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THESIS

NON-MONETARY PERFORMANCE METRICS FOR USE IN A TECHNOLOGY EXCHANGE ORGANIZATION

by

Rick T. Taylor

June 2001

Thesis Advisor: David R. Henderson
Associate Advisor: Brad R. Naegle

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The Joint Technology Exchange Group (JTEG), a part of the Joint Depot Maintenance Activity Group (JDMAG), exists to disseminate information on new technologies throughout the DoD depot community. Its objectives are to reduce redundancy and enhance the capabilities of depots, potentially lowering sustainment costs for the equipment they work on. However, because JTEG operates in a technology environment where financial benefits are vague and uncertain, JDMAG has identified a need to assess the effectiveness of the JTEG. To judge which attributes are most beneficial, this thesis performed a review of technology transfer, value of information, communication, and current performance measurements in organizations. Four depots were visited to understand their use of new technology. An analysis of the roles and abilities of JTEG and needs of the depots is done, and metrics are developed to properly capture the effectiveness of JTEG. Performance metrics are based on balanced scorecard methodologies to emphasize effort that is linked to goals. The study finds the service JTEG supplies is not in line with what depots demand. The performance metrics highlight two major areas of activity for JTEG, processes and projects. Metrics generative are primarily non-monetary in nature, and bring visibility to how effort is linked to organizational goals. This study has applicability to other service-oriented, public organizations.

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NON-MONETARY PERFORMANCE METRICS FOR USE IN A TECHNOLOGY EXCHANGE ORGANIZATION

Rick T. Taylor
Lieutenant Commander, United States Navy
B.S., Aerospace Engineering, Iowa State University, 1987

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June 2001

Author: ______________________
Rick T. Taylor

Approved by: ______________________
David R. Henderson, Thesis Advisor

____
Brad R. Naegle, Associate Advisor

____
Kenneth J. Euske, Dean
Graduate School of Business and Public Policy

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ABSTRACT

The Joint Technology Exchange Group (JTEG), a part of the Joint Depot Maintenance Activity Group (JDMAG), exists to disseminate information on new technologies throughout the DoD depot community. Its objectives are to reduce redundancy and enhance the capabilities of depots, potentially lowering sustainment costs for the equipment they work on. However, because JTEG operates in a technology environment where financial benefits are vague and uncertain, JDMAG has identified a need to assess the effectiveness of the JTEG. To judge which attributes are most beneficial, this thesis performed a review of technology transfer, value of information, communication, and current performance measurements in organizations. Four depots were visited to understand their use of new technology. An analysis of the roles and abilities of JTEG and needs of the depots is done, and metrics are developed to properly capture the effectiveness of JTEG. Performance metrics are based on balanced scorecard methodologies to emphasize effort that is linked to goals. The study finds the service JTEG supplies is not in line with what depots demand. The performance metrics highlight two major areas of activity for JTEG, processes and projects. Metrics generative are primarily non-monetary in nature, and bring visibility to how effort is linked to organizational goals. This study has applicability to other service-oriented, public organizations.

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TABLE OF CONTENTS

I. INTRODUCTION 1
  A. PURPOSE 2
  B. RESEARCH QUESTIONS 3
  C. THESIS OUTLINE 5
  D. EXPECTED BENEFITS OF THIS THESIS 6

II. BACKGROUND 7
  A. JOINT TECHNOLOGY EXCHANGE GROUP 7
    1. JTEG Mission 8
    2. JTEG Organization 9
  B. INFORMATION AND COMMUNICATION 11
    1. Value of Information 13
    2. Communication 15
  C. TECHNOLOGY TRANSFER 17
    1. Technology Transfer Defined 18
    2. Technology Transfer Strategies 21
    3. Technology Transfer Methodologies 22
  D. PERFORMANCE METRICS 25
    1. Non-monetary Metrics 25
    2. Performance Measurement in DoD 27
  E. MEASURING TECHNOLOGY TRANSFER 28
  F. SUMMARY 31

III. JTEG AND DEPOT STUDY 33
  A. RESEARCH APPROACH 33
  B. JTEG VISITS 34
    1. JTEG Strategy 35
    2. JTEG Purpose and Success 37
    3. JTEG Metrics 39
  C. DEPOT VISITS 40
    1. Naval Air Depot Visit 40
      a. NADEP's Technology Activities 40
      b. NADEP's Relationships 41
    2. Marine Corps Logistics Base Visit 42
      a. MCLB's Technology Activities 43
      b. MCLB's Relationships 44
    3. Naval Shipyard 45
      a. Naval Shipyard Technology Activities 45
      b. Naval Shipyard Relationships 47
    4. Air Logistics Center Visit 47
      a. ALC Technology Activities 48
      b. ALCs Relationships 49

D. SUMMARY OF DEPOT VISITS....50
E. SUMMARY....52

IV. METRICS ANALYSIS....55
A. JTEG'S COMPETENCIES....55
1. Outcomes....57
2. Inputs and Outputs....57
B. METRICS....58
C. PROCESS METRICS....58
1. JTEG Meetings....60
2. Points of Contact....62
3. JTEG Visits....63
4. Newsletters....63
5. Demonstrations/Validations....64
6. Feedback....64
D. PROJECT METRICS....66
1. Project Inputs from Depots....66
2. Projects....68
3. Success Stories....71
E. VALUE ADDED....72
F. SUMMARY....73

V. CONCLUSIONS AND RECOMMENDATIONS....75
A. CONCLUSIONS....75
B. RECOMMENDATIONS....78
C. SUGGESTED FURTHER STUDIES....80

APPENDIX A. JTEG PROJECTS....81

APPENDIX B. PERFORMANCE METRICS....111

APPENDIX C. INTERVIEW QUESTIONS....113

APPENDIX D. DEPOTS VISITED....115

APPENDIX E. DEPOT RANKING CRITERIA....117

LIST OF REFERENCES....123

INITIAL DISTRIBUTION LIST....129

LIST OF FIGURES

Figure 1. DoD Maintenance Depot System (from JDMAG, 2001). 10
Figure 2. Message Equivocality/Media Richness For Communication Effectiveness (from Trevino, Daft & Lengel, 1991). 16
Figure 3. Technology Transfer At Three Levels Of Involvement (from Gibson & Smilor, 1991). 20
Figure 4. Technology Transfer Process (from Kingsley, Bozeman & Coker, 1992). 23
Figure 5. Technology Transfer Grid (from Gibson & Smilor, 1991). 24

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LIST OF TABLES

Table 1. Metrics For Exchange Process. 59
Table 2. Metrics For Technology Inputs. 66
Table 3. Metrics For Technology Projects. 69

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I. INTRODUCTION

This research explores performance metrics that can capture the operational characteristics of the Joint Technology Exchange Group (JTEG), a technology transfer organization within the Department of Defense's (DoD) Joint Depot Maintenance Activities Group (JDMAG). This technology transfer organization is charged with helping maintenance depots increase efficiencies through information exchange. Because JTEG does not have direct funding for development of new technologies, traditional financial measures typically used for organizational performance do not apply. Non-monetary aspects of the organization's operations and benefits of the projects it tracks are the only types of measures that can capture the organization's ability to meet its mission goals and objectives.

Non-monetary metrics and measuring the effectiveness and benefits of new technologies are ubiquitous and controversial; there is no definitive way to model or measure the process. To establish the success or failure of an organization, it is necessary to have some indicators, monetary or otherwise, of how well the organization is meeting its objectives. This is especially relevant in public organizations, in which success is not measured by the bottom-line profitability used in the private sector. This study focuses on non-monetary metrics that can be used by the JTEG group and its superior organization, JDMAG, to judge how well it is meeting its mission statement and supporting the mission of its users, the maintenance depots.

A. PURPOSE

The Joint Technology Exchange Group (JTEG) exists to help achieve new products or practices that make the depots more effective. In accomplishing this, the governing body of JDMAG, JG-DM (Joint Group Depot Maintenance) has identified a need to accurately measure the value of the service JTEG provides to its customers, the depots. Since attributing monetary benefits of JTEG was usually not possible, and no other metrics had been identified, measuring JTEG's effectiveness was problematic. Anecdotally, JTEG personnel concluded that there were benefits to the technology information exchange and insertions; however, no practical metrics were employed to measure any of those successes. What metrics, besides monetary cost savings, should be used to accurately assess the value of the information exchange and subsequent technology insertions? This question is the focal point of this thesis.

Depot-level maintenance is a primary source of sustainment and readiness to operating forces. To achieve maximum efficiency, the twenty-four organic DoD maintenance depots are continually exploring ways to improve their products or processes. Improved technologies in material or processes can lower life-cycle support costs for existing weapon systems and their supporting structure.

JTEG provides a potentially valuable service to depots. Ideally, it provides the depot community with information about the latest developments in other depots and in private sector companies. Examples of potential areas of improvement are performance, readiness, quality of life (safer, easier, timelier, more efficient, less burnout), transportability, storage requirements, environmental, and process time. Other savings might include reduced training time, reduced technical publications, or remote site capability. Even if a depot does not ultimately use newly developed technologies, having knowledge of features that are *not* desirable to a depot may save time and resources better spent elsewhere. These positive benefits can be realized through information exchange and reduced search time, services that JTEG provides.

New technologies inserted in a depot's operation may offer potential benefits that cannot be related directly to cost data. New technologies are not typically end items, but, rather, are enhancements to equipment or processes, such as an improved way to paint or weld. Estimating the value of the information JTEG provides is important.

