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Department of Defense Laboratories--Finding a Future in Technology Transfer

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ABSTRACT

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The Clinton Administration expects great things from the DoD laboratories' participation in technology transfer. Following an overview of the laboratories, their funding, acquisition role and legislative history, the paper details implementation policy. Based on review of directives and interviews with DoD and individual service coordinators, DoD guidance is minimal and service implementation varies. Comparisons of progress are difficult with no agreed standard for measurement or management. The marketing of technology transfer, President Clinton's goals, a relevant Japanese technology transfer case study, partnerships with educational institutions and the issue of reconstitution are discussed. Recommendations are given to address major implementation problems. The case is made for an overall increase in DoD leadership in the entire spectrum of technology transfer.

Captain Joe Lee Frank III, U.S.N.

April 22, 1993

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EXECUTIVE SUMMARY

DEPARTMENT OF DEFENSE LABORATORIES – FINDING A FUTURE IN TECHNOLOGY TRANSFER

The Clinton Administration is expecting great things from the Department of Defense's (DoD) participation in technology transfer. Central to this plan is the participation of the DoD laboratories, both staff and facilities. Six years after the first major technology transfer legislation, the individual services have implemented programs differently. Each faces substantial challenges for further development.

Following an overview of the DoD laboratories, their funding, acquisition role and legislative history of technology transfer, the paper details implementation policy and practice. Information is based on review of directives and interviews with the DoD and individual service coordinators. DoD guidance is minimal. Service implementation varies greatly. But comparisons of progress are difficult because there is no agreed standard for measurement or management of technology transfer. The marketing of technology transfer is discussed at length and several plans for improvement are given. A representative view from industry is also provided.

A discussion of President Clinton's goals and a relevant Japanese technology transfer case study lay the foundation for a discussion of laboratory partnerships with educational institutions and the issue of reconstitution.

Individual issues are discussed in greater depth including budget, DoD's leadership role and specific problems raised by other researchers. Based on a literature search and interviews, recommendations are given to address most of the major implementation problems, including increasing DoD's role; re-examining laboratory missions; increasing the resources, manpower and level of effort throughout the department; establishing a means to measure and manage the entire technology transfer program; improving communication and especially public knowledge of department efforts; and a number of other issues. Most importantly, the case is made for an overall increase in Department of Defense leadership in the entire spectrum of technology transfer. This is a necessary condition to retain the future well-being of our laboratories.

DEPARTMENT OF DEFENSE LABORATORIES – FINDING A FUTURE IN TECHNOLOGY TRANSFER

DEFENSE LABS IN THE NEW WORLD ORDER

As the size, character, missions, alignments and funding of the Armed Forces of the United States change, in the turbulent period following the cold war, no part of the Department of Defense can escape scrutiny. This is especially true of the entire defense research and development establishment, and its laboratories. In the wake of one of America's longest recessions, a massive federal deficit and painful imbalance in overseas trade, Congress and industry are calling on the technological engine of federally funded and federally conducted research to build steam and take the United States into a new age of economic strength; technological superiority; and untold safety, security and comfort. One of nine recommendations of the 1992 Council on Competitiveness in making better uses of the American research and development infrastructure is for DoD to establish an out-reach program to make its labs more accessible to industry.[1] This paper examines critically DoD implementation and status in the technology transfer role for its laboratories.

What Is Technology Transfer?

Tech transfer by any other name would smell as sweet. A decade ago in the Pentagon, use of the term "technology transfer" automatically suggested a long, painful staff review to insure that no equipment, information or technology, not approved for clearance, was passed to the "bad guys." Now after a decade of Congressional and Executive Department action in response to waning American competitiveness, the term has an entirely different connotation, at least for Defense laboratories. It can mean:

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[1]Reilly, Lucy. "Another $1B to Labs, Says Panel". Washington Technology. Vol. 7 #13. Oct 8, 1992.

- Existing technology shared between the government and industry (also state and local governments)
- Use by industry of government facilities, special equipment and personnel
- Joint research and development with industry and government researchers working side-by-side

Though not generally recognized as such, some government organizations involved in the program include the following time consuming, but nonetheless productive, activities:

- technology transfer marketing
- answering technical questions by phone, fax and electronic mail
- professional publications
- participation in professional meetings, seminars, etc.

FLC definition. The Federal Laboratory Consortium (FLC) defines "technology transfer" as a term that:

> "... includes a range of formal and informal cooperation between federal laboratories and U. S. businesses, universities, state and local governments, and the federal agencies. The purpose of the transfers is to strengthen the nation's economy by enhancing the application of federal laboratory technology and resources to these groups' needs and opportunities. Product improvement, service efficiencies, improved manufacturing processes, joint development to address government and private sector needs, and the developments of major new products for the international market place, are examples of proven technology transfer results."[2]

The Army definition. The U. S. Army has their own definition that is very helpful:

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[2]Untitled brochure from DelaBarre & Associates, Inc. for the Federal Laboratory Consortium.

"The process of cooperatively adapting existing DA (Department of the Army) R&D (research and development) results, technology, or technical know-how to meet civilian needs. Technology transfer is also the process of matching the solutions resulting from DA programs in the form of existing science and engineering knowledge and capabilities to the problems of industry or the public."[3]

What is it really? All of the above definitions are accurate. Each service, each lab and probably each researcher has a slightly different view. At the foundation though, this transfer will become known by the extent to which United States' markets benefit from the extensive brains, experience and facilities of Federal laboratories; and to the extent that the laboratories can remain flexible in responding to legitimate Federal requirements while supporting industry, universities, states and local governments.

The Department Of Defense Laboratories

Brief description. The Federal Advisory Commission on Consolidation and Conversion of Defense Research and Development Laboratories provides an instructive summary of the laboratory system:

"The DoD operates a large and complex laboratory system. The DoD laboratories (42 Army, 20 Navy and 4 Air Force) spend approximately $6.5 billion annually and employ nearly 60,000 people, of whom over 26,000 are scientists and engineers. The DoD laboratory system has evolved over the past 150 years. Each Service's system is different and is a product of its historical origins, culture, and method of systems acquisition. Several laboratories are embedded in larger organizations. A significant

[3]"Military-Civilian Technology Transfer". Army Regulation 70-57. Headquarters, Department of the Army. Washington, DC. Jul 25, 1991. Glossary p. 14.

number of the laboratories are relatively small and geographically isolated."[4,5]

What they do. DoD laboratories have varying missions but, in my opinion, exist primarily to exploit science for the national defense. The above commission defines the laboratories' mission, "...to provide the technical expertise to enable the Services to be smart buyers and users of new and improved weapons systems and support capabilities. The function provided by the DoD laboratories are an essential part of the acquisition process. Dedicated organizations **free from commercial pressure** are required to provide these functions."[6]

None of the scientists and engineers with whom I have associated, primarily in Navy labs, would view their role so narrowly as this. Such a restricted definition excludes the contributions of thousands of researchers, whose breakthrough discoveries have not had immediate technological and weapons use, taking decades, if ever, for the full ramifications to be understood. For example, consider Michelson's speed of light experiment at the Naval Academy. His work has influenced physics for the last century, but did not directly develop a weapon. Notwithstanding this, there is currently DoD emphasis on development and acquisition, not science, for DoD laboratories. At issue though, is how current functions and missions support commercial technology transfer.[7]

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[4]Adolph, Charles E., et al. "Report to the Secretary of Defense". Federal Advisory Commission on Consolidation and Conversion of Defense Research and Development Laboratories. Sep 30, 1991. p. 1.

[5]Interestingly one of the problems in dealing with DoD laboratories is getting a handle on the size of the problem, including the number of laboratories. A year after the report quoted above, the Defense Conversion Commission in its report "Adjusting to the Drawdown" gives a dramatically different count of the number of laboratories, i. e. "...the military owns and operates ... 95 research laboratories." During the course of this research, I made a concentrated effort to find a single list of DoD laboratories involved and presumably responsible for making headway in this effort. The most complete list of Defense research resources is DTIC/TR-91/3 AD-A241 750 entitled "Referral Database Directory." Unfortunately, as described in its preface it lists "specialized libraries, depositories, laboratories, testing facilities, and other research centers." It would seem essential to usual management practice that DoD had a complete list of laboratories.

[6]*Op. Cit.* Adolph. p. ES-2. (emphasis added by author)

[7]*Op. Cit.* Adolph. p. 3. The Commission report ascribes little scientific motivation to the mission of DoD laboratories. It does not allow for the essential difference in the types of RDT&E funding, i.e. 6.1, 6.2, 6.3, etc. In furtherence of their mission statement the Commission provided a table of functions which only indirectly alludes to science except for training:

1. Infuse the art of the possible into military planning
2. Act as principal agents in maintaining the technology base
3. Avoid technological surprise and ensure technological innovation
4. Support the acquisition process

Commercial pressure. If as the Commission found, DoD laboratories have an aging work-force and facilities,[8] how then can one expect them to make meaningful inroads in the highly competitive realm of commercial research? As DoD acquisition programs disappear, the funding base for "cutting edge" facilities lessens.[9] Two issues come to mind. First, DoD labs are not really intended to be more than minor players in commercial research. Second, DoD will turn increasingly to commercial acquisitions that in turn will demand improved research and development in industry. Furthermore, the Commission reports that, "Laboratory managers believe that their effectiveness is impeded by outside control of various aspects of laboratory operations."[10] This seems to be also true in some of the technology transfer arrangements. Technology transfer initiatives that have some potential for improving DoD laboratories are not mentioned in the Commission's report.

