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HOW ONE FEDERAL RESEARCH LABORATORY VIEWS TECHNOLOGY TRANSFER

ROY WILLIAM HALE

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Although literature in the technology management field has abounded with insights into technology transfer (T2) as viewed from industrial and academic research, relatively little is known about management attitudes on the federal side of the interface. Some writers have tried to characterize what aspects of federal technology transfer are important in order to maximize the efficacy of the T2 process. From such writings, federal participants have wrestled with applying these sometimes conflicting recommendations effectively. Resultant models have confounded efforts to produce meaningful contributions to federal technology managers' education and skills. Such an unresolved picture prompted this paper's research as an attempt to help clarify the interface between non-federal technology recipients and federal lab donors, via inquiry into the latter's technology managers' attitudes toward T2.

Analogous federal dispositions to a recent Industrial Research Institute attitudinal survey of industry executives toward T2 were sought from federal executive counterparts at one federal research laboratory. The two surveys' paired rankings were compared and found slightly dissimilar, revealing one corroborated mismatch between federal and private ideas of T2 barriers. Analyses herein from these data suggest that alternative approaches for maximizing the probability of T2 from federal R&D should be modeled and tried.

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How One Federal Research Laboratory Views Technology Transfer

by

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Presented at Lehigh University's College of Business and Economics on 13 December, 1994, in partial fulfillment of the requirements for the degree of Master of Science in Management of Technology from National Technology University

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ABSTRACT

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ROY Wm. HALE

Although literature in the technology management field has abounded with insights into technology transfer from industrial and academic viewpoints, relatively little is known about management attitudes on the federal side of the interface. Levied by recent successive public laws, technology transfer from federal labs to the public and private sectors is considered a prime ingredient of national policy for public economic lifeblood, job creation, international competitiveness, defense industry health, and a host of concomitant indicia. With such spotlighted viewpoints, writers have tried to determine what aspects of federal technology transfer are important to maximize the efficacy of the process. Federal participants have wrestled, with varying successes, to apply these sometimes conflicting recommendations effectively. Resultant efforts have produced mixed transference models and have confounded the efforts to produce meaningful contributions to technology managers' education and skills. Such an unresolved picture has prompted this research as an attempt to clarify the interface between technology recipients and federal labs via inquiry into the latter's technology manager's attitudes.

Analogous federal dispositions to a recent Industrial Research Institute attitudinal survey of industry executives were sought from counterpart federal executives at one Department of Defense research laboratory. Counterpoint hypotheses and unifying background literature research, thus, provided the framework for a supplementary survey. From these data analyses, theses were derived for the larger technology management community. And, although not revealed herein, some recommendations have been tendered to federal lab management to improve the technology transfer processes over which they have influence.

Graphs and figures subsume that the federal lab's transferrence tools do not comprise barriers to technology transfer on the federal side of the interface with recipients. However, just as the IRI survey revealed a preferred order of technology sources desired by industry, so did a preferred order of receivers surface at the laboratory. These surveys' paired rankings are slightly dissimilar, so herein lies one corroborated mismatch. Incentivizing federal laboratory executives to encourage technology transfer appeared to countervail prevailing myths popularized by extant literature. Finally, perceptions of a public/private R&D funding barrier, thought to exist in the majority of the American populace, proved to be mostly absent in these federal technology transfer leaders. Such boldness may prod reconsideration of existing R&D management theory and future technology transfer applications.

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I take this opportunity to express my sincere gratitude for the encouragement and support provided by individuals and organizations who made this research possible.

To individuals in the Air Force must go a sincerely respectful "thank you". Dr. G. Keith Richey provided the steadfast advocacy and leadership to initially encourage me to pursue this educational opportunity. He, as well, unflaggingly exampled the scholarly dedication to complete the course. Colonel David Herrelko instilled the vision for reaching beyond minimum coursework knowledge to understandings as yet unexplored. Other management, who supported the time and commitments necessary to accomplish this degree work, will always be warmly respected for making that investment in me. Moreover, colleagues, who lightened my load in myriad ways, will also always remain inadequately acknowledged for their both enabling and simultaneously enduring my participation in this rigorous curriculum.

To the federal lab participants surveyed goes a hearty "thank you" for expending the time and energy to thoughtfully complete the data which made this paper possible. Unsolicited comments and observations, furthermore, made this educational effort rich for future inquiry into the federal technology transfer process.

To the faculty and administration of the National Technological University's Management of Technology curriculum goes a meek "thank you" for furnishing rich academic environs for individual discovery. Those, who reached out to become friends, as well as guides, reap esspecial appreciation. Dr. Alden Bean of Lehigh, in addition, deserves a separate accolade for creating the fertile configuration of courses and professors for growing tomorrow's technology managers. Without his designs, visiting professorial connections, and personal touches, this curriculum would be merely elegant and not the splendid experience it now is. A "well done", to achieve these successes, also must go to his dedicated alter egos of Diane Bean and her associates.

To my advisor and confidante, Dr. Madison Daily of the University of Missouri - Rolla, must go a special "thanks" with a salute. His exceptional humor, wisdom, and guidance likened this field research to an expansive stroll with a friend. My fellow classmates fall closely into this category of development by their heartening expressions of "peerless" standards and levity.

To my wife, Sharon, goes my ultimate "thank you". Her unflagging attendance to my personal and professional needs went not unnoticed. And her quiet toleration and coping with accumulating pressures, both within and without the home, deserve my deepest love and admiration. Without her, this journey toward mastery of tools for managment of technology would have been futile and hollow.

BIOGRAPHY

ROY Wm. HALE

"Bill" Hale was born and raised on the Osage Reservation, called Osage County, in northern central Oklahoma. After high school, he matriculated at Oklahoma Baptist University, Shawnee, Oklahoma, where he graduated Cum Laude with a Bachelor of Science degree in Physics. After a brief tour with the U.S. Navy in Pensacola, Florida, he returned to Oklahoma and Tinker Air Force Base where he worked as an electronics engineer for repair of specialized electronics components requiring Clean Room facilities. After earning a certificate in National Security Management from the Industrial College of the Armed Forces, he was selected for the Advanced Programs for mid-level and executive managers at Tinker. He earned a Master of Arts in Public Administration and moved to successively more responsible jobs. As an aircraft Modification/Repair Systems' Analyst, he had opportunity to become critically aware of management techniques and responsibilities necessary for Management Information Systems in today's industrial environment. He became Lead Electronics Engineer over a group of 10 civilian and 5 military engineers for birthing the E-3A Airborne Warning and Control Systems' mission avionics into the Air Force Logistics Command. From additional similar duties for the B-1 and Air Launched Cruise Missiles' acquisitions, he was requested by the B-52 System Program Manager to serve as manager of the entire B-52 Software Subsystems. After cooperatively creating and publishing Tinker's first weapon system Computer Resources Integrated Support Plan, which defined the resources and procedures of three Air Force commands' sharing correction of interlocking software deficiencies and modifications, he volunteered to serve as the Foreign Military Sales' Senior Electronics Engineer to the Headquarters, NATO Airborne Early Warning Force, at Mons, Belgium. As principal advisor to the Commander for depot activations in Italy, Germany, and the Netherlands for NE-3 electronics' repair facilities, he gained valuable experience and international friends in dealing with European governments and industry leaders, such as Aeritalia and Dornier. Concurrently, he achieved close relationships with the Supreme Headquarters Allied Powers Europe research facility at Den Haag, Netherlands, for targeted logistics-related research for the NE-3A. At the conclusion of his five-year tour, not surprisingly, he requested assignment to Wright Laboratory, an Air Force research facility, in Dayton, Ohio. As a Plans' Division electronics engineer, he participates in widely varied resource planning for cooperative research strategies and initiatives with national, state, and local technology transfer agencies, as well as private industries of all sizes.

He has been married to the former Sharon G. Andersen for 26 happy years of enjoying helping raise two daughters while mixing in golf, music, woodworking, quail hunting and community activities. Bill has a commitment and desire for Wright Laboratory to produce the highest quality research, readily transferable to both public and private enterprises, for innovation of technology which makes the defense industrial base strong for the United States. This paper's research was geared to that precise purpose.

1. INTRODUCTION

1.1 Objective

Why is there a dismal record of transferring research findings from the the national labs? This troubling question has occupied industry, academe, and politicos who have subscribed to the intent of national domestic technology transfer legislation of 1980, 1986, 1989, and 1990. The importance and goals of such transference have been made very clear, and barriers, problems and issues have been illuminated. Throughout the process of inquiry into these hindrances, however, the emphasis and focus has predominantly been on finding out what is desired and needed by industry and academe. Background literature searches appear to indicate that little has been exposed and written concerning the conceptions of the transfer process on the federal side of the interface. As an example of the former, recent research by David Roessner of Georgia Tech and Alden Bean of Lehigh has provided a useful roadmap of private industry's desired sources of technology for commercialization.[1] In follow-on discussions and surveys for research topics with senior federal laboratory management, a need for this sort of information was likewise voiced. Therefore, one objective to gain from this study is an understanding of the analogous federal attitudes and desires equivalent to those that Roessner and Bean found in their study.

During the course of this paper's literature search, analysis found that the "tools" of federal Research and Development (R&D) had also not been covered as a subject of laboratory management attitudes. Such tools included, but were not limited to: the R&D project selection process itself; the Management Information Systems (MISs) by which the laboratory kept track of the individual projects; and the physical appearance and order of the R&D project documentation

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[1]Roessner, J. David. "What Companies Want From the Federal Labs". Issues in Science and Technology. Fall (1993): 37-42.

when accessed by entities seeking lab technology. Were any or all of these tools part of the barrier to successful technology transfer? Federal laboratory management has always followed the legislated and regulated research project procedures, using the prescribed tools as axiomatic to internal lab functioning. However, the question of whether industry and academe would influence or even use these tools, if given access to them, has apparently not been evaluated.

One of the criticisms of the federal Civil Service, in general, and R&D lab management in particular, is the notion that public servants are disincentivized to do their jobs without enduring forces similar to the competitive pressures of private industry. The media and commentators espouse several variations on this theme, because it is popular and inspires controversy wherever used. But the message remains the same. Are federal managers, indeed, not stimulated in the area of technology transfer? Are they sensitized to the curious combination of factors which impinge on successful Cooperative Research and Development Agreements (CRADAs/CRDAs), which comprise one of the government's primary avenues to transfer technology from the various labs? Are these managers aware of the policies and regulations which define business for the federal bureaucracy in this critical area? The need, expressed by advisors, seemed to be that these and other similar questions need to be researched for laboratory management implications.

And, from National Technology University's (NTU's) seventh residency seminar for the Management of Technology (MoT) degree, there arose a third looming issue for future technology transference import. Given the U.S.' history of keeping private and public funding clearly separated, is it even remotely possible for federal labs to approach the Japanese and European models of public/private cooperative funding to create competitive and marketable

industrial products?[2] The NTU Study Mission to Japan, on which MOT students participated, revealed the extraordinary leveraging of such funding arrangements toward effecting international competitive advantage. Therefore, the seminal idea for testing this scheme on U.S. federal lab management was born out of a concern for the federal lab's future as a potentially hobbled change agent moving rapidly toward the twenty-first century.

These three subquestions under the umbrella topic of finding out the attitudes existent on the federal side of the technology transference interface formed the framework for creation of the survey instrument described in 1.2 below. The interlocking nature of these questions seemed to provide a natural bridge between visible practical tools, hidden human attitudes, and germinating social science implications of this research without broadening the objective of the effort.

1.2 Organization, Methodology and Overview

This Field Research Project (FRP) was planned for three distinct phases: literature search and canvassing for suggested topics ; creation of a survey instrument; analysis and reporting of the results. The literature search built upon sources obtained from the NTU MoT curriculum and other repositories with the purpose to find past, present, and forward thinking on the state of technology transfer from the federal labs. The search's primary focus was initially limited to Department of Defense (DoD)-related literature. This restriction presented a myopic view of other U.S. governmental agencies' experiences, which seemed appropriate at the onset. But upon reflection, commonalities were found to exist, so those non-DoD sources were also documented for this paper, as appropriate.

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[2]Complex technology and community; implications for policy and social science. Rycroft, Robert W. and Don E. Kash ms. 0048-7333/94. Elsevier Science Publishers.

The creation of the survey instrument was accomplished in three steps: following the Instrument Development Process of Emory and Cooper[3] of (a) creating and refining the initial questions; (b) performing a field test (pilot survey) among (1) selected non-participating military managers and civilian academicians at one federal lab, (2) this student's research paper advisor, and (3) a retired research professor with a Ph.D. in statistics - and a last step, (c) refining all of these inputs into the 9 question product contained in Appendix A. This humbling experience was accomplished through latter August and early September, 1994, with the final survey being distributed 11 October and requested for return by 25 October. Four hundred thirty two questionnaire forms were distributed with 288 returned by the due date, a 67% participation rate. The high participation rate can be attributed to sending out the form under the lab's highest-ranking scientist's signature; no doubt, his prestige and endorsement for action motivated the large number of recipients to willingly comply. To a lesser extent, the abbreviated format of the survey was informally cited as a welcome relief from the exhaustive survey instruments also circulating in this period. The number of questions was deliberately set at less than 10 in order to gain assent, on the surveyed person's part, to first, examine the survey, and second, to "buy into" the content of the questions. One criticism, heard often of then-prevailing lengthy survey questionnaires, was that their length posed an "insult" to these scientist's and engineer's high intelligence levels; so, one lesson learned is that further surveys arising from this effort are well advised to keep questions short to this population. Other federal labs' executives may exhibit these same proclivities. Notwithstanding its shortness, the survey was deemed to have worth as a statistical

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[3]Emory, William C. and Donald R. Cooper. Business Research Methods. Homewood, IL: Irwin, 1991.

instrument.

The returned data was input manually and analysis accomplished automatically, using SPSS® version 6.0 for Windows[4] and various textbooks for additional insight into statistics theory and applications. A prime consideration in creating the questionnaire was the ease and error elimination from manually inputting and massaging the data. This consideration was exercised using several trial formats for inputting data into files before the final form was adopted. One will notice that the Likert Five Step scale was used where degrees of fine differentiation between responses were deemed important. One question had only three degrees of differentiation, not counting the fourth value of "unknown" to account for those managers with absolutely no acquaintance with technology transfer. Such roughness of differentiation was deemed the best possible, given the intuitive nature of the question. Categories were used to segregate the population for hypothesis testing by subcultures in the lab, as well as the aggregate total; however, this paper will cover only the aggregate response.

One observation should be made to clarify biases built into this effort. The student had minimal experience to create the format and content of the survey questions. Nevertheless, even with using great caution and seeking expert advice and council, an amazing number of respondents chose to answer the questions in unanticipated ways. The pre-testing did not reveal this phenomena. For example, question 3 was a listing question, seeking ordinal responses from 1 to 9, using each ordinal only once. Some responses had unfilled blanks with responses from 1 to something less than 9. These responses were coded, as received, into the data files. SPSS™

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[4]Norusis M.J. Base System User's Guide to SPSS for Windows, Release 6.0. Chicago: SPSS, Inc.

treats such absent data as "missing". Where responses contained "x", multiple x's, or multiple ordinals (e.g. 1,2,1,1,5,2...) these survey questions or personal data responses were not entered, thus increasing the amount of absent data for the population rather than eliminating the entire 9-question survey response from a valid respondent. Any biases from this technique are solely induced by this author. Otherwise, the questions lent themselves handily to dichotomous treatment, even using variable sets for the multi-response questions. Respondents generally circled one each of the Likert scaled responses; however, a notable distrust was evidenced in some respondents who refused to circle any response, as well as to omit one or some of the appropriate aggregating data blanks. These type responses and those with more than one of the multi-choice responses circled are evidenced in the statistics as missing data also. Additionally, a small minority of respondents chose to answer all the multiple choice questions by circling most or all of the available central responses. One may surmise that these responses represent negative or unknowledgeable S&E's; in either case, the number graphed significantly in a couple of instances. Therefore, any bias which might arise from treating this group so is deemed inconsequential to the larger population's tendencies. Thus, even with these randomly missing data, the number of overestimators and the number of underestimators in the survey are considered balanced. Generally speaking then, the common approach utilized was to perform stem-and-leaf diagrams for each data set under consideration, then determine the most appropriate statistical technique for that data. Where the population congregated in the above central response categories, additional statistical techniques and aggregating schemes were employed to make sense of the unclear attitudes.

With a self-imposed limit of less than 10 questions to be served to these executives, no

effort was made to try to use a funnel approach to increase specificity. Questions were deliberately close-ended; although, a number of respondents felt compelled to supply comments, from which this author has gratefully gained further insight. Every question achieved no less than 7 revisions to the final wording, and still there were some obvious misreadings, judging from the comments received. To illustrate this point, consider the terms technology transfer and technology transition. The former is defined as an action between governmental and usually private sector interests. The latter is defined as an action between laboratories and federal acquisition agents, such as buyers of airplanes, aircraft carriers, tanks, and even radios, clothing, etc. How does one phrase a question to cover the entire broad spectrum of technology transfer and technology transition? This dilemma was assuaged by staying at the topmost level of questioning, so as to give the most general impression without dwelling on narrow definitions, which would require many more questions to resolve. Question 3 was the hardest to handle, because it contained both transfer and transition targets, and was the most altered in design so as to make a valid comparison to Roessner's and Bean's work. Additional question wording deficiencies in the multiple choice questions were minimized through the use of the test survey. One assumption made at the start of this paper's survey creation was that there existed a common vocabulary in the lab. The pilot test survey proved this assumption relatively false, so a tactic of minimizing the words in the question was employed with far greater success in the larger group. The balance between brusqueness and clarity proved very difficult to find. One will note that wording of responses varied among questions 1 through 4, with that quartet being different from questions 5 through 7, and the couplet 8 and 9. This tactic had two purposes: (a) to pique the respondent's interest by making him "look" for non-repetitive responses; and (b) to provide a

selection that approximated the most common responses which one could imagine to the question asked. Questions 5 through 7 were made "standardized", because all had to do with "tools". Questions 8 and 9 were emphatically required to be as identical as possible, because of the public/private funding question's import for the future. Perhaps one could criticize the number and degree of alternatives to each question, but for this initial survey of laboratory executives, the results were very heartening as to the perception of "common" understanding. Of course, it was never anticipated that one executive would choose to checkmark (✓) the blank for "Grade", rather than supply the common government parlance of GS-14, GM-15, etc. As one wag wrote, "There is no perfect survey"!

From the foregoing laborious description of the survey organization and methodology, one is tempted to skip an overview. But before passing this subject, one should note three items. First, military personnel were excluded from this survey. One could criticize the resultant population surveyed as skewed to an unrealistic appraisal of lab management, especially since the commanders of the different divisions of the labs are usually field grade rank. In this author's 26 years of DoD experience, the longevity of civilian executives has been observed as the primary influence over the attitudes and character of any organization, more so than the two or three year longevity of assigned equivalent rank military. Second,the choice between doing a systematic, stratified, or cluster sampling of civilians, versus doing a disproportionate sampling was decided in favor of doing the disproportionate sampling for three reasons: (a) the time to complete this paper during critical laboratory downsizing and the migration of mature leadership from the lab prompted a choice for speed; (b) the effort and time to stratify, identify, and weight the myriad of groups or clusters then obtain agreement from a participant (or upon rejection find another

candidate) simply was untenable for this large population; and (c) the statistical treatment required to do justice to academic integrity was deemed not warranted nor justified, given the coarse nature of what was sought.