Done properly and used effectively, technology exchange between depots should lower costs for the *entire* depot system. Sharing the technology of products and processes can potentially make the defense depot organization as a whole, more competitive with private industry, which is important in the current fiscally restrained DoD environment, with its outsourcing and budgetary pressures. Military equipment is becoming older, on average, requiring more sustainment by the depot-level maintenance organizations. Dealing with ways to lower total life-cycle costs through technological improvements of depot activities has potentially far-reaching savings. Acquisition programs, through acquisition reform, are now investing considerable effort in life-cycle sustainment costs, and introduction of new technologies early in a program's development can obtain large cost benefits throughout the life of a project.

B. RESEARCH QUESTIONS

The primary goal of this research was to explore the environment in which JTEG operates, the role JTEG plays in technology transfer, and how best to capture the important elements of JTEG's performance. To that end, the following primary research questions were used:

1. What are the best metrics to use to capture the performance of the technology information exchange group?
2. What is the definition of success at the technology exchange organization?
3. How does the added value of technological exchange relate to readiness, surge capacity, process time, and reduced logistical requirements of supported systems? Are any of these accurately measured now, and do they reflect back on the value of the joint technology exchange group?
4. Is a general system of cataloguing objective and subjective metrics feasible in the framework of the exchange group?

The secondary research questions deal primarily with the views and actions of the depots, JTEG's primary customers. Although there are few hard data on the decision-making processes, a general notion of the challenges depots face and how they approach technology implementation is important to ensure that JTEG is working to provide them with valuable information. These questions are:

1. What are the users' (customer depots') organizational values?
2. What is the value of information/networking exchange (in general)?
3. Is there value to depot participation in the information exchange even if it doesn't immediately apply any of the new technology?
4. What are the opportunity costs and the benefits of choosing a new technology? How much value must be added to proceed with a technology insertion?
5. What are measurable values of a technology that replaces a process already doing the same job? (e.g., a better way to weld). Do technological advances in products have the same metrics as improved processes?
6. What value does the exchange service add that the individual depot does not already have?

C. THESIS OUTLINE

The methodology used in this thesis research consists of the following steps:

1. Conduct a literature search of books, magazine articles, CD-ROM systems, and other library information resources.

2. Interview JTEG, review consultant report to gain insight of JTEG operations and responsibilities.

3. Interview depot commanders and technical professionals to sample organizational values.

4. Review data of existing similar organizations that specialize in technology transfer.

4. Identify core competencies of Information Exchange Organization.

6. Determine accurate metrics to measure effectiveness of technology exchange group.

This thesis is structured as follows. Chapter II provides background information on JTEG, as well as a literature review of performance measurement systems, their applicability in the technology exchange area, and a review of information exchange and communication. Chapter III outlines the methodology for addressing the problem, includes the methods and results of depot interviews, and outlines the framework of the metrics analysis JTEG can use. Chapter IV brings together the ideas from Chapter II and the interviews from Chapter III. Chapter IV also identifies the most promising metrics JTEG can use to measure its performance and how these derived metrics on past and current projects of the Joint Technology Exchange Group can be applied to demonstrate the value of the group. The analysis looks at benefits for internal-depot processes and depot-supported systems, such as aircraft, vehicles, and ships. Chapter V makes a recommendation for implementing the metrics to allow JTEG to more effectively exchange and promote new technologies. Chapter V also includes recommendations for additional research related to technology exchange.

D. EXPECTED BENEFITS OF THIS THESIS

This study provides the information necessary to assess the effectiveness and value of the Joint Technology Exchange Group. More generally, benefits from technology information exchange, if properly identified, can justify technology incorporated to support specific platforms. The study focuses on the value of information and other measures not easily quantifiable in monetary terms. In addition to providing JTEG with more-definitive measures, this study may also benefit potential users of new technology, such as program managers who use these ideas to assess the potential benefits of technology insertion in their programs. The study should also be useful to other organizations that specialize in providing an information conduit between users.

This thesis is not a "better business practice" study. It does not attempt to identify needed improvements in the management of the JTEG, only to identify metrics to judge the group's effectiveness in meetings its customers' needs.

II. BACKGROUND

This chapter provides background on the JTEG organization and the environment in which it functions. First, JTEG's organization and mission is described. Next, the value of its information and the communication of its knowledge is examined, with an emphasis on describing the challenges of an information exchange process. Following this, the chapter examines aspects of technology transfer, concentrating on framing the process of transfer and the different roles that JTEG plays in the process. Performance metrics, with emphasis on non-monetary measures, also are discussed. Finally, the chapter brings together the ideas of technology exchange and performance measurements, looking at the metrics applicable in the technology exchange arena. The ideas presented in this chapter provide a framework for ideas in later chapters.

A. JOINT TECHNOLOGY EXCHANGE GROUP

Joint Technology Exchange Group was created to improve coordination in the introduction of new technology, processes, and equipment into DoD depot maintenance activities. JTEG and its parent organization, JDMAG, are part of the Joint Depot Maintenance Program which is operated by the flag-level Joint Group on Depot Maintenance (JG-DM). The purpose of JG-DM is to foster and develop a strong corporate environment across the DoD maintenance depots. (JDMAG Website). The establishment of JTEG and JDMAG reflects an effort throughout the U.S. Government's effort throughout the 1980s to foster technological growth throughout the U.S. and to make the DoD operate more jointly to capitalize on service-specific areas of expertise.

In 1980, the Stevenson-Wydler and Bayh-Dole Acts were signed into law. These were followed in 1986 by the Federal Transfer Act and, in 1989, the National Competitiveness Technology Transfer Act (Wood & Eernisse, 1992). These Acts collectively encouraged federal Research and Development activities to transfer technology to private sectors, with the intent of making the country's overall economy stronger. The combined legislative effort had a number of effects, including the development of the Offices of Research and Technology Application (ORTAs) in each federal laboratory, the Cooperative Research and Development Agreements (CRADAs) between federal laboratories and private enterprises, and the general easing of antitrust barriers, allowing easier formation of multi-corporate, public and private consortia.

In this environment of encouragement for technology transfer; JTEG was created to capitalize on the R&D opportunities in the depot environment.

1. JTEG Mission

JTEG was chartered by the JG-DM in 1984. In 1998, the JG-DM assigned the technology exchange mission to JDMAG, and JTEG came under JDMAG administration. JTEG's mission statement is:

> to improve coordination in the introduction of new technology, processes and equipment into DoD maintenance activities. The JTEG will seek ways to avoid unnecessary duplication in the areas of technology improvement. (JDMAG website, 2001).

To do this, JTEG has identified the following functions in its Standard Operating Procedure:

1. Identify depot maintenance requirements for new and emerging technology, processes and equipment.

2. Review current technology projects, maintain status of new technology developments, and facilitate coordination among the services to minimize duplication-associated costs.

3. Identify ways to improve the capability or efficiency of the depot maintenance community.

4. Recommend a lead service, if necessary, to develop necessary prototypes. (JDMAG Website, 2001)

JTEG, then, facilitates exchange among internal DoD activities and the depots, as well as among external DoD activities, including consortia, universities and private organizations, with the intent of making their DoD depot customers operate more efficiently. The type of technologies JTEG concerns itself with address improvements to existing products and processes primarily. Since these technologies do not fundamentally change the nature of the work depots do, JTEG's effort remains within the requirements of Title 10,U.S. Code, which governs depot level maintenance.

2. JTEG Organization

JTEG is part of the joint component of the DoD depot infrastructure. JTEG does not report to the depot commanders themselves; instead, through JDMAG, it runs through the JG-DM, ultimately to the Joint Logistic Command (JLC). The JG-DM and JLC are not permanent commands; they are ad hoc groups made up of logistics and depot commanders from the various services. There are 24 organic maintenance depots, about 20 of them major activities. The entire depot system employs over 64,000 people with $15 billion in expenditures, repairing equipment ranging from small arms to huge capital ships, and everything in between. Figure 2-1 shows the current depot locations. This gives a sense of the geographical and industrial diversity of the depot system.

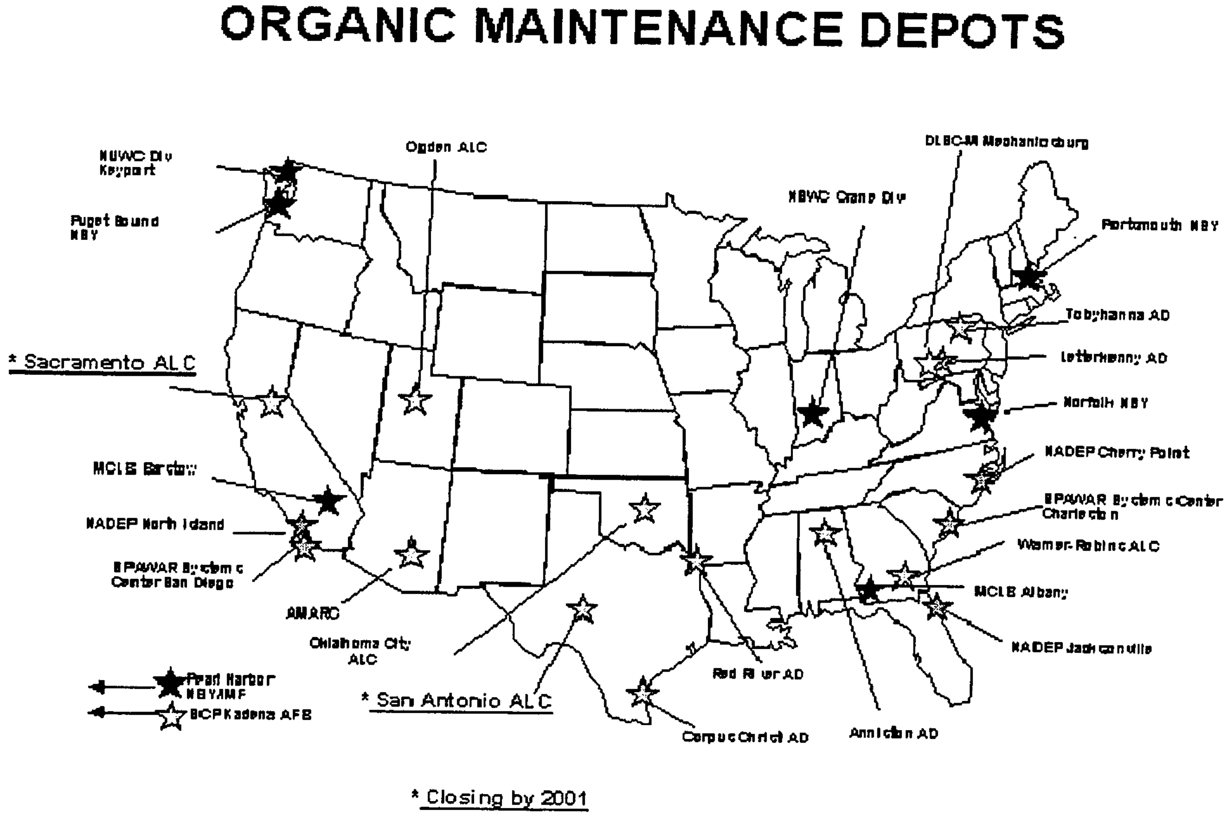


Figure 1. DoD Maintenance Depot System (from JDMAG, 2001).