Relations with industry. The Commission's report has little to say about industry. Mostly it connects with a description of "Good Laboratory" attributes.[11] It calls for, "A strong linkage to universities, industry and other government laboratories, including foreign ones, to ensure that opportunities for technology advancement are utilized most effectively." Technology transfer is not mentioned as part of this attribute.

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5. Provide special-purpose facilities not practical for the private sector
6. Respond rapidly in time of urgent need or national crisis
7. Be a constructive adviser for department directions and programs based on technical expertise
8. Support the user in the application of emerging technology and introduction of new systems
9. Translate user needs into technology requirements for industry
10. Serve as a science and technology training ground for civilian and military acquisition personnel

The link to science is expounded in Appendix C to the Commission's report, "...Their {the laboratories} role is to bring the national technology base (Government, academia, and industry) to bear on defense problems. The DoD laboratories identify areas where the base is inadequate and stimulate additional expertise in virtually all areas of science and, most important, must have in their employ experts in all areas appropriate to each laboratory's mission." This is a tall order and very important. Why it is buried in the report is not clear.

[8] *Op. Cit.* Adolph. p. 5

[9] *Op. Cit.* Adolph. p. 6. However the Commission calls for "State-of-the-Art Facilities and Equipment." This is seemingly inconsistent with the acquisition technology thrust.

[10] *Op. Cit.* Adolph. p. 5

[11] *Op. Cit.* Adolph. Appendix D. p. D-1.

A broad survey of issues. A very thorough study by Coursey and Bozeman adds some different insight on these issues. Their study which surveyed 1137 R&D organizations, including the DoD laboratories, highlighted four conclusions:

> • "First, lab directors, regardless of sector or laboratory mission, are generally optimistic about the payoffs from technology transfer, at least in the sense that they cite more significant benefits than problems.
> • "Second, there is surprisingly little difference in the views of university and government laboratory directors.
> • "Third, the mission of the laboratory has an influence on directors' assessments of the advantages and disadvantages of technology transfer. The directors of laboratories emphasizing basic research have different assessments of the benefits than directors of laboratories focusing on technology development and commercially oriented applied research.
> • "Finally, labs stressing development research are less likely to encounter problems with technology transfer than labs emphasizing basic or applied work."[12]

But more important to this paper is their finding that,

> "... **the results suggest university and government lab directors believe the greatest benefit of technology is increased public visibility of the lab and its activities.**"[13]

To the extent this is true and to the extent that these results from a much larger sample can be applied to DoD laboratories, then one could conclude that perception is more important than fact. This would seem to call for increased attention to the goals of technology transfer, better training and more stress in publicity on the concrete results of the Defense laboratories' work.

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[12]Coursey, David and Bozeman, Barry. "Technology Transfer in U. S. Government and University Laboratories: Advantages and Disadvantages for Participating Laboratories". IEEE Transactions on Engineering Management. Vol. 39, No. 4. Nov 1992. p. 350.
[13]*Ibid.* p. 348.

Defense Spending In Research And Development

Billions and billions. The laboratories' role in technology transfer ought to be seen in perspective of DoD spending on the whole of research and development. Historical funding of Defense research is well documented in the literature, so the roughly $38 Billion appropriated (fiscal year 1993) to DoD is neither remarkable nor unexpected in view of previous years.[14] Nearly eight percent more is appropriated for defense use in Department of Energy (DoE) laboratories and those have technology challenges of their own. Beyond the Defense budget there is, of course, an equally large research budget of other funds administered by the entire spectrum of federal agencies and departments. The bottom line is that DoD laboratories receive only about 18 % of the total Federal research dollars or nearly $7 Billion.[15]

Awash in the acquisition sea. The Defense laboratory research effort represents only the first few strokes swimming into the hundred billion dollar acquisition sea. All the study, investigation, audit, review, etc., that the entire acquisition process undergoes, continuously and unendingly, spill onto the laboratory effort. If DoD acquisition too frequently ignores *good enough* commercial technology and products in favor of *over specified* defense developed ones, then that criticism will apply to Defense labs. If Defense over-committed to the development of weapons systems far in excess of that which could be reasonably procured, then undoubtedly the laboratories are over-committed to weapons development that has little or no industrial, commercial or civic potential. To the extent that Congressional, White House, academic, industry and even internal DoD criticism of the acquisition process is true (and it may be considerably so), then the laboratories will bear their share of responsibility.

Each laboratory has little freedom or funds to work beyond the strict limits demanded by the statutory constraints of the acquisition system. It is not the

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[14]The reader should keep in mind that a considerable portion of this is for test and evaluation, not research nor development.

[15]DoD laboratories receive a small amount of additional funding from other sources and appropriations (DBOF/NIF payments, MILCON, OTHER MAINTENANCE, etc.), but it is not really germane to this analysis except in the context of paying overhead.

purpose of this paper to examine the acquisition system, the difficult and frequently unfathomable requirements of Federal Acquisition Regulations (FAR), intellectual property restrictions, etc.; but the DoD laboratories exist – and ultimately – will either sink or swim in the acquisition system.[16] Finally and most importantly, the labs' major mission is defense. The difficulty arises in finding the areas where technology transfer can be juxtaposed.

Far from shore. It is well known by operational military officers that commercial products are frequently available that fulfill unit requirements. More than one ship has had commercial electronic navigation equipment in operation, while waiting for the military equipment. How many units are operationally restricted by decades and generations-old computers and electronics, while waiting for prohibitively priced replacements? How many new systems in communications, command and control, sensors, guidance, data management, etc., are doomed in test and evaluation, or worse in combat, by the high priests of military specifications and the cardinals of "not invented here." Notwithstanding our outmoded procurement laws, the problem is clearly defining, developing and procuring systems that are good enough. There may be some special cases in which exclusive DoD developed technology must be used. This should not be the norm. If not the norm, DoD laboratories will benefit from increased technology transfer in every direction and at every level not excluded by security or special operational considerations.

The Department of Energy. Literature of the last few years is full of exemplars regarding The Department of Energy's (DoE) aggressive efforts on technology transfer, especially highlighting the number and description of Cooperative Research and Development Agreements (CRDA), one of the major

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[16]Berteau, David J. et al. "Adjusting to the Drawdown." Report of the Defense Conversion Commission. Dec 31, 1992. This reference lists the following problems with diversification for current defense firms and problems that apply in whole or part to Defense laboratories working at technology transfer:

- Unique accounting practices
- Unique standards and specifications
- Government claim of ownership of rights in technical data
- Unique contract and information collection requirements
- Audit and oversight rules

tools of technology transfer.[17,18,19,20,21,22] In fact, DoE has been aggressive and visible. Despite an excellent DoD program, which exceeds DoE in numbers of CRDAs, the leadership being shown by DoE officials is paying off with industry, the Congress and the public. For example, DoE (along with Commerce, Transportation and the National Aeronautics and Space Administration {NASA}) was a principal sponsor of the National Technology Initiative (NTI).[23] This is good because not only is DoE seen as being on board with the effort, the publicity acts as a catalyst in developing the overall effort. The Cole article points out two main areas (taken from a master's thesis by Hittle)[24] for improvement, which came up repeatedly through the course of my research:

- Getting information to industry
- Bureaucratic and legal impediments to technology transfer[25]

Marketing to the top. I detect further evidence that DoE weapons laboratories expect big returns on changing technology policy from a letter to President Clinton (President-elect at the time) prepared jointly by the directors of the three main labs. Senator Bingaman in his cover letter calls it, "... an

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[17]Cole, Bernard. "DoE labs: models for tech transfer." IEEE Spectrum. Dec 1992. p. 53-57. This article uncritically sings praises to the DoE effort. For example, "Perhaps farthest along are the laboratories administered by the Department of Energy (DOE), particularly those involved in weapons work. Weapons R&D will remain a large part of their charter; in addition, they are developing strategies to implement their new R&D mission." Quotes from lab officials push all the proper technology buttons. For example, " 'Our new role is not turning swords into plowshares,' said Ted Dellin. 'Rather, it is to provide the tools to build both plowshares and swords.' " Later in the article, Cole reports a commerce official as giving a 1992 year end estimate of 300 CRADAs. The number CRADAs may not be a good metric for measuring progress, but the technical press is using the number just the same; and the Department of Defense is not winning in the perceptions category.

[18]Barrett, Randy. "DoE Labs Begin Pushing Environmental Tech". Washington Technology. Nov 19, 1992. p. 36. This article keys on a "sell, sell, sell" attitude in DoE labs. The author quotes DoE lab officials making positive statements, e.g. "Partnering is more important than ever before," and "CRADAs are getting better, but they're not as flexible as they need to be."

[19]Scott, William B. "U. S. Labs Increase Focus on Technology Transfers". Aviation Week & Space Technology. Feb 17, 1992. p. 38.

[20]Slutsker, Gary ed. "Swords into Plowshares". Forbes. Jul 23, 1990. p. 284.

[21]Inman, Bill. "Peace Work". Business. Jun 1991. p. 73.

[22]See section of "Selected Definitions" following the text of this paper on p. 40.

[23]"National Technology Initiative Summary Proceedings". Oct 1992. p. iii.

[24]Hittle, Captain Audie E. USAF. "Technology Transfer through Cooperative Research and Development". Massachusetts Institute of Technology Thesis. Jun 1991. DTIC AD-A239 330.