Third, no ethnic or cultural personal data was sought to ensure minority or other differentiated populations were adequately represented in the final survey. Again, the reasons given above precluded the time and effort required to do so. Thus, this survey has no guarantee that important subgroups are represented. As Gene Slowinsky has observed, diversity is a strength in the performance of R&D.[5] This paper, in no wise, attempts to address such an important parameter's influence on the success or failure of technology transfer. On the other hand, there may not be any significant differences in minorities' responses as compared to the whole population. Since the entire survey is anonymous, the minority groups may be very well represented.

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[5]Slowinski, Gene, George F. Farris and David Jones. "Strategic Partnering: A Process not an Event". Paper. 1992. Center for Innovation Management Studies. Lehigh University.

2. CONTEXT OF THE PROBLEM

2.1 The Times

After the Desert Storm campaign and the reunification of the former German Democratic Republic with the Federal Republic of Germany into one united Germany, the draw-down of the U.S. Department of Defense (DoD) became an obtainable goal similar to the aftermath of previous World Wars. Politically speaking, it became very correct to want a "Peace Dividend" to be distributed to the populace of the country in the form of less expenditures on defense and more expenditures on domestic concerns. The infrastructure of the country was singled out for rebuilding, as well as a commitment to national competitive advantage in foreign markets, since the demise of the former Union of Soviet Socialist Republics (USSR) appeared to signal a change from previous Soviet rule. Popular perception of the release from the former threat, which had occupied the USSR and the US in the "Cold War", justified a partial dismantling of the standing armed forces which had been created after World War II to counter Communist Imperialism across the globe.

The DoD Laboratory infrastructure, which had helped create technology supremacy for the US in many areas of warfare was not spared this downsizing. The Federal Civilian Restructuring Act of 1994 set limits for the entire DoD such that all installations had to share the burden of coping with changed missions while simultaneously losing many senior personnel to voluntary retirements and a significant portion of the younger replacements, who should have shouldered the remaining responsibilities, to involuntary reductions. Another critical factor to the downsizing equation was the creation of the Base Realignment and Closure (BRAC) commissions. These groups were formed to create a list of installations which, by some process

of economics and divvying of purposes to avoid duplicative work across the military services, were voted on as a whole by congress for closure without benefit of list modification. Ostensibly, this process would take the usual "politics" out of base closures, which were causing such a furor from senators and representatives over the loss of jobs in that targeted base's district. Therefore, any federal laboratory could also be a target for closing, whether on a remaining active base or not. Curiously, Rome Laboratory at Griffiss Air Force Base in Rome, New York, has survived as a research entity, even though all other base tenants there did not, including active B-52 operational and support functions.

Additionally, a draw-down of DoD in-house research has been mandated by authorities. What was once a source of hands-on technological inquiry and pride has become a mandated taboo. Some of the best research facilities anywhere are now prioritized for cooperative, academic, or like activities with the private sector. The resultant low morale of both younger and more senior researchers from this loss of opportunity to pursue their interests in a very real manner has not been quantified nor has the loss of the necessary facilities to keep up researchers' skills.

2.2 Report Card

In this same era of approximately 10 years, congress became enamored with the idea of creating a technology "pump" via the Defense Advanced Research Projects Agency (DARPA) to distribute appropriated funds, through competitions, to militarily critical industries which would learn to compete in non-military markets - and to create such industries where absent. DARPA changed its name at the behest of congress to ARPA to better communicate the broadening nature of this new dual-use mission for the national industrial base. However, ARPA still had to use the

military research laboratory personnel to administrate and technically oversee the winning contractors, because ARPA did not have the personnel resources to cope with the ballooning of congressional funding and myriad programs for multi-application technologies.

Part of the emerging picture, then, has been a new appreciation of the capability of the federal lab to accomplish national aims primarily for private industry's benefit. As a result, the amount of dollars supervised by a federal lab for ARPA has become a relative indicator of the lab's importance to these national programs. Moreover, from a slightly different approach, congress undertook to expand the lab's importance to the national economy by levying technology transfer requirements on the lab similar to ARPA's "pump priming". However, in this new scenario, appreciation of the federal lab by congress has been directly proportional to the number of CRADAs consummated with private industry, state agencies, or universities. The dazzling success of ARPA's experience has been tempered somewhat by the slower acceptance by industry, academe, and state/local agencies to utilize the treasure trove of technology residing in these labs. Naturally, academic inquiries into the cause(s) of this disparity in success on one hand and a lack of the same level of success on the other hand have resulted in many models and reasons being touted to correct the imbalance. To their credit, some federal labs - both DoD and others - have tried initiatives and have written of their resulting experiences in limited circulation journals (or have shared experiences at federal meetings or symposia on the subject) in an attempt to increase these newly forged linkages to the non-federal sectors of the economy.

Somewhat more recently, the Laboratory Commander in the DoD installations, has been tasked to preside over the CRADA process as a principal signatory to the agreement. The number of CRADAs, then, has also became a type of report card to the military career of these

officers. Transmission of the importance of CRADAs has diffused to the lowest echelons of scientists and engineers to emphasize the military and national needs served by these instruments. As a result, in one federal lab, growth of the number of CRADAs in 1993 reached an astounding rate of 1667% over 1992 figures. Growth in 1994 has reached the approximate gross number of 1993 CRADAs, but it is too soon to acknowledge this circumstance as a subsidence of interest by private industry or waning of effort by a lab's researchers. More than likely, the easiest technology to transfer to private industry, i.e., technology most amenable to marketing, may have been identified and transferred. It is too early to make this heroic assumption, however. In this era of downsizing the federal labs, a leveling off of CRADA activity may be taking place, or the number of researchers may be lessening. In any case, the number of inquiries from industry is increasing in every lab. Thus, the report card aspect of the current federal lab picture is muddled, if one uses the metric, number of CRADAs.

2.3 Why?

Roessner's work has supplied several insights into the technology transfer process from the federal labs by citing them as both outsourcing, via contracts to technology-hungry private industry or academe that R&D which the labs need, and simultaneously providing a source of technology and/or expertise which private industry needs or desires to access.[6] Roessner writes that technology transfer is not enough and that interactions with the federal labs and access to their resources are most desired by industry. Twice surveying private industry executives in a space of approximately 5 years, Roessner with Alden Bean, noted that bureaucratic barriers, lack of marketing expertise by the federal labs, and lack of market pull were hindering the technology

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[6] Roessner, "What Companies Want", 37-42.

transfer process from the federal labs. To minimize these barriers, Roessner recommended that close federal personal interaction with private industry counterparts should be enabled via use of public funds to support travel by both federal and non-federal researchers to each other's facilities, sabbaticals, or temporary assignments. Additionally, private industry should participate in the R&D project selection process at the labs, thereby increasing the probability of idea transfer rather than technology transfer measured by the aforementioned CRADA count metric.

Another insightful work on the potential of CRADAs as a "dominant design" in U.S. Federal technology transfer activities is the excellent treatment by Audie Hittle.[7] His analysis showed that the level of awareness of technology transfer possibilities by both federal management and researchers was a clear barrier and that negotiating conditions of the CRADA was a "sticky" catalyst, if not manifestly critical, to creating an adversarial atmosphere. Hittle recommends a strong approach of training, marketing, and an aggressive campaign to delete regulatory barriers to the technology transfer process in order to resolve perceived problems at the federal labs. Interestingly, he admits that further research is needed to clarify the characteristics and ultimate dissolution of these barriers.

One attempt to focus on these problems in the federal labs was eloquently captured by Mr. Dan Goddard of NTU's MoT class four.[8] Dan revealed that the experimental approach to deal with management of technology problems in one federal lab proposed creation of an organization

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[7] Hittle, Audie Eugene. "Technology Transfer Through Cooperative Research and Development". Master's Thesis. Alfred P. Sloan School of Management and the School of Engineering, Massachusetts Institute of Technology, Boston, June 1991.

[8] Goddard, Daniel G. "Improving the Management of Technology at the Aeronautical Systems Center". Master's Field Research Project. Center for Innovation Management Studies, Lehigh University, Lehigh, August 1994.

to perform management research on techniques which would energize the federal lab environs and which would ultimately benefit far-flung Air Force organizations. By concentrating on the human elements involved in federal technology transfer, Dan's insights have contributed to understanding the complexity of establishing such a management research tool in the context of a first generation R&D enterprise.[9]

Yet another view of the technical transfer problem is in the context of process examination. Maj William K. West has attempted to expand on Hittle's initial work from the viewpoint of the federal lab's controls over the process.[10] This approach has the advantage of dispassionately reviewing the determinations made at each step of the technology transfer gauntlet and assessing how these determinations affect succeeding steps and the overall transfer outcome.

It seems clear then, that the context of the technology transfer phenomenon at the federal labs encompasses political, regulatory, experimental, and process reviews in order to find an integrated systems' approach to maximize the probability of technology transfer from the labs. The federal landscape is, in several ways perhaps, more complicated to analyze and model than panoramas modeled in the current literature. As noted previously, the postures of private industry and academe unto the present toward bridging the gulf to the federal labs are couched in singular profit-making viewpoints. This paper attempts to present another alternative for private industry and academe to consider. Learning the attitudes and feelings on the other side of the interface can succeed in bringing both parties to that point in negotiations where adversarial notions abate and

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[9] Roussel, Philip A., Kamal N. Saad and Tamara J. Erickson. Third Generation R&D: Managing the Link to Corporate Strategy. Boston: Little, 1991.

[10] West, William K. Unpublished thesis. Air Force Institute of Technology, 1994.

true bridging begins. By comparing works, such as Roessner's, to similar survey findings of federal counterparts, enlightened negotiations may proceed... at least for one lab. Avoidance of cross-purposes when attempting to extract technology from the federal lab system, or gain access to resources therein, seems to be a worthwhile endeavour. What is presented here may not be true for all DoD laboratories, for all DoE labs, or other federal labs, but, on the other hand, there may be no reason to think otherwise. At least one attempt will have been made to expand our understanding of the federal side of the transfer equation.

3. Overarching Problem Selection

What management question must be answered in order to understand the nuances outlined in section 2 above? The concern, succinctly put, is: Why hasn't one federal lab done better in filling a national need? The approach is basically a "troubleshooting" endeavour, to find out what is deficient in one lab's performance not meeting (admittedly open-ended) requirements. Can the problems' factors be ascertained by merely "baselining" management's and senior scientist's perceptions? How does identification of any salient factors inhibit or promote the lab's avowed purposes and strategies for existence?

These questions led to the single overarching question for this paper. ***How can a federal lab be made more responsive to private industry's need for technology transfer***? That question led to the breakdown of areas contributing to responsiveness: a well-defined and well-understood policy; motivation of the federal lab's researchers; buy-in by lab management to promote technology transfer; and finally, adequacy of the "tools" existent at the lab to accomplish the transfer. Some scholars may quibble about the selection of these elements, but the selection has proven to lend itself to the comparison process very readily. Therefore, the design of the survey

instrument and data handling considerations could proceed.

Admittedly, this paper can not answer the overarching question. This was not the design. The design was to get management's view on these vital factors of the transfer process. From management come the attitudes of the organization, the emphases of the organization, and the future thrusts of the organization (through promoting like-minded or unlike-minded executives). Are management's views the only views, or even the most important views? Only further research into the actual participants' views of the process can expose differences in philosophy and ethos for correction by either camp - perhaps even both at once. It is enough to ascertain one piece of the transfer puzzle at this juncture. How senior scientists and managers perceive the efficacy of these factors' in technology transfer is vital to understanding the overarching question.

4. Hypotheses

The hypotheses selected reflect the journey through the hierarchy of questions suggested by Emory and Cooper.[11] The list that follows attempts to explain the testable aspect of the hypotheses and their adequacies given the assumptions stated in the introduction to this paper.

Hypothesis 1: *Laboratory executives embrace technology transfer directives for federal labs.*

Although this hypothesis does not appear testable in the formal sense, a measurement of awareness of regulations, laws, legal interpretations, etc., is quite necessary to understanding the laboratory executive's self-perceptions for the baseline attempted herein. At the level of maturity of those surveyed, there was no missing data in the question asked; this indicates a relatively high proportion of those who most likely understood the the intent and meaning of what was asked in

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[11] Emory, Business Research Methods, 77-80.

question 1, contained in appendix A.

To continue, the adequacy of this approach is couched upon the correctness of subsuming the qualities of (a) definition and (b) understanding of the applicable directives under the term "awareness". In government parlance, this term in senior circles implies more than a passing recognition; it also implies having been briefed or having a working-level knowledge and probably more. Since one of the elements of the survey was asking whether the respondent had received any formal training in technology transfer and eliciting an overwhelmingly negative response, then it follows that no missing responses to the awareness question implies either a very large population of fraudulent answers (which is most unlikely in a group of such senior career executives), or these individuals have wrestled in some manner with the nuances of technology transfer promulgations. Decidedly, one can opt for the latter by perceiving a large amount of truthfulness contained in unsolicited comments, such as: "I don't believe xx understands the process" and "(with respect to what is needed)" appended to the question.

The purpose of the question was to assess the level of awareness of technology transfer regulations and other directives in this population of senior executives. The criteria of testability and adequacy appear to be adequately met by question 1: **How would you describe your awareness of policies, regulations, processes and directives governing technology transfer at xx?** Data from the survey is presented in the results, section 6 of this paper, and in Appendix A.

Hypothesis 2: *Federal labs' executives are disincentivized to accomplish technology transfer.*

Motivation is an abstract concept that, perhaps, may fail the adequacy and testability criteria for hypotheses; yet, seemingly some attempt should be made to ascertain just how important technology transfer is to these senior managers and researchers who have much

influence over their colleagues and younger emulators. The search for a surrogate measure finally yielded the concept of one's career as a measure of importance, and linking technology transfer to one's career appeared a reasonable compromise.

Federal policy and directives, especially the latest Air Force Instruction (AFI) 61-301, state clearly that technology transfer is co-equal with technology expertise in an individual researcher's performance ratings. Theoretically, a researcher and manager should be as concerned in one area as in the other, so using career as a surrogate for incentivizing appears plausible. No literature was found forbidding such substitution. Therefore, question 2 was stated as: **To what extent does technology transfer matter to your career?** Again, no missing data in the responses was interpreted as a willingness on the part of the respondents to buy-in to this surrogate substitution approach. One insightful comment was stated thus: "To the extent that there are no career 'wickets' that I know of. On the other hand, our job is to generate useful technology, and I think that there is a general awareness of the technology transfer track record of a person who comes up for promotion." Another was: "If you do it, then that becomes the norm. If you don't do it, then nobody else is doing it either." Yet again: "We are not profit motivated in the government". These responses indicate that the question hit a vulnerable issue, at least in a few of the respondents. On the down side of the responses was the terse "Dumb Question!". This area of executives' incentivization appears ripe for further research.

Hypothesis 3: *Federal executives prioritize tech transfer differently from industry executives.*

Question 3 is the only ranking question on the survey, in which the respondents were asked to provide the counterpoint to Roessner and Bean's findings. Roessner wrote that industry has 4 preferred sources for technology in this order from highest to lowest: other U.S. industry;

universities; foreign-based companies and private data-bases; federal laboratories and government data bases. What is the corresponding ranking by federal executives?

An attempt to corral the universe of technology recipient possibilities resulted in the following breakout, which was not sequenced on the survey as directly as here. Government entities included "**other U.S. federal agencies**", "**U.S. state agencies**" and "**DoD Acquisition Agents**". **Universities** were labeled as such. Industry included: "**U.S. defense industry**", and "**non-defense U.S. industry**". Foreign-based companies were lumped under: "**European entities (including NATO)**" and "**Asian Nations**". The category of "**Other (Israel et al)**" was forged to gather more foreign insights, and surprisingly, was interpreted in several non-foreign ways.

Although pilot surveys did not detect any bias built into these groupings and the group members were randomized in order, bias may have crept into the phrasing of certain descriptors, such as "entities" versus "nations". Hopefully, the randomizing of errors arising from this approach may offset any tendencies this wording bias may have induced. Stem and leaf diagrams, exampled in Appendix B, indicate that such offset may be evidenced by the nearly normal distributions plotted. However, the large amount of missing data, 26.4%, does not lend much confidence to the conclusions reached in that section's explanation of findings. Previously covered in this paper were the ingenious ways of performing the ranking (check marks, etc.), which regrettably resulted in discarding some data in the tabulation phase of this paper; thus some of the missing data is caused, perhaps, by a flawed design of this listing. Nevertheless, a counterpoint to Roessner's list was produced and is analyzed in section 6 of this paper.

Hypothesis 4: *Tools for technology transfer from this federal lab are considered adequate.*

This hypothesis encompasses questions 4, 5, 6, and 7. These questions individually address the mechanisms used in the technology transfer process at one federal lab. Question 4 covers the "speed" of support organizations in processing the CRDA, patent, or other form of transfer. Speed is a touchy issue in the federal labs due to the inordinate amount of criticisms of slowness generated both within and without the lab. To reiterate, question 4 is the only attempt to address the "human element" in the "tools" cubicle. The other 3 questions address inanimate mechanisms involved in the process; but, in order to preserve a semblance of balance to the subject of tools, a human dimension also needs to be evaluated. It was deemed impossible to evaluate idea interactions and researcher to researcher encounters as aids or hindrances to the technology transfer process; so again, a modified variable approach was taken.

Questions 5,6, and 7 are straightforward and similarly phrased to cope with minimizing bias injection into the survey. As mentioned previously, the response choices were articulated to seem as natural as possible and to not be expressed exactly alike. One could not very well use "ineffective" to describe a project selection process, because the process itself effectively screens out less desirable projects,regardless of whether technology transfer is considered or not. Therefore, the best approach here was deemed to be a naturally sounding response approach. Three percent missing cases comprised the maximum error in these questions due to missing data. Appendix C highlights the survey's responses to these questions.

Hypothesis 5: *The separation between using public funds for private research purposes and public research purposes is considered inviolate.*

This test area was driven by Professor Don Kash's writing on what U.S. public/private funding paradigms must be overcome in order to compete with countries who do not have our

tradition of marked separation of public and private funding.[12] Trying to phrase this question in a consistent manner provoked all sorts of outraged indignations from the pilot survey. The cause was finally traced to this author's not making the two scenarios presented to the respondents exactly parallel. Once the situations of paying to move personnel from labs to private industry and vice versa, moving equipment bi-directionally, and relocating personnel likewise were composed, then the credibility of the approach appeared assured. Basically, question 8 involves the normal state of affairs in a federal lab. Paying for federal researcher's visits to private industry, for example, is commonplace and necessary, being acceptable by a long history of regulations and precedents. Therefore, question 8 can be viewed, somewhat, as a control or calibrating question. One would expect to get practically 100% agreement from the lab's executives. Such did not prove out as expected.