JTEG is organizationally small. It has two full-time and one part-time staff, located at JDMAG headquarters at Wright-Patterson Air Force Base (WPAFB), in Dayton, OH. Additionally, there is an immediate supervisor, followed by the civilian deputy director and finally the director of JDMAG, a Navy Captain or Air Force Colonel.

The director is also the chair of the JTEG executive committee. This committee is comprised of the core JDMAG staff mentioned above and service principals representing each branch of the DoD. These principals, who come from systems or material headquarters, provide the committee with a broad-based, multi-service experience level.

JTEG uses a number of methods to communicate with the depots and other technology participants. One of the primary methods is the JTEG meeting, held three to four times a year at various locations throughout the country. This is a forum for internal and external developers to brief the depot community on their products. Another method is a website containing information on upcoming events, projects currently tracked and minutes from past meetings. Other means include e-mail, published circulars, and phone contact.

JTEG holds information of present and past projects in a database. Some of these projects are listed on the website, and additional information can be obtained by contacting the JTEG staff directly. In addition to a description of the project, one can find out if it is active or inactive, what its current status is, and other information. Minutes from JTEG symposiums also contain data on various projects. About two years of meeting minutes are posted on the website.

JTEG was reviewed by a management consultant (Fox, 2000), and the program evaluation report highlighted areas for possible improvement. The review's recommendations were structured around management practices and were not necessarily related to the peculiarities of technology exchange. As a result, the recommendations for improvement were not linked with the goals and strategies to make technology exchange successful at JTEG. This thesis expands on some of the ideas in the program evaluation report and links measures that provide indicators of strategic goals accomplishment.

B. INFORMATION AND COMMUNICATION

Before technology transfer is introduced, the general notion of how information and its communication play in an exchange will be discussed. Since JTEG is primarily a broker of information, some insight into the economic value of information will provide a foundation for evaluating JTEG's performance.

Intuitively, there is power in information held by one person over another. A market is the classic example of deciding how much information costs and leveling out the costs between buyer and seller. The seller will place an item on the market and, depending on the amount of information both the buyer and the seller have, a value will be determined. If the seller has information that will cause the buyer to offer a lower price, then the seller has valuable information. To get all the information about an item, a person would need to invest more of his time. In effect, he is substituting time for dollars (assuming he will find the lowest, or close to the lowest, price). Price conveys much information in markets. If a buyer is willing to pay a market price, that is essentially all the further he has to go in searching for that product (Henderson, 1999). Not having price information is one of the pitfalls of a technology exchange.

This lack of information is typically due to the immaturity of the product; there is no established market yet. The pace of introduction depends on how well information is transmitted and assimilated. Prices charged may not reflect the true value of the technology. For example, if royalties or licensing fees are charged, they may not reflect how much the buyer values the product, preventing the purchase. In the absence of meaningful prices, attempts to infuse a technology may not convey the importance of the technology. Something given away for free implies that it is not as valuable as something that costs $100.00. Information transmittal in this environment is strewn with obstacles. In the absence of true markets, organizations like JTEG can bridge some of the information gaps that exist with a developing commodity.

1. Value of Information

> The economic problem of society is . . . the utilization of knowledge not given to anyone in its totality. (Hayek, 1945)

No one can have complete information about something; in fact, it would be difficult, if not pointless, to get information about many things. For instance, Read makes the point that to use (or buy) a pencil, a person does not need to know how the wood was milled, the chemical process for making the eraser, or the transportation requirements to bring it to market. All a person needs is a desire to own a pencil and what the price is (Henderson, 1999).

Lacking the information provided by a market price, an exchange organization such as JTEG fills in some of the information gap. The central point of Friedrich Hayek's seminal article on information, quoted above, is crucial to an exchange organization, which can reduce search costs in exchange. If there is perfect information by everyone in a transaction, there is no need for search and no costs in terms of time, price, etc. However, since no one has perfect information, there are always costs of search, or conversely, costs of not searching. Identification of sellers or buyers and discovery of price create search costs, and markets exist to reduce these costs. For example, a department store is a market where people go to buy clothes, shoes, etc. Knowing that it is a department store signals the buyer what products it offers, thus reducing search costs. Storeowners have a higher chance of selling to buyers who are armed with knowledge of what the store sells when they walk through the door (Stigler, 1961).

Public information results in societal benefit, whereas private information does not (Heirshleifer, 1973). By having information that is not hoarded, society—or in the case of this research, the depot system—can be improved. Having access to information lets a user of that information better weigh his options by having better estimations of his opportunity costs. Many costs can be directly measured or accurately estimated, while others cannot. Information helps answer the basic question of opportunity cost of a technology; that is, if a technology is implemented, what was given up because of it? Many times, decision-makers must evaluate this question subjectively. Experience, the business environment, and intuition all play a part in deciding which factors, monetary and non-monetary, are more important than others.

In gathering information about an innovation, information does not come all at once, but flows. So users must reevaluate the probability of gain if a technology is implemented now versus waiting for more information to come in (McCardle, 1985). Models have been developed to describe this action, but it is important to realize that this reevaluation occurs formally or informally (McCardle, 1985). This is relevant in the technology exchange organization because, lacking indicators a mature market might provide, information provided to the depot customers can affect this continual reassessment of technology innovations. The good of something may not be apparent until more information is gathered. Ultimately, no one can gain all the information required, and there are dynamics in waiting for the 'appropriate' level of information to make a decision. The dilemma is this: jump in too early, and possibly get stuck with a white elephant; or, wait until it's too late, and watch the industry pass you by.

Like all organizations, maintenance depots face decisions of this nature every day. By capitalizing on available information, the probability of a correct decision increases (installing technology that pays off or holding back on technology that would not work). JTEG offers an avenue to increase these probabilities.

2. Communication

Central to JTEG's effective operation is its ability to communicate with a wide variety of entities. As mentioned previously, JTEG uses a number of communication media. How the message is communicated is just as important as the content of the message. A few key points about communicating in a complex environment are worth highlighting.

The first is the nature of the communication—is it asymmetric or symmetric? That is, is it one-way communication or two-way feedback? Most people feel that they communicate effectively, but asymmetric communication is common. Web sites, circulars, and fliers are examples of one-way communication. Even when using other media, it is easy to for the sender to assume that someone has received the message when, in fact, he or she either did not physically receive it or did not internalize the message as the sender intended. Symmetric communication alleviates this problem by ensuring that the sender receives feedback indicating that the message was received and understood correctly (Trevino, Daft & Lengel, 1999). The richness of the communication should match the content.

The richest form of communication is face-to-face in that it offers the benefits of two-way communication. Descending in richness are phone calls, e-mail, letter, memo, report, fliers and bulletins, respectively. Not every message needs to be conveyed with the richest form of communication, but, for effective communication, the message and the form of media must match. Asymmetric communication can be appropriate for some messages; an advertisement in a newspaper can suffice to announce an upcoming baseball game (one-way communication). But to invite an important acquaintance to a game, a richer form (face-to-face or phone call) is more appropriate. Figure 2-2 represents the importance of matching the message to the method (the richness).

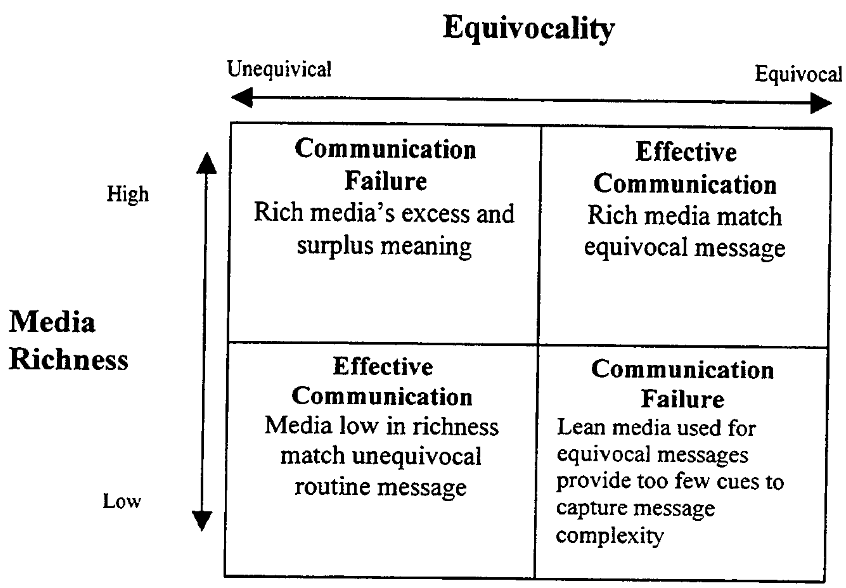


Figure 2. Message Equivocality/Media Richness For Communication Effectiveness (from Trevino, Daft & Lengel, 1991).