[25]*Op. Cit.* Cole. p. 57.

extraordinary letter, a letter historians may well one day cite as the beginning of the post-Cold War era at these laboratories."[26] In their letter the directors provide President Clinton with a vision for their future. They say, "We appreciate the serious problems that face the country and the challenge you have in seeking to solve them. We would like to offer the help of our three labs in areas where science and technology can help make a difference." They go on to describe specific ways they can contribute to President Clinton's Technology Policy and provide specific examples of how they intend to achieve those ends.[27] There is more to this than self-indulgence.

Congressional Views On Technology Transfer

Congressional initiative. The Congress has made their feelings known regarding the DoD role in technology transfer through hearings and resulting legislation. A history and summary of this legislation is available in many sources, one of which is an excellent booklet prepared for and distributed by the Federal Laboratory Consortium.[28] While most people in government can reasonably conclude that the Defense budget is declining appropriately to the decrease in the Soviet threat, there is nonetheless no general call for elimination of the Defense labs. President Clinton referred to America's 726 laboratories (including DoD) as "national treasures."[29] Two years earlier, Senator Bingaman (D-N.M.) responded to a Business Week article about shrinking defense labs, quoted in part as follows:

> "At a time when the overlap between critical defense and commercial technologies is rapidly increasing, the weapons labs should not be shunted off into an ever narrower military mission. Instead, the labs' work in

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[26]Bingaman, Senator Jeff. Letter to the Honorable Bill Clinton. Dec 1, 1992.

[27]Hecker, S. S.; Narath, A.; and Nuckolls, J. H. Letter to the Honorable Bill Clinton. Nov 25, 1992.

[28]"Technology Transfer". West Publishing Company. 1991.

[29]Clinton, President William J. "Technology: The Engine of Economic Growth". Final Version. National Campaign Headquarters Clinton-Gore. Final Version. Sep 21, 1993. p. 14.

dual-use technology should be used to bolster our economic competitiveness and meet our environmental and educational challenges."[30]

While Senator Bingaman was responding to an article that concentrated on DoE laboratories in the defense business, I have no doubt that generally the same is true about DoD laboratories as well. With the commencement of the Clinton Administration and the scrutiny of the 103rd Congress, it will be incumbent on the Defense laboratories to show "more bang for the buck," in the technology transfer area as well.

New oversight. The FY-1993 Defense Authorization Act poses some new challenges for DoD. Previous legislation treated the services as separate agencies for technology transfer purposes, but this act implements some new responsibilities regarding defense conversion, of which technology transfer is part. Specifically:

- Requires annual technology transfer plan from labs with funding exceeding $50 Million research and a one time report to Congress.
- Establishes an Office of Technology Transition to monitor R&D, identify R&D uses/results in technology, coordinate with Commerce and Energy Departments, and assist industry in resolving problems. Requires reports describing the organization and its activities.
- Orders "Dual Use Critical Technology Partnerships" that may involve DoD labs' equipment, facilities and people.
- Orders many other related initiatives relating to Defense Conversion.[31]

DoD action to implement this newest legislation is only now beginning.

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[30]Bingaman, Senator Jeff. "Maybe the Weapons Labs are Just the Right Size". Business Week. Oct 15, 1990. p. 8.

[31]Appler, David. "FY-1993 Defense Authorization Act". Undated briefing.

OVERVIEW OF DEPARTMENT OF DEFENSE LABORATORIES' TECHNOLOGY TRANSFER

Department of Defense Policy And Practice

SECDEF orders. The current Defense guidance, in its directive implementing prior Congressional action (primarily the Federal Technology Transfer Act of 1986), is a masterpiece of brevity and conciseness.[32] Prepared by Mr. David Appler, an expert in getting government scientific and technical information to the public, this instruction takes the literal Congressional guidance, and provides the individual service departments and major DoD agencies all the implementing latitude possible under law. In my January 28, 1993, interview with Mr. Appler, I got the firm impression that he felt one of the strengths of this initial direction was the independence the services had in finding their own way.

The DoD guidance defines the military services as equivalent to agencies for implementation purposes. This puts for example, the Navy and the Strategic Defense Initiative Office, on even footing for technology transfer initiation and removes some bureaucratic impediments. The broad guidance delegates to the services implementation and execution of the law. The only explicit guidance concerns royalty sharing, which Appler felt was a real strength of the law and the directive, thereby avoiding unending discussion and fiscal conflict.

Current DoD management of technology transfer. The services and their respective laboratories are truly on their own. Consistent with the political tone of the previous administration, DoD requires no regular reports and has no formal organization in place to manage technology transfer. While some senior DoD executives have nominal responsibility for various aspects of technology transfer, no organization currently exists to more than oversee the service initiatives. Appler who for a short period served on the staff of the Defense Director, Research and Engineering, in the Pentagon, has returned to his small

[32]Appler, D. "Domestic Technology Transfer Program Regulation DoD 3200.12-R-4". Department of Defense Regulation reissued under authority of DoD Directive 3200.12 dtd 27 Dec 1988.

office in the Defense Technical Information Center, Cameron Station, Alexandria, Virginia. Working as head of the DoD Scientific and Technical Information Policy Office, and with a staff of three, he responds to technology transfer inquiries, stays in touch with his service counterparts and represents DoD at various national meetings hosted usually by the Federal Laboratory Consortium (FLC) or more recently by the National Technology Transfer Center (NTTC). For better or worse, and with great dedication and clear enthusiasm on Appler's part, it is a "hands-off operation." When he needs information, he simply calls his service counterparts.

Impacting the economy. I initially posed to Appler a question concerning the measurement of our implementation progress over the last six years. He felt the only true measure is and will be the impact of the department's technology transfer efforts on the economy. It's not that quantitative measurements aren't important. They are, but there is no clear agreement on how they should be used. Appler confirmed that, in fact, DoD has more CRDAs than any other agency.

The need for quantitative measures continues. It is not unusual for the Government Accounting Office (GAO) to seriously inquire for exact data on "the number of contacts," with government researchers. This is beyond any reasonable expectation. Scientists must strike a balance among their research, publishing, meetings, and everything else. For many scientists in government labs, pursuing concerns related to patenting, licensing, etc., is the antithesis of the usual academic pursuits of "publish or perish."

A niche perspective. Appler provided some interesting thoughts on Defense research and development and the not-so-apparent ways DoD is already deeply involved in technology transfer. The majority, 70%, of Defense research and development funds already go to private labs and universities. DoD must focus on research niches that industry has abandoned.[33] Much technology transfer has already occurred, for example, patents being used for government developed

[33]Of the remaining funds, a substantial portion of DoD RDT&E funds are spent on test and evaluation, not research.

microchips and no royalties being paid.[34] Looking at the people and resources available, DoD could be doing just about the best it can.

The Republican administration and implementation to 1992. Secretary Cheney and his staff issued no guidance to impede technology transfer. They also made no special effort beyond implementation of the law, a low key approach so as not to overplay the issue. Real political concerns of "industrial policy" motivated a minimalist implementation policy. Besides, there are long-standing government employees' concerns regarding the explicit implementation of the Federal Acquisition Regulations (FAR), that have indirectly diluted Congressional intent in a wide range of technology transfer initiatives, especially CRDAs. Appler shared with me some other issues that may have impacted technology transfer in the last four years including, lack of knowledge of industry's requirements, how to link technology transfer to reconstitution and just plain intrusion into the private sector. But in the final analysis, '...political tone more than bureaucratic impediments will do more to change DoD's direction than anything else."[35] Dedicated and enthusiastic civil servants, such as Mr. Appler, stand ready to move into high gear.

Department Of The Army

The Army in the Lead. The Army's guidance in Army Regulation 70-57 is particularly clear and succinct.[36] Although his name does not appear on the document, the author, Mr. Cliff Lanham, is an especially knowledgeable and enthusiastic leader for Army technology transfer.

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[34]More takes place outside of labs, for example government production engineers working with industry in the building of weapons systems. There are also the massive amounts of information already made available to the public through the National Technical Information Service, the Defense Technical Information Center, the DoD Domestic Technology Referral Database, and a host of government publications, libraries, facilities, etc.

[35]Appler, David A. Private correspondence March 18,1993.

[36]"Military-Civilian Technology Transfer." Army Regulation 70-57. Headquarters, Department of the Army Washington, DC. Jul 25, 1991.

Army Football. With technology transfer the Army has picked up the football and is running for the goal line. The language of their guidance is motivating and plainly put. It takes the spirit of the law and its letter for implementation at the Department level. For example, their concept is explained in part as follows:

> "The intent of National policy on technology transfer from Federal laboratories is to increase both the speed and the extent of applications in the domestic economy of the technological resources of Federal laboratories and R&D centers. Thus, greater payback for the investment in Army R&D is sought through more rapid and diverse spin-off of Army-developed technology for new and improved products and processes which will allow U. S. industry to achieve a better competitive position. Greater payback is also sought through the use of Army expertise to improve the cost-effectiveness of services provided to the public by State and local governments."[37]

Marketing. In paragraph 3-3 the Army lays out its marketing strategies. In discussing technology transfer with Lanham, he stressed the marketing aspects and the need for individual effort by each laboratory's Office of Research and Technology Applications (ORTA). The regulation describes two efforts.

First, "...marketing the service of technology transfer." Army expectations for this effort are requests for "...technical assistance efforts and frequent referral to other laboratories." The Army understands its role as a cog in the nationwide technology pool and is enthusiastic in helping, "...potential users become more aware that Federal activities have valuable technology which is available." The Army understands the Congressional intent. With the information on laboratories and their technology readily available, companies, especially small and medium ones unlikely to have major research departments of their own, can employ what the Army terms "technology pull" to focus some laboratory assets on applications defined by private sector clients.[38] Army use of

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[37] *Ibid.* Chapter 3, Section I, para 3-1. p. 6.

