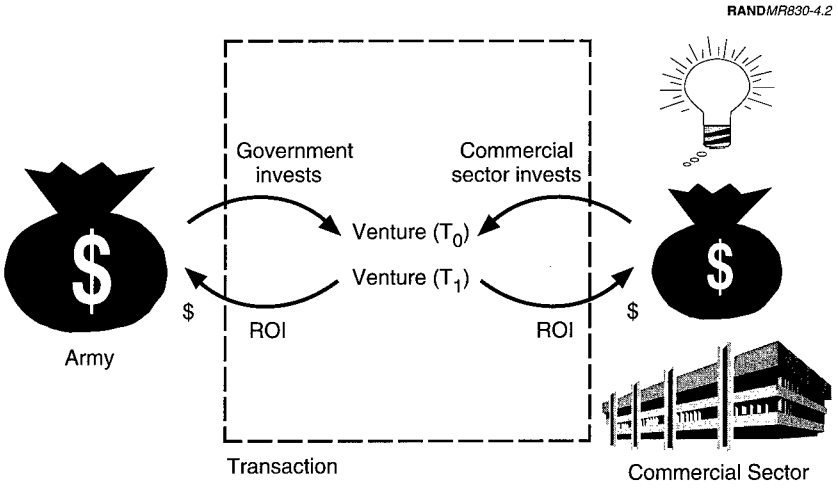


Figure 4.2—Conceptual Illustration of Revolving Fund Using OTs

nerships. The program objective is to achieve a high rate of return and augment the supply of venture capital. As of December 1993, the trust was capitalized at $19 million. Other states have installed similar venture capital trusts.

While the above comparison of features reveals that OTs should be a useful option in attracting NTMSs, there is other evidence of their effectiveness. DARPA asked the Institute for Defense Analyses (IDA) to survey DARPA's experience with OTs (IDA, 1995). DARPA program managers selected the OTs to be reviewed, and points of contact were identified for each participating organization. Many issues were addressed in the subsequent interviews, from program administration, to potential for fraud, waste, and abuse, to suggestions for improving the process.

With regard to cost-sharing, most participants felt that this requirement did not pose a serious financial burden, except possibly in the case of small companies and when the technological risk involved was very high. In fact, many felt that it was a positive test of commitment, that it stretched company R&D dollars, and that it tended to keep the company's technical talent busy (IDA, 1995).

ANALYSIS OF NTMS WILLINGNESS TO WORK WITH THE ARMY USING OTs

We felt that it was important to solicit inputs from some NTMSs to independently confirm that DARPA's findings were transferable to the Army's unique situation and that other concerns, beyond those specifically addressed under CAs and OTs, did not inhibit NTMSs from working for the Army.

Analysis Approach

For the same reasons discussed earlier, we selected IT as the leading-edge technology area for analysis. Within this technology area, we picked representative companies that covered the spectrum of NTMS types. Some of the companies interviewed were not on our original list of 44 leading-edge IT companies because interviews could not be arranged with some of that initial group. In the end, however, all 12 companies that were interviewed were top-notch, innovative IT firms.

As shown in Table 4.2, most of the companies interviewed were small to medium size in terms of sales, with the smaller companies usually being more specialized in terms of product lines. (To keep the company responses anonymous, the twelve company names have been randomly replaced by letters of the alphabet and designated by their product lines.) Annual sales and money spent on R&D were compiled from annual reports and from *Business Week*'s "R&D Scoreboard for 1995." The percentage of sales devoted to R&D ranged from a low of 4 percent (Company E) to a high of 23 percent (Companies F and L). Excluding Company H, the average amount spent on R&D was 14 percent of sales. This amounts to over $600 million for R&D, or more than what the Army currently devoted to S&T for the ten technologies that are suitable for research collaboration. Some companies had a small government sales operation, but it was restricted to selling nondevelopmental items (NDIs).