Question 9 was the reverse of question 8. In question 9, the use of public funds was entirely oriented to support the private researcher (industry, academe, e.g.) in the very same manner as public funds supporting the federal researcher in question 8. The responses to this question provided the greatest surprise in this survey, with the responses to question 8 not far behind. Only 3 percent of the surveyed chose to not answer this question. One may not know the reasons, but the error from these omissions appears acceptably small.

The matter of bias being induced by wording questions 8 and 9 so similarly that the respondent "glossed over" the differences has been considered. However, the chosen approach seemed the best trade-off from 7 attempts to differentiate the two scenarios enough to be valid

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[12] Kash, Don E. Perpetual Innovation: The New World of Competition. New York: Basic Books, (year TBD).

and yet still be amenable to a calibration exercise, too. As previously noted, keeping the survey down to less than 10 questions proved very difficult, and perhaps this dyad was a casualty of the minimizing effort. However, comments, such as: "The MIT name for such persons is "Gatekeeper"; it is an informal process and success depends on this person." "Not enough people to do our own work, let alone someone else's" indicated more than indifference to the concepts contained in the scenario. Questions 8 and 9 also provoked the largest number of unsolicited reponses, but perhaps not the strongest responses. Why that is presents an intriguing set of questions which should perhaps be the subject of other research. But one cannot leave this subject without speculating... perhaps the depth of risk-taking or paradigm-breaking that the federal researchers might actually exhibit, if policy and regulations allowed, far exceeds the popularized arch-conservative role model. The boldness exhibited by the federal executives indicates that the theoretical model of public/private co-funding does not have as much resistance in the federal domain as might have been previously thought. From these data, one is tempted to suggest that the resistance to the "scrambling" of public and private funds, in order to promote technology transfer inside more relaxed research relationships, may exist only in the public at large...or maybe not at all. The finding is a curiosity and is graphed in Appendix D.

5. Literature Review

The potential contributions of the national federal labs to the U.S. economic commonweal have been depicted variously as...

> *If the industry can articulate specific areas of generic research that conform to the capabilities of the national laboratories, and the laboratories can adjust their operations and mobilize their resources to address those research areas, the potential contribution of the national laboratories for future industry competitiveness can be realized.* [cited from National Research Council, *The Semiconductor Industry and the National Laboratories, p.4*][13]

and in a slightly different vein...

> A long-standing mission at the national laboratories is to develop, build, and operate user facilities - sophisticated research machines that are too expensive to build on every campus or in every industrial park. Industry and universities use them at no cost if they publish their findings,or rent them for proprietary research. We need new ways of making user facilities accessible to smaller firms.[14]

That the national labs are a national asset provokes little dissent. That they are also contributing to the national well-being appears to foment controversy. From the foregoing, one can readily grasp the two competing views of the strengths of these R&D entities - in the first, accessing R&D capabilities of personnel; in the latter, utilizing the facilities and equipment by others outside of the federal sphere. The one commonality linking these two viewpoints is the emerging government emphasis on "technology push" to jump-start the American industrial engine.

> During the past decade, government officials have sought new goals for their research dollars. The most important emerging theme in their programs is

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[13] Howell, Thomas R., William A. Noelbert, Janet H. MacLaughlin, Alan Wm. Wolff. The Microelectronics Race The Impact of Government Policy on International Competition. Boulder: Westview Press, 1988.

[14] Schriesheim, Alan. "Toward a Golden Age for Technology Transfer". Issues in Science and Technology. Winter (1990-91): 52-58.

> international competitiveness; the federal government should support R&D to increase American industrial productivity, thereby helping industry in global economic competition.[15]

Although, the competitiveness theme is acknowledged to have changed federal R&D programs by (1) emphasizing that intellectual property rights resulting from contracted or cooperative research rightly belong to industry and less to government, and (2) increasing collaboration among American firms and research organizations, this theme cannot replace national security as a basis for a bi-partisan consensus on funding federal R&D to the levels of the past.[16] Therefore, at least two results are possible from the federal labs overtly aiding industry:

> In principle, government can solve the problem of underinvestment in R&D in two ways[:]...promote the ability of innovators to obtain higher profits, [traditionally via] patents, copyrights and legal protection of trade secrets; [and] ...for the government to pay for R&D through targeted programs. The first creates higher profits through the establishment of monopolies, which are inefficient; [plus] limit[ing] the diffusion of research results. The second [approach's weaknesses - that] the government is not likely to pick the best projects... [Moreover, expensive auditing and cost accounting] monitoring [of] public research projects to assure that private contractors are putting forth their best efforts, is notoriously difficult. ....When a project becomes successful, outside firms perceive it as unfair on the grounds that the government is interfering with the success or failure of companies in the industry. Technical and economic failure seldom lead to the timely demise of a major project; [rather] the cost sharing requirements...were abandoned when industry was unwilling to shoulder its share.[17]

However, with an eye to the future's scenario of relying on synthetic innovation, Don Kash writes:

> This capacity to innovate rests on: a capability to synthesize products and processes...[an idea] that only government/private-sector cooperation and support can lead to [national] competitiveness...[that] in the synthetic society, competition

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[15] Cohen, Linda R. and Roger G. Noll. "Privatizing Public Research." SCIENTIFIC AMERICAN Sep. 1994; 72-77.

[16] Cohen, 72-77.

[17] Cohen, 72-77.

> is structured by innovation-to-obsolescence cycles...[and that] success requires being continuously involved in an incremental experiential learning process. ....Synthetic innovation involves the development and use of products or processes to solve some problem, meet some need, or to create and/or supply some market. What is critical for scientific success or technical advance at the individual level is for the scientist, engineer, or technician to have state-of-the-art knowledge. ....[However], it is not seen as appropriate for government to support commercial product development directly. Government's role in the commercial sector is, with few exceptions, limited to funding and stimulating fundamental research. ...for political/ideological reasons government laboratories ... and government 'captive' nonprofits...play a very limited role in the commercial high-tech complex except where the commercial innovations are direct spinoffs of defense technology.[18]

So, against this muddled background, federal laboratory executives are expected to pick those R&D projects which facilitate the DoD component's traditional mission, a mission which is politically and generally unpopular...and is changing by congressional mandates very frequently. Moreover, these executives are expected to facilitate new mission[s] to private industry, without much knowledge or experience as to what industry wants, needs, or can use. In addition to the foregoing, these same executives are also expected to make their facilities and experts available to academe, small business, non-profit organizations, and state/local agencies in order to: (1) promote the general welfare; (2) increase the education opportunities and levels of experience for graduates/undergraduates/faculty and visiting academicians; and (3) practice good citizenship. Meanwhile, at the highest levels of government, political decisions are being made to cut severely those self-same resources necessary to accomplish all these required activities for the good of the nation. When analyzed against what academe writes is required of federal labs, this juxtaposition of inordinately difficult and simultaneous taskings appears nonsensical and fatally flawed for maximizing national economic returns from the federal labs.

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[18] Kash, Perpetual Innovation, (TBD).

Breaking up the groups, teams, and organizations that have acquired incremental learning results in a serious loss of future capabilities, yet it is an instinctive response given the central importance our ideology assigns to efficiency. ....Individual experts are not simply interchangeable parts in an innovating machine; innovation involves team building and continuous team learning. Because such cumulative experience and understanding is so critical, this network of people must be maintained over time. Their collective capacity, by assumption, cannot be translated into standard operating procedures and transferred to other workers. THE CAPACITY TO ADD VALUE RESIDES IN THE WHOLE [emphasis added].[19] The displaced scientists and engineers would have difficulty transferring to universities or industry, even if all the research funds were redistributed.[20]

Federal R&D institutions, because they are supported by the taxpayer, are not and cannot be primarily driven by market considerations. Federal research can complement but never substitute for the initiative and unique capabilities of individual companies that are organized to maximize their technology assets for market-driven objectives. Our more than 700 national laboratories do maintain world-class expertise in areas such as biotechnology, advanced materials, advanced manufacturing, high-performance computing, and advanced optical technologies. U.S. companies should not view these unique facilities as competitors to their internal R&D divisions but as resources that can contribute to a company's proprietary R&D agenda.[21]

Now, Congress has given the National Science Foundation a startling order: spend 60% of its $2 billion research budget on projects deemed relevant to national needs. If the NSF doesn't pursue "activities where science leads to technology, products, and jobs," says Senator Barbara A. McKulski (D-MD), her appropriations subcommittee may slash its budget by up to two-thirds.[22]

There is no better way to establish broad lines of communication with the world of science than through the natural personal relationships which occur among scientists who are peers. If the laboratory has gained the respect of the scientific community and its scientists are similarly respected, then they will be welcomed

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[19] Kash, Perpetual Innovation, TBD.

[20] Roessner, "What Companies Want", 37-42.

[21] Wince-Smith, Deborah. Letter. Issues in Science & Technology. Winter (92-93): 11.

[22] Carey, John; Robert D. Hof; Emily T. Smith; Peter Burrows; and Resa King. "Could America Afford the Transistor Today?" Business Week March 7, 1994: 80-84.

> within the most elite professional circles. Many modern developments are so specialized that they can only be interpreted by a man who has a working familiarity in a new field. Thus, it may sometimes be of value to support a specialist and his small research effort in order to keep an eye on the new field. ....A study of the relationship of salary to productivity shows that rewards do not keep pace with increasing production [of ideas or publication generation; logarithm of the rate is normally distributed across a lab]. To win a 10T raise, a research worker must increase his output between 30 and 50 percent. This fact may account for the difficulty of obtaining efficient operation in many government laboratories in which top pay is low compared to industry, with the result that very few highly creative individuals are retained.[23]

> The prioritization of technologies in a multitechnology government laboratory is a complex task involving to a great extent "subjective" criteria and uncertain technology contributions toward these criteria.[24]

> What should President Clinton do to spur industrial R&D? [Sudden change in government labs' agendas.] How can their agendas be altered? A proposal that I think makes a lot of sense is to tax the laboratories' budgets by a large amount, like 20 percent, and give the money back to them on the basis of who can come up with industrially competitive products.[25]

The above quotes illustrate the quandaries that beset federal lab executives in trying to comply with directives which pull their resources in every direction while they try to steer a central course. They can derive precious little comfort from reading the results of closely similar experiences. In Great Britain, for example, technology transfer appears to be hindered by lack of commitment on the part of industry there to long-term research - this observation from an industrial researcher who saw his work in development of new vectors for gene therapy picked up

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[23] Burgelman, Robert A. and Modesto A. Maidique. Strategic Management of Technology and Innovation. Homewood: Irwin, 1988.

[24] Melachrinoudis, Emmanuel and Ken Rice. "The Prioritization of Technologies in a Research Laboratory". IEEE Transactions on Engineering Management August (1991): 269-278.

[25] IBM Research Goes Back to Basics". Management Review. December (1993): 22-24.

by U.S. investors and ignored in Great Britain.[26] Still closer to home, Mary Ellen Mogee has articulated the concepts that all federal scientists will have to become "systems integrators" in the sense that they will have to be aware of and calculate/forecast how their research projects contribute to national business goals of expanding technology bases, technology transfer, innovation deployment, and information accessibility.[27] Scholarly research has already indicated that few federal lab projects at one installation are selected via a formal decision method model; most are selected via consensus of agreement between the various levels of management.[28] Erickson observes that this first generation R&D style is an intuitive mode of management, where considering the R&D project as a strategic asset runs counter to the federal culture established over the last 40+ years.[29] Even if moved into a second generation R&D mode, these federal executives engage the risk of eroding their technology base, even sacrificing their core competencies, if they begin to use highly quantifiable linkages to private industry's financial indicators of project selection.[30] Identical problems seem to beset the federal executives if they

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[26] Science. "An Industry-Friendly Science Policy". Volume 265, 29 July 94. pp 595-597.

[27] Mogee, Mary Ellen. "Technology Policy and Critical Technologies A Summary of Recent Reports". Discussion Paper No. 3, The Manufacturing Forums of 1990-91 under the auspices of the National Academy of Engineering and National Academy of Sciences. National Academy Press, Washington, D.C. December, 1991.

[28] Prince, Jeremy R. "Research and Development Project Selection Methods at the Air Force Wright Aeronautical Laboratories". Thesis. Air Force Institute of Technology, Wright-Patterson AFB, OH. 1985.

[29] Erickson, Tamara J. "R&D: Managing the Link to Corporate Strategy." Management Review. December. 1993: 10-18.

[30] Erickson, "R&D: Managing", 10-18.

embrace the exhortations of some academicians and industry executives who want the federal labs to concentrate on basic research. Harold Brown observed that...

> "...if left alone, basic research is of little commercial value. ....Because of the great uncertainties and risks involved in trying to turn generic technologies into products, private firms tend to invest well below what is socially optimal. As a result of this market failure, the government has a responsibility to invest in projects aimed at promoting more, and more rapid, product commercialization.".[31]

Hecker has noted from his perspective that...

> The key to the government's success in enhancing industrial innovation will be to support multiple approaches, such as those at the DoE labs and Departments of Commerce and Defense. [However] instead of a relationship between the government and the private sector that is based on trust, we have highly prescribed rules and regulations backed up by an army of auditors. This adversarial environment has hurt the cost-effectiveness of the laboratories and hampered cooperation with industry. The laboratories must now demonstrate not only that they develop technology of interest to the government and the private sector, but that they can do it at an affordable price.[32]

Another NTU student summarized the foregoing dilemmas facing government executives very neatly by observing from one of the FORTUNE 500's viewpoint...

> Industry doesn't know what game it is playing, and we don't know whether government is part of the team. ...is it[the gov't] team member, umpire, traffic cop...what?[33]

With all the preceding observations, illuminations, and recommendations, one is surprised that they are all made without "translations" - the feelings and insights of those federal participants on the other side of this interface, which is expected somehow to provide, simultaneously, the

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[31] Brown, Harold and John Wilson. "A New Mechanism to Fund R&D". ISSUES IN SCIENCE AND TECHNOLOGY. Winter (1992-93): 36-41.

[32] Hecker, Siegfried S. "Retargeting the Weapons Laboratories". ISSUES IN SCIENCE AND TECHNOLOGY. Spring (1994): 44-51.

[33] Ed Cattron, KODAK, (directed to Prof. Kash) 7/19/94, NTU Residency 970.

security and economic "jump start" that this society desires to exploit. Perhaps Slowinski, Farris, and Jones stated the situation above best...

> [Partnerships] can be complex arrangements to manage. The purpose of this article is to identify management factors critical to success. Selecting a project core to the needs of both firms is an important first step. Taking an inventory of all resources needed to accomplish the goals and assessing the strengths and weaknesses of the partners relative to that inventory identifies potential weaknesses. Negotiating a win-win agreement that includes the ownership of intellectual property and exit strategies sets the tone for a cooperative relationship. Developing strong interpersonal relationships and integrating the operating styles of the two firms lead to the trust and respect so important in strategic partnerships.[34]

Apparently, Europe has discovered a key to cooperation and coordination, since the 7 largest aerospace research labs recently indicated a willingness to join forces to better coordinate their activities, increase their interdependence, and make most effective use of the European technology base.[35] Although these labs are fraught with national political prejudices, the legacy of having to cooperate since World War II has forged a "NATO-like" will in many cases, which leads to a blurring of public and private enterprises to accomplish European projects, such as the "Chunnel" between England and France. One marked difference in the U.S. sphere, not present significantly there, is what BGen Paul described thusly...

> Maintaining strong technological work in an environment of "management turbulence" is becoming increasingly difficult. But if the [federal] labs are to continue with internal quality initiatives...and retain the personnel needed to perform to the levels of past defense research for the nation's strength, enlightened executive and congressional actions are needed.[36]

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[34] Slowinski, "Strategic Partnering". Paper.

[35] Defense News. May 23-29, 1994. p. 10.

[36] Paul, Richard. Address. Air Force Science & Technology -- Spring Review "94". Wright Patterson AFB, OH. May 10, 1994.

But, history also warns against government and industry cooperating too closely, by identifying factors in the rise of the military-industrial complex of the 1950's to the present...

> Since the peak spending for weapons in 1986, our military-industrial complex has been undergoing a major transition in response to markedly new world conditions. Industry was asked to beat swords back into plowshares: the buzzword now is "conversion". ...Effective conversion requires more than a stable of advanced technologies supported by sound design and production capabilities. ...the defense industry was not formed in the entrepreneurial style; it was formed by the government as a national security necessity. The choice of this quasi-free enterprise form instead of a nationalized arsenal system was apparently a deliberate decision, but the long term implications of the choice were not fully thought through.[37]

> Investing in New Technology will not alone ensure the competitiveness of U.S. industry. ...In the organization, teamwork and sharing must be valued as highly as technical competence.[38]

This latter quote states the emerging appraisal of necessary future relationships with the federal laboratories and punctuates the end of the military-industrial era in the DoD. With defense industries scrambling to survive and mergers/take-overs becoming commonplace in the shake-out that is occurring, it is no mystery why many of the former defense industrial base companies do not trust this latest government initiative, with the federal labs in the forefront of responsibility. Many of these individuals voiced their views at the recent Los Angeles Economic Roundtable ...

> The technical and managerial capabilities in the defense industry are without question. The industry also owns impressive laboratory and production facilities, indeed an impressive and valuable national resource. If it [defense industry] is no longer needed at full strength, what should be done? The preferred role of government is to continue the effort to ensure a generally healthy, expanding

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[37] Horton, Peter. "Converting the Military-Industrial Complex: Why It's Difficult". Acquisition Review Quarterly. Defense Acquisition University. Vol 1, No. 2. Spring 1994: 100-113.

[38] Putnam, Arnold. "A Redesign for Engineering". Harvard Business Review. Vol 63, No 3, May-June (1985): 139-144.

> economy, and, as noted above, simplify and stabilize the regulatory environment. In such an economic environment the provision of venture capital is much more likely to produce viable new commercial business enterprises, and expand the economy, than is a federally funded and bureaucratically planned technology development program.[39]

Morone and Ivins believe that, since the 1950's, technology transition from the labs occurred mainly through spin-off applications. For spin-off to occur in the present environment, they opine that matching the large and ill-defined set of technologies or solutions at the labs with an even larger and more poorly defined set of problems and opportunities in industry is required. Such changes include: (1) promotion of interaction between industry and lab scientists; (2) provision of goods and services by labs; and, (3) nurturance of spinoff firms. For transfer of market driven technologies by the labs, necessary changes in the lab environment include: (1) allocation of projects so as to reduce the need for technology transfer; and, (2) implementation of projects based upon industry interest.[40] To solve the latter problem, they ask the poignant question...

> If ... technology is intended for the market from the outset, and if the labs are not experts in the technology at the time government decides to support its development, does it make sense to allocate the technology's development to the labs? Why not simply allocate the technology's development to industry in the first place and thereby circumvent the problem of transferring the technology out of the labs to industry?[41]

Even with the mechanisms of subcontracting, collaborative research, and staff exchanges, Morone and Ivins recommend that...

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[39] Horton, "Converting" 100-113.

[40] Morone, Joseph and Richard Ivins. "Problems and Opportunities in Technology Transfer from the National Laboratories to Industry". Research Management. May (1982): 35-44.