[38] "Technology pull" is termed "market pull" by some other technology transfer professionals.

the Small Business Innovation Research Program is an important part of this effort.

Second, the Army marketing effort. Termed "technology push," this involves the search for commercial or public use of specific technology currently or soon to be held by the laboratory. This requires knowledge and appreciation by both the researchers, and the ORTA, of the potential for commercial exploitation. Though unstated it also requires a desire to see the technology translate beyond the laboratory and narrow military application.

Department Of The Navy

The Navy plan. Navy implementation of technology transfer, while quantitatively behind the Army in number of CRDAs, is correctly structured and accelerating.[39] Based on an extraordinarily concise policy and guidance directive of the Secretary of the Navy,[40] the Chief of Naval Research (CNR) is in overall control. Through his executive agent, a staff member, currentiy Dr. Ron Culpepper, maintains very tight control over new agreements. The oversight extends to actual approval of the CRDAs submitted by Navy laboratories and while the goal is 30 days for review and approval, my interview of laboratory personnel indicates that at worst it has taken 18 months to achieve an approved contract, not a speed to inspire industry to invest.[41] While both Navy directives are models of brevity and correctly constructed to implement the law, they contain no language likely to inspire great things in technology transfer at the laboratory level. They are at worst perfunctory directives. Interestingly, one Navy laboratory has published its own CRDA Handbook, which contains much of

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[39]Whiting, G. A. "Navy Domestic Technology Transfer Program". Chief of Naval Research Instruction 5700.1 (OCNRINST 5700.1). Jul 24, 1991.

[40]"Domestic Technology Transfer". Secretary of the Navy Instruction (SECNAVINST 5700.16). Oct 27, 1989.

[41]This relationship between the laboratories and the service department appears to have been unique to the Navy. My discussion of this with Culpepper indicates that this policy was well intentioned; protected the laboratories and the Navy; and seldom caused any significant delays. On April 6, 1993, Culpepper informed me that a new directive would be signed very soon. This will provide CRDA approval authority to the six major centers of Navy research, which together account for 90% of all Navy research.

the detailed guidance one would expect to find available in an agency level publication.[42]

Notwithstanding this, some Navy laboratories are forging ahead at flank speed. One such laboratory is the Naval Research Laboratory in Washington, well respected for its recent technology efforts by a senior Congressional staff member with whom I discussed these matters.

The example of the Naval Research Laboratory (NRL). This laboratory has an enthusiastic and aggressive executive for technology transfer, Dr. Richard H. Rein. Rein, who successfully completed a previous career in industry, has correctly, in my opinion, focused on the fact that success in technology transfer for his laboratory is directly linked to his ability to **market** capabilities.

Marketing a Navy laboratory. Rein in a paper presented to national technology transfer executives[43] describes two systems to "facilitate" federal technology transfer. First, the Federal Laboratory Consortium (FLC) and the National Technology Transfer Center (NTTC) provide data and assistance to allow industry to find the right technology, laboratory or federal researcher for their idea or problem. Rein calls this "market pull." The second system, labeled "technology push" puts laboratories in the offensive to find new partners for the sole purpose of reaping the benefits of a commercial technology transfer.

Steps to successful technology transfer. Rein in the same paper describes three elements that have led to considerable success at NRL and provide a framework to consider how improvements might be generated in laboratories not so engaged. These elements, collected in the table below, I discuss in the paragraphs that follow.

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[42]November, R. "Cooperative Research and Development Agreement (CRDA) Handbook". Naval Ocean Systems Center, San Diego CA 92152-5000. Technical Document 2074. Mar 1991. DTIC AD-A237 474.

[43]Rein, Dr. Richard H. "Developing Marketing Strategies and Finding the Right Partners". Presentation at Federal Laboratory Consortium Fall Meeting Atlantic City, NJ. Nov 6, 1991.

ELEMENTS OF TECHNOLOGY TRANSFER

1. IDENTIFYING TECHNOLOGY READY FOR TRANSITION
2. DEVELOPING A STRATEGY
3. FINDING A PARTNER

1. Identifying technology. Rein's first element is very challenging due to the size and variety of projects. He estimates that his office is able to efficiently transition only about one percent of the 1,000 projects in process at his lab. Specifically he looks for research meeting the following criterion:

- Does the technology satisfy a market need?
- Does it offer significant advantages?
- Is it ready to transition?
- Is there a committed champion?

Rein indicated that this limitation exists from the small size of his staff, the demands for his time both in the lab and nationally, and the requirements to execute elements two and three. He tours part of his laboratory weekly seeking potential candidates. He also gleans possibilities from the usual technical reports, management reports and publications of his major laboratory. But he counts on the commitment of "champions" in the lab, because "...without the benefit of committed champions the process will grind to a halt."

2. Developing a strategy. The existence of industry partners for technology transfer is not always obvious. Since so many possibilities exist for some of the technology, the technology transfer staff must carefully consider what industry specialists or groups may be worth approaching. Correct first choices greatly aid reaching successful agreement, simply from the savings in staff time and energy. Rein uses the following game plan:

- Develop a vision.
- Identify the end markets.
- Identify the companies serving the market.
- Identify strengths required of partner including —
  technology, marketing, manufacturing and financial

3. Finding a partner. Getting a successful partner usually requires considerable research. Beyond the product champion's ideas concerning possible companies, Rein makes use of commercial data bases, networking and an aggressive marketing program. The astounding fact is that his success has been achieved by a staff of three. Key to this success has been enthusiasm, personal technical expertise and **industry experience.**

Industry pull. I found it interesting that no industry had come forward to simply use laboratory facilities or expertise to solve a problem. Each CRDA has been a "technology push" agreement. Rein suggests that the uniqueness of DoD laboratories may minimize their importance to industry. On the other hand, it is possible that many small or medium sized companies, unable to capitalize their own research facilities, may not yet know of the capabilities available. This is an area worthy of additional research, because if our laboratories are appropriately configured with modern facilities, one could reasonably expect some commercial interest in their use.

Incentives. Lastly, as a result of this visit and my discussion with Dr. Rein, I became aware that the technology transfer effort in the DoD laboratories may not be correctly or sufficiently given incentives. While an individual researcher may profit from the commercial use of a patent developed at a DoD laboratory, and the lab itself share in that profit and from the CRDA itself — no such incentives exist for the marketing team. Presumably the research would have been conducted in any case, just as it was before technology transfer became an issue. But it is clear that sophisticated marketing and tireless enthusiasm to get government technology into the marketplace must come about through the sort of effort that Rein and his team demonstrate. I doubt that the government civilian

and military services awards are sufficient, in and of themselves, to sufficiently leverage the billions of DoD research dollars. **We need a plan to attract, train and reward successful technology transfer executives to get a greater than one percent involvement.** Such a plan would also attract experienced individuals from industry to government service.

Department Of The Air Force

Air Force implementation. Although the Air Force reportedly has 50 CRDAs in being, I found formal implementation quite different from both other services. I was fortunate to interview Air Force executive, Dr. C. J. Chatlynne. While Chatlynne monitors Air Force implementation in four major lab groups, the structure seems quite informal. A Deputy Assistant Secretary is the actual responsible official and Air Force representative to the Federal Laboratory Consortium, but in practice Chatlynne is the point of contact and action officer.

Hands-off Implementation. As formal implementation is largely left to the Air Force Systems Command and the seven designated Offices of Research and Technology Applications (ORTA), I limited my discussion with Chatlynne to the management aspects of his program. He felt strongly that the independence of each service in implementing technology transfer was a great strength in the program. This follows from Congressional wording making each service a separate implementing agency. He felt that the DoD role was just about right, primarily in seeing to it that everyone was using the same rules. As his counterparts in the other services, he felt that quantitative measures of progress were difficult and misleading, for example the number of CRDAs. He did not disagree that DoD and the services needed to improve their ability to show progress. But he made a convincing argument that technology transfer is much more than CRDAs, meetings, publications, etc. He felt that much was going on by phone and electronic mail that was, what I'll term, the hidden technology transfer. I doubt this will remain a convincing position.

Chatlynne was very convincing, that under existing guidance, technology transfer is not a DoD mission and that further Congressional action would be required to make it so. This then would cause additional resources to flow, including to the Air Force. He also felt strongly that for technology transfer to succeed there "has to be industry pull, not government push." Like the Army, the Air Force does not exercise central approval over its labs' CRDAs, relying on simple review and correction.

A View From Industry

Meeting business needs. No doubt industry is making their views on technology transfer known through their lobbyists. But aside from whether or not Governmental policies are structured to their liking, there is the consideration of the degree to which Federal laboratories, including Defense ones, are meeting industries' needs. While recent literature is full of very positive stories regarding the successes of various technology transfer schemes, there is little critical analysis, especially as seen from industry. **A more open and extensive critique from industry would probably be most helpful.** One such critique, which has gotten serious review (it was brought to my attention by the DoD coordinator of technology transfer) is an interview of Mr. Jim Wessel, Dow Corning's Director of Cooperative Research and Development.[44]

Constructive Criticism. This interview, though nearly two years old and focusing on CRDAs, appears to be based on reasonably wide experience at four different Federal laboratories, including some of the Army's. Wessel's response to the query of the easiest labs and agencies to work with matches my own perceptions based my interviews with the head of each military service's technology transfer. He says, "We've had the best results with the Army. They seem not to have had any trouble with the procedures."[45] His very constructive

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[44]Stockdale, Grant. "As Seen from Dow Corning: The Challenges of Federal Technology Transfer". Cooperative Technology R&D Report of the Business of Technology Commercialization at Federal Laboratories and Universities. Aug 1991. Vol. 1 # 1.