Equivocal messages are messages that are non-standard or that may be construed in different ways. These should be conveyed via a richer media. Unequivocal, or routine, messages require only lean media. Just as using too lean a media for an equivocal message may not result in the required connection, using too rich a media for relatively routine messages may connote an importance that does not exist. This model is particularly relevant for JTEG since many of the technologies it deals with are not well defined (high equivocality). On the one hand, the developers have the best knowledge of what their new process can do; on the other hand, the potential adopters of the process know their own needs. Because this information gap may be quite large, the form of communication between developer and adopter is a critical element of transfer.

An example of how difficult communication is in technology transfer comes from the Palo Alto Research Center (PARC), a research arm of Xerox Corporation in Silicon Valley. In the 1970s, PARC developed may of the elements of the desktop personal computer, including the Graphical User Interface (GUI), which is how virtually all PCs are now operated (the mouse point-and-click). The product engineers at headquarters in Dallas saw little utility in these embryonic ideas and, because the researchers at PARC failed to convey the potential of their inventions, the technology ended up in the hands of Steve Jobs, who took it and created Apple, Inc. Even within the same company, poor communication of information between the developers (PARC) and the adopters (headquarters) led to a huge mistake—Xerox let impressive technology slip through its hands (Brown, 2000).

Successful communication can be difficult within an organization's internal structure, and the barriers to communication increase as organizational boundaries are crossed. But to have effective information transfer, the links between developer and adopter must be established through meaningful communication channels. An information exchange organization that communicates well provides a crucial linkage in the transfer of technology.

C. TECHNOLOGY TRANSFER

> Karl Marx and Adam Smith both agreed that in the long run, economic progress is determined by technological change (Stewart, 1987).

Technology transfer implies that there is a better way of doing something. It also suggests that producers are not maximizing efficiency if they have not switched to the new technology.

If an assumption is made that a producer (say, a depot) is producing efficiently at the start, and then a technology comes along that is superior to the current one, then that depot is no longer efficient, even though there was no change in its operation. With the new technology, the depot could do the same job with fewer resources, or, alternatively, using the same input resources, it could produce more. Its production possibility frontier has shifted. Transitioning to the new frontier is the realm of technology transfer. This section defines the terminology of technology transfer and discusses transfer strategies and methodologies.

To have transferred, there must be a sender and receiver. In the context of technology transfer, the sender, (the originator of the technology) will be referred to as the developer. The receiver is usually referred to as the adopter. The primary adopters with whom JTEG deals are the maintenance depots.

1. Technology Transfer Defined

Since the term "technology transfer" is nebulous—it depends on the context in which it is used—it is necessary to clarify the terminology used in this paper. Technology is a capability—that is, a physical structure or knowledge embodied in an artifact (software, hardware, methodology) that aids in accomplishing some task. Technology transfer involves some source of technology possessed of specialized technological skills that transfers the technology to a target group of receivers who do not possess those specialized skills (Leonard-Barton, 1990). Gibson and Smilor (1991) defined transfer as "the movement of technology via some type of channel: person-to-person, group-to-group, or organization-to-organization." There are terms that further refine the notion of "transfer," the two most common being diffusion and absorption.

The terms "transfer", "diffusion" and "absorption" are often used interchangeably, but they have slightly different meanings. Leonard-Barton (1990) uses diffusion to capture the spectrum of transfer modes, from point-to-point to a widely diffused audience. Another subtlety of diffusion involves the exploitation of the knowledge. Stewart (1987) states that all developers desire diffusion of use—having products or processes used by (sold to) a wide variety of users. However, transfer is the transfer of the knowledge of the technology itself, and once this is transferred, the developer cannot further capitalize on the technology. An example would be industrial secrets: companies want to sell their products, but do not want to give away the secret ingredients (Stewart, 1987). The second term, absorption, refers to the phenomenon of a developing partner incorporating new technologies into his own operation. In this case, the developer is also the user (Gibson & Smilor, 1991).

Figure 2-3 presents another model helpful in characterizing technology transfer. Level I, technology development such as research papers, journal articles, etc., is largely passive. The second level includes making the technology available to receptors(s) who can understand and potentially use the technology. The third level, the most involved, includes profitable use of the technology in the marketplace. This conceptual model of technology transfer is useful to keep in mind during follow-on discussions.

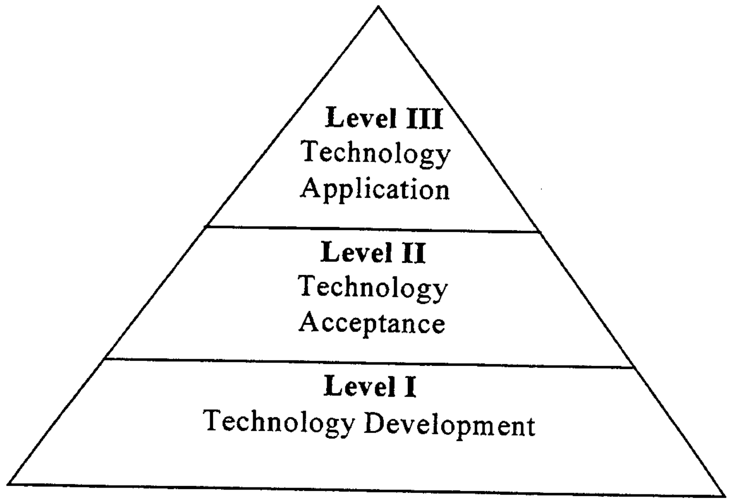


Figure 3. Technology Transfer At Three Levels Of Involvement (from Gibson & Smilor, 1991).

Between the developer and adopter, there can be a number of other participants who take on various roles. One key role is an intermediary, known as the sponsor, who links the developer to the adopter (Jolley & Creighton, 1983). The sponsor's function, in addition to linking, usually entails funding either the developer or the adopter to facilitate a transfer. A sponsor can belong to the developer's or the adopter's organization, or the sponsor can be an independent third party.

JTEG's role in technology transfer is that of intermediary, primarily linking developer to adopter. JTEG's developer can be a private organization with a new idea, a federal research lab, a consortium of private corporations, or even another depot. Linking these myriad activities with the diverse depot system is one of JTEG's challenges. To help clarify its role in the technology exchange process, two concepts will be addressed, strategies and methodologies.

2. Technology Transfer Strategies

A number of strategies for developing and transferring technologies have been identified. These identify the level of effort in accomplishing a transfer process. Shama (1992) identified four transfer strategies: passive, active, entrepreneurial and national competitiveness. Most activities deal in the first two.

Passive involves responding to a specific inquiry, helping either developer or adopter find a user for a technology that will solve a need. Passive strategy reflects a conservative culture. Typical activities within this strategy are distributing documents, attending meetings, and responding to phone inquires (Smith, 1995). Most federal laboratories, when thrust into the transfer activities of the 1980s, adopted this approach, but it increasingly has been shown ineffective in transferring technology (Spann, Adams & Souder, 1995; Wood & Eernisse, 1992; Gibson & Smilor, 1992).

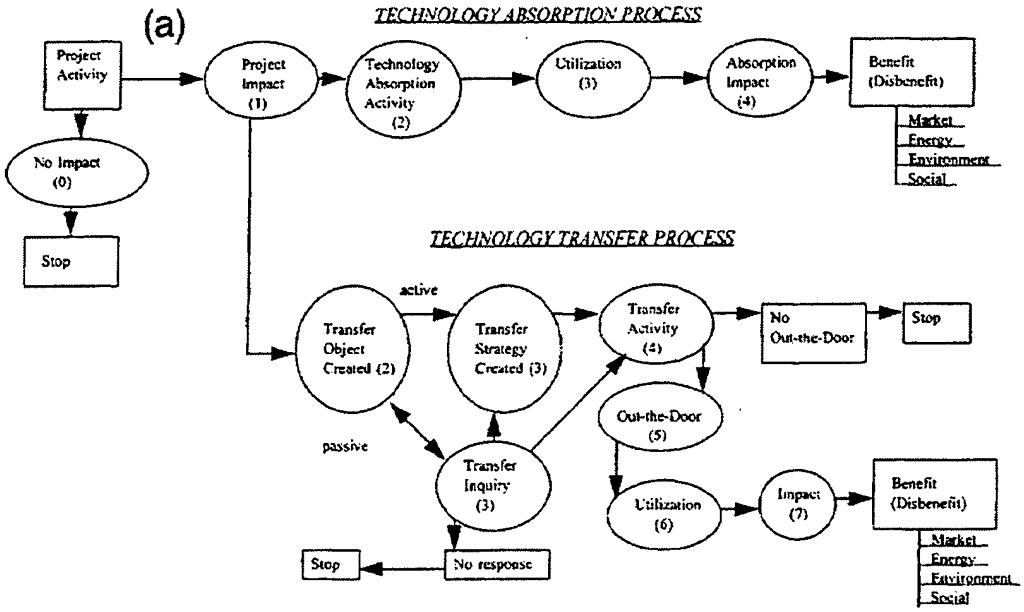
An active strategy builds on the passive strategy and actively attempts to market and install new technologies in the marketplace. In this case, the market is the depot system. This strategy seeks to actively improve the national economy and improve U.S. industry by shaping technology, often using licensing or CRADAs to implement the transfer (Smith, 1995).