[41] Morone "Problems" 35-44.

> ...when projects are allocated to the labs, the best way for them to acquire information about market requirements is to interact with the firms in the marketplace.[42]

Siegfried Hecker, an "insider" to the national labs, has observed...

> Over the past two decades the balance of economic strength has shifted significantly toward Europe and Japan, where government and industry have developed effective partnerships. As a nation, we can no longer afford to pursue basic research, mission research, and industrial research independently and expect the forces of nature to provide synergy. All components must be looked at as part of a system that accomplishes societal goals, keeps our industries competitive, and provides a constant flow of new ideas from the relentless pursuit of knowledge. I want to suggest three changes in how science can be managed on a national scale:
>
> - Improve R&D coordination among federal agencies. To have maximum impact, the agencies should specifically target their programs to yield societal and commercial benefits which should allow the basic research programs to focus on the creation of knowledge and not be burdened with demonstrating short-term benefits.
> - Increase private sector input in setting directions and evaluating research in federal agencies. Representatives of industry and the public should serve on advisory and review boards that help direct government research. ...the private sector can not drive all civilian R&D, since the public good is not necessarily advanced by companies trying to maximize returns to stockholders. The government must ensure that the public interest is protected and that the focus is on the long-term well-being of the nation.
> - Enhance university research.
>
> As President Clinton said in his speech at Los Alamos, "There is a peacetime commercial mission for these labs, and there is a national defense mission for these labs, and the line between those two missions is coming down fast."[43]

And what may happen when government takes this course? Are there any lessons from the past that might be applicable? Often ARPA is extolled as the shining example of the way government should cooperate with industry. Government executives are aware of this also...

> Former DARPA director Richard Cooper told a Senate hearing that..."Every ARPA director, to my knowledge - and I have known them all and have had close relationships with them all - [has] done the thing that the White House dislikes the

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[42] Morone, "Problems" 35-44.

[43] Hecker, "Retargeting" 44-51.

> most. That is, they have [promoted a particular] company and got [sic] its first product to the point where the government could buy it. In many cases - in most cases - those products were dual-use products." Since 1988, Congress has countered the administration [antagonism to DARPA by reducing its budget requests] by adding several hundred million dollars a year to DARPA's budget for dual-use technologies. ...Congress' identification of which technologies to supplement reflects a broad industry consensus rather than any narrow political interest.[44]

Alexander Flax, a former Assistant Secretary of the Air Force for R&D, altered the above...

> The attribution of all successful DoD developments to DARPA...tends to...foster the illusion that all significant technological progress comes from research breakthroughs. Congress and the public have always been more appreciative and understanding of breakthroughs than of evolutionary technological progress, which tends to involve more complex interacting elements and is more difficult to comprehend. For a nation to promote and count on only the advanced basic and applied research stream for its technological programs is to provide a rich flow of advanced technology that will be exploited mainly by other nations, who appreciate the importance of user-oriented product development and the essentiality of the continuous improvement process in the competitive marketplace.[45]

Continuing this often contradictory and incessantly changing scenario with which the federal laboratory executives must cope, perhaps the current state of affairs should be mentioned...

> Fearful that the U.S. is losing its technological edge to foreign competition, the White House has placed a high-profile emphasis on forging an alliance between the federal government's vast research and development apparatus and business. The goal: to help reduce the time it takes to move ideas from the laboratory to the commercial marketplace. To underscore this new thinking, the DoD has been directed to prioritize so-called dual-use technologies, projects that can be used for both military and commercial practices. ...the government's network of 700 federally operated laboratories...have been told to devote up to 20 percent of their

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[44] Bingaman, Jeff and Bobby R. Inman. "Broadening Horizons for Defense R&D". ISSUES IN SCIENCE AND TECHNOLOGY. Fall (1992): 80-85.

[45] Flax, Alexander. Letter. ISSUES IN SCIENCE AND TECHNOLOGY. Spring (1993): 5-6.

> total annual $25 billion budget to commercial and joint research projects with private firms. These labs are now also to help companies identify current on-the-shelf technologies they've created that can be licensed and transferred to the private sector.[46]

Since dual-use has been required by the White House and technology transfer has been legislated by the Congress, how do the federal executives cope with satisfying both at once? The Technology Reinvestment Program (TRP) has been the primary vehicle to convert previous defense industries' products to the private marketplace. Technology transfer has been accomplished primarily by CRADAs. Justification of lab existence partially hinges on successful administration and technical management over dollars for the TRP. To the latter CRADA effort, aggressive marketing/penetration of private industry to "sell" lab research/technological findings, and provision of technological expertise and/or facilities at little or no cost, must be pursued. Where do the legal ramifications lie?

Lurking in the background may be the first federal lawsuit over selection of a CRADA partner. In a recent decision, the question of who benefits from a CRADA resulted in an important distinction for federal lab executives to ponder...

> The decision (*Chem Service Inc. vs. Environmental Monitoring Systems Laboratory, 12 F. 3d 1256 (3d Cir. 1993)*) highlights important policy issues for CRADAs. Do they represent enlightened policy, or are they just pork-barrel politics with a high-tech spin?
>
> If government help has any value, then choosing the beneficiary is an important - and controversial - job. Apparently, the government has little to restrict its choice in a CRADA partner, unless it trespasses into the domain of procurement contracts.
>
> This poses an unanswered question. Private concerns must vie for procurement contracts in open competitions with announced criteria. Why

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[46] Reynolds, Larry. "Business and Government Join Hands". MANAGEMENT REVIEW. December (1993): 19-21.

shouldn't they [similarly compete] to reap the benefits of technology transfer?[47]

If CRADAs are justified partially by the fact that intellectual property - patents, et al - belong now to industry and the government's previous policy has been that any research done for the government belongs to the public interest at large[48], how are government executives to deal with the spectre of possible lawsuits arising from their choice of CRADA partners? Berkowitz summarizes these concerns of public interest for the federal executives nicely...

> The first issue [,then, is]whether a government-funded research facility should be permitted to participate in a profitmaking joint venture operation. Traditionally, such cooperation [has been] viewed as an unfair subsidy in which tax dollars [are] used to benefit an individual company.
>
> The second issue concerned property rights. Most government contracts [stipulate] that the government retain[s] patent and licensing rights to any technology or products produced under a government-funded program. This principle [has] served the public interest, because it [has given] the government maximum flexibility when bargaining for similar products under [later] contracts.
>
> These policies reflect an implicit belief that any research funded by the government belong[s] to the public, even when a private company [has] carried out much of the work. Unfortunately, [these policies have] also effectively prevented commercial applications of government-funded R&D. Indeed, the traditional buyer-seller relationship between the defense R&D community and industry requires DoD officials to deal with private corporations at arm's length. It even promotes a certain amount of suspicion. Technology transfer, on the other hand, requires quite the opposite - cooperation and good faith in the expectation of mutual profit.[49]

Should federal executives shift the consummation of CRADAs with private industry to a competitive scenario in order to avoid the appearance of favoritism? Will succeeding

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[47] Petrillo, Joseph J. "A contract called a CRADA still must play by the rules". Government Computer News [Federal Contract Law Section]. May 2, 1994: 58-59.

[48] Berkowitz, Bruce D. "Can Defense Research Revive U.S. Industry?". ISSUES IN SCIENCE AND TECHNOLOGY. Winter (1992-93): 73-81.

[49] Berkowitz,. "Revive" 73-81.

administrations promulgate the same policy as previous ones? Berkowitz implies that because CRADAs are confined to DoD labs and research institutions, this is one reason why DoD's record of technology transfer, [as measured by the ratio of each dollar of R&D spent to the number of CRADAs consummated] is poor when compared to, say, the National Institutes of Health. However, Berkowitz may not have known about the NIH's attempt to set the price of one drug on the open market, to benefit the U.S. populace...only to have this attempt countermanded.

> NIH adopted rules that prohibit its scientists from entering into any research collaboration with a private company unless the company promises that the price of any product from the collaboration reflects the government's role in developing it. [to the revelation that Burrough's Welcome was charging $2000 for a year's supply of AZT, to treat AIDS; although, NIH scientists had collaborated in developing the drug] ...an NIH advisory panel heard complaints from industry and NIH scientists...that this so-called "reasonable pricing" policy has been, at best, misguided. They charge that [the policy] has hampered potential collaborations between industrial and federal scientists and led to NIH racking up one of the worst records of any federal lab in fulfilling Congress' aim of commercializing government funded research. The panel's recommendation...: Abandon all attempts to influence drug pricing.[50]

One can readily see the dichotomy from what one believes is true, using data that seems to be securely founded, versus an alternate truth from another, perhaps inside, perspective. The apparent slowness, described above, has roots in legal implications, changing policies, suspicion and distrust by industry, career motivation, congressional whims, regulations panting to catch up with multiple sources' changes, and finally what experiences are shared among the federal executive community. Even the above attempt to lessen the cost of drugs to the U.S. citizen failed. How can academe and private industry continue to criticize the federal labs for performing to the best of their abilities, given the impossible criteria upon which to make difficult choices?

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[50] Science. "NIH Panel Rejects Pricing Clause". Volume 265, 29 July 94. p 598.

The answer lies somewhere in affording the interface between private industry and federal labs an opportunity to work to a degree that, at least, partially satisfies elements of the foregoing discussions. It is the sense of the rest of this paper to portray the attitudes on one lab's side of this interface, in the hopes that shedding some light thereupon may enlighten private industry, academe, ...and yes, the federal lab's executives, too...to an understanding which will empower federal lab and private industry individuals to trust one another more by understanding each other better.

6. Findings

For the reader's convenience, this paper's 5 hypotheses, their dependent and independent variables, are summarized, respectively, in the following table.

1. Lab Mgmt's embracing	directives, et al	(not done classically)
2. Lab Mgmt's incentives	technology transfer import	career aspirations
3. Lab Mgmt's listing	tech transfer recipients	execs' prioritization
4. R&D tools	technology transfer	adequacy of: org'n speed; MIS's; proj sel'n;document'n
5. Public/Private funding	support of coop research	mix of public/private funding

Table 1

This following section will be divided into describing the federal lab personnel who were sampled and some salient characteristics which might warrant further research. Subsequent sections will address each hypothesis, in turn, and the findings with analyses. All references in these sections are to the graphs and printouts in the appendixes. These appendixes are arranged in the order of the question's appearance on the survey after Appendix A which contains the survey sheet used. Points from the literature sources will be annotated in the section(s) involved, plus preliminary findings from other unfinished Field Research Projects undertaken by this author prior to accomplishing, in full, this final project.

6.1 The "Fed"

The participation rate, by division, is enumerated below for the federal lab surveyed.

a	b	c	d	e	f	g	h	i
59%	20%	73%	76%	66%	52%	58%	57%	50%

Table 2

The low participation rate in division b was due to the fact that there was such a small number of executives in that division. The bias built into the response distribution is thought not significant, as mentioned previously.

The academic degrees represented in this survey are listed below and in Appendix A.

BACHELORS	MASTER'S	Ph.D.'s
68	142	73

The number of missing degrees is due to missing data as explained previously. This error constitutes less than 2% of the responses returned and is considered not significant. There was no attempt to identify multiple degrees, but such were volunteered by a few respondents. This consideration was not considered significant enough to warrant further questioning of the survey population.

The 2 genders break down into the following, also listed in Appendix A.

MALE	FEMALE
283	3

The 2 non-responses are presumably "others" (but perhaps unclassifiable!). A cursory inspection of the addressee list of names to whom the survey was sent revealed only 7 typically western female names. Oriental and Asian sub-continent names could not be cursorily identified as female or male, so the total female population may be larger than 7. With 286 out of 288 responses

known, the error from absent data is considered not significant.

The age of the population appeared to be, somewhat, an antagonizing request. Only 222 out of 288 volunteered to answer. In this population of 222, the mean years was 49.7 and the median years was 50.5. A count of all ages above 51 showed 47.5% of the population, with those above 49 constituting approximately 56.5%. These numbers indicate a strongly homogeneous population clustered around 50 years of age. The motivation to complete this survey quickly before the senior executives opted to take retirement due to downsizing and attractive financial inducements appears justified. At a minimum, there will be a large turnover of management in a few years at this federal lab. The stem and leaf diagram has been included in Appendix A to illustrate this age distribution phenomena.

The years at this particular federal lab clustered at an average of 21 years. Correspondence to the mean and median ages above appears to make sense, so that no error or bias appears evident. The total of years of civilian service was requested to ensure the military element was removed from the population. This number averaged 24 years, again a good fit with personal age data revealed in the preceding. Both age figures are in Appendix A.

The grade distribution at this lab shows that the largest population occupies grade GM-14, which is also the median grade. This is a fortuitous occurence, since the lowest executive grade population is balanced by the upper 3 grades almost exactly in numbers, meaning that no grade overshadows the character of the total response distribution as shown in Appendix A.

One item that this survey was intended to uncover was the level of formal training in technology transfer which the executives may have taken. Several courses on the subject of technology transfer exist through the federal training channels , so that the possibility of a highly

trained management in this subject is possible. However, the responses indicated that approximately only 1 out of 8 is formally trained in technology transfer nuances. This is probably not surprising, given the enormous pressures of downsizing, teaming, plus normal administrative duties impinging on the executives from all directions. To attend one of these courses requires at least one week and sometimes two weeks out of one's schedule, so the disparity between those trained and not trained is explainable by the "management turbulence" described by BGen Paul[51] in a preceding part of this paper. The statistic of 12-13% trained may not seem mathematically important, but the content of effects from this factor may exceed its number significance. The desire to compare these "trained" responses to the "untrained" responses, as a whole, was strong, but using inductive reasoning seemed counterproductive to the goals of this study. Therefore, only after a significant number of the executives are trained should this survey be repeated. Other federal labs should also baseline their executives' technology transfer training, if a survey similar to this one is contemplated.

The level of first-hand experiences to the one category of second-hand experience showed the following numbers: first-hand experiences as a technical person, 86 cases; first-hand experiences as a team-leader or manager, 56 cases; and, second-hand experiences as a manager, 155 cases. The pilot survey did not reveal the possibilities of double counting among these categories, but the full survey did show this phenomenon. Therefore, these numbers are indicators only, not cumulative figures for a given segment of the responding population. As indicators, these figures may show that the probability of a sizable segment of the executives not having first or second hand experience with CRADAs appears substantial. When compared to the

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[51] Paul, Address.

total number of CRADAs processed in this lab over the past year or even two, the respondents' numbers obviously have a lot of duplication.

In summary, the typical executive at this federal lab is likely to be about 50 years old, a GM-14, having about 24 years total civil service, with over 20 of that in a federal lab environment, perhaps in this very lab. He probably has at least one master's degree, is probably untrained formally in the particulars of technology transfer, and probably has no first-hand experience with processing CRADAs.

6.2 Awareness of Technology Transfer Directives

Air Force Instruction 61-301 was received in the Office of Research Technology Applications (ORTA) at this federal lab 2 November. The regulation was dated effectively 21 July 1994. This regulation's receipt post-dates the survey, so the executives answering the awareness question, number 1, were doing so regarding previous Air Force regulations covering technology transfer. A diffusion process has to occur for 61-301 to all scientists and engineers at the laboratory before another survey can be taken, to have any accuracy.

Appendix A contains stem and leaf diagrams for the five possible answers: poor, fair, undecided, good, and excellent. Previous discussion on the techniques employed in this survey's analysis indicated that the variables were treated as dichotomous entities. If no answer was circled, a zero was employed in the statistical spreadsheet for that position: "ans1a, ans1b, etc." The "CI" used in the last line of the numerical statistics stands for "confidence interval", but it is not significant since only gross responses were evaluated. Only the frequencies were of interest. One will notice that SPSS® changes the scale in answers 1b and 1d from the other three. Presumably, this treatment is done when the responses show a significant frequency variation. In

diagram 1e, there were only 11 non-zero responses; whereas, in 1d the 0's were 161 strong with the 1's (indicated by "10" on the stem and leaf diagram) being 127 in count. These stem and leaf diagrams with accompanying statistics were obtained through the "exploratory analysis" function in the software. These data are included in Appendix A for illustration purposes only, to show the general approach given to each question in the survey. The preferred method of gaining information from analysis of the data was the bar graph.

Appendix A's bar graph clearly shows the relationship among the entire population of responses. For this question alone, there was no missing data, so there are no uncharted data about which to speak. If one considers the "undecided" as basically a neutral position, then the population is divided into those respondents who feel that their awareness of the regulations, policies, and the like is toward a facile degree, and the other portion of the population who feel that their awareness is less than perhaps desirable, given the subject. With 48% in the former stance and 46% in the latter, obviously the 8% could be the deciding factor between the two.

The best that can be said from interpreting this question is that there may be a sizable population who feel that their knowledge of technology transfer directives is inadequate. This circumstance could be due to the lack of training all around; the limited access to regulations because of cost-cutting measures (e.g., limiting regulation "libraries" to one per division); lack of emphasis by higher management (e.g. not discussing "new" regulations at regular organizational staff meetings); lack of time to review these regulations due to press of other priority business; or a combination of these and, perhaps, some other factors not mentioned. This finding is not cause for management alarm, but is strong enough to warrant a sustained effort to bring all participants to a facile level with the technology transfer regulations, because 72% of the population grades

out "fair" or "good". Obviously, the desired goal is for everyone to reach the "good" or "excellent" individual assessment in a follow-up survey, if such is deemed worthwhile.

6.3 Do Federal Executives Care?

Question 2's graph and summary of answers are contained in Appendix C. This is one of the more important findings in this survey. Why? Because there is a sizable portion of the R&D literature which purports that federal lab personnel are not motivated to enable technology transfer. Although this paper's finding does not cover "all" federal lab personnel, it does cover the personnel who should influence the "general characteristics" of one federal laboratory the most. The attitudes of the laboratory executives were compared to statements like...

> ...NASA examined its tech--transfer programs and concluded that "all too often, NASA employees, managers, contractors, and grantees don't consider technical transfer to be part of their jobs.[52]

> The difficulties of identifying spinoff applications and transferring lab technologies to those applications are compounded by a lack of motivation on the part of both industry and labs. For the labs, transferring technologies to spinoff applications is akin to missionary work. By definition it is peripheral, if not irrelevant, to the goals of the labs' programs. Lab managers are primarily concerned with successful performance of their projects, not with possible side benefits. And except for those in programs directed at the market, lab scientists are motivated by science for its own sake, not by unintended industrial applications of their work. [So] [a]nother way to give labs incentives is...to fund lab programs devised for the express purpose of transferring lab technologies to spinoff applications.[53]

> Yet a third reason - and possibly the most important - why DoD lags behind [in the number of CRADAs consummated with private industry] is simply that DoD officials do not consider technology transfer to be a high priority.[54]

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[52] Anderson, Christopher. "Rocky Road for Federal Research, Inc." SCIENCE, 22 October (1993): 496-498.

[53] Morone, "Problems " 35-44.

[54] Berkowitz, " Revive", 73-81.

The above comments are, by no stretch of the imagination, atypical of the press, scholarly magazines, and popular public opinion. What do the numbers for question 2 show for the apparent attitudes in one federal lab?