[45]*Ibid.* p. 16.

criticisms and comments are applicable to all Federal laboratories. In summary, as I interpret his remarks, they are:

- "Exclusive rights." The labs deal with this issue inconsistently.
- Too much time to get CRDAs signed. Some of this is connected with negotiating around "exclusivity concerns."
- "There's no policy that labs can go by." This comments was related to the two points above. Further comments expand on this point by explaining how the problems vary lab to lab.
- The creation of more technology transfer agents specializing in specific areas.
- The need to educate and enhance the industry researchers on how to find the right government resource. This currently takes too long. Better information resources. Industry researchers need an "electronic catalog" on their desks.[46]
- Overcoming the reluctance of some government researchers to move beyond basic research.
- Emphasis on helping small companies.
- Government availability of very expensive and specialized research equipment that everyone in a region can use.

The bottom line of this interview is that industry is challenged to find out how to access the wealth of government resources, figure out how to use them, and efficiently get government and industry people moving in the same direction. Clearly, it is incumbent on Defense laboratories to work on these challenges, and indications are that the services are doing just this – even if results are difficult to assess.

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[46] *Ibid.* p. 16. Wessel's comments regarding establishing contact are especially telling. In part:
"But often what we do is spend an awful lot of time calling people and visiting with people. It can be literally months before you come up with the correct answer. Since it's not the only thing you're doing, it can easily be four or five or six months before you find the right person. In terms of intense work on it, you might find it in a matter of weeks. But you have to remember that once you find the right person, not every lab person is interested in doing that kind of joint work you're proposing. So you have to wade through those folks, too."

Later he says, "The number one thing is for that industry scientist to be able to sit at his desk with his computer, and to be able to key in and call up who is doing what at the national labs, so he knows who he can contact to talk bout joint work. He can do that now on technical reports that have been written, but he can't do it for work-in-progress at any particular laboratory."

PRESIDENT CLINTON'S PLAN FOR TECHNOLOGICAL REVITALIZATION

"Don't Stop Thinking About Tomorrow"

Thorough consideration of Defense laboratories' role in technology transfer is impossible without review of the plans of the new administration. During the '92 campaign then Presidential candidate Clinton published his vision for technological transformation.[47] While attesting a role for government to play, he says, "... in restoring America's competitiveness, most responsibility rests with the private sector." He then calls for government support of industry efforts based on adoption of six broad initiatives.[48] Two of these challenges have direct application to Defense laboratories.

First, building a 21st century technology infrastructure. The fourth of five elements in President Clinton's infrastructure initiative is "Involving the federal labs, companies, and universities in conducting R&D on key issues."[49] This certainly is meant to include Defense laboratories and laboratories operating on Defense managed dollars. Since direct tasking and funding of a Defense laboratory to work on a commercial technology in unlikely and unprofitable, we may assume that their participation in this element of the plan is going to be done through technology transfer.

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[47] *Op. Cit.* Clinton.

[48] *Op. Cit.* Clinton. p. 10. The six broad initiatives are:

1. Investing in a 21st century infrastructure
2. Establishing education and training programs for a high-skill workforce
3. Investing in technology programs that empower America's small businesses
4. Refocusing federal R&D programs on critical technologies that enhance industrial performance
5. Leveraging the national R&D investment
6. Creating a world-class business environment for private sector investment and innovation

[49] *Op. Cit.* Clinton. p. 11. The five elements that the infrastructure program should contain are:

- Funding the establishment of key networks and demonstration projects
- Benchmarking U. S. programs against those of other major industrial nations
- Establishing standard and a regulatory climate that fosters private sector investment
- Involving the Federal labs, etc.
- Providing training for users of networks and databases

Second, leveraging the existing federal investment in technology to maximize its contribution to industrial performance. President Clinton's concerns here are especially important. He says in part,

> • "Private corporations should compete for this funding through review by panels managed by the labs and made up of corporate and academic experts. Lab directors should have full authority to sign, fund and implement cooperative R&D agreements with industry. Some labs, such as NIST, already have this authority, but others do not.[50]
>
> • "Industry and the labs should jointly develop measures to determine how well the technology transfer process is working and review progress after 3 years. If these goals have not been met, industry and the labs should reevaluate their involvement, and funds should be redirected to consortia, universities and other organizations that can work more effectively with industry for results."[51,52]

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[50]Emphasis here and in the next paragraph is added.

[51]*Op. Cit.* Clinton. p. 14-15.

[52]More complete transcription of the President Clinton's text follows:

"Despite several years of legislative reform and many new directives, the labs still do not have the autonomy or funding to pursue joint ventures and industry aggressively. These labs and other private non-profit research centers are national treasures because they house large, multi-disciplinary teams of researchers who have honed the skills of balancing basic and applied research for long-term, mission-oriented projects. It would take years to match these special capabilities elsewhere. Today, the labs and industry cooperate on defense needs; we need to change regulations and orientation to get this cooperation on technology development for commercial usage.

"To remedy these problems, I propose the following:

- The budget of the National Institute of Standards and Technology should be doubled.
- Federal labs which can make a significant contribution to U. S. competitiveness should have ten to twenty percent of their existing budget assigned to establish joint ventures with industry.
- Private corporations should compete for this funding through review by panels managed by the labs and made up of corporate and academic experts. Lab directors should have full authority to sign, fund and implement cooperative R&D agreements with industry. Some labs, such as NIST, already have this authority, but others do not.
- Industry and the labs should jointly develop measures to determine how well the technology transfer process is working and review progress after 3 years. If these goals have not been met, industry and the labs should reevaluate their involvement, and funds should be redirected to consortia, universities and other organizations that can work more effectively with industry for results."

On February 22, 1993, President Clinton, in a new speech entitled "Technology for America's Economic Growth, A New Direction to Build Economic Strength, " gives the framework for implementation of his plan. It includes the following points:

- A significantly higher ratio of civilian and dual-use R&D to purely military R&D
- Laboratory budget review with the aim of devoting at least 10-20 percent to R&D partnerships with industry

A Metric for Technology Transfer

In this final point President Clinton is correct, but as discussed above, there is no commonly accepted means to do it. In a technical memorandum of the Office of Technology Assessment (OTA), Congress published the results of a study concerning research and development to "... prov[illegible] information on the extent to which decision making would be improved through the use of quantitative mechanisms associated with the concept of investment." OTA considered a number of techniques, but concluded, "... that basic science is not amenable to the type of economic analysis that might be used for applied research or product development." OTA also added, "... that even in the business community, decisions about research are much more the result of open communication followed by judgment, than the result of quantification."[53]

Although the OTA Memorandum does not specifically address technology transfer, each of the quantitative methods it considers (econometric studies, spin-offs and spillovers, bibliometrics, science indicators, models, etc.) can by logical extension be seen to have some relation to technology transfer investment similar to the initial R&D investment. There is no mention of DoD even trying. This, then, presents a problem for Defense technology transfer management. The President expects both contribution and progress from Defense efforts in technology transfer from Defense labs – but no accepted quantitative means exists for so demonstrating. **This** is a **problem** which **requires** further Department sponsored **study**, **a solution and guidance** to the services' and laboratories' managers.

• Removal of obstacles to CRDAs and facilitation of industry-lab cooperation

[53]"Research Funding as an Investment: Can We Measure the Returns? – A Technical Memorandum". U. S. Congress, Office of Technology Assessment, OTA-TM-SET-36. Washington, DC. Apr 1986. p. iii.

WHY NOT PRIVATE INDUSTRY ALONE?

American industry operates in one of the world's most free markets. But modern pressures of government, changing priorities, overseas subsidized competition and the brunt of the current financial crisis have left a playing field, not only rugged, but frequently mined. Is it realistic for every entrepreneur to start his own research and development center?

A Japanese Model

Dr. James I. Merz provided an in depth analysis of a single Japanese experience. The broader question of government's role in science and technology is beyond the scope of this paper, but Merz's findings seem especially applicable to the issues of technology transfer for DoD laboratories.

MITI

Merz among others gives high marks to cooperative development of technology in Japan through the Ministry for International Trade and Industry (MITI). Cooperative agreements under MITI auspices, that range from four to eight years, are not unusual. This fact is indicative of the long term view in Japanese thinking regarding technology. Despite difficulties in judging the quality and quantity of research, and notwithstanding his admiration for their work in Optoelectronics, Merz speculates on reasons for expected Japanese success:

- Joint endorsement of the importance of the project
- Commitment to follow-on projects based on excellent results
- Guarantee of follow-on employment in a responsible position for experienced researchers
- Commercial companies willing to send their better researchers
- Cultural factors
- Opportunity for individual researchers to conduct more basic research than possible within the parent company.

On the other hand, Merz points out that simultaneous cooperation with Japanese universities is not possible because of the Japanese bureaucracy. In this lies a possible strength that the United States can exploit for as Merz says, "Should the Japanese rectify this situation and take full advantage of the research talent and capability that exists within their educational system, the United States will really be in trouble."[54]

[54]Merz, Dr. James L. "The Optoelectronics Joint Research Laboratory: Light Shed on Cooperative Research in Japan". University of California, Santa Barbara, CA 93106. undated. DTIC AD-A170 700. DTIC selected Aug 8, 1986.