The final two strategies are the entrepreneurial and national-competitiveness. The entrepreneurial offers the benefits of the passive and active and additionally encourages formation of new business to exploit the technology. This is essentially an implementer, as described above. The final strategy is the national-competitiveness model, which focuses on building the strength of the U.S. over other countries, building on the other strategies already mentioned. The essence of this strategy is to maximize the R&D benefits of the federal laboratories through widespread applications.

3. Technology Transfer Methodologies

Strategies affect the methodology of transfer. A number of models have been produced to capture the process of the transfer, including assimilation, information-dissemination, communication-based, cognitive-mapping and technology transfer continuum (Crutcher & Fieselman, 1994; Dorf & Worthington, 1987). These models range in complexity from intuitive to abstract, and each has informative aspects. Because it is beyond the scope of this study to analyze all models, two of the most applicable and complementary ones will be presented.

The first method maps the technology transfer process. It offers a logical representation of the flow and interactions to bring technology from developer to adopter (Kingsley, Bozeman & Coker, 1996). The lower arm of the model shows the transfer process, while the upper shows absorption. In this model, the process ends when the technology has made it "out-of-the-door" of the developer.



(b)

TECHNOLOGY TRANSFER STAGES

(0) *No Project Impact* -- the RD&D project did not produce an output.

(1) *Project Impact* -- the project produced scientific or technological output. The nature of this achievement may be independent of the goals of technology transfer.

(2) *Transfer Object Created* -- two forms of transfer object could be created by a project: a technological artifact or a report. Often both types were created.

(3) *Transfer Strategy Created* -- one of the organizations participating in the project develops a plan for disseminating the transfer object.

(4) *Transfer Activity* -- an organization participating in the project sends out the transfer object or information about the object.

(5) *Out-the-Door* -- a potential adopter receives the transfer object.

(6) *Utilization* -- a recipient attempts to use the transfer object in some fashion. Behaviors indicating utilization ranged from tests to local adaptations of the transfer object.

(7) *Transfer Impact* -- there is evidence that the transfer object had either a positive or negative impact on the recipient.

TECHNOLOGY ABSORPTION STAGES

(0) *No Project Impact* -- the RD&D project did not produce an output.

(1) *Project Impact* -- the project produced scientific or technological output. The nature of this achievement may be independent of the goals of technology absorption.

(2) *Technology Absorption Activity* -- an absorption object is produced by an organization participating in the project and either adopted by that same organization or received by another organization participating in the project.

(3) *Utilization* -- an organization participating in the project attempts to use the absorption object in some fashion. Behaviors indicating utilization ranged from tests to local adaptations of the absorption object.

(4) *Absorption Impact* --there is evidence that the absorption object had either a positive or negative impact upon the adopting organization.

Figure 4. Technology Transfer Process (from Kingsley, Bozeman & Coker, 1992).

While Figure 2-4 gives a clear view of the flow of technology, it does not fully capture the interactions between participants in the transfer process. Therefore, another model is offered to capture the quality of these interactions. This model uses the ideas presented in the communication model shown in Figure 2-2, but builds technology transfer emphasis.

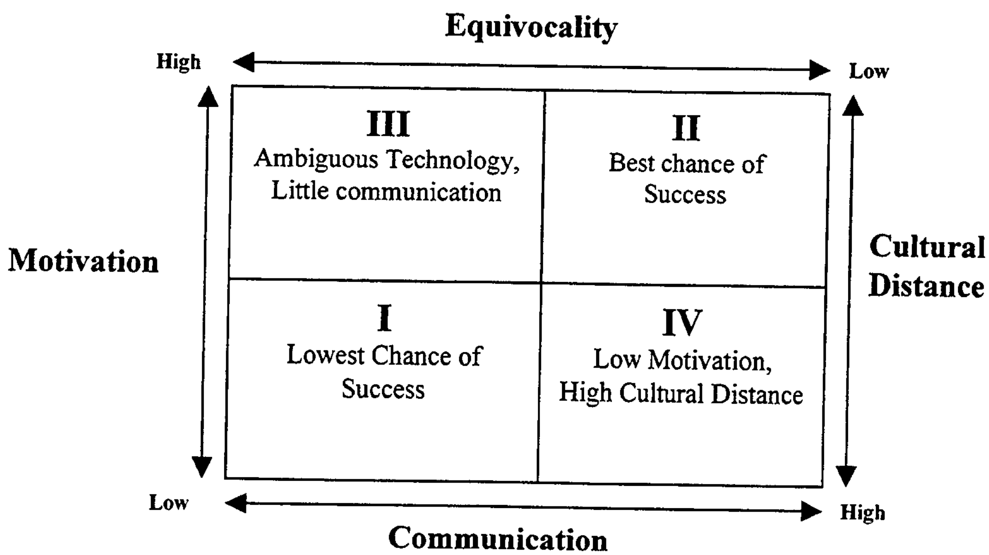


Figure 5. Technology Transfer Grid (from Gibson & Smilor, 1991).

Figure 2-5, the technology transfer grid, describes the quality of the links (arrows) in Figure 2-4. It relates the equivocality of the technology (how well defined it is), as well as the distance, motivation, and communication of the participants. The upper right (block II) has the highest chance of success because it has everything going for it: an unequivocal technology, high motivation and communication, and low cultural distances. Conversely, block I is the least likely to succeed in that everything is working against it. Blocks III and IV have competing factors that depend on the specific case (Gibson & Smilor, 1991). This model demonstrates the interlinking relationship between the different factors involved in a transfer; these interactions will determine the success or failure of a transfer.

Feedback in the transfer process is critical to the successful transmittal of information or ideas. Unfortunately, asymmetric, or one-way, communication is rampant and, as a result, many ideas and technologies are lost due to mismatches in the above factors.

D. PERFORMANCE METRICS

Attempting to measure the performance of an organization is fraught with difficulties. However, over the last decade, the increasing complexity and rate of change of technology in the world have driven organizations beyond the traditional methods of the past (Neely, 1999). Traditional performance metrics have focused primarily on financial issues, such as balance sheets, expense accounts, earnings ratios, rates of return on investment (ROI), etc. While these types of measurements are valid, they do not capture all of the elements that comprise a successful organization. Because of this, recent attention has focused on non-monetary performance metrics that should be considered when evaluating an organization.

1. Non-monetary Metrics

In 1992, Kaplan and Norton published the Balanced Scorecard (BSC), which has become a benchmark for capturing all the aspects important to an organization's performance. The basic model has four major areas: customer perspective, innovation and learning perspective, internal business perspective and financial perspective. It does not eliminate financial measures, but complements them with other indicators not found in accounting.

Since it was first published, BSC has been widely implemented in industry and used as a basis for other management frameworks (Midori and Steeple, 2000; Neely et al, 2000, Parker, 2000; Levy & duMee, 1998; McCunn, 1998). It can be used as a strategic tool or as a complementary part of a larger management system (Kaplan & Norton, 1996). A recent strategic management model—SUCCESS (Super Unified Customer and Cost Evaluation Strategic System)—uses the BSC as its measurement system in conjunction with the Plan-Do-Check-Act cycle and the Baldrige Award criteria (Bernard, Melese and O'Keefe, 2001). Logistics Management Institute (Klapper et al, 1999) has used it in developing metrics for supply chain management. These are just two of many other uses and adaptations. As a framework, BSC has widespread acceptance; however, there is considerable room for debate on exactly which types of non-monetary measures to adopt.

Generally, metrics attempt to capture inputs, actions (processes), outputs or outcomes. Many inputs, actions and outputs can be measured directly, but outcomes are more difficult. Outcomes depend on outputs, but may not necessarily be correlated. For instance, an objective of a social service office may be to serve the indigent people of the community. An output measure would be how many people were served in a week. But this output measurement may drive the social workers to serve as many as possible, with little regard for the quality of the service the customer received. Outcomes, even if they can be measured, may have timeframes that make tracking them extremely difficult.

The very act of investigating can prod the organization into action. This is one of the benefits of any performance review. Measuring non-monetary, or non-traditional, areas poses challenges to the leader or manager of an organization. What should be measured, and how? There is no simple answer, for it depends not only on the organization itself—its goals, structure, and culture—but also on the strategic objectives of the measurements (Kaplan & Norton, 1996). Some companies have used a BSC only to spur the organization to self-evaluate; the actual implementation was not as critical. Others have implemented the BSC completely, with varying degrees of success (Stivers et al, 1998; Lewy & duMee, 1998; Kaplan & Norton, 1996).

A study of 253 companies identified metrics most often considered valuable by corporations. The major categories were customer service, market performance (market share), goal achievement, innovation, and employee involvement. A significant finding was that there were large gaps between what was identified as important, what was actually measured, and whether those measures were put to any meaningful use (Stivers et al, 1998). This gap is important to recognize. Even though important aspects of an organization may be difficult to measure or quantify, this should not be a reason to ignore them.

Careful consideration must be made of how much should be measured versus what would be nice to measure. A balance is required: getting enough high-quality measures of the organization's health without inundating the personnel with data collection requirements, which can quickly lose relevance for the organization. The fact that there are numerous possible measures can be one of the greatest challenges facing a manager when selecting appropriate metrics for his organization (Neely, 1999).

2. Performance Measurement in DoD

Just like industry, the DoD has attempted to better define its performance through use of accurate metrics. The Government Planning Resource Act of 1993, Government Management Reform Act of 1994, and other initiatives have forced federal agencies to demonstrate that they are spending resources effectively (Bernard, Melese, & O'Keefe, 2001). This has resulted in a range of materials, from general guidance publications by GAO and others to detailed metric matrices developed for specific commands for specific purposes (OASN, RD&A, DCMC, etc.). Most tend to rely on discernible output or input measures, such as cost, schedule, and technical performance drivers.