Referring to Appendix A, one can readily see that only one-fourth of the respondents had "unknown" or "no" marked for the impact of technology transfer on their careers. Fully three-fourths of the lab's executives measured an appreciable impact on their careers, with about one-third of the respondents taking the high road of "large impact" as an indicator of their concern. Since the typical executive at this lab has, for all intents and purposes, reached the upper limit of his career, the fact that so many of these individuals register a positive acknowledgment of technology transfer as a factor on their careers is particularly meaningful. The popular conception of the life cycle of these executives, according to media and politicians, is that because of increasing tenure in service, these individuals will soon become jaded and practically indolent...mere hangers-on to the government payroll. This is one study that explodes that myth. Another study, excerpted below, also shows a complementary side to the federal lab worker...

> Results of this study based on data collected from 114 engineers in a bureaucratic work environment indicate that... Tenure was also found to be important: increased satisfaction, increased performance, but also increased problems with the superior were associated with longer tenure in the organization. The present study involves civilian engineers employed by the government at a U.S. military [R&D] installation. The survey instrument was designed to assess job attitudes, perceptions of bureaucratic problems, and job performance in addition to collecting biographical data.[55]

These two 1994 studies indicate that popular conceptions of professional scientist and

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[55] Baugh, Gayle S. and Ralph M. Roberts. "Professional and Organizational Commitment Among Engineers: Conflicting or Complementing?". IEEE TRANSACTIONS ON ENGINEERING MANAGEMENT. May (1994): 108-114.

engineer government bureaucrats need drastic revision. The question used in this paper's survey, as explained before, used a surrogate indicator. As such, it had the advantage of following an innocuous question (no missing data), and it also belied its true value by reasons of brusqueness and obliqueness. If anything, the question might even be accused of leaning in the negative direction, by using extremely mild wording. This tactic was deliberately employed in order to catch the respondent off-guard, thereby eliciting, hopefully, the most honest reply possible. As mentioned previously, the Likert scale was reduced from 5 categories to 3 (with a fourth, "unknown"). Admittedly, the graininess of the reply does not lend itself to surety in analysis; however, the overwhelming perception of some kind of positive impact of technology transfer on these executives' careers correlates nicely with the findings of Baugh and Roberts describing tenured engineers. It could be strongly argued that these two researchers found a reason for the persistence of the myth of slothfulness in the civil service by the following...

> The importance of the tenure variable suggests that engineers do adapt to their organizational environment over time. But problems with the supervisor also increased with increasing tenure, suggesting that length of service does not have uniformly positive effect.[56]

Perhaps the tenured individuals may also be the most vocal, privately, about the perceived shortcomings of their organization. Due to these senior individuals' wide purviews, their successes could be obscured by and subordinated to the excessive daily demands upon which they dwell...

> Anyone who has spent time in government knows that there is a perpetual concern with strategic plans and performance objectives and evaluations. Because the information and expertise are dispersed throughout the organization in the best organizations, top management does not solve problems nor set specific direction.

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[56] Baugh, "Commitment" 108-114.

> " It creates an environment in which people can identify and solve problems for themselves" [quoted by Kash on page 66]. The distinctive individuals in the synthetic society are neither inventors/entrepreneurs nor managers per se; they are individuals who can in some way motivate and lead large numbers of people in complex organizational systems to accomplish what has never been accomplished before.[57]

And still yet, new administration directives require ever more from these same executives...

> What is the new job of the federal executive?
> First...federal executives need to involve all employees in developing a clear vision and a shared sense of mission. In this administration, we want managers and employees to work together to paint a clear vision and articulate a compelling mission.
> Second...federal executives will need to help staff cross boundaries to work effectively with other organizations.
> Third...federal executives must empower their employees to achieve the goals of the organization, within statutory constraints and the agreed-upon vision of the organization.
> Fourth...federal executives will need to work to satisfy their customers.
> Fifth...federal executives will need to communicate through every layer in their agencies.
> Sixth...federal executives will need to ask subordinates what they will need to get their job done.
> Seventh...federal executives will be expected to concentrate on performance and carefully measure results - output, not input...
> Over time, old ways of thinking will fade and will be replaced by a new culture that promotes innovation and quality.[58]

The high motivation exhibited by the responding career government executives does credit to their persistence toward quality, in spite of the mounting burdens they must carry to satisfy all the stakeholders in the R&D process, the technology transfer process, and all the other demands of their positions. Do federal executives care? Seventy-five percent do!

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[57] Kash, Perpetual TBD.

[58] Gore, Albert. Address. Marver H. Bernstein Symposium on Governmental Reform. Georgetown University, Washington. Late March, 1994. [Excerpted in Government Executive, May 1994, pp. 52-53]

6.4 Here's Our List, Dr. Roessner

This section of the survey, contained in Appendix B, was dedicated to find the counterpart list to Dr. Roessner's findings, which placed the federal labs last in the desired sources of technology list as determined by industry executives. The following table summarizes the order of questions with the highest frequency ranking by the respondents.

3a	3b	3c	3d	3e	3f	3g	3h	3i
7	3	4	5	2	8	6	1	9

Table 3

The top four in this list are, in order: (1) U.S. defense industry; (2) DoD acquisition agencies; (3) Other federal agencies; and, (4) Non-DoD U.S. industry. If one considers both (1) and (4) to be components of the same category, then the next "(4)" defaults to U.S. Universities. Comparing Roessner's list and this list reveals the following comparison:

IRI Executives' Desired Sources	DoD Executives' Desired Recipients
1. Other U.S. Companies	1. U.S. industry - DoD, et al
2. Universities	2. DoD acquisition agencies
3. Foreign-based companies	3. Other federal agencies
4. Federal laboratories	4. Universities

The degree of mismatch may not appear to be an important issue; however, in order to reach the level of understanding postulated in section 4 to be the most important and conducive to gaining or achieving trusting relationships with the federal labs, the above knowledge may enable the two parties to reach accord quicker than without this knowledge. The federal laboratory executives revealed that their primary cares, of course, revolved around the DoD industrial base achieving

and inserting technological improvements into acquired items/weapons for the defense of the nation. This has been the laboratory's traditional role over the last 40+ years. Changing the primary recipient to U.S. industry under the technology transfer legislation is not such a radical change; only the primary avenue has been altered. Previously, the emphasis was on "selling" researched ideas or demonstrations to the acquisition agents foremost, and through them, to primary contractors involved in building the items needed by the DoD. Criticism has been levied upon the labs for not doing this job very well, but the fact remains that the U.S. enjoys technological superiority in warfighting capability, largely as a result of the federal lab's efforts. Emphasizing industry in modern management literature as the primary recipient of the lab's technology appears to be a good "fit" with what the laboratory executives also want, provided the above caveats are recognized.

The placement of universities in the two lists appears to be an opportunity for personnel exchanges between the federal labs and such institutions to enable each participant to gain better understanding of what motivates or concerns the other party...

> Although competition exists in the research community, it does not necessarily drive down costs, as would be expected in typical "markets". In the face of inherent uncertainty about the eventual outcomes of research, sponsors must apply various criteria in predicting the likelihood of eventual project success, such as access to sophisticated equipment or the availability of appropriately trained personnel. A common perception during the 1960s was that Federal dollars that supported research also benefited undergraduate teaching because these top researchers would communicate their excitement about development "at the laboratory bench" to undergraduate and graduate students alike. In the 1980s, with the separation between research and undergraduate education becoming more pronounced, the connection between research progress and the cultivation of human resources grew more tenuous. These calls for increased undergraduate teaching by faculty seek to alter an academic research and teaching model in the U.S. that is already under strain. In the 1990s, the research work force - in its myriad forms of organization and scale of effort - has reached such a size that it

> feels strain under the Federal Government's present approach to supporting the conduct of research.[59]

Access to federal lab facilities can create more cordial relationships between research peers, and federal researchers can gain valuable insights into the problems of the university research infrastructure, upon which the labs might be able to assist in improving.

The rest of the list from the federal executives is as follows: (5) U.S. state agencies; (6) European entities (including NATO); (7) Asian Nations; (8) Other. Interestingly, some respondents rated "Other" as number 1 or number 2 by reason of transferring technology to the industrial arms of the services, e.g. the Air Logistics Centers in the Air Force. Otherwise, the priority is clearly the U.S. first, Europe second, Asia third, for geographically desired recipients.

6.5 R&D "Tools"

The federal labs have a certain set of "tools" by which the R&D process is accomplished. Some of the tools are legislated for use, e.g. the record files of projects. Some tools arise from increased usage in pragmatic problem-solving , e.g. the R&D project selection process. This paper will cover these tools' findings briskly, because the results were not very enlightening in comparison to good coverage in the literature. All tools' graphs and data are in Appendix C.

6.5.1 Support Organizations' Speed

As mentioned previously, this was the only tool question involving rating of human elements. Charges in the R&D management literature that bureaucracy impedes technology transfer abound. Typically, comments are phrased thus...

> [Regarding CRDAs]...but the road to commercialization has been rocky and many

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[59] Congress of the United States. Office of Technology Assessment. Federally Funded Research: Decisions for a Decade. Washington, U.S. GPO, May 1991, 314 pp.

> potential collaborators are now backing away, discouraged by stifling bureaucracy, delays, concerns about access, and limits on pricing.[60]

Fully 46% of the one federal lab's executives seem to agree that their support organizations tasked to participate in the technology transfer process tend to be slow. But there is also a 42% undecided segment. This could be closer to the number of executives who don't have first-hand or second-hand knowledge, as covered before, or this number could mean that the processing speed initiatives instituted at the lab recently may be commencing to work, making appraisal of speed an uncertainty. In any case, there is a wide margin for improvement. The technology transfer process needs to be flow-charted and improvement candidates identified. Missing cases constitute 3.4% error, which is acceptable.

6.5.2 MIS

> There is also increasing recongnition of the importance of tracking and adopting relevant technology developed outside the firm. ...Edwin Mansfield has found that Japanese firms are faster and more efficient at developing new technology when it originates outside the firm. They do not have such an advantage when the technology originates inside the firm.[61]

In 1986, Roessner and Schwartz published results of a pilot study of information systems in industrial research labs; they did not recognize at that time any requirements to document research findings in a computerized data base. In 1994, straw polls with this author's NTU student-colleagues from private industry's R&D labs revealed that 6 to 8 years later, there still was not a recognition of any need for an R&D data base. These student colleagues indicated that

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[60] Anderson, "Rocky Road" 496-498.

[61] Mogee, Mary Ellen. "Educating Innovation Managers: Strategic Issues for Business and Higher Education". IEEE Transactions on Engineering Managment. November (1993): 410 - 417.

a database documenting research findings, such as found in this federal lab, simply did not exist to their knowledge, in their own companies. They indicated that, in order to find out research results of previous internal R&D, one had to find the principal investigator and proceed to "wring" out the details from that person's memory. When one contrasts those findings to the quote from Mary Ellen Mogee about the strategic advantages of tracking technology both within and without the firm, one realizes the significant gaps which exist and which possibly penalize a firm by imposing unnecessary time to find and gather information about the R&D involved.

Before this paper's topics suggested themselves for a field research project, this author pursued the idea of what management questions a federal R&D database could answer, and, more importantly, what questions the database could NOT answer. Through exploratory data analysis of two financial database fields, two items became abundantly clear. First, the database had to have some sort of error-checking capability for data input in order to forestall any problems with porting this data later to another Automated Data Processing (ADP) system. Researchers will have to be "led" into making the proper entries; otherwise, one risks encountering what this author did - blanks, backspaces, and all sorts of input "trash" which kept the SPSS® software from ordering the data fields for proper statistical analysis. Fortunately, the menu windowing environment appears to be tailor-made for this task. Secondly, having an integrated statistics and database package is definitely advantageous. Even though the database attempted for conversion described here was a popular ORACLE® product, completely compatible with SPSS®, the data corruption prevented any analysis without major manual data massage.

If the "Information Highway" becomes a reality, as is likely, accessing the federal lab's database(s) by private industry may become a more central issue. Although Roessner and Bean

indicated that the greatest overall payoffs to industry in interacting with federal labs lay in informal interactions with personnel,[62] it may be that in the future this informal interaction will come about more freely by one's informally browsing through that lab's database first. Security and proprietary concerns will always be a problem with allowing private industry access to any data in the federal labs, but the current hardware and software appear capable of maintaining the integrity and security of accesses to a reasonable level.

The queried executives did not feel that their MIS's had any effect on technology transfer from the lab. The large number of "undecideds" could easily tilt the interpretation of the question's results, if they committed to one side or the other. However, at present, practically half of the executives feel fairly negatively about the existing MIS' viability as a technology transfer catalyst. This MIS area appears ripe for future thinking in terms of Mogee's writings.

6.5.3 Project Selection

From Dr. W. E. Souder's early 1970's research to the present,[63] [64] a preoccupation with the R&D project selection process has permeated the R&D management literature. Federal labs have been criticized for their selection methods, and the labs have only recently been exonerated. The General Accounting Office (GAO), however, recommended improvements, such as: to include more young scholars on review panels; elucidate stricter judging criteria; and enforce

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[62] Roessner, J. David and Alden S. Bean. "Industry Interaction With Federal Labs". Research Technology Management. September-October (1993): 38-40.

[63] Souder, William E., P. Michael Maher, and A.H. Rubenstein. "Two Successful Experiments in Project Selection". Research Management September (1972): 44-54.

[64] Souder, W.E., "A Scoring Model Methodology For Rating Management Science Models", to appear in Management Science.

consistency of discipline on the reviewers. There are alternative viewpoints...

> Q4: How would you quantify pure research?
>
> "A few trivial answers are: (1) Peers think it's terrific; (2) number of publications in learned journals; (3) Frequency of citation by peers in other papers; (4) Results in a new product or process; (5) The value of basic research, like art, lies in the eyes of the beholders." Harvey Drucker
>
> "I would kill any pure "peer review" systems that did not include the participation of generalists and end or intermediate potential beneficiaries of the work." -Walter Berninger, Chairman of the AMA R&D Council
>
> "Does it satisfy a need for fundamental knowledge impacting our business vision? Does it challenge our assumptions about the foundations of our business?" -Mark B. Myers[66]

Both Roessner[67] and Hecker[68] are two of a chorus exhorting private industry's active participation in the federal lab project selection/policy process; while Brown[69] stipulates that a "rigorous process" by independent experts is all that is needed.

Federal lab executives are almost evenly split over whether R&D project selection is a catalyst to technology transfer of those projects from the federal lab. Almost one-third of all respondents are undecided, however, so the opportunity is ripe to convince this population that R&D can have far-reaching effects on the New Process Development process as Millson wrote.[70]

6.5.4 Case Files

This element was inserted into the questionnaire to follow up on Clark's study of another

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[66] Erickson, "R&D: Managing", 10-18.

[67] Roessner "What Companies Want", 37-42.

[68] Hecker, "Retargeting", 44-51.

[69] Brown, "A New Mechanism", 36-41.

[70] Millson, Murray R., S.P. Raj, and David Wilemon. "A Survey of Major Approaches for Accelerating New Product Development". Journal of Product Innovation Management. March (1992): 53-69.

federal lab. He recommended that ranking projects on an Overall Assessment (OA) over periods of years...and keeping records so that ranking validities could be assessed...would be a good reference in allocating resources.[71] This paper's federal lab executives were overwhelmingly against the idea that the organization and content of case files might facilitate technology transfer. Since a great deal of effort is spent on precisely ordering and validating the data in these files...and electronic file means are available, in a time of budget cutting reducing such an effort on these files appears justifiable. The cost of storing these files and accessing them upon request by private industry would, of course, have to be weighed against the elimination of this record-keeping.

6.6 Public and Private Funding

The combination of questions 8 and 9 provided surprising results. The background of asking these questions has been developed previously, but the arguments from the literature have not been elucidated. Roessner supports Kash's recommendation for the use of public funds to directly enable industry's participation in lab activities...

> Public funds would be well spent to support travel to conferences by federal lab and industry researchers, industry visits to federal labs, and sabbaticals or temporary assignments of federal lab scientists to industry and vice versa. The federal labs should do all they can to ensure that industry has intimate knowledge of where the labs' expertise lies, what their facilities are capable of, and what is in their research portfolios.[72]

Apparently the impetus behind these tradition-breaking recommendations is grounded in...

> Most industrialized countries have governments that actively promote commercial technology advancement and application as part of their economic growth policies.

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[71] Clark, H. J. and Koplyay, J. B. Prioritizing Research and Development Projects of the Air Force Human Resources Laboratory. Thesis. Air Force Human Resources Lab., Brooks AFB, TX, 1988.

[72] Roessner, "What Companies Want", 37-42 .

> The U.S. is perhaps the only major nation without such a policy. In the U.S., commercial technology development traditionally has been seen as the responsibility of the private sector, and the Federal Government becomes involved only for certain limited purposes.[73]

> The labs are publicly funded institutions. Therefore, it is inequitable to the public if labs are allowed to serve private needs and inequitable to consulting firms if labs are allowed to compete with them. ...equity must be balanced against the benefits of technology transfer.[74]

Question 8 was an attempt to capture Roessner's words, using the federal researcher as the object of funding. The graph in Appendix E shows that 69% had no reservation about public funds used in this manner. The first surprise, however, was the 20% disagreement on what is normally done at federal labs in order to assure that the federal researcher has the opportunity to interact with his peers in private industry on the latest technology or other events of interest. Perhaps the "public steward" role was being made manifest by some of these executives who might be worried over the present state of federal deficit financing and are protesting this situation via this survey. Both here and in question 9 the "undecideds" have the lowest frequency of all, except for question 1; so apparently, this is yet another issue upon which the federal researcher has strong feelings.

Question 9 provided the most surprising survey results of all. It has the third lowest "undecided" population of all of the Likert-styled questions, only slightly higher than its companion, question 8. The percentage of federal executives agreeing with funding private industry researchers to accomplish exactly the same jobs that the federal researchers would

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[73] Library of Congress. Congressional Research Service. Technology Policy Initiatives in the Clinton-Gore Administration. by Glenn J. McLoughlin and Wendy H. Schacht. Washington March 18, 1993. 48 p. CRS Report 93-357.

[74] Morone, "Problems", 35-44.

accomplish decreased only from 69% to 57% agreement. Strong agreement only decreased 3%, and since there was no missing data in both questions 8 and 9, it was evident that there may be some emotions involved in the executives' responses to this question.

In spite of the historical separation of public/private funding, the ethos of public servanthood and stewardship of public funds being ingrained in these executives over, probably, 20 years minimum...these individuals indicate a definite boldness in agreeing with this politically controversial and volatile funding issue. The numbers are too large to warrant some doubt due to error, since both the pilot survey experience and expert advice eliminated most residual bias from the wording of these questions. Plus, these executives probably are aware of civil service careers being scuttled by imprudent application of public funds to private uses; Inspector General (IG) and GAO reports periodically publicize these events. So, what is the import of this survey data?