Company H is the one industrial giant among the twelve IT companies we interviewed. Its dominance in the telecommunications market is staggering—$22 billion in sales last year, with over $1.8 billion (about 8 percent) devoted to R&D. Even though Company H was the outlier in our sample, we felt it was important to include it because of

Table 4.2

Sales and R&D for Information Technology Companies Interviewed

IT Company/Product Line	Sales ($ million)	R&D ($ million)
A/Software shells	465	70
B/Semiconductors	775	105
C/Routers/smart hubs	385	40
D/Routers/smart hubs	600	60
E/Telecommunications	370	15
F/Semiconductors	545	125
G/Database design	470	70
H/Telecommunications	22,245	1,860
I/Network diagnostics	115	15
J/Telecommunications/wireless	270	50
K/Low-power consumption chips	195	15
L/Software automation CAD/CAM/AI	195	45
Total	26,630	2,470

its leadership role in the IT area and because of its innovative and dynamic approaches to conducting R&D.

To form a consensus on key issues, we interviewed a range of appropriate company officials. They included a CEO/president; seven vice presidents (of operations, administration or strategic planning); many directors or managers of product development, production or government sales; and two general counsels.

We presented the same questions to each interviewee group. They covered administrative regulations, management oversight, cost-sharing, intellectual property rights, subcontractor relations, socio-economic requirements, proposal solicitation, foreign access limitations, and personnel exchange agreements. Below is a sampling of the questions we asked.

- What is your reaction to CAs and OTs?
  - — Are they flexible enough?
  - — Are there other barriers that prevent you from working for the government?

- How does your company initiate and conduct R&D?
- Is cost-sharing a major potential drawback?
- Is personnel exchange an issue?
- Are intellectual property rights a serious concern?
- How important are foreign access limitations to your business?

In preparing for the interviews, background material was faxed to each company. Also, considerable preparation time was required to become familiar with the company and its product line. In general, if we were not familiar with the company, then we had a difficult time convincing its officials to participate in an interview.

The interviews lasted from less than one hour to over three hours. In some cases, they were one-on-one interactions; in other cases, up to four company representatives were present. Most interviews were conducted at the company's location. In a few cases, the interviews were conducted by telephone, and in one case, follow-up documents were sent to us.

Analysis Results

Table 4.3 summarizes the responses we received from the twelve companies on whether OTs should help attract NTMSs. In every case, the companies said that, with the current contractual mechanisms in place, they would not now do research with the Army. Six said that they would be interested if OTs were used. However, they all said they would have to better understand the ramifications of OTs. Five of the twelve companies said "maybe." Three companies said they might consider research with the Army, but only on a case-by-case basis, and two expressed serious doubts about the Army being willing to reduce the administrative load. Only one company said it was not interested.[14]

[14]It is interesting to note that some of the companies saw OTs as more suitable for traditional defense contractor firms than for NTMSs.

Table 4.3

Interview Results with 12 IT Firms About Use of Other Transactions

IT Company/ Product Line	Will Do Research with Army Now	Would Do So Using OTs	Major Concern or Conditional Requirement
A/Software shells	No	Interested	Need to understand better
B/Semiconductors	No	Interested	Need to understand better
C/Routers/smart hubs	No	Maybe	Case-by-case basis
D/Routers/smart hubs	No	No	Not interested
E/Telecommunications	No	Interested	Need to understand better
F/Semiconductors	No	Maybe	Skeptical that administrative load actually reduced
G/Database design	No	Maybe	Case-by-case basis
H/Telecommunications	No	Maybe	Skeptical that administrative load actually reduced
I/Network diagnostic	No	Maybe	Case-by-case basis
J/Telecommunications/ CDMA	No	Interested	Need to understand better
K/Low-power consumption chips	No	Interested	Need to understand better
L/Software automation CAD/CAM/AI	No	Interested	Case-by-case basis

Recurring Issues From Interviews

Despite the encouraging nature of the responses, our interviews did surface some recurring issues that highlight potential problems that could discourage NTMSs from working for the Army.

With regard to responding to government requests for proposals (RFPs), it was pointed out that commercial companies do not have large administrative infrastructures in place to write proposals and administer military research. Several companies remained skeptical that the Army would live up to its promises. (A typical response was, "I don't believe they appreciate the reluctance and aversion to do

government business that the years of government effort to ferret out waste, fraud, and abuse have caused.")

With regard to product life, the companies are concerned with the big differences in time scale—years for the military versus months for the commercial firms.