The Logistic Management Institute (LMI) developed a more general guide for metrics for supply chain managers. LMI based it on the SCOR (Supply Chain Operations Reference) model, to which the BSC was applied to generate various non-monetary metrics. Since supply chain is a broad term cutting across many disciplines, LMI's methodology has broad DoD applications (Klapper et al, 1999).

Coming up with a useful measurement system is a challenge throughout the DoD. JTEG's challenge is to combine the elements of performance measurement within the ever-changing environment of technology transfer.

E. MEASURING TECHNOLOGY TRANSFER

Attempts to measure technology transfer have emphasized trying to capture how well a technology has been passed from developer to adopter. This has been difficult for a number of reasons: the time lag, the lack of commonality of technologies, and the different notions of success.

Measuring technology transfer combines many of the topics covered in previous sections of this chapter—the value of information, how well it is communicated, peculiarities of technology transfer, and measuring performance of organizations. Measures of effectiveness usually deal with quantifiable aspects: number of licenses granted, CRADAs consummated, royalties received, etc. It is more difficult, however, to identify measures to capture benefits of technology transfer because of the long lead-times for future pay-offs, the uniqueness of each technology, and the different notions of success.

One version of success is the "out-the-door" model, in which a transfer is considered successful merely because it was adopted. Measures of this can be in the form of licenses granted, royalty payments, etc. But this may not answer the question of how beneficial the technology was to the adopter. For example, if a lab transferred every product it developed, but, after one year, each adopter abandoned it, was the lab successful? From an out-the-door perspective, the lab was successful, but from a business perspective it was not. The variety of technologies and their applications make generalizing complex: some are "pushed" by the developing lab, some are "pulled" by a user with a need, some are actively marketed, and others sit on a shelf waiting for a user.

The difficulty of measuring technology transfer is apparent in the literature. In 1997, the Technology Transfer Society devoted an entire symposium to metrics (Technology Transfer Society, 1997). While many issues were raised, there was little consensus on what works. Numerous studies have examined the important measures of transfer (GAO, 1999; Kingsley, Bozeman & Coker, 1996; Spann, Adams & Sounder 1995; Spann, Adams & Souder, 1993; Bozeman & Coker, 1992; Wood & Eernisse, 1992; Gibson & Smilor, 1991). These studies and others have highlighted some issues regarding measurement of technology transfer.

The first issue is the role of the organization (developer, sponsor, adopter) in the transfer plays an important part in determining which measures are used (Spann, Adams & Souder, 1995). Thus, adopters are more concerned with productivity gains and cost savings; intermediaries value site visits, presentations, and requests for help; and developers favor measures such as licensing, royalties, and CRADAs. Many of these factors are easy to identify, but very difficult to measure directly (Spann, Adams, & Souder, 1995; Crutcher & Fieselman, 1995).

A second major issue is identifying and overcoming barriers in the transfer process. Some of the most common and relevant barriers are (Hesselberth, 1992: Gibson & Smilor, 1991):

1. Lack of a champion for the cause
2. Adopters unaware of technology
3. Long payback times
4. No communication network
5. "Not invented here" syndrome
6. Lack of funding
7. Distrust among participants

Understanding barriers will help in identifying the appropriate measures to employ. Using metrics that will make common barriers more visible can help an organization overcome them. Without visibility, problem areas can persist for extended amounts of time. The 1997 Technology Transfer Society proceedings resulted in a matrix of measures addressing the barriers that each role player in technology transfer faces.

Recent studies have incorporated the BSC philosophy in building metric structures. LMI (Klapper et al, 1999) did this for supply chain management. Hacker and

Garst (2000) did this to evaluate a public legal information system. The difficult hurdle to overcome in technology transfer is linking the measurable outputs to the outcomes desired—in some instances, there is a huge gap between the two (Dziczek, Luria &Wiarda, 1997; Stewart & Gibson, 1992).

The final issue in measuring performance of organizations involved with technology transfer is that there are two major functions to measure. The first is the process—that is, the act of transferring, regardless of the actual product. This relates to how well information is transferred, quality of networks, number of meetings, etc. The other function is measuring the product itself—what the technology is, what applications it has, and what its potential benefits are. No universal measures can capture both functions. They are separate, but related. An extensive network of contacts will do little good without products, while a useful product will useless if no one knows about it.

F. SUMMARY

This chapter provided background on the JTEG organization and the transfer technology environment in which it operates. Understanding the economic value of information, effective communication, and the process of technology transfer provides a foundation for follow-on analysis in subsequent chapters.

Chapter III focuses on the characteristics of the depots and how JTEG fits into the depot structure.

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III. JTEG AND DEPOT STUDY

A. RESEARCH APPROACH

This study is exploratory, relying on the literature review background and interviews with involved parties. Chapter II described the JTEG. This chapter reviews the results of two JTEG visits and the separate depot visits. It also summarizes the differences and commonalities between the depots. Chapter IV uses this information to explore metrics for capturing elements of JTEG operations that are most beneficial to the depots.

This chapter uses interviews with JTEG personnel to expand on JTEG strategies and efforts in its operations. Since its mission goals are tied closely to depot actions, understanding the variety and nature of depots is important in identifying the value-added features JTEG can bring to the depot community. Understanding the cultural, environmental, structural and other aspects of the depot community is necessary to identify areas to focus on when generating and evaluating metrics for JTEG.

Developing meaningful metrics for an organization requires knowing its ultimate criteria for success. The section on JTEG amplifies the areas JTEG personnel (staff and principals) consider important to their success. Success and goal achievement mean different things to different people, even in the same organization, and JTEG personnel are no exception. These issues are presented to gain insight on the elements which lead the organization to its desired goals.

A customer's needs and wants heavily influence the scope of the service an organization provides. Thus, JTEG needs to have a sense of what depots consider important in technology improvements, how they collect technology information, and what they do with it internally. Depots are the primary users (adopters) of technology facilitated by JTEG and, as such, are major stakeholders in JTEG's operation.

A cross-section of DoD depots was chosen to provide a balanced perspective. Four sites were visited—two aircraft rework facilities (one Navy, one Air Force), one naval shipyard, and one ground vehicle rework facility. The visits pursued the answers to the secondary research questions: what is important to the depots in terms of new technologies? in terms of information exchange?

B. JTEG VISITS

Two visits to JTEG personnel yielded valuable information. The first visit involved interviews with JTEG staff, including the director of JDMAG. The second visit took place two months later and coincided with a JTEG-sponsored meeting held at Wright Patterson Air Force Base. As part of this meeting, the JTEG principals' business meeting was held, a segment of which was devoted to the subjects of JTEG's purpose, success, and metrics. The following paragraphs summarize the results of these visits.

JTEG realizes that it faces a tough task in quantifying and measuring what it does. Chapter II highlighted the many different facets of the JTEG environment of technology exchange. As an intermediary with no funding to support developer or adopter, JTEG's role has been that of information gatherer/sender. One of its primary challenges is determining whether or not these efforts meet the organization's goal of helping the depots function more efficiently from a corporate viewpoint.

1. JTEG Strategy

JTEG's strategy defines the efforts of its personnel. As a technology exchange organization, JTEG functions as an intermediary between adopters (depots) and developers. Depending on the type of transfer, it could be considered either a third party or a part of the adopter's organization. For example, a technology obtained from a private industry, JTEG functions more a depot representative, while a depot-to-depot transfer, JTEG functions as a third party intermediary.

JTEG uses primarily a passive strategy, as defined by Shama (1991), in most of its conduct. A passive strategy includes attending meetings, distributing documentation, responding to inquiries, and other similar activities. JTEG staff indicated that one of their primary roles is coordinating and setting up the three or four JTEG meetings per year. Secondary duties include responding to inquiries from depots, principals, materiel commands, private industry, and consortia. Other duties are maintaining their web site and tracking current projects. These tasks occupy most of the staff's time. (Adams and Siens, Sept. 2000)

As an intermediary, JTEG's communication media form the backbone of its efforts in exchanging information. The JTEG meetings, web site, e-mail, and phone inquiries were most often used. Beyond these, to facilitate information to the depots, points of contact (POCs) were nominally identified as a conduit to those organizations. The staff maintains a list of primary and secondary POCs for each depot. (Adams and Siens, Sept. 2000) The service principals also communicate with depots, though not necessarily through the same person through which the staff communicates. (JTEG Principals' Meeting, Nov. 2000).

Maintaining these lines of communication has proven difficult. During the course of this study, every name but one obtained from JTEG as a depot POC was out of date, for various reasons. Some people transferred or retired, job requirements changed, or a re-organization occurred at the facility. Having reliable, stable POCs is difficult, but necessary, to maintain. This lack of reliable POCs at the depots highlights a barrier to JTEG's mission of making depots more efficient. Without regular contact between depot and JTEG staff or principals, gaps between what depots need (or desire) and the information JTEG provides will widen.

The majority of the interaction between staff and principals is at the business meetings (usually held in conjunction with a JTEG meeting), with irregular contact in between. Principals, who work mainly at Materiel or Systems Commands, bring to JTEG different service priorities that, ideally, would coincide with the depots' priorities. Because principals use different avenues of communication with their service depots than the staff at JTEG do, their views on an issue often differ from the staff's. This highlights the importance of keeping different levels of contact between organizations—i.e., executive to executive or staff to staff—because no one can possess all the information relevant to any one situation. Since no one can have perfect information, losing the direct POC contact with depots limits the information JTEG could potentially use to make its efforts more effective.

JTEG members also communicate with a host of other organizations, typically research entities such as DoD research labs, DoD-affiliated organizations such as ManTech, RepTech, National Center for Manufacturing Science (NCMS), university centers of excellence (COEs), and other consortia and companies. Much of the interaction with these technology developers occurs as part of presentations at JTEG meetings and specific inquiries to JTEG. The principals rely on the database and knowledge of the JTEG staff to answer their questions (JTEG Principals' meeting, Nov. 2000).