It may be that these seasoned executives see sympathetic competitive advantage for both private industry and the federal lab's goals. If one accepts that these executives are committed to performing cooperative research in any setting for the good of the nation, then these data are not absurd at all. If such research would require the lab's funding of private industry personnel, movement of private industry equipment to the federal lab or vice versa, then the decisionmakers would be supportive of doing it. In Public Administration courses, law courses, and other similar courses, this separation is emphasized as axiomatic to proper functioning of the U.S. governmental system, as mentioned previously. Further research into this issue would be fully warranted to determine if other federal research lab executives feel similarly. If they do, then this one lab's senior cadre is not alone, and textbooks and curriculums need to be revised. If, however, this lab's executives are "alone", then further research appears justified.

7. CONCLUSIONS

This paper attempted to assess one federal laboratory's executives' attitudes toward technology transfer against current theoretical and applied concepts of R&D management. In a context of extreme management turbulence, the question of how to improve the lab's responsiveness to the needs of industry and academe was considered, and an approach for a partial answer was formulated. This partial answer revolved around the perceived need for a management construct which included understanding the federal participants' attitudes and constraints in bridging the federal/private interface in addition to the non-federal attitudes. From multiple iterations of a survey instrument, a final design was submitted to 432 executives at one federal lab. The compilation of results provided some interesting insights into the lab's executives' conjoint thinking; however, one should not extrapolate from this limited survey of one lab that all federal labs and their executives are homogeneous in exhibiting this paper's derived dispositions. More surveys at this and other federal labs should be accomplished to overcome this survey's design weaknesses and to establish more broadly based conclusions before a large senior executive exodus occurs and other factors come into play.

Increasing demands on these executives' energies have limited their opportunities to pursue formal training in technology transfer, including a sizable segment of the population having little or no first-hand experience in the process. Nevertheless, attempts to share experiences have been and are being made to improve the federal corporate knowledge, primarily through the efforts of the Federal Laboratory Consortium and the Office(s) of Research Technology Applications (ORTA), this latter organization being a legislated required entity at each federal R&D installation.

Howsoever these executives differ in personal makeups and experiences, their awareness of technology transfer directives and policies is almost evenly split between feelings of being fully compliant and being minimally compliant. Approximately one-quarter of the surveyed population exhibits a need for further awareness training and absorption of the rapidly changing transfer rules, largely resulting from on-going legal testing.

The popularized concept of federal executives not caring for or otherwise debasing technology transfer as an ingredient impacting their careers is clearly a myth at this one installation. These executives may be cautious in their initial encounters with the rapidly improving and responsive CRADA vehicles; however, these same individuals definitely exhibit a noteworthy commitment to making technology widely available to the U.S. industrial base, as well as to academe. Criticisms to the contrary appear to be unfounded when measured against this segment of the indicted federal population. Further research into the non-executive scientist and engineer (S&E) population at this lab is particularly warranted to ascertain the correlation of motivation between the "influenced" and the"influencing" personnel segments. Analysis of variables (ANOVA) such as age, degree of first-hand experience, education, et al, from that comparison could present a clearer picture of this lab than what this paper has presented. The covariant aspects of these comparisons would make a particularly good analysis, and, perhaps, a more meaningful indicator of motivation than "impact on career" can possibly be created. The compiled executives' listing of "most likely recipients" of federal technology does not match the Roessner and Bean surveys of Industrial Research Institute participants exactly, but as a first approximation, the federal's list is valuable to enable a clearer understanding of the interface between combinations of two or more possible negotiating parties. Thirty to 40% more of these

executives surprisingly projected industry over the traditional acquisition agents as the most likely primary recipients of federal technology. This feature appears to be the strongest hope for negotiating speedy laboratory/industry CRADAs in the future. Another likelihood is that industry will be handicapped in trying to obtain federal lab technology through the circuituous route of foreign-based companies. Although the blurring of what is a "foreign-based" company has been a source of controversy in technology transfer legislation and academic writings, antipathy by the federal lab is clearly evident, much akin to, perhaps, a reverse of the documented "not-invented-here" syndrome...a "not-for-export-invented-here" feeling. Again, it would be instructive to perform this same ranking exercise, or similar, upon the rest of the S&E population in this one federal lab to ascertain the depth of feelings or gauge the impact of recent emphases on marketing federal technology as an influence on the choice of probable recipients. Recognition of global competition by the U.S. industrial base could be evidenced more then, perhaps, by the non-executives than the executives.

For federal technology transfer to universities to occur briskly, similar survey instruments should be administered to faculty interested in seeing that this transfer is encouraged, not to all faculty. The degree of mismatch between the perceptions of private industry and federal executives regarding U.S. universities' possible roles with respect to federal technology, should be explored. Existing legislation and policies encouraging federal researcher and faculty member interchange do not appear to encompass an expanded university technology transfer posture, either to aid in technology push from the federal lab or as a matchmaker of market demand to federal lab technology. Moreover, states are actively pursuing this latter matchmaker function, so universities would probably encounter competition from the very entities which fund them.

Research into alternative modes of federal lab/university cooperation is also justified in order to overcome the apparently disparate perception of the two functioning as attractive "technology sources" to industry, if in fact this disparity exists. Moreover, prevailing literature indicates that universities are interested primarily in grants so that insulation from outside influences and academic freedom are maximized; DoD appears to be moving toward directing research into those areas deemed most appropriate for the purpose(s) of the service. These two differences sully the negotiating parlance of the two strong potential collaborators. It is necessary to research, then, just what forms of federal lab/university collaboration can best serve this nation's interest in promoting U.S. technology strategies for international competitiveness.

The data in this paper may indicate that a little less than half of the respondents feel that support organizations' speed and other inanimate "tools" in the federal lab contribute to technology transfer. These are the functions which, in a quality sense, should not be pursued if they don't enhance the firm's competitive strategy. Preventing implementation of this drastic action, however, is the extremely large "undecided" population. The ambivalence in the collected data, moreover, doesn't lend itself to further research into the present findings. The lab should, instead, seek to determine the cost-effectiveness of these existing tools and then ascertain the economic sufficiency of retaining them.

Regarding the issue of public funding for private research purposes, clearly there is a distinct need for further research. Over half of all respondents firmly believe that this funding "freedom" is requisite to effective R&D. The "undecided" population constitutes only one in ten executives, so the feelings are skewed definitely in the pro direction. Could the effectiveness of traditional 6.1, 6.2, and 6.3 laboratory funding be multiplied if the funding regulations' shackles

were removed, allowing much more flexibility to directly fund private researcher's travel, equipment moves, and so forth? It remains for follow-on field research projects, surveys, and experiments to explore and map this exciting possibility for the federal labs. Of course there will be outside-DoD opposition, probably from congress, and certainly from private industry who does not get funded for these same or similar opportunities. To fund everybody who asks is clearly impossible. So then, how will the determinations of recipients, if such *nouveau vogue* activities are allowed, be made? By whom and under what criteria will be central to the debate(s). Protests and legal suits will most surely occur. But what about a future that "levels" the playing field with world commercial competitors, such as Japan and Germany? Is that future worthwhile to pursue with multi-pronged experiments and studies? The Management of Technology curriculum embraced by this paper would seem to indicate such an approach would be very worthwhile, controversial, and exhilarating. Such an approach is fervently desired by this author.

Never before have we had so little time in which to do so much.

Franklin D. Roosevelt

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APPENDIX A

Survey of WL Executives' Attitudes Toward Technology Transfer

Thank you for participating in this survey. The results will be used to set a baseline for WL executives, as well as complete a student's field research project for an M.S. degree. The purpose of the survey is to obtain WL executives' responses to various questions involving technology transfer from WL. Technology transfer, in this instance, is defined as "the process by which technological ideas are generated, developed, and transformed into new business products, processes, and services that are used to make a profit and establish marketplace advantage".

Please provide the aggregating data below then answer the succeeding 9 questions and place in the on-base mail to WL/XPT as soon as you can. Anonymity is assured, so please do not put your name on this form. Only aggregate statistics will be compiled.

Aggregating data:

Directorate (two letters only) _____
Highest degree earned _____
Male _____ Female _____
Age _____ Years at WL _____
Total years of civilian federal service _____
GS Grade _____ GM Grade _____ SES Level _____

Have you taken any formal courses in technology transfer? Yes _____ No _____

How many instances of CRADAs/CRDAs, patents, or licensing efforts have you personally initiated: as a **Career Technical Person?** _____ as a **Manager?** _____

As a supervisor or team leader, how many instances of CRADAs/CRDAs, patents, or licensing efforts have been coordinated through you? _____

For the following, please circle only one answer (except question 3).

Q1. How would you describe your awareness of policies, regulations, processes and directives governing technology transfer at WL?

Poor Fair (Undecided) Good Excellent

Q2. To what extent does technology transfer matter to your career?

No impact Some impact Large impact (Unknown)

Q3. Please rank to whom you are most likely to transfer WL technology. One (1) is the most likely, and 9 is the least likely. .

___ European entities (incl NATO)
___ Other U.S. federal agencies
___ Non-defense U.S. industry
___ Universities, U.S.
___ DoD Acquisition Agents (SPOs)
___ Asian Nations (Japan, et al)
___ U.S. state agencies
___ U.S. defense industry
___ Other (Israel, et al)

Q4. How would you describe the speed of service from support organizations (procurement, legal, et al) for prompt technology transfer from WL?

Slow Somewhat slow (undecided) Somewhat fast Fast

Q5. How would you describe WL Management Information Systems' effectiveness in aiding technology transfer?

Ineffective Somewhat Ineffective (undecided) Somewhat Effective Effective

Q6. At WL, how effective is the current research project selection process in promoting technology transfer of those projects?

Hinders transfer Has no effect (undecided) Some positive effect Positive effect

Q7. How effective are the ordering and organization of research project case file contents in promoting technology transfer from WL? [what goes in and in what order]

Hinders transfer Has no effect (undecided) Some positive effect Positive effect

Q8. Public funds should be expended for: WL personnel to visit private labs; moving and installing WL apparatus for cooperative research; relocating WL personnel temporarily for cooperative research opportunities with industry?

Strongly disagree Disagree (undecided) Agree Strongly agree

Q9. Public funds should be expended for: industry personnel to visit WL; moving and installing industrial apparatus into WL for cooperative research ; relocating industry personnel temporarily to WL for cooperative research.

Strongly disagree Disagree (undecided) Agree Strongly agree

APPENDIX B

BACHELORS Sum	MASTERS Sum	PH D Sum	TOTAL LAB DEGREES
Grand Total 68	142	73	283

FEMALE Sum	MALE Sum	TOTAL SEXES
Grand Total 3	283	286

AGE AGE

Valid cases: 222.0 Missing cases: 20.0 Percent missing: 8.3

Mean	49.6847	Std Err	.5337	Min	30.0000	Skewness	-.1721
Median	50.5000	Variance	63.2304	Max	73.0000	S E Skew	.1633
5% Trim	49.7312	Std Dev	7.9518	Range	43.0000	Kurtosis	-.5139
95% CI for Mean (48.6329, 50.7365)				IQR	12.0000	S E Kurt	.3252

Frequency	Stem &	Leaf
4.00	3 *	&&
28.00	3 .	566677778899
28.00	4 *	0122333344444
41.00	4 .	5555666677778888899
52.00	5 *	00000111112222223344444444
50.00	5 .	55556666666777788899999
16.00	6 *	0001233
2.00	6 .	&
1.00	7 *	&

Stem width: 10
Each leaf: 2 case(s)

& denotes fractional leaves.

# YRS LAB	# YRS, AVG
Grand Total 21	24

GS-14 Sum	GM-14 Sum	GS-15 Sum	GM-15 Sum	SES Sum	TOTAL OF EXECS
Grand Total 90	100	24	51	8	273

ANS1A GOOD

Valid cases: 288.0 Missing cases: .0 Percent missing: .0

Mean	.1285	Std Err	.0198	Min	.0000	Skewness	2.2323
Median	.0000	Variance	.1124	Max	1.0000	S E Skew	.1436
5% Trim	.0872	Std Dev	.3352	Range	1.0000	Kurtosis	3.0039
95% CI for Mean (.0896, .1673)				IQR	.0000	S E Kurt	.2862

```
Frequency     Stem &  Leaf

  251.00        0 *  0000000000000000000000000000000000000000000000
   37.00 Extremes    (1)

Stem width:  *
Each leaf:       6 case(s)
```

ANS1B FAIR

Valid cases: 288.0 Missing cases: .0 Percent missing: .0

Mean	.3160	Std Err	.0274	Min	.0000	Skewness	.7958
Median	.0000	Variance	.2169	Max	1.0000	S E Skew	.1436
5% Trim	.2955	Std Dev	.4657	Range	1.0000	Kurtosis	-1.3763
95% CI for Mean (.2620, .3700)				IQR	1.0000	S E Kurt	.2862

```
Frequency     Stem &  Leaf

  197.00        0 .  00000000000000000000000000000000000000000000000000
     .00        1 .
     .00        2 .
     .00        3 .
     .00        4 .
     .00        5 .
     .00        6 .
     .00        7 .
     .00        8 .
     .00        9 .
   91.00       10 .  0000000000000000000000

Stem width:  0
Each leaf:       4 case(s)
```

ANS1C UNDEC

Valid cases: 288.0 Missing cases: .0 Percent missing: .0

Mean	.0764	Std Err	.0157	Min	.0000	Skewness	3.2063
Median	.0000	Variance	.0708	Max	1.0000	S E Skew	.1436
5% Trim	.0293	Std Dev	.2661	Range	1.0000	Kurtosis	8.3384
95% CI for Mean (.0455, .1072)				IQR	.0000	S E Kurt	.2862

```
Frequency     Stem &  Leaf

  266.00        0 *  00000000000000000000000000000000000000000000000000
   22.00 Extremes    (1)

Stem width:  *
Each leaf:       6 case(s)
```

ANS1D GOOD

Valid cases:	288.0	Missing cases:	.0	Percent missing:	.0		
Mean	.4410	Std Err	.0293	Min	.0000	Skewness	.2390
Median	.0000	Variance	.2474	Max	1.0000	S E Skew	.1436
5% Trim	.4344	Std Dev	.4974	Range	1.0000	Kurtosis	-1.9565
95% CI for Mean (.3833, .4987)				IQR	1.0000	S E Kurt	.2862

Frequency	Stem &	Leaf
161.00	0 .	0000000000000000000000000000000000000000
.00	1 .	
.00	2 .	
.00	3 .	
.00	4 .	
.00	5 .	
.00	6 .	
.00	7 .	
.00	8 .	
.00	9 .	
127.00	10 .	00000000000000000000000000000000

Stem width: 0
Each leaf: 4 case(s)

ANS1E EXCELLENT

Valid cases:	288.0	Missing cases:	.0	Percent missing:	.0		
Mean	.0382	Std Err	.0113	Min	.0000	Skewness	4.8441
Median	.0000	Variance	.0369	Max	1.0000	S E Skew	.1436
5% Trim	.0000	Std Dev	.1920	Range	1.0000	Kurtosis	21.6157
95% CI for Mean (.0159, .0605)				IQR	.0000	S E Kurt	.2862

Frequency	Stem &	Leaf
277.00	0 *	000000000000000000000000000000000000000000000000
11.00 Extremes		(1)

Stem width: *
Each leaf: 6 case(s)

ANS3A EUROPE

Valid cases: 212.0 Missing cases: 76.0 Percent missing: 26.4

```
 Frequency     Stem &  Leaf

     7.00 Extremes     (2)
    19.00        3 *  000000000
      .00        3 .
    21.00        4 *  0000000000
      .00        4 .
    27.00        5 *  0000000000000
      .00        5 .
    33.00        6 *  000000000000000
      .00        6 .
    84.00        7 *  000000000000000000000000000000000000000000
      .00        7 .
    20.00        8 *  0000000000
      .00        8 .
     1.00        9 *  &
```

Stem width: 1
Each leaf: 2 case(s)

& denotes fractional leaves.

Group $EUROPE FED LAB'S PROPENSITY, T2 TO EUROPE

Category label	Code	Count	Pct of Responses	Pct of Cases
	0	1	.4	.4
	1	2	.9	.9
	2	7	3.1	3.1
	3	22	9.9	9.9
	4	23	10.3	10.3
	5	30	13.5	13.5
	6	32	14.3	14.3
	7	83	37.2	37.2
	8	21	9.4	9.4
	9	2	.9	.9
Total responses		223	100.0	100.0

65 missing cases; 223 valid cases

ANS3B OTHER FEDS

Valid cases: 212.0 Missing cases: 76.0 Percent missing: 26.4

Frequency	Stem &	Leaf
13.00	1 *	000000
.00	1 .	
41.00	2 *	00000000000000000000
.00	2 .	
61.00	3 *	0000000000000000000000000000000
.00	3 .	
40.00	4 *	0000000000000000000
.00	4 .	
33.00	5 *	000000000000000
.00	5 .	
10.00	6 *	00000
.00	6 .	
9.00	7 *	0000
.00	7 .	
2.00	8 *	0
.00	8 .	
3.00	9 *	0

Stem width: 1
Each leaf: 2 case(s)

Group $MORFEDS FED LAB'S PROPENSITY, T2 TO FED AGNCYS

Category label	Code	Count	Pct of Responses	Pct of Cases
	0	1	.4	.4
	1	14	6.0	6.0
	2	42	17.9	18.0
	3	70	29.9	30.0
	4	46	19.7	19.7
	5	35	15.0	15.0
	6	11	4.7	4.7
	7	10	4.3	4.3
	8	2	.9	.9
	9	3	1.3	1.3
Total responses		234	100.0	100.4

55 missing cases; 233 valid cases

ANS3C NON-DoD US IND'Y

Valid cases: 212.0 Missing cases: 76.0 Percent missing: 26.4

Frequency		Stem &	Leaf
10.00		1 *	00000
.00		1 .	
23.00		2 *	00000000000
.00		2 .	
36.00		3 *	000000000000000000
.00		3 .	
57.00		4 *	000000000000000000000000000000
.00		4 .	
35.00		5 *	00000000000000000
.00		5 .	
26.00		6 *	0000000000000
.00		6 .	
11.00		7 *	00000
14.00	Extremes		(8), (9)

Stem width: 1
Each leaf: 2 case(s)

Group $NONDOD FED LAB'S PROPENSITY, T2, NON-DOD U.S. I

Category label	Code	Count	Pct of Responses	Pct of Cases
	0	1	.4	.4
	1	13	5.6	5.6
	2	31	13.4	13.4
	3	40	17.3	17.3
	4	61	26.4	26.4
	5	36	15.6	15.6
	6	24	10.4	10.4
	7	11	4.8	4.8
	8	12	5.2	5.2
	9	2	.9	.9
Total responses		231	100.0	100.0

57 missing cases; 231 valid cases

ANS3D UNIVERSITIES

Valid cases: 212.0 Missing cases: 76.0 Percent missing: 26.4

```
Frequency    Stem &  Leaf

    8.00 Extremes    (1)
   17.00        2 *  00000000
     .00        2 .
   22.00        3 *  00000000000
     .00        3 .
   43.00        4 *  0000000000000000000
     .00        4 .
   51.00        5 *  000000000000000000000000
     .00        5 .
   41.00        6 *  00000000000000000000
     .00        6 .
   14.00        7 *  0000000
     .00        7 .
   10.00        8 *  00000
    6.00 Extremes    (9)

Stem width:  1
Each leaf:       2 case(s)
```