In addition, most companies were concerned with intellectual property rights. However, some felt that intellectual property rights would not be an issue if OTs were used so that the rights, royalties, and licensing agreements could be negotiated with the government.

Personnel exchange was an issue of great concern, since the companies typically viewed the exchange of technical staff as an unequal one, especially if the company employee was away from the firm for more than a few months at a time.

Finally, foreign access limitations could present a serious problem if the restrictions were more confining than what companies already must follow under State Department and Commerce Department oversight.

Given these concerns, there are three things the Army will have to do to attract NTMSs. First, the Army cannot expect the NTMSs to come to them. Instead, the Army must aggressively "market" research programs to the NTMSs. This involves advertising in appropriate trade journals (e.g., *IEEE Spectrum*) and using their preferred telecommunication media (i.e., faxes). Also, the Army must understand the NTMSs to be targeted (i.e., it must do its homework, just as we did in preparing for our interviews). This means knowing the NTMSs' market niches, their technology interests, their business concerns, and their strategic goals. Also, the Army must communicate to NTMSs in a manner that they will understand and at forums they attend (e.g., trade shows such as COMDEX). The company personnel we talked with felt that the Federated Laboratory kickoff meetings were definitely not the appropriate mechanism to attract them. The briefings were designed for audiences already familiar with the Army and its jargon and not for commercial companies. Also, the briefings did not contain anything that commercial companies could readily use to assess the market potential of the technologies.

Second, the Army must establish an environment of trust. The Army must abide by all advertised promises. This is especially the case with promised funding and start dates. Again, the slow startup of the Federated Laboratory hits home at this concern. To a commercial firm, time to market is critical. If anything slows or hinders this process, the firm views it as a potential loss in profit. Even though the Federated Laboratory was advertised to start rapidly, in the end it took well over a year before the winners of the competition were under contract. This slow start was attributed to unanticipated delays in the competitive selection process. Several companies we interviewed were particularly concerned that the Army could not keep its "hands off." (This, by the way, is one justification for conducting a pilot program to show industry that the Army can do business differently.)

Third, as we mentioned earlier, the Army must be flexible in its dealings with the NTMSs. This applies especially to enforcing intellectual property rights, foreign access limitations, and personnel exchange requirements.

Chapter Five

WHAT IS THE BEST STRATEGY FOR EXPLOITING OPPORTUNITIES FOR COLLABORATING WITH NTMSs?

Given that significant opportunities exist for collaboration with NTMSs and that the Army can attract NTMSs to collaborate with in important technology areas, the next step is to set up and conduct a pilot to demonstrate that (1) NTMSs can indeed be attracted, (2) the Army can abide by rules associated with the new way of doing business, and (3) the Army can benefit from research collaborations with NTMSs.

In this chapter we discuss an analysis to identify suitable candidates for a pilot program and present some general observations about what the Army will need to do to ensure that the pilots—and that collaborations in general—are successful in the future.

ANALYSIS OF PILOT CANDIDATES

Below we discuss the candidates that were selected, the criteria used to evaluate them, and the results of the analysis.

Pilot Candidates Selected

In Chapter Two we identified nine technology areas where collaborative efforts with NTMSs were deemed most promising: artificial intelligence, automotive, electronics/C4, human factors, logistics, materials, medical, models and simulation, and soldier support. In this step, we identified a specific technology and associated Army organization for each of the nine technology areas (as shown in Table 5.1) that we believe is a possible candidate for an NTMS pilot.

Table 5.1

Candidate Army Organizations/Technologies Suitable for an NTMS Pilot

Collaborative Technology	Army Organization	Specific Technology
AI	DISC4	Expert systems
Automotive	NAC	Vehicle technologies
Electronics/C4	ARL	Information warfare
Human factors	ARL	Man/machine interface
Logistics	CECOM	System integration
Material	ARL	Composites
Medical	MRMC	Telemedicine
Models/simulations	STRICOM	Advanced simulation
Soldier support	Natick RDEC	Food/clothes/biotechnology

A variety of inputs were used in generating these candidates. Some candidates were suggested by the sponsor (e.g., STRICOM in the area of advanced simulators), others were identified by us (e.g., ARL in the area of knowledge acquisition), and still others were derivatives of ongoing collaborative efforts (e.g., ARL in the area of information warfare). Clearly, some candidates are better suited for an NTMS pilot than others.