JTEG tracks numerous projects. Typically, there are be a small number of "active" projects tracked (20 or fewer) and a large number of inactive projects archived. A current list of active and inactive projects is listed in Appendix A. The decision to make a project "active" or "inactive" is a judgment of the principals. Frequently, active projects are generated through a particular principal expressing interest in an idea. Active projects that have been "completed" become inactive. "Completed" can mean that a technology was inserted; a technology transfer connection was consummated, and no further action by JTEG is required; or a project was judged to be of little use, so further effort would not be justified.

Many of the participants in the active projects are located at the Materiel or System Command level or are a part of the developer lab or company. Through their Materiel or Systems command, depots may be asked to field test or otherwise participate, but a direct depot-level representative is often not identified for the projects.

2. JTEG Purpose and Success

The purpose and success of any organization are often difficult to measure. During the business meeting, a discussion took place on the purpose of JTEG, which is highly related to the discussion of success. The consensus was that JTEG's goals and objectives are important and reflective of the organization's purpose. However, there were different notions of what constitutes success in the organization (JTEG Principals' meeting, Nov. 2000).

One view of success dealt with the act of transferring information. Connecting someone with a need to someone with a solution was considered a success, regardless of the consequences of those transactions. This could result in a number of contacts being made (i.e., success), but no technology transfers actually occurring. Connecting people and giving them information satisfies the goal of building relationships among the depots, but because technology may not be transferred, the depots may not become more efficient and productive (JTEG Principals meeting, Nov. 2000).

Another definition of success was a depot technology insertion, facilitated through JTEG, into a depot operation. This measure does not necessarily provide an answer to the question of whether the depot improved its productivity. For instance, some new technologies are dropped after an initial period, while others are not closely tracked to see if promised benefits were realized (Interview with David Beck, Nov. 2000).

There was agreement that JTEG's ultimate goal is to support the JDMAG mission of making the depot organization more efficient as a corporate entity through technology information exchange. Even though the participants agreed with the mission statement (stated in Chapter II), JTEG members differed on what measures would capture JTEG's success in accomplishing its mission.

3. JTEG Metrics

Also discussed at the business meeting were the results of the consultant report, specifically the metrics that JTEG could use to monitor its performance. While the report described the organization and listed possible metrics for use, it did not explain how to use them or why particular ones would be useful. The report did not make an explicit link between the proposed metric and the desired outcome. The staff did some introspection on the subject of useful metrics and identified a few it felt were particularly relevant.

The participants discussed the list of potential metrics developed in the consultant report (Appendix B), as well as other ideas. A few garnered most of the discussion: trying to estimate cost avoidance or savings; developing a depot-needs list; and making referrals. A larger goal of trying to measure a reduction of duplication of effort was also discussed, although the parameters in attempting this would be elusive. While a lively discussion about metrics ensued, there was no consensus as to the measures that would capture the most important elements of JTEG (JTEG Principals' meeting, Nov. 2000; Gorman, Nov. 2000).

Trying to measure financial benefits for any project was deemed futile for JTEG. While it may be possible for a particular technology in a specific application, there would not be universal utility in such analyses. The specifics for one depot may be totally irrelevant to another. Since many projects are tracked at any given time, detailed analysis was not considered a prudent use of JTEG manpower (Interview with Carl Adams and Steve Siens, Sept. 2000).

C. DEPOT VISITS

The researcher visited various depots in order to understand the environment in which JTEG operates. The purpose was to clarify each depot's perspective on technology exchange and, essentially, to determine what was important to each. Two particularly relevant questions were: what organizations did the depot interact with? and what internal mechanisms were in place to facilitate information exchange? Appendix C lists the depots visited and personnel interviewed. The list of questions in Appendix D was used to facilitate the discussion. The results from each visit are summarized below.

1. Naval Air Depot Visit

The visit to Naval Air Depot (NADEP), North Island, included interviews with an environmental compliance engineer and an industrial engineer, both of whom are responsible for improving existing technologies. The production control officer of the depot was also interviewed. The POC obtained from the JTEG staff was no longer the POC, having been promoted out of the position.

NADEP is responsible for programmed and unprogrammed major repair and overhaul of naval aircraft and components, primarily for the F/A-18, E-2/C-2, and S-3 airframes. Improved processes can lower the sustainment costs for the aircraft worked on. NADEP operates in an environmentally sensitive area, so it is constantly looking for ways to improve environmental programs.

a. NADEP's Technology Activities

The depot's production control officer stated that cost is on a per-item basis and that they are always looking for improvement in their processes to drive those costs down. The depot personnel are looking at facility problems and solutions; weapon systems improvements were not their main concern. Weapon systems may be improved as a consequence of a new procedure; for example, a better paint system might extend the interval between repaintings of a weapon system (e.g., an airplane), thus keeping it operational longer. Improvements in facilities often require close involvement with the weapon system engineers, who, in NADEP's case, are co-located at the NADEP (Interview with Fred Cleveland, Feb. 2001).

Any new technology introduced to the depot must undergo a comprehensive review, with all management levels participating through an electronic evaluation program (Appendix E). NADEP has developed an evaluation form to help personnel make technology insertion decisions. This form has been useful because it captures the elements the depot considered important in a new technology decision. Cost is included, but non-monetary factors also are considered, such as regulatory compliance, safety, pollution reduction, productivity gains, quality, technical feasibility (risk), and impact to stakeholders. These factors are rated on a simple 1,2,3 scale to determine a relative score used to rank new projects. Whether a project is initiated purely for environmental purposes or whether it involves production improvements, the electronic evaluation form is used (Interview with Ray Paulson, Feb. 2001).

b. NADEP's Relationships

The NADEP has had little JTEG involvement in the recent past. The two personnel interviewed were recently given the responsibilities of JTEG POCs; both were in positions where technology decisions were made, one from the environmental office, and the other from the industrial engineering office.

In the past, the depot relied on its own network of resources. Most of the environmental contacts were within the state, due to the nature of state laws and regulations. For new production technologies, the depot relied primarily on Research & Development laboratories in the NAVAIR system. Labs in NAWC Patuxent River, MD, were its primary sources. The depot used other sources (federal labs, consortia, companies), but on a more ad hoc basis, usually involving a one-on-one, specific application. The industrial engineering office has always developed and submitted a technology needs list to NAVAIR (and its labs) and indicated that this list could be sent to JTEG, but it has not been sent in the past (Paulson, Feb. 2001; Interview with Mike Holleron, Feb. 2001).

NADEP felt that networking among other depots and outside common interests could be an important function of JTEG. However, this depot has not relied on JTEG in this regard in the last few years. The industrial engineer went to his first JTEG meeting in March 2001 and reported that it was a worthwhile endeavor (Holleron, March 2001).

All personnel interviewed had a flexible, open attitude. This depot was willing to share new technologies with other depots and, if required, to work with others to solve problems (Cleveland, Feb. 2001).

2. Marine Corps Logistics Base Visit

The Marine Corps operate two maintenance depots, called Marine Corps Logistic Bases (MCLB), one each on the east and west coasts. MCLB in Barstow, California, was visited. It has the responsibility of supporting all Marine ground weapon systems west of the Mississippi. These systems include all tracked and heavy-wheeled vehicles, major gun systems, electronic components and numerous small arms. The MCLB Barstow had the one POC who was still current. Located in the environmental office, he did not interact with JTEG on a regular basis.

a. MCLB's Technology Activities

Because both maintenance depots repair essentially the same equipment, most new technologies at the depot for product line are investigated and facilitated through the depot headquarters, Commander Marine Corps Logistics Bases, which is located at the same site as the east-coast MCLB at Albany, Georgia. Because of the co-location of the headquarters and east coast depot, much development of depot processes are handled through the Albany facilities. Specific issues unique to the individual depots are evaluated through a process that usually is in the form of a written proposal, including considerations for cost, labor savings, production gains, and environmental impact. As with the NADEP, many of the technology issues faced by the MCLB are environmentally driven (Interview with Randy Spencer, Feb. 2001).

This depot is small compared to others (approximately 800 people), so there are fewer internal barriers to communication. The small size has generated close working relationships between different departments of the depot. As a result, the technology needs in one area of the depot are known throughout. (Spencer, Feb. 2001; Interview with Luis Alvarez, Feb. 2001).

The Marine Corps does not have the dedicated research labs that the other branches have; consequently, the MCLB depots have established relationships with outside organizations for their research needs. The primary research vehicle used has been DoD ManTech program, linked to developers such as Penn State University (Alvarez, Feb. 2001).

While the reliance on Albany is high for new technologies, this depot does have innovative programs it is pursuing. It has needs specific to the facility which must be addressed. The major facility need during the time of the visit was to improve the ventilation system for the painting facility. It also has installed some innovative management systems, including MRP II, Earned Value Management (EVM), and it was evaluating Theory of Constraints (TOC) for future use.

b. MCLB's Relationships

There has not been much active participation from the MCLB with JTEG. Since most of the needs of the depot are handled through Albany, which, consequently, has most of the interaction with JTEG. The Barstow depot personnel were not interested in attending every JTEG meeting. Their feeling was that if something looked particularly promising, then a representative would go; otherwise, they would rely on the USMC principal to feed them information. However, by relying on the external representative, it is possible that potentially useful information to the depot did not reach the correct people (Spencer, Feb. 2001). By accepting a third party to relay information, there is an implicit acceptance of lesser quality information.

The depot personnel felt that information by email would be the best form of communication. The depot could receive it and quickly determine the relevance to its operation. They believed that email would be better than using a web site, which the depot had never used anyway (Spencer, Feb. 2001; Alvarez, Feb. 2001).