PARTNERSHIPS WITH SCHOOLS AND UNIVERSITIES

Relatively little has been written concerning links between DoD laboratories and the educational establishment. While it is not unusual to find research funds flowing from DoD projects to universities, it is apparently unusual to find substantive university research at our major labs, using government equipment and government facilities. Notwithstanding the relatively large investment in Government Owned, Contractor (sometimes a university) Operated facilities, greater effort by the mainstream Defense laboratories in reaching out to colleges and universities is required.

An Extreme Measure

Lubell observes that we must "... redefine the relationship between the universities (possibly our greatest economic assets for the competitive challenges of the future), corporate laboratories and the military." His solution is possible, barring immediate action by DoD to demonstrate commitment to technology transfer -on a more realistic scale. Lubell says, "The nation's military laboratories can still serve an important function. Instead of shutting many of them down, convert them to civilian use. Much of their research prowess can be directed toward commercial applications."[55] In a related piece Coia reports concerning two publications of the Office of Science and Technology that call for changes in the relationships between universities, Federal laboratories, and private industry. Largely though, this article describes a need for new definitions and resource shifts.[56]

Reconstitution

Assuming that the universities would even want to take over some of the DoD laboratories, careful analysis must be given to the role of these laboratories in maintaining a defense establishment that is reconstitutable. For the time being

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[55]Lubell, Michael S. "Getting the Right Mix on R. & D." New York Times. Dec 28, 1992. p. III-11.
[56]Coia, David A. "Research goals are changing". Washington Times. Dec 22, 1992. p. 6

reconstitution is one of the four cornerstones of our defense strategy. Ongoing defense research is an essential part of that. The challenge is for DoD to find a balance in most laboratories that maintains the defense research base, while taking on the immediate threat of economic domination by foreign powers, all too ready to use their governmental resources in achieving technological and commercial victory in the world marketplace.

ISSUES BEARING ON THE FUTURE OF DEFENSE LABORATORIES AND A ROLE IN TECHNOLOGY TRANSFER

Budgets

There is every indication that DoD can expect continued downward pressure on its research budget. Based on the President's statements and Congressional action in the last ten years, it is clear that Defense laboratories are going to have little success operating apart from a philosophy that counts on technology transfer, dual-use development, defense conversion, off-the-shelf commercial acquisition, etc., to achieve Defense budget savings and improve American commercial competitiveness. While maintaining our technological lead in defense, it is incumbent on the entire department to do its part in achieving economic security as well. This is a case in which DoD must "have its cake and eat it too!"

Attacking The Technology Transfer Hydra

Many different initiatives have emerged as part of the overall downsizing, conversion and transition of Federal technology efforts. Technology transfer is one of these. It is essential to the economy, reconstitution, future defense, and our relative lead in defense technology, that DoD laboratories be leaders in selected efforts, both in perception and fact. The Defense Conversion Commission report puts it well:

> "Defense conversion cannot solve all of America's economic problems. However, actions that ease the transition are part of the answer to the question of promoting overall economic growth. In addition, effective defense conversion programs can serve as models for the roles of both Government and business in the transition of other sectors of the economy."[57]

[57] *Op. Cit.* Berteau et al. p. ii.

In a slightly different vein, Shaker and Mallin state, "...the challenge of defense conversion – shifting the military complex toward a greater role in civilian production, research and development – will confront the U. S. defense establishment."[58] While undertaking "tentative steps" for DoD such as chairing the Defense Conversion Commission, establishing the Office of Economic Adjustment and moving out on technology transfer are good, these efforts are only going to be enough to control a few of the "Hydra's" heads.

A Defense Extension Service

Shaker and Mallin make their case for a number of DoD programs, most of which are beyond this paper's scope. But one applies directly to DoD laboratories:

> "Employ National and DoD Labs as Technology Extension Agents to Industry: A new governmental service, modeled on the Agricultural Extension Service, could provide technical expertise to assist defense conversion. ... Departments of Defense and Energy laboratories maintain the largest share of the engineering and scientific talent in the government. There the pool of expertise available to serve as extension agents to industry could include those residing in defense research and development establishments."[59]

This is just the kind of thing DoD must avoid. We don't need a new service, but only a more aggressive and enthusiastic technology transfer drive on the part of the laboratories which will beat down calls for this sort of government expansion. Reilly reports a similar finding by the private sector Council on Competitiveness in their report "Industry as a Customer of the Federal Laboratories, "DoD should

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[58]Shaker, Steven and Mallin, Maurice. "Defense Faces Conversion Challenge". Defense News. Nov 9, 1992. p. 19.

[59]*Ibid.* Besides than the quoted material, the authors make a case of the following conversion initiatives:

- More funding for worker retraining
- Contribute to the establishment of a civilian DARPA
- Identify requirements for dual-use technologies
- Buttress intelligence community support to U. S. business
- Clarify roles and missions, on the battlefield and off

establish an outreach program to make labs more accessible to industry."[60] While this is somewhat softer than a call for extension agents and based on a DoE focused report, it is nonetheless indicative of a need. DoD must accelerate its pace, if further, less acceptable, direction from the Congress is to be avoided.

A Related View

In another feature, presumably concerning the same Council on Competitiveness report, Yates provides a cogent and more expansive analysis. His major points are:

- "...federal labs need to refocus their activities and develop customer-driven technology-transfer programs..."
- "...the nation's federal laboratories are a microcosm of the broader competitiveness challenges..."
- Quoting Erich Bloch, '...federal laboratories ... are well positioned to address generic issues and technologies critical to the competitiveness of American industry such as manufacturing processes, creation of new materials, superconductivity, information technology and biotechnology.'
- Problems are:
  - "... few labs are set up to serve private industry
  - "Too many labs tend to view issues related to industrial technology and competitiveness as peripheral concerns rather than as part of their core missions

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[60] *Op. Cit.* Reilly. The nine recommendations of the Council as summarized Reilly are:
- Assign 10 percent of the DoE and NASA budget to joint civilian technology programs ...
- The government should launch a national technology infrastructure program to strengthen U.S. industrial competitiveness and foster public/private cooperation
- Give government-owned, contractor-operated lab directors authority to negotiate R&D ventures with industry
- DoD should establish an outreach program to make labs more accessible to industry
- Federal labs should work closely with state technology development programs and non-profit technology consortia
- Encourage non-DoD labs to establish industrial advisory committees...
- Industry and the labs should jointly re-evaluate the tech transfer process. If insufficient, redirect funds to the private sector
- U. S. industry should work actively with the labs and their agencies to establish model and umbrella CRADAs and to maximize use of existing agreements
- U. S. industry should be a good customer of the labs.

- "Too many administrators and researchers feel threatened by this new role
- "Only a small fraction of the federal labs' resources go toward technology-transfer agreements ...
- "Most of the federal labs are technology-driven and concentrate on developing enabling technologies ...
- "They are concerned primarily with long-term responses to problems. Private industry, on the other hand, is market-driven."[61]

Find a Measure

Strangely, neither Reilly nor Yates picked up on issue of metrics. In fact Reilly incompletely quotes the exact language of the report, which actually reads:

> "7. Industry and the Federal labs should jointly establish metrics to determine how well the technology transfer process is working and review progress after 3-5 years."[62]

The Council on Competitiveness hit on one of the real issues in this point. Certainly, review of DoD progress in technology transfer through its labs will be required; but preliminary to that effort is definition and promulgation to all concerned of exactly how progress is to be measured.

A Specific List Of Problems

Coursey and Bozeman provide a table entitled "Problems Experienced with Technology Transfer Activities." This paper based its results on the most complete survey I found concerning technology transfer and government laboratories. From government laboratory directors' input, the problems most commonly given are:

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[61]Yates, Ronal E. "Refitting Cold War Science". Chicago Tribune. Oct 27, 1992. p. IV-1.

[62]Fisher, George M. C., et al. "Industry as a Customer of the Federal Laboratories". Undated report of the Council on Competitiveness. Washington, DC.

- "Takes time from other research activities
- "Moved research agenda from fundamental research
- "Disharmony and discord among research personnel
- "Intellectual property disputes
- "Research interruptions by outsiders seeking technical information"[63]

Hittle's research, mentioned earlier, brings in a heavier view from industry. His findings of concerns about "red tape" in technology transfer are not unexpected; but his findings of "... an adversarial perception of industry by government labs," requires immediate attention and, if warranted, correction.[64]

[63] *Op. Cit.* Coursey. p. 349.
[64] *Op. Cit.* Hittle. p. 140.

SUMMARY OF PROBLEMS AND RECOMMENDATIONS FOR IMPROVEMENTS

People will determine the future success of technology transfer in DoD labs; and I met many such enthusiastic people during the course of this research. This program is young compared to some other defense conversion efforts. Based on the overall results so far, I conclude that DoD has farther to go in getting a majority of senior policy officials, laboratory managers and staff researchers on board. In paragraphs below I attempt to summarize the problems and to give recommendations to aid our leaders and managers in finding a future in technology transfer for our laboratories.

A Continuing Challenge – Now and in the Future

The technology transfer challenge in Defense laboratories is only one part of the Defense Conversion effort. Problems in implementation only seem overwhelming. While there have been success stories, some labs show minimum participation, at best, or have not as yet found their niche in the effort. As the momentum, funds and personnel increase, the challenges should seem relatively easier. There are many recommendations for easing the pathway. One reasonable and subjective analysis is from Perry.[65] She suggests three ways as follows:

- Encourage research staff to be alert for commercial opportunities
- Energize industry to get more from labs and universities
- Break down the communication barriers that too often preclude defense use of commercial technology

While Perry's article deals primarily with the much broader area of defense conversion, key themes for the Defense laboratories that frequently arose during this research are closely tied to her points.