Evaluating Pilot Candidates

We devised a two-step winnowing process to narrow down the list of possible candidates to the most promising few. It is important to point out that an organization/technology candidate had to pass all the criteria in the two-step process. If a candidate failed to pass any one of the criteria, then it was deemed not suitable for the pilot.

To be an NTMS pilot contender, the nine organization/technology candidates were first evaluated against a series of five "screening" criteria:

- The technology is important to the Army;
- The technology is appropriate for collaboration;
- The Army desires improvements with current process;

- NTMSs are acknowledged leaders in this technology;
- NTMSs have not participated in the past.

Candidates that passed through all the screening criteria were then evaluated in terms of the following five "necessary" criteria:

- A champion exists within the Army;
- The technology is central to the organization;
- Support for a pilot exists up the management chain;
- The organization is amenable to new contractual methods;
- NTMSs are interested in participating.

Analysis Results

Table 5.2 shows how the candidates ranked when passed through the screening criteria. As shown in bold, five candidates passed all the screening criteria: (1) DISC4 in the areas of expert systems; (2) NAC in the area of vehicle technology; (3) ARL in the area of information warfare; (4) STRICOM in the area of advanced simulation; and (5) Natick RDEC in the areas of food, clothing, or biotechnology. In the end, however, it may turn out that the best candidate for an NTMS pilot has not yet been identified.

The other candidates in the table did not rate as high as the five described above. In some cases, collaborative efforts have already been set up by the Army (e.g., NRTC, Medical Federated Laboratory). And in a couple of other cases, we discovered that NTMSs were already participating (e.g., man/machine interface); therefore, these candidates were dropped from the list.

Table 5.3 shows how the top five candidates from Table 5.2 fare against the five necessary criteria. Some of the criteria cannot be fully evaluated at this time because of incomplete information. One of the most complete assessments can be made of the Natick RDEC candidate. In this case, the Technical Director of the RDEC has been identified as the champion, the technology is central to the organization, support exists for a pilot, and the contracts office appears to be amenable to using new forms of contracting. While the Natick

Table 5.2

Ten Candidates Evaluated Against Screening Criteria

Technology/ Organization	Important Technology	Appropriate Technology	Army Desires Improvement	NTMS Leader in Technology	NTMS Has Not Participated
Expert systems/DISC4	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Vehicle technology/NAC	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Smart cockpit/ATCOM	Yes	Yes	Established NRTC	Yes	No
Information warfare/ARL	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Man/machine interface/ARL	Yes	Yes	Yes	Yes	No
System integration/CECOM	Yes	Yes	Not Army specific	Yes	NDI only
Composites/ARL	Yes	Yes	?	Classified	?
Telemedicine/MRMC	Yes	Yes	Established Med Fed Lab	Yes	Yes
Advanced simulators/ STRICOM	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Food/clothes/biotech/ Natick RDEC	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**

RDEC is interested in creating pilot programs in the food, clothing, and biotechnology areas, only in the food area has a potential collaborative effort with an NTMS been identified at this time.

STRICOM is also seriously interested in conducting a pilot program with NTMSs. Its seriousness is demonstrated by its willingness to revise its Broad Agency Announcement to permit the use of CAs and OTs. While a number of NTMSs have been identified in the advanced simulation area, their potential interest in performing collaborative research with STRICOM must still be determined.[1]

The other three organizations are not as far along in fulfilling all the criteria, especially the one that addresses whether NTMSs are interested in participating. Nevertheless, based on our promising findings to date, the Army plans to set up at least one pilot program with NTMSs in fiscal year 1997.

ENSURING A SUCCESSFUL PILOT DEMONSTRATION

Regardless of which NTMSs are selected for the pilot(s), there are a number of things the Army can do that would significantly help ensure that the pilots (and ultimately any collaborations) are successful and that the Army maximizes its benefits. Studying what happened to the TRP and ATP yields some of these insights; our investigation of flat-panel displays as part of the Administration's Dual-Use Technology Program provided some useful insights on foreign access restrictions and cost-sharing, and the Federated Laboratory and its clone program, the Medical Federated Laboratory, provided some valuable insights on solicitation procedures/delays and budgetary issues.