Group $COLLEGE FED LAB'S PROPENSITY, T2-U.S. UNIVERSITY

Category label	Code	Count	Pct of Responses	Pct of Cases
	0	1	.4	.4
	1	9	4.0	4.0
	2	18	8.1	8.1
	3	25	11.2	11.2
	4	44	19.7	19.7
	5	54	24.2	24.2
	6	41	18.4	18.4
	7	14	6.3	6.3
	8	11	4.9	4.9
	9	6	2.7	2.7
Total responses		223	100.0	100.0

65 missing cases; 223 valid cases

ANS3E DoD ACQ'N AGENTS

Valid cases: 212.0 Missing cases: 76.0 Percent missing: 26.4

Frequency		Stem &	Leaf
68.00		1 *	0000000000000000000000000000000000
.00		1 .	
61.00		2 *	00000000000000000000000000000000
.00		2 .	
34.00		3 *	00000000000000000
.00		3 .	
18.00		4 *	000000000
.00		4 .	
18.00		5 *	000000000
13.00	Extremes		(6), (7), (8), (9)

Stem width: 1
Each leaf: 2 case(s)

Group $ACQUISN FED LAB'S PROPENSITY, T2-DOD ACQ'N AGENT

Category label	Code	Count	Pct of Responses	Pct of Cases
	0	1	.4	.4
	1	79	34.1	34.2
	2	65	28.0	28.1
	3	37	15.9	16.0
	4	20	8.6	8.7
	5	17	7.3	7.4
	6	7	3.0	3.0
	7	2	.9	.9
	8	1	.4	.4
	9	3	1.3	1.3
Total responses		232	100.0	100.4

57 missing cases; 231 valid cases

ANS3F ASIAN NAT'NS

Valid cases: 212.0 Missing cases: 76.0 Percent missing: 26.4

```
Frequency    Stem &  Leaf

   10.00 Extremes    (1), (2), (3), (4)
    3.00        5 *  0
     .00        5 .
   16.00        6 *  00000000
     .00        6 .
   33.00        7 *  0000000000000000
     .00        7 .
   75.00        8 *  000000000000000000000000000000000000
     .00        8 .
   75.00        9 *  000000000000000000000000000000000000

Stem width:  1
Each leaf:       2 case(s)
```

Group $ASIANS FED LAB'S PROPENSITY, T2-ASIAN NATIONS

Category label	Code	Count	Pct of Responses	Pct of Cases
	0	1	.5	.5
	1	2	.9	.9
	2	2	.9	.9
	3	5	2.3	2.3
	4	3	1.4	1.4
	5	1	.5	.5
	6	17	7.9	7.9
	7	33	15.4	15.4
	8	74	34.6	34.6
	9	76	35.5	35.5
	Total responses	214	100.0	100.0

74 missing cases; 214 valid cases

ANS3G US STATE AGENCIES

Valid cases: 212.0 Missing cases: 76.0 Percent missing: 26.4

Frequency	Stem &	Leaf
6.00	2 *	000
.00	2 .	
8.00	3 *	0000
.00	3 .	
16.00	4 *	00000000
.00	4 .	
29.00	5 *	00000000000000
.00	5 .	
60.00	6 *	000000000000000000000000000000
.00	6 .	
32.00	7 *	00000000000000000
.00	7 .	
31.00	8 *	000000000000000
.00	8 .	
30.00	9 *	000000000000000

Stem width: 1
Each leaf: 2 case(s)

Group $USSTATE FED LAB'S PROPENSITY, T2-US STATE AGNCYS

Category label	Code	Count	Pct of Responses	Pct of Cases
	0	1	.5	.5
	2	6	2.8	2.8
	3	8	3.8	3.8
	4	17	8.0	8.0
	5	29	13.7	13.7
	6	62	29.2	29.2
	7	29	13.7	13.7
	8	30	14.2	14.2
	9	30	14.2	14.2
Total responses		212	100.0	100.0

76 missing cases; 212 valid cases

ANS3H US DoD IND'RY

Valid cases: 212.0 Missing cases: 76.0 Percent missing: 26.4

```
Frequency    Stem &  Leaf

  107.00        1 *  00000000000000000000000000000000000000
     .00        1 t
     .00        1 f
     .00        1 s
     .00        1 .
   54.00        2 *  000000000000000000
     .00        2 t
     .00        2 f
     .00        2 s
     .00        2 .
   28.00        3 *  000000000
   23.00 Extremes    (4), (5), (6), (7), (8), (9)

Stem width:  1
Each leaf:       3 case(s)
```

Group $DODINDY FED LAB'S PROPENSITY,T2-US DOD INDUSTRY

Category label	Code	Count	Pct of Responses	Pct of Cases
	0	1	.4	.4
	1	118	49.8	50.0
	2	66	27.8	28.0
	3	30	12.7	12.7
	4	7	3.0	3.0
	5	6	2.5	2.5
	6	2	.8	.8
	7	1	.4	.4
	8	4	1.7	1.7
	9	2	.8	.8
Total responses		237	100.0	100.4

52 missing cases; 236 valid cases

ANS3I OTHER

Valid cases: 212.0 Missing cases: 76.0 Percent missing: 26.4

```
Frequency    Stem &  Leaf

   15.00 Extremes    (1), (2), (3), (4)
   11.00        5 *  00000
     .00        5 .
   14.00        6 *  0000000
     .00        6 .
   26.00        7 *  0000000000000
     .00        7 .
   56.00        8 *  00000000000000000000000000000
     .00        8 .
   90.00        9 *  000000000000000000000000000000000000000000000000000

Stem width:  1
Each leaf:       2 case(s)
```

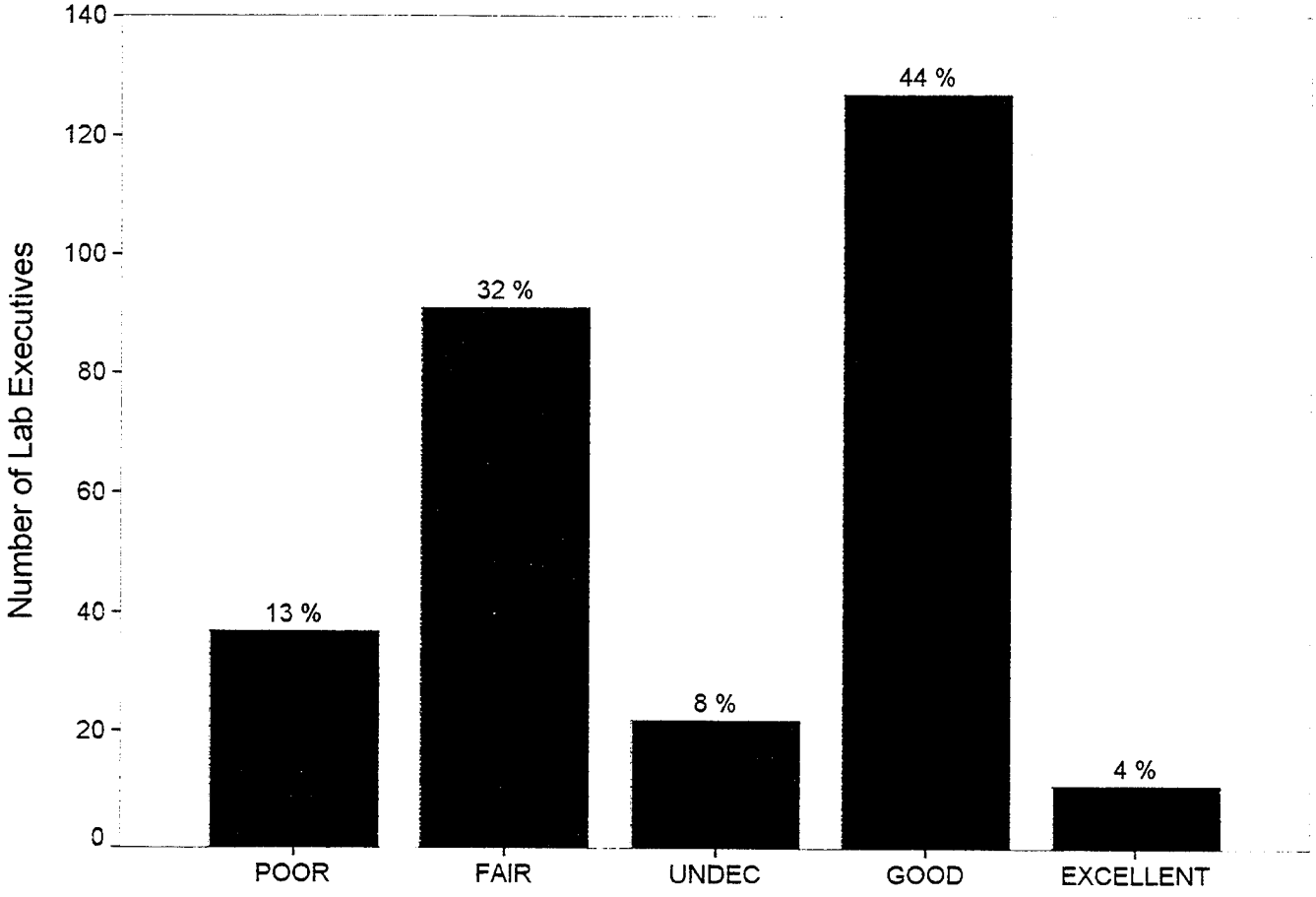
Group $OTHERS FED LAB'S PROPENSITY,T2-"OTHER" CATEGORY

Category label	Code	Count	Pct of Responses	Pct of Cases
	0	1	.5	.5
	1	4	1.9	1.9
	2	5	2.4	2.4
	3	1	.5	.5
	4	6	2.8	2.8
	5	12	5.7	5.7
	6	16	7.6	7.6
	7	25	11.8	11.8
	8	56	26.5	26.5
	9	85	40.3	40.3
	Total responses	211	100.0	100.0

77 missing cases; 211 valid cases

APPENDIX C

POLICY & REGS AWARENESS

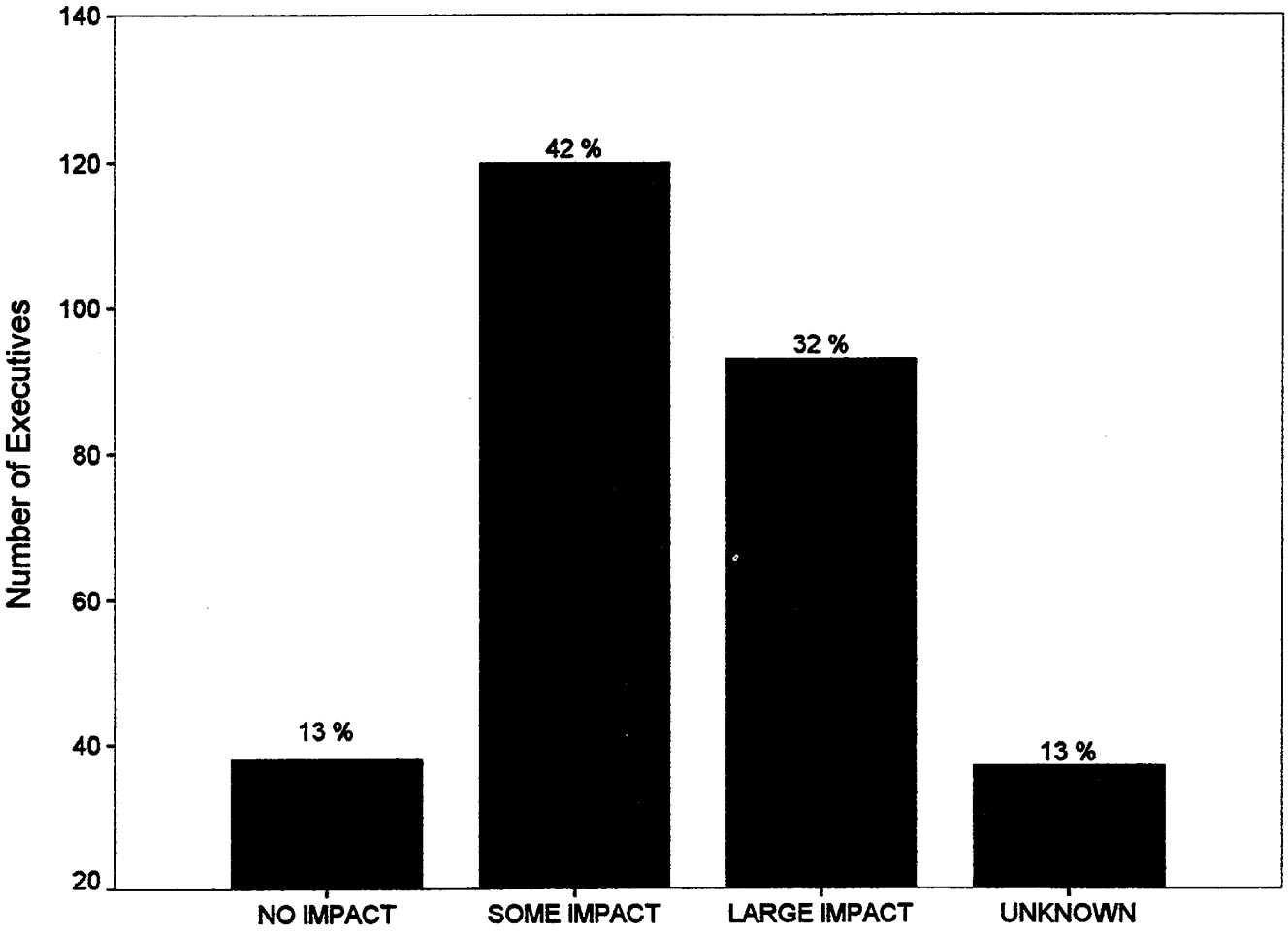


(No missing cases)

(rounding error sums to 101%)

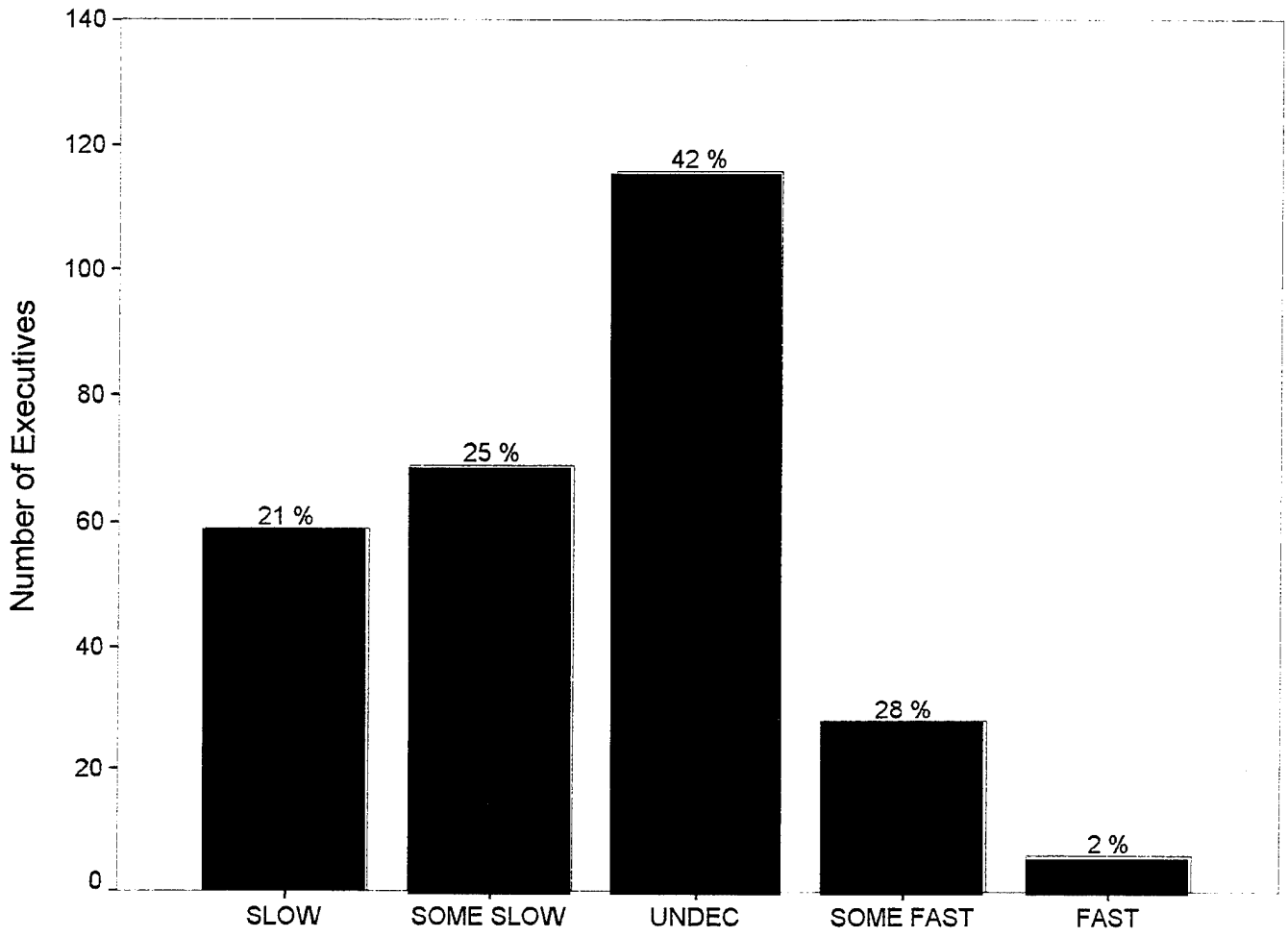
	POOR Sum	FAIR Sum	UNDEC Sum	GOOD Sum	EXCELLENT Sum	# OF CASES
# Executives - Question 1	37	91	22	127	11	288

T2 IMPACT ON CAREER



(No missing cases)