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[65]Perry, Nancy J. "More Spinoffs from Defense". Fortune – The New American Century. 1991. p. 60.

Mission

DoD's research mission and that for each laboratory needs to be examined against the reality of technology transfer and updated appropriately. Planning, programming, budgeting and executing a workable balance between research and technology, and dual-use technology, will be affected by accurate mission statements.

Consider A Total Quality Management Approach

The application of a Total Quality Management Approach to the DoD technology transfer program seems appropriate, even though specific implementation details are beyond the scope of this paper. Consider how closely half of Deming's "Fourteen Points" seem to apply to the many problems discussed in this paper:

1. Create constancy of purpose for improvement of product or service.
2. Adopt the new philosophy.
6. Institute training.
7. Institute leadership.
9. Break down barriers between staff areas.
13. Institute a vigorous program of education and retraining.
14. Take action to accomplish the transformation.[66]

Applying the Deming Management approach would initiate solutions to many of these problems. A DoD working group could improve communications, prepare a mission statement, prepare a vision statement, and prepare a strategic plan for the Department's implementation.

Level Of Effort

Additional manpower is required at nearly every level. DoD efforts are actively coordinated by a single senior civilian with a support staff of two or three. One

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[66]Walton, Mary. The Deming Management Method. Perigee Books. New York. 1988. p. 34-36.

of the services has but a single person coordinating its efforts and the other services have no more than three or four people coordinating the effort, at least at the service department level. The result is uneven, uncoordinated implementation, although there is a working technology transfer effort in every service.

Officials named to duties in each lab's Office of Research and Technology Applications (ORTA) sometimes have other duties that conflict with the marketing effort required. Some may have only a scientific background, with no marketing or industry experience, and their training is limited to several Federal Laboratory Consortium (FLC) activities. Barrett's criticism of NASA in a recent article could easily have been leveled at DoD. He says in part, "NASA tech transfer centers understaffed and badly coordinated." They "do not feel technology transfer is part of their job."[67] Implementation of the 1993 Defense Authorization Act provides the perfect opportunity to examine the allocation of human resources to this effort. This examination should embrace not only raw numbers, but the breadth and kind of expertise that the management and marketing of technology transfer currently demand.

Funding

The effort I am describing is not going to be accomplished with the funding gleaned from other program elements. No specific authorization of funds exists and to a certain extent the DoD program reflects the level of funding. As Appler points out, "Promoting technology transfer by eating it 'out of hide' while budgets for mission needs are shrinking dramatically is not a very good way to gain enthusiastic support at the working level."[68]

Measuring Progress

No agreement exists on how DoD, each service and each laboratory should measure or monitor its progress in technology transfer. Everyone I interviewed

[67]Barrett, Randy. "NASA Admits Exaggerating Tech Transfer". Washington Technology. Jan 14, 1993. p. 1.
[68]*Op. Cit.* Appler. Mar 18, 1993.

agreed that the number of CRDAs (or other technology agreements such as Small Business Innovation Research) were not a good measure, and yet that single variable appears more often than any other in the various reports about technology transfer in the laboratories. All the service department leaders agreed that there was much more to their department's effort, but nonetheless felt unable to express their effort quantitatively.

The potential size and demand for Defense technology transfer calls for some sort of statistical method in its management. Without getting into further heuristic discussion of Deming's Total Quality Management and statistical process control, DoD should take responsibility to develop appropriate tools and implement them. This would also seem consistent with initiatives legislated in the 1993 Defense Authorization Act.

Communications

Greater internal and external communications about every facet of the Defense Technology Transfer are required. Notwithstanding Congressional intent of giving each service relative freedom in the implementation of its program, the users' problems are made difficult by varying methods, requirements, and even vastly different structures of the research establishments. Even as the great libraries of this nation, each under different management and perhaps using even different cataloging techniques, are developing means for sharing data with all users and among themselves, so is it incumbent on DoD to assist in building the means by which potential users can access the wealth of government resources, which they require.

Public Affairs

Technology transfer admittedly has a limited audience, but DoD is losing in the public affairs arena, mostly to DoE and NASA. The same is true in the service departments. Consider the 1992 Review of the Naval Research Laboratory, as an example. This 300 page volume, intended to provide an information exchange concerning highlights of unclassified research and development, barely mentions

technology transfer. The index includes no mention of CRDAs nor technology transfer. There is a listing for Office of Research and Technology Applications Programs, which refers the reader to page 277, where one could find a single sentence ORTA description, under the heading TECHNOLOGY TRANSFER. Also included under this heading are the unrelated Navy Science Assistance and Scientists-to-Sea Programs. This is hardly a level of publicity to inspire great strides in technology transfer.

Other labs publish similar volumes annually and, in general, the attention to technology transfer is about the same. Mr. Appler, the DoD action officer for technology transfer, pointed out to me during our interview, the good that could accrue from an annual DoD publication simply describing our facilities and CRDAs. But DoD has no one responsible to do this, no personnel and no budget. Even such press as DoD gets on technology transfer seems to be driven by press inquiry, rather than DoD or service press releases.[69] Given the importance of good marketing to the technology transfer effort, DoD needs to establish a specific program to report our efforts and especially our successes.

Bureaucratic and Legal Impediments

There may be some real problems that require either DoD or further Congressional action to meet industry's legitimate needs. This would be a good time for DoD to meet jointly with industry and explore together proposals for new legislation or department rules. These groups would also provide a forum to discuss marketing incentives parallel to those for intellectual property.

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[69]There are significant exceptions to this within DoD. For example, the Strategic Defense Initiative Organization, Office of Technology Applications, has published an outstanding pamphlet entitled Technology Applications Report (August 1992). This seems to be just the sort of publication that Mr. Appler described, but currently limited to the research and development under SDIO's purview.

Size and Number of Defense Laboratories

Separate legislation covers the criteria on which laboratories may be closed or severely downsized. This is an additional constraint on DoD technology transfer policy which must be monitored and adjusted accordingly.

Training

Legislation, regulation and handbooks will not achieve the level of participation that will make DoD technology transfer a huge success. Training is the medium through which we can encourage most of the Defense research and development team, complete to the individual researchers. DoD should take the lead in establishing the minimum training requirements and in particular, decide on the extent to which specific marketing skills should be employed through hiring or training.

Relations with Industry

Critics of industrial policy wonder why the government should be involved at all. But government is involved just because the laboratories, their facilities and staffs are already there and in place. The issue, at least for DoD and its laboratory managers, is to keep the problem in perspective. Schrage has posed the question about making Washington the "The Nations Innovation Capital (*sic*)."[70] Application of his concerns, if correct, means that DoD, and other government agencies, must walk a thin line to avoid stifling competition, innovation, competition and small businesses. It is for this very reason that authority for conducting technology transfer must be delegated to laboratories, the lowest management level in which business can be reasonably conducted and presumably the most efficient. Addressing all the problems above can only help to improve relations with industry. Visible Defense leadership, reaching out to industry, might also serve to lure from that sector to government service, the kinds of marketing leaders DoD needs to have.

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[70]Schrage, Michael. "Making Washington the Nation's Innovation Capital Would Be Risky". Washington Post. Jan 1, 1993. p. F8.

Agreement on Critical Technologies

Almost annually there is a call for some new definition and description of key technologies, critical technologies, strategic technologies, etc. These redefinitions invariably imply priorities for funding within the political realm. For example, in a recent article, Senator Mikulski (D-MD) calls for, "... the Critical Technologies Institute to put together navigational charts for the key pre-competitive technology areas that deserve the federal government's highest support. These priorities should be set on the basis of merit, and not regional or partisan politics."[71] This is another area in which continued Defense leadership is the really important issue.

"What Is Required Here Is DoD Leadership."

This thought from Gansler[72] seems on track. While the efforts of the services are adequately structured and most personnel assigned technology transfer duties are enthusiastically seeking opportunities, implementation is incomplete. There would seem to be room for a greater number of laboratories to find their own technology transfer niche. **This is the Department of Defense's challenge for the future.**

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[71]Mikulski, Senator Barbara. "Put New Thinking into Action". Washington Technology. Dec 17, 1992. p. 11.
[72]Gansler, Jacques S. "Restructuring the Defense Industrial Base". Issues in Science and Technology. Spring 1992. p. 56.

CLOSING THOUGHTS

My impression following this research is that to the extent Defense technology transfer is taking place, it is doing so on the enthusiasm and drive of a few key individuals. Political demand and legislation regarding technology transfer are proceeding much faster than DoD and the services can match. Leadership is shifting more and more to the Department of Commerce and other government entities. Perhaps this is appropriate.

DoD must drive fundamental organizational and philosophical changes, if Defense laboratories are to survive and to achieve large scale success in technology transfer. An alternative decision or maintaining the *status quo* may not only control future funding, but create a fundamental blockage in achieving greater commercialization in defense acquisition. Given the predicted trend for Defense budgets such a blockage could be potentially disastrous. I recommend that DoD drive the entire department into a higher gear concerning defense conversion and technology transfer in the laboratories, in particular.

SELECTED DEFINITIONS

The following definitions are taken from the current DoD regulation:[73]

Application Assessment. A summary emphasizing the potential application of each technological development from DoD R&D projects that has potential usefulness to state and local governments or private industry.

Cooperative Research and Development Agreement (CRDA).[74] Any agreement between one or more Federal laboratories and one or more non-Federal parties under which the Government, through its laboratories, provides personnel, services, facilities, equipment or other resources with or without reimbursement (but not funds to non-Federal parties) and the non-Federal parties provide funds, personnel, services, facilities, equipment, or other resources toward the conduct of specified research or development efforts that are consistent with the missions of the laboratory; except that such term does not include a procurement contract or cooperative agreement as those terms are used in 3 U.S.C. 6303-6305 (reference [c]) and as such the Federal Acquisition Regulation (FAR) and the DoD FAR Supplement are not applicable to these agreements.