It turned out that two of the most useful sources were DARPA's experience using OTs and our interviews with commercial firms. Both provided ideas for extrapolating commercial practices and strategies to managing Army research.

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[1]In the case of STRICOM, three promising areas for collaboration with NTMSs have been selected from its Board Agency Announcement: image generation/situation awareness, compression/decompression, and wireless transmission/reception. While NTMSs are acknowledged leaders in each of these technology areas, their interest in working with STRICOM has not been ascertained.

Table 5.3

Remaining Candidates Evaluated Against Necessary Criteria

Technology/ Organization	Champion Exists Within Army	Technology Central to Organization	Support Up/Down Management Chain	Amenable to New Contracting	NTMS Interested
Expert systems/DISC4	Yes	Yes	TBD	TBD	Possibly
Vehicle technology/NAC	Yes	Yes	Yes	Yes (CAs only)	Possibly
Information warfare/ARL	Yes	Yes	TBD	Yes	Possibly
Advanced simulators/ STRICOM	Yes	Yes	Yes	Yes (CAs/OTs)	Companies identified
Food/clothes/biotech/ Natick RDEC	Yes	Yes	Yes	Yes	Promising candidate[a]

[a]A potential collaborative effort with an NTMS in the food industry has been identified.

Based on these sources, we identified three critical elements of a pilot or any collaboration: align technology objectives, exchange key features of business plans, and plan for success.

Align Technology Objectives

The first thing that needs to be done to guarantee the Army benefits from an NTMS collaboration is to make sure the Army aligns its technical objectives with the company's strategic goals. This will help screen out NTMSs with strategic goals different from the Army's. Both the Army and the NTMS must be capable of articulating their needs and visualizing the desired end products and their intended applications.

These strategic goals or visions must be regularly reassessed, and both sides must be capable of modifying their objectives as the research progresses. This give-and-take process is consistent with the nature of a working partnership, in which both parties have to be flexible in working toward common goals.

Exchange Key Features of Business Plans

The second thing that needs to be done is to require both the Army and the NTMS to exchange key features of their business plans. This is one way of capturing the "visions" discussed earlier. Business plans will make sure that both parties—the Army and the NTMS—have similar visions. They need to be written down and key features should be shared.

Candidate features of the Army's business plan should include development plans, expected windows for technology insertion, anticipated milestones, proposed schedules, budget estimate requirements, and risk assessments and available options, including research termination. The plan should be more complete and thought out than the typical technology road map shown in the Army Science and Technology Master Plan.

The Army should generate an initial version of the plan prior to the solicitation process, and it should be made available to all prospective bidders. Key features of the NTMS's business plan should be used in the proposal selection process. It is important that both the

Army's and the NTMS's business plans are revisited and updated frequently. Both plans should be used in the context of living documents.

Plan for Success

The third thing that needs to be done is to make sure that the Army plans for success from the outset. While this may seem simply like a "motherhood" statement, we mean it to be much more. Certain practices must be followed for the collaboration to be successful. Any deviation from this path could result in failure. Therefore, unless the Army plans for success at the outset, such deviations could likely occur.

Here, we list five actions that we believe will help guarantee success from the outset.

- Funds must be fenced off before the formal solicitation process starts. It would be inexcusable to line up the NTMSs and then tell them the funds have evaporated.
- The elapsed time from proposal solicitation to research start must be very short. From our interviews, we have found that six months seems to be acceptable to an NTMS, while twelve months is definitely not.
- As we have discussed throughout this report, administrative oversight by the Army must be minimal if NTMSs are to participate as partners. The Army has to accept this from day one and not try to inject more red tape once the research effort has started.
- The Army's interest must be apparent to the NTMSs from the start. This means assigning top-notch Army personnel who are true believers.
- At all times, clear and open lines of communication are needed between the Army and the NTMS.