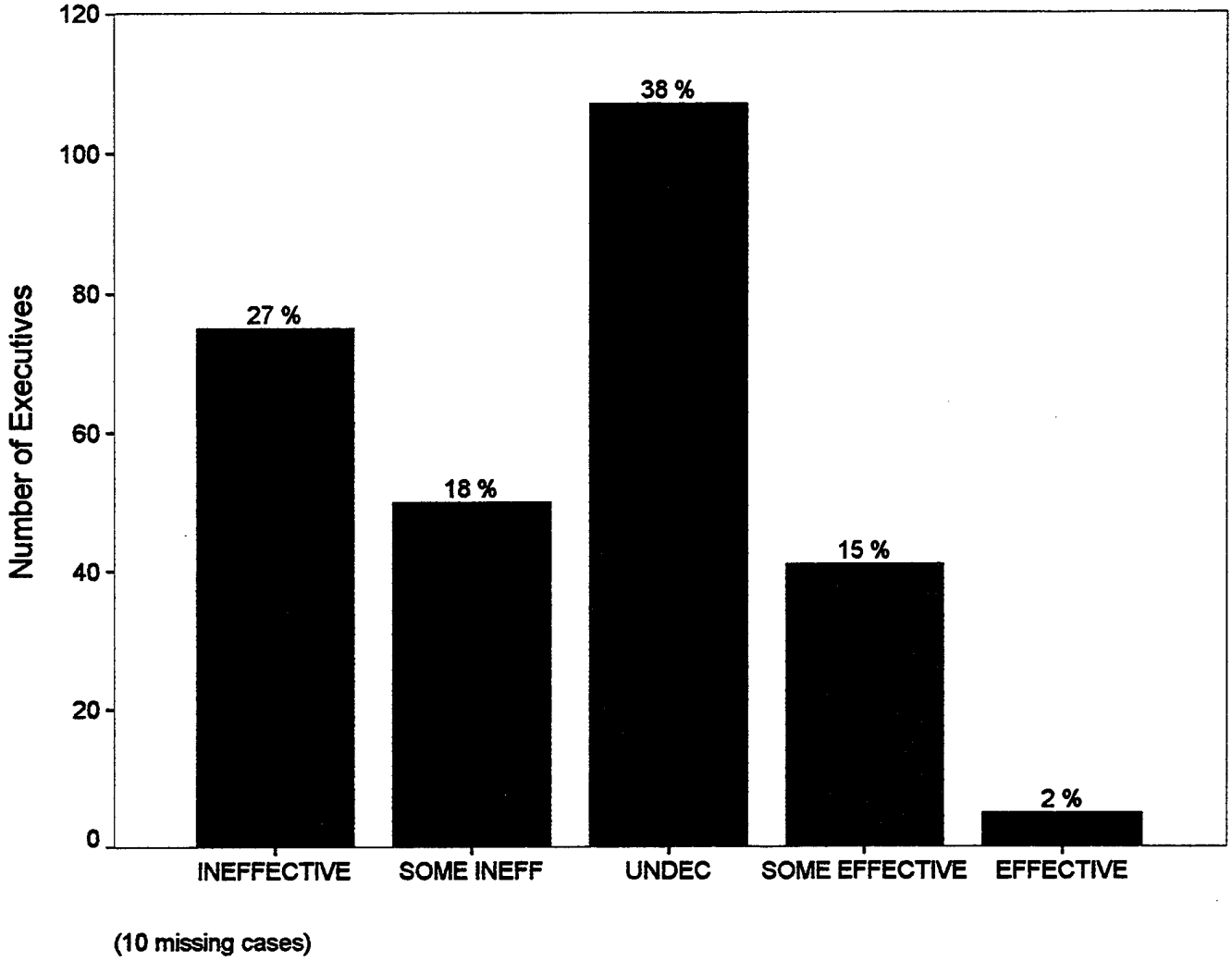
IMPACT Sum	IMPACT Sum	IMPACT Sum	UNKNOWN Sum	# of cases
# Executives - Question 2				
38	120	93	37	288



(10 missing cases)

SLOW Sum	SLOW Sum	UNDEC Sum	FAST Sum	FAST Sum	# CASES
Ques. 4:	No. of Executives				
59	69	116	28	6	278

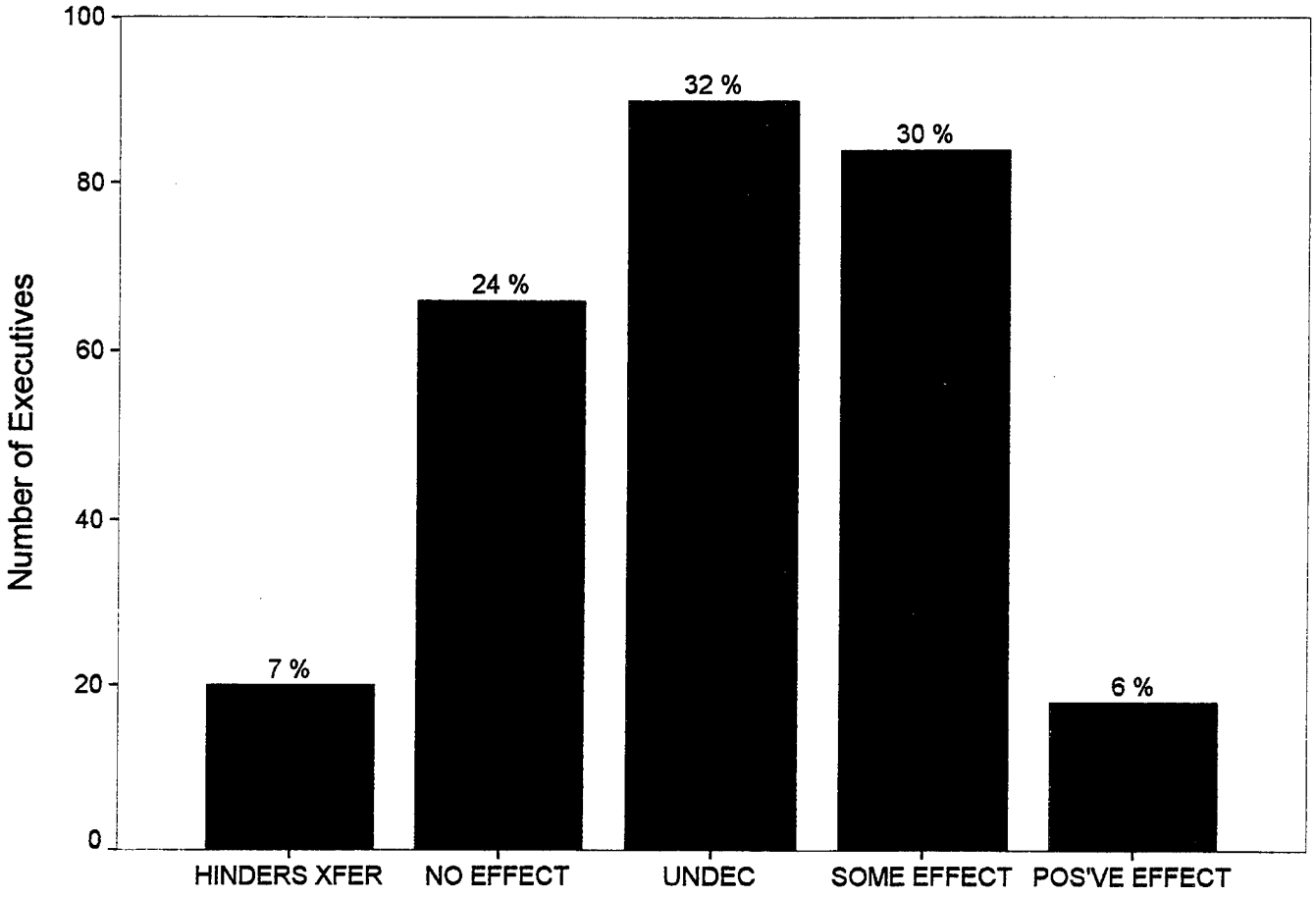
MIS' EFFECT ON T2



(10 missing cases)

INEFFECTIVE Sum	INEFF Sum	UNDEC Sum	EFFECTIVE Sum	EFFECTIVE Sum	# of cases
# Executives - Question 5					
75	50	107	41	5	278

R&D PROJ. SELECT EFFECT ON T2



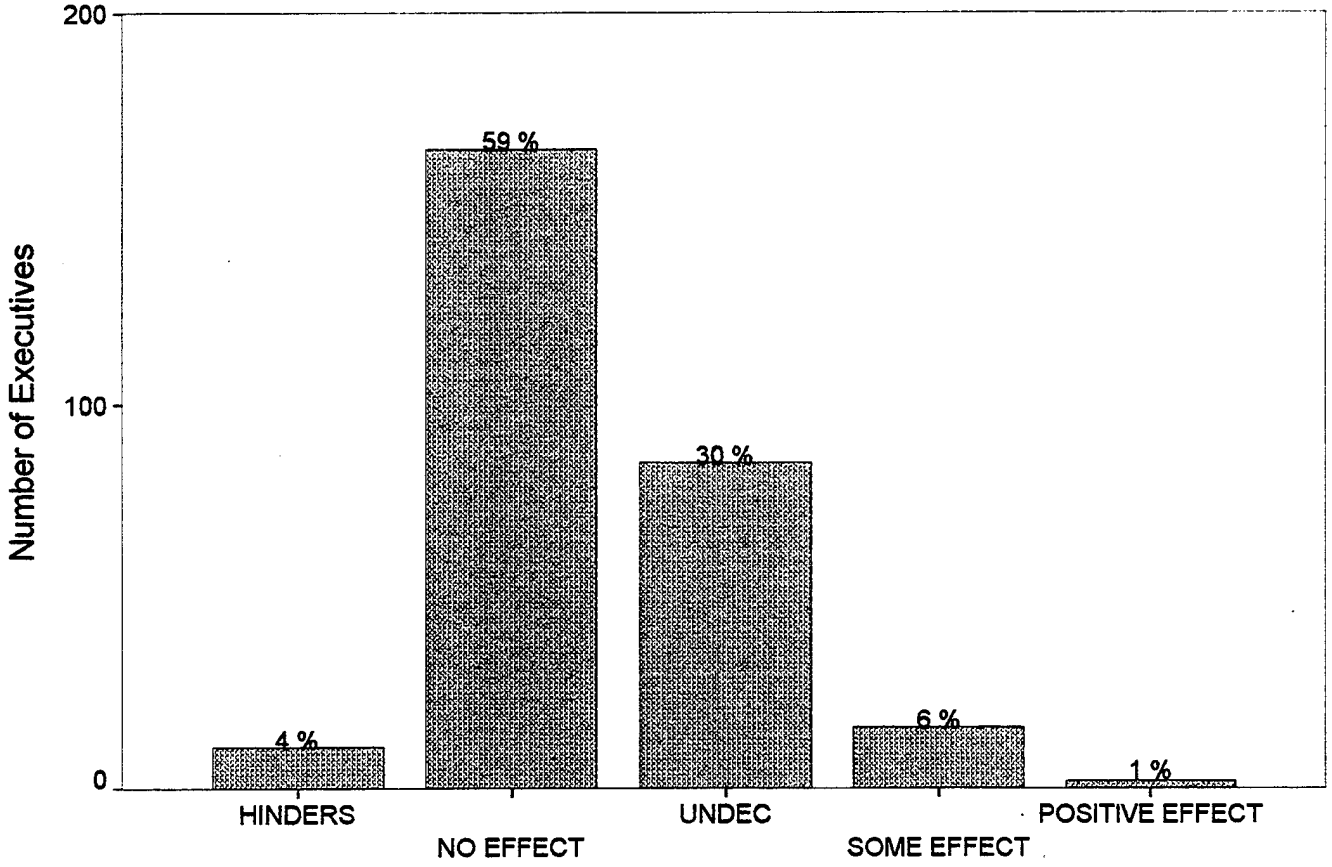
(10 missing cases)

(rounding error sums to 99%)

XFER Sum	EFFECT Sum	UNDEC Sum	EFFECT Sum	EFFECT Sum	# of cases
# Executives - Question 6					
20	66	90	84	18	278

CASE FILE UTILITY ON T2

Order and Contents



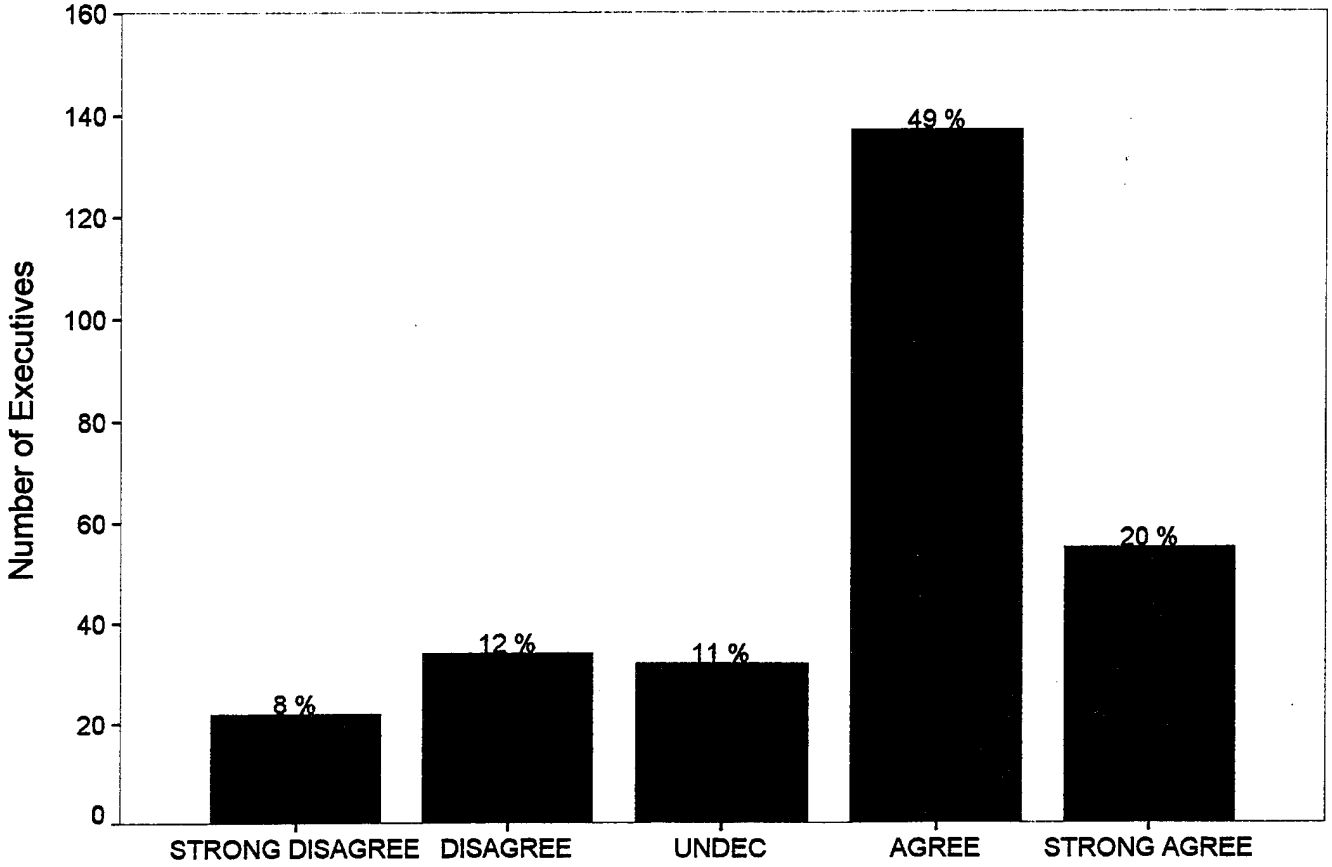
(9 missing cases)

HINDERS Sum	EFFECT Sum	UNDEC Sum	EFFECT Sum	EFFECT Sum	# of cases
# Executives - Question 7					
11	165	85	16	2	279

APPENDIX D

PUBLIC FUNDING OF LAB "FEDS"

Visits, Equip. Moves, and Relocations

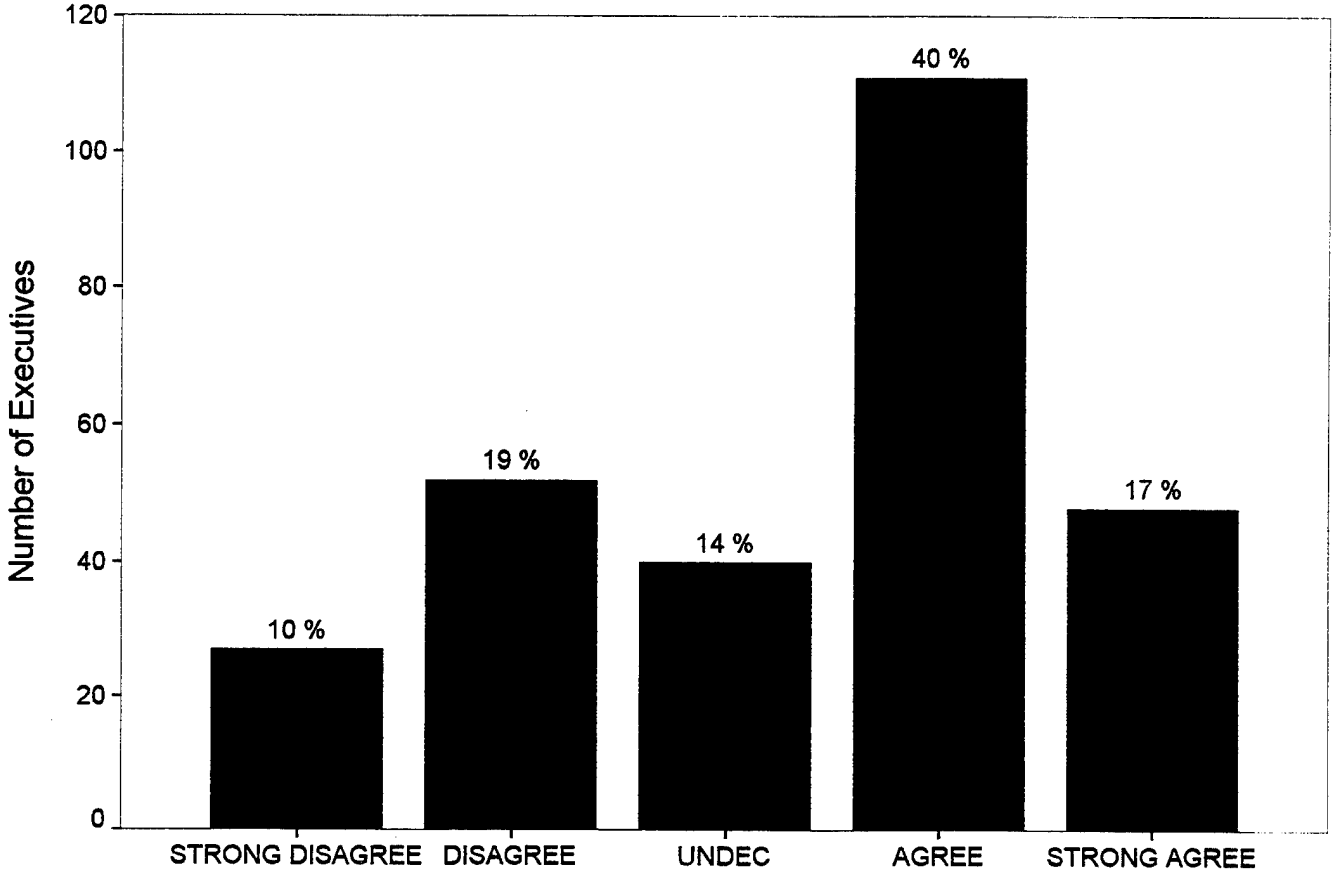


(8 missing cases)

DISAGREE Sum	DISAGREE Sum	UNDEC Sum	AGREE Sum	AGREE Sum	# of Cases
# of Executives - Ques 8					
22	34	32	137	55	280

PUBLIC FUNDING OF U.S. INDUSTRY

Visits, Equip. Moves, and Relocations



(10 missing cases)

STRONG DISAGREE Sum	DISAGREE Sum	UNDEC Sum	AGREE Sum	STRONG AGREE Sum	# OF CASES
# of Executives - Ques 9					
27	52	40	111	48	278