Federal Laboratory. Any federally funded R&D facility that is owned, leased, or otherwise used by a Federal Agency and funded by the Federal Government, whether operated by the Government or by a contractor. A substantial purpose of such a facility or activity is the performance of research, development, or engineering by employees of the Federal Government or a contracted facility having such a prescribed Government purpose.

Federal Laboratory Consortium (FLC) For Technology Transfer. An organization of Federal Research And Development Laboratories and Centers chartered by P.L. 96-480 as amended by P.L. 99-502 to identify and mobilize the necessary resources to provide the environment, the organization, and the

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[73]Appler, D. "Domestic Technology Transfer Program Regulation DOD 3200.12-R-4". Department of Defense Regulation reissued under authority of DoD Directive 3200.12 dtd 27 Dec 1988. p. iv.

[74]Also referred to as CRADA in other references.

necessary technology mechanisms required to facilitate the fullest possible use of federally sponsored R&D results by both public and private sector potential users.

Office of Research and Technology Applications (ORTA). A function established in each DoD R&D activity to coordinate the Domestic Technology Transfer Program and to perform the actions specified in public law and other responsibilities as outlined in the regulation.

SELECTED BIBLIOGRAPHY

Appler, D. "Domestic Technology Transfer Program Regulation DoD 3200.12-R-4". Department of Defense Regulation reissued under authority of DoD Directive 3200.12 dtd 27 Dec 1988.

Bar-Zakay, Samuel N. "Policymaking and Technology Transfer: The Need for national Thinking Laboratories". Dec 1970. DTIC AD731268.

Barrett, Randy. "CRADA Success Bogs Down DoE". Washington Technology. Dec 17, 1992.

Barrett, Randy. "DoE Labs Begin Pushing Environmental Tech". Washington Technology. Nov 19, 1992.

Barrett, Randy. "NASA Admits Exaggerating Tech Transfer". Washington Technology. Jan 14, 1993.

Beedham, Brian. "Defense in the 21st Century – Meet Your Unbrave New World". Economist. Sep 5, 1992.

Berteau, David J. et al. "Adjusting to the Drawdown." Report of the Defense Conversion Commission. Dec 31, 1992.

Bingaman, Senator Jeff. "Maybe the Weapons Labs are Just the Right Size". Business Week. Oct 15, 1990.

Blair, Douglas E. "Technology Transfer: An Overview". Air Force Human Resources Laboratory, Office of Research and Technology Applications, Brooks Air Force Base, TX 78235-5601. undtd.

Brooks, Harvey and Branscomb, Lewis. "Rethinking the Military's Role in the Economy". Technology Review. Aug/Sep 1989.

Carey, John. "Can U. S. Defense Labs Beat Missile into Microchips?". Business Week. Sep 17, 1990.

Clinton, President William J. and Gore, Vice President Albert. "Technology for America's Economic Growth, A New Direction to Build Economic Strength". Feb 22, 1993.

Clinton, President William J. "Technology: The Engine of Economic Growth". Final Version. National Campaign Headquarters Clinton-Gore. Final Version Sep 21, 1993.

Coia, David A. "Research goals are changing". Washington Times. Dec 22, 1992. p. 6.

Cole, Bernard. "DOE labs: models for tech transfer." IEEE Spectrum. Dec 1992.

Cook, William J. "Sparking the Future". U. S. News & World Report. Nov 16, 1992.

Coursey, David and Bozeman, Barry. "Technology Transfer in U. S. Government and University Laboratories: Advantages and Disadvantages for Participating Laboratories". IEEE Transactions on Engineering Management. Vol. 39, No. 4. Nov 1992.

Defense Science and Technology Strategy. Director of Defense Research and Engineering. Jul 1992.

Department of Defense Appropriations Act, 1993. Public Law 102-396 – Oct 6, 1992.

DoD Key Technologies Plan. Director of Defense Research and Engineering. Jul 1992.

"Domestic Technology Transfer". Secretary of the Navy Instruction (SECNAVINST 5700.16). Oct 27, 1989.

Fisher, George M. C., et al. "Industry as a Customer of the Federal Laboratories". Undated report of the Council on Competitiveness. 900 17th Street, NW, Suite 1050, Washington, DC.

Federal Laboratory Consortium Handbook Series. Federal Laboratory Consortium for Technology Transfer. Nov 1992.

Gansler, Jacques S. "Restructuring the Defense Industrial Base". Issues in Science and Technology. Spring 1992.

Gilmartin, Patricia A. "House Lawmaker Pushes U. S. Arms Labs Overhaul". Aviation Week & Space Technology. Feb 17, 1992.

Hecker, S. S.; Narath, A.; and Nuckolls, J. H. Letter to the Honorable Bill Clinton. Nov 25, 1992.

Hittle, Captain Audie E. USAF. "Technology Transfer through Cooperative Research and Development". Massachusetts Institute of Technology Thesis. Jun 1991. DTIC AD-A239 330.

Inman, Bill. "Peace Work". Business. Jun 1991.

Jaggar, Sarah F. "Small Business Involvement in Federal Research and Development". GAO Report Feb 2, 1988. DTIC AD-A190 755.

Kodama, Fumio. "Technology Fusion and the New R&D". Harvard Business Review. Jul-Aug 1992.

Krueger, Jonathan. "Referral Directory System Specification". Defense Technical Information Center, Cameron Station, Alexandria, VA 23304-6145. Mar 30, 1990. DTIC AD-A219 900.

Leopold, George. "Industry Awaits Clinton's Action on Dual-Use Technology". Defense News. Nov 30, 1992.

Leuthold, Captain Mark A. USAF. "An Investigation of Factors Affecting Domestic Technology Transfer at the Wright Aeronautical Laboratories". Air Force Institute of Technology Thesis AFIT/GSM/LSM/88S-16. Wright-Patterson Air Force Base, OH. Sep, 1988. DTIC AD-A201 581.

Lubell, Michael S. "Getting the Right Mix on R. & D." New York Times. Dec 28, 1992. p. III-11.

Mather, Dr. Gary. "Peacetime Conversion". Washington Technology. Jan 14, 1993. p. 17.

McCloskey, Peter F. Statement of President Electronic Industries Association before the Committee on Armed Services United States Senate. Feb 26, 1992.

Meckstroth, Daniel J. Improving U. S. Competitiveness Through Technology Transfer From Defense Research and Development. Washington: Manufacturers' Alliance for Productivity and Innovation (MAPI), April, 1991.

Merz, Dr. James L. "The Optoelectronics Joint Research Laboratory: Light Shed on Cooperative Research in Japan". University of California, Santa Barbara, CA 93106. undated. DTIC AD-A170 700.

Mikulski, Senator Barbara. "Put New Thinking into Action". Washington Technology. Dec 17, 1992.

"Military-Civilian Technology Transfer." Army Regulation 70-57. Headquarters, Department of the Army. Washington, DC. Jul 25, 1991.

"National Technology Initiative Summary Proceedings". Oct 1992.

November, R. "Cooperative Research and Development Agreement (CRDA) Handbook". Naval Ocean Systems Center, San Diego CA 92152-5000. Technical Document 2074. Mar 1991. DTIC AD-A237 474.

Perry, Nancy J. "More Spinoffs from Defense". Fortune – The New American Century. 1991.

Reilly, Lucy. "Another $1B to Labs, Says Panel". Washington Technology. Vol. 7 #13. October 8, 1992.

Reilly, Lucy. "Navy Plans to Reorganize, Consolidate Research Labs". Washington Technology. Dec 17, 1992.

Rein, Dr. Richard H. "Developing Marketing Strategies and Finding the Right Partners". Presentation at Federal Laboratory Consortium Fall Meeting Atlantic City, NJ. Nov 6, 1991.

"Report of the Task Force for Improved Coordination of the DoD Science and Technology Program". Institute for Defense Analyses (IDA) Report R-345. Alexandria, VA. ed. Riddell, Frederick R. et al. Aug 1988. DTIC AD-A208 638 and 639.

"Research Funding as an Investment: Can We Measure the Returns? – A Technical Memorandum". U. S. Congress, Office of Technology Assessment, OTA-TM-SET-36. Washington, DC. Apr 1986.

Schrage, Michael. "Making Washington the Nation's Innovation Capital Would Be Risky". Washington Post. Jan 1, 1993.

Scott, William B. "U. S. Labs Increase Focus on Technology Transfers". Aviation Week & Space Technology. Feb 17, 1992.

Shaker, Steven and Mallin, Maurice. "Defense Faces Conversion Challenge". Defense News. Nov 9, 1992.

Slutsker, Gary ed. "Swords into Plowshares". Forbes. Jul 23, 1990.

Solomon, Jolie. "The Plowshare Problem". Newsweek. Dec 7, 1992.

Stockdale, Grant. "As Seen from Dow Corning: The Challenges of Federal Technology Transfer". Cooperative Technology R&D Report of the Business of Technology Commercialization at Federal Laboratories and Universities. Aug 1991. Vol. 1 # 1.

Whiting, G. A. "Navy Domestic Technology Transfer Program". Chief of Naval Research Instruction 5700.1 (OCNRINST 5700.1). Jul 24, 1991.

Yates, Ronal E. "Refitting Cold War Science". Chicago Tribune. Oct 27, 1992.