Chapter Six

CONCLUDING REMARKS

In this document we have indicated that the Army has the option to make radical changes in the way it conducts R&D. CAs and OTs were specifically created by Congress as contractual instruments to stimulate the development of technology with both military and commercial applications and to remove barriers to integrating the defense and commercial sectors. These instruments are intended to permit the military to conduct more innovative research.[1] CRDAs cannot fulfill this need.

Army warfighting capability depends on technological superiority, and in many technology areas the state of the art now rests with NTMSs. As we have discussed in this document, the new contractual instruments have the potential to attract more NTMSs to work for the Army. In fact, the application of these instruments can lead to a new investment paradigm wherein private industry and the government are partners, share costs, recoup the benefits, and operate under a corporate-type board of directors concept. A key feature of the investment paradigm is the sharing of research costs.

Although the Army is using CAs, it has not been successful in attracting NTMSs. In fact, the CA has primarily been used only as a replacement for a traditional grant or as a streamlined funding mechanism. The Army Research Office (ARO) has created 11 CAs with

[1] "Awarding agencies should consider the authority to enter into other transactions as an opportunity to develop innovative approaches to carrying out basic, applied, or advanced research projects." Memorandum to the Military Departments from Anita Jones, February 1994.

universities so that it can be more substantially involved in the research,[2] while the National Automotive Center (NAC) has used CAs to conduct cost-sharing research, although for the most part, it appears to have done so with traditional military suppliers.[3]

Our research indicates that OTs are required if the Army hopes to attract NTMSs. CAs and CRDAs are too restrictive for NTMSs to consider.[4] Through our interviews with NTMSs and our observations of the Army's unsuccessful attempt to attract NTMSs using CRDAs, we believe that OTs offer the flexibility needed.[5]

Our research also suggests that NTMSs appear to be more willing to collaborate in some instances if the Army offers some in-house research expertise. This means that the Army should not, as a general policy, contract out all its research. The implications of this are twofold: (1) it will be difficult for Army R&D organizations that are essentially contracting offices to attract NTMSs, which are looking for shared expertise, and (2) it provides a good rationale for the Army to maintain in-house research expertise.

It is important to remember that the selection of a flexible contractual instrument is a necessary but not sufficient condition to attract NTMSs. In addition, the Army must act in a commercial-like manner in dealing with NTMSs. This includes understanding NTMS markets and niches, contracting rapidly, providing minimum oversight, using business plans to define research objectives, and negotiating mutually acceptable intellectual properties.

Our research further indicates that collaboration should be included in an Army strategy to develop advanced technologies and that for

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[2]Janet Lockhart, Army Research Office, private communication, February 1996.

[3]NAC has two CAs, one with a small business and the other with divisions of Ford, General Motors, and Chrysler that historically have not done business with the Army. Ford, General Motors, and Chrysler have government divisions that have traditionally done business with the Army.

[4]While there is some flexibility in generating CRDAs, the existing Army regulations and Army CRDA manuals or boilerplates tend to be rather restrictive in their interpretation of intellectual property rights.

[5]Authority for Army-initiated OTs is scheduled to expire at the end of fiscal year 1996. Based on our analysis, we recommend an extension of that authority. In addition, we recommend that the Army implement a rapid-approval process.

collaboration to be successful, the Army should use CAs and OTs to attract NTMSs for collaborative R&D, should use cost-sharing whenever possible, and must act like a commercial business partner in collaborative R&D efforts with NTMSs.

RAND has performed an analysis to help the Army find suitable candidates for a pilot program. We are using the analysis to complete our design of candidate pilot programs to attract NTMSs using CAs or OTs. The pilot programs will demonstrate the principal components of our strategy to manage the development of advanced technologies. The Army plans to conduct these pilot programs in fiscal year 1997. To do this, however, two actions must be taken: (1) the authority to use the CA and OT instruments[6] must be extended, since the current authority expires on September 30, 1996, and (2) an expedited case-by-case approval process needs to be implemented for approving OTs.

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[6]September 29, 1994 memorandum from the Secretary of the Army to the Assistant Secretary of the Army for Research, Development and Acquisition regarding Delegation of Authority in 10 U.S.C. §2358 and 10 U.S.C. §2371; and December 12, 1994 memorandum from the Assistant Secretary of the Army for Research, Development and Acquisition to the Army Research Laboratory regarding Authority under 10 U.S.C. §2358.

Appendix

CRDAs AND THEIR POTENTIAL FOR COLLABORATION

To be an effective collaborative mechanism for attracting NTMSs, CRDAs should possess the following characteristics:

- Flexibility in dealing with the NTMS's interests;
- Prompt benefits to both partners;
- Measurable status of progress;
- Proactive Army participation;
- Broad influence.

A major concern of NTMSs is their ability to retain ownership of intellectual property rights. In principle, CRDAs can be written with certain flexibility in dealing with intellectual property. Unfortunately, existing Army boilerplates for CRDAs and Army Regulation 70-57, which prescribes policy and responsibility in this area, are not necessarily written with this flexibility in mind.

By prompt benefits, we mean there must be some way to reduce the long lag times traditionally associated with "spin-offs." Cost-sharing is one way to increase the interest of the NTMSs and possibly accelerate the technology development process leading to "spin-ons" to the Army. However, under a CRDA, the government is prohibited from contributing funds, and this stimulus cannot be used to generate and maintain interest in a collaboration.

Measurable status of progress requires that some metrics be in place to help determine the status of the collaborative effort. Unfortunately, many companies usually go into CRDAs with a wait-and-see

attitude, so there aren't mechanisms in place to track how the collaborative effort is progressing. As a result, many CRDAs simply die because of a lack of enthusiasm from one or both partners.

In most cases, proactive Army participation is also lacking with CRDAs. The normal interactions occur at the researcher level within the Army and industry, and, consequently, Army interests are not necessarily pushed.

Broad influence refers to whether CRDAs can be generated to cover all the potential areas of collaboration with NTMSs. To assess this characteristic, RAND performed an analysis of the Army's efforts to date to generate CRDAs.[1]

The information for the analysis on CRDAs was provided by the Army in the form of a computer-generated listing of all accepted CRDAs, PLAs, and Construction Productivity Advanced Research (CPARs) the Army had generated since 1986.[2] The CPAR program[3] is a cost-sharing partnership between industry and the construction industry designed to address joint R&D needs.

The resulting list included 374 CRDAs, of which 312 were used in the analysis. The other 62 CRDAs were excluded because they were not described well enough for us to associate them with a specific technology. For the analysis, we mapped the CRDAs against 14 technologies taken from the Army Science and Technology Master Plan that represent the important technology areas the Army needs to pursue to maintain its technological edge.

Figure A.1 shows the distribution of the CRDAs in terms of the critical technology areas and reveals that they are not evenly distributed. In fact, almost 50 percent of them fall under the biotechnology category. In other important technology areas, few CRDAs have been

[1]The cutoff date for this analysis was October 1994.

[2]"Army Accepted Cooperative Research on Development Agreements and Patent License Agreements," published by the Army Domestic Technology Transfer Office (through 31 December 1994).

[3]Public Law 100-676 authorized the federal government to provide up to one-half of the partner's cost. The Corps of Engineers has successfully used CPARs to work with the construction industry. In fiscal year 1994, seven projects were funded by the Corps of Engineers laboratories.

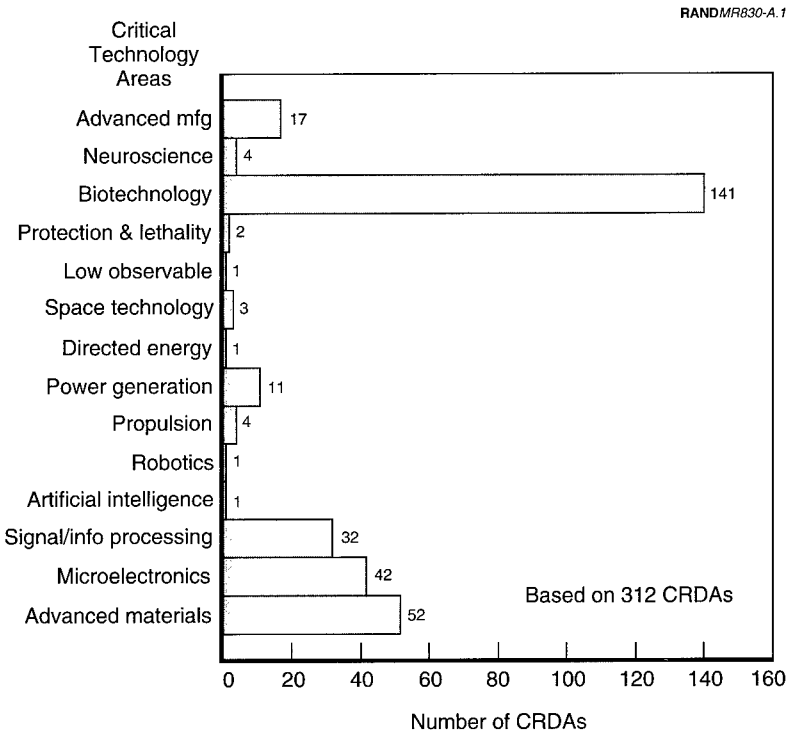

Figure A.1—Distribution of CRDAs Against Critical Technology Areas

generated, even though many of these technologies are dominated by the commercial world. For example, the robotics and artificial intelligence technology areas have generated only one CRDA each.

Figure A.2 plots the results of Figure A.1 in terms of their potential for collaboration with industry. Three general categories of potential collaboration are shown—wide, limited, and very narrow. Under the "wide" category, there are ten technologies listed. Except for the large number of CRDAs generated in the biotechnology area and, to a lesser extent, in the advanced materials, microelectronics, and signal/information processing areas, the other technologies in this category have produced few CRDAs in the past.

We concluded that CRDAs, as formulated today, cannot fulfill the need for generating collaborative research with NTMSs. They play a useful role as a "spin-off" mechanism, but only a limited role as a collaborative mechanism. To be an effective collaborative mechanism, they must be tailored to specific technology areas and must be thoughtfully conceived and closely monitored. The key requirements for generating such CRDAs include: (1) a set of measures to monitor status, (2) an adequate dissemination system for sharing information, (3) an incentive structure to sustain commitment, and (4) a flexible interpretation of the intellectual property rights clause.

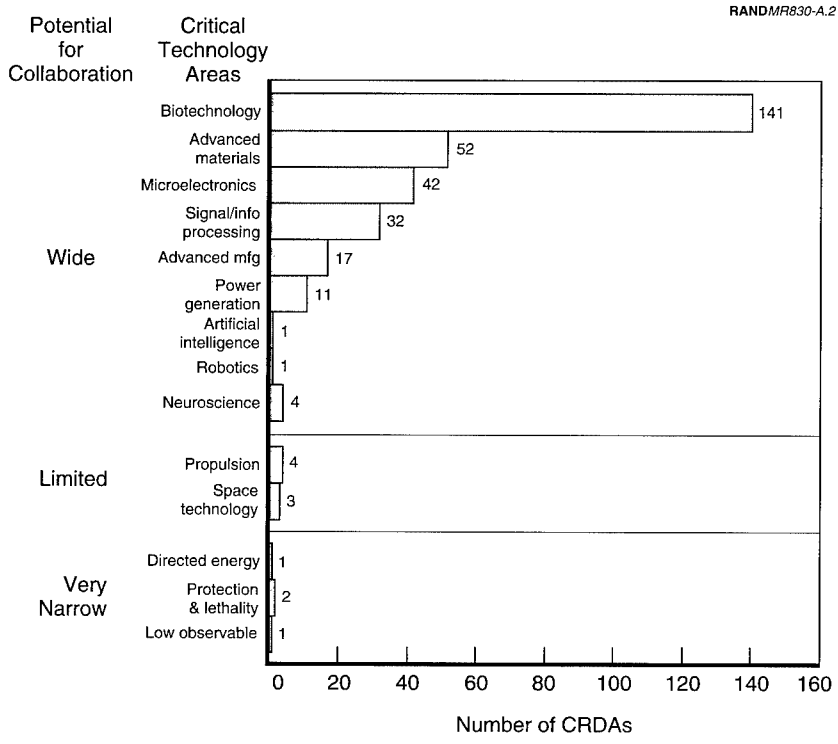

Figure A.2—CRDAs and Their Potential for Collaboration

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