3. Naval Shipyard

Puget Sound Naval Shipyard (PSNS) was also visited. The shipyard, which serves the entire west coast of the U.S., can handle all classes of ships, from tugs to aircraft carriers, including all of the nuclear-powered ships in the Pacific Fleet. It is currently experiencing a heavy workload in dismantling (scrapping) a number of nuclear-powered submarines and ships. Because dismantling processes historically have accounted for a low percentage of operations, reducing inefficiencies in the process was not a high priority. However, now the shipyard is looking for ways to improve processes that, a short time ago, had been minor issues.

A group discussion with nine mid- to senior-level managers was held in the morning, followed by individual interviews with some key personnel in the shipyard organization. The morning session was an open forum focusing on the types of technologies that were most important and how the depot made technology choices.

a. Naval Shipyard Technology Activities

This shipyard has a process improvement branch in its headquarters. This group continually looks for ways to improve process and business practices at the shipyard to increase efficiencies (Interview with Jim Colebank, Mar. 2001). Many of the programs instituted by the industrial engineering division are tracked at this level for benefits to the shipyard. The shipyard wanted technology already proven—it did not want to be in the business of research for research's sake (PSNS group meeting, Mar. 2001).

This group felt that reducing their search costs would be the greatest benefit from JTEG. Also important would be establishing a network of contacts with similar interests (Interview with Nick Eutizzi, Mar. 2001). The biggest benefit, they felt, would be having JTEG research the multitude of research centers—universities, labs, consortia and companies—with the goal of keeping tabs on current research so that any inquiry could be directed to the right place (PSNS group meeting, Mar. 2001).

The industrial engineering office is responsible for evaluating improvements in the shops. Many of the ideas for improvement come from the shop line workers. The head of the engineering division made the point that JTEG should concentrate on the most pressing depot issues and, if a lower-priority solution pops up, then seize the opportunity, but don't focus energy on those (Interview with Jan Brunson, Mar. 2001).

The primary element used to make a technology decision was cost—specifically, what is the Return on Investment (ROI)? If the initial capital investment were greater than $100,000, a formal evaluation process involving top levels of management would take place. Below $100,000, the business units in the shipyard could make their own decisions, based on their needs and expected future benefits. Although there was not a standardized process for evaluating each potential technological improvement, the managers agreed that factors such as environmental, safety, productivity, throughput, and other factors similar to those listed in Appendix E were used (PSNS group meeting, Mar. 2001).

The participants discussed a relevant example of how information exchange could have saved resources. The shipyard invested time and money in evaluating a product that chemically cleaned heat exchangers using an environmentally friendly process. The shipyard was unaware that a sister shipyard had already done the preliminary work and had successfully implemented the product. The shipyard could have saved numerous man-hours and costs by capitalizing on the other shipyard's prior work in this area (Colebank, Mar. 2001).

b. Naval Shipyard Relationships

Since hosting a meeting almost two years ago, JTEG has had little interaction with the shipyard (PSNS group meeting, Mar. 2001). Shipyard personnel did not see utility in attending every JTEG meeting; again, they chose to rely on their service principal to relay relevant information to them. The shipyard personnel did not think the potential gains in terms of reduced costs were worth their costs in time and effort. The depot wanted from JTEG reduced search costs through a centralized clearinghouse and a network of contacts, but the shipyard did not see those functions in JTEG currently. Using this indirect communication approach loses its impact, and what the service principal thought relevant may not coincide with the depot's priorities. There had not been regular communication with JTEG or the service principal regarding depot needs or current JTEG projects.

This shipyard would be willing to share information on products and processes it has used, but there would need to be some sanitation of the data. It would send needs lists to JTEG if prompted (Interview with Lon Overson, Mar. 2001).

4. Air Logistics Center Visit

The Ogden Air Logistics Center (ALC) was the last facility visited. This ALC, which supports tactical and transport aircraft for the Air Force, is one of three major ALCs. The ALC supports many aircraft and aircraft components. The center is the exclusive rework facility for the F-16, C-130, A-10 and other aircraft and components. It also has the lead responsibility for a number of specialty areas, such as landing gear and composite repair, for the entire Air Force. Other ALCs have the lead responsibility for other aircraft and components.

The visit consisted of attending a briefing by the "science projects" group for the vice-commander of the ALC (a brigadier general) on process improvement initiatives. Follow-up interviews were conducted with the metrics and automated information systems team members. In addition, senior engineers in the Technology Integration and Engineering Directorate (TIE) were interviewed.

a. ALC Technology Activities

The ALC exhibited more dedication to research activities than did any other depot visited. This is a reflection of the Air Force philosophy of co-locating labs with the repair facilities, in full or part. However, this relationship has a danger. Since there is a high level of technical competence for developing solutions, the "not invented here" syndrome can pervade the organization and prevent it from looking outward for solutions to problems. The vice-commander made specific reference to this tendency and the need for the ALC community to overcome it by recognizing that there are many other good people and resources outside of the Center (Science Projects Brief, Apr. 2001).

Six months earlier, the ALC had instituted a program called the "science laboratories project" which condensed into one program the many improvement initiatives that were taking place throughout the command. The "science projects" were broken down into six major groups, and the command felt that, within these groups, all depot processes were covered. The six groups were Problem Parts, Data Information Systems, Automated Information Technology, Quality Discrepancy Reporting, Metrics, and Failure Forecasting. The initiatives that have come out of this "science project" working group have generated high-level interest in the Air Force for their innovative thought and quick action. Some of these initiatives have already been implemented at the ALC and local Air Wing, with the ultimate goal of exporting these programs outside the ALC (Interview with Bill Endres, Apr. 2001).

The Technology Integration and Engineering (TIE) Directorate of the ALC generally is involved with most technology decisions and supports many of the "science programs." This directorate also supports the industrial operations and works closely with the on-site aircraft engineering offices on improvements to the depot processes. The ALC and, especially, the TIE generate different needs lists. These come in a variety of formats, from SBIR (Small Business Innovation Research) solicitations to data calls for Materiel Command headquarters. Just prior to the visit, the TIE directorate generated a technology needs list for the NCMS consortium (Interview with Dave Chaston and Tom Gailey, Apr. 2001).

b. ALCs Relationships

The ALC has had little meaningful contact with JTEG in recent years. Some of the reasons given for this were the reductions in manpower, which led to many internal job shifts due to retirements, re-alignments, and consolidations. As a consequence, many programs, including JTEG, fell into neglect and were not restored when the organizational perturbations were settled. The TIE directorate also has a technology transfer office, although no contact has been made between it and JTEG (Chaston and Gailey, Apr. 2001).

Although the depot was open to sharing its technology, its personnel were less willing than those at the other depots visited to use outside solutions to solve their problems. Personnel stated they would welcome other ideas, but they did not have or spend the time to go out and research them (Chaston and Gailey, Apr. 2001).

D. SUMMARY OF DEPOT VISITS

The depots in the DoD system are diverse. Each has its unique equipment to support, often without any civilian counterpart. It is difficult to summarize the depots using common descriptors, but some general observations can be made.

First, the incentive to work with JTEG was not high. The depots were all busy trying to do their main mission and did not have time to call JTEG or visit its web site each time a problem surfaced. Familiar problem solvers were used, such as ManTech, organic labs, and only occasionally JTEG. Many times, a solid contact for JTEG at a depot would transfer or retire and, when no one picked up that duty, regular contact was lost. This happens to principals, as well. Many commands have experienced major re-structuring over the past five to ten years, and traditional billets that would have served as the JTEG POC have disappeared. Along with losing an information source, depot personnel had to exert extra effort to re-establish contact, which they infrequently did.

This lack of incentive of use may indicate JTEG is supplying a service that few demand. There is no visibility on what aspects of JTEG provide the service that depots want. Having metrics which allow JTEG to show what are the more beneficial activities to the depots and provide JTEG some incentive to change operating ways to meet the demands of their customers.

Second, cost is a primary factor for the depots during their decision-making. While they play an extremely important role in maintaining fleet readiness by restoring war-fighting assets, the depots do not use factors such as readiness rates, sortie rates or other typical fleet metrics. Instead, they generate readiness indirectly, by supporting the program office that pays the depot to repair that program's equipment, be it ship, plane, tank or other.

While non-monetary factors are considered, most are related to dollars during the evaluation process. For instance, better working conditions (a non-tangible benefit) could be related to more efficient (i.e., more satisfied) workers, so the non-tangible could become quantifiable. These relationships are not directly correlated, but estimations of this nature are often made in the decision to go ahead with a new technology. Because there is no standard way to relate these benefits, each organization applies different standards to benefits in dollar terms. An approach JTEG could use would be to quantify the benefits in non-monetary terms and then let the depots use that information in their own analyses.

Third, depots are generally concerned more about their own facility or process improvements, not about improvements to the equipment they support. Although the equipment and the process the equipment goes through at the depot are related, and technology improvements will overlap, the depots are primarily interested in depot activities that will turn the equipment around faster and more efficiently and keep it in the field longer.

Fourth, networking and providing a clearinghouse function would be valuable to the depots. Retrieving information without having to go to numerous sources would increase the efficiency of personnel tasked with investigating a subject. This is something JTEG could do, but better communication with depots is required to give JTEG an accurate picture of the issues depots face. This two-way communication network is not in place at this time.

Last, not all depots showed enthusiasm for attending every JTEG meeting. This is due to smaller TAD budgets and the lack of consistent information exchange with JTEG. The consequence of this is that JTEG loses the insight and participation from different hierarchies of the depot organizations. If only a few depots or just the service principal attends the meetings, then the vast knowledge of lower level managers, engineers, and workers will not come to light, and the efforts of JTEG, or any like organization, will drift away from the issues important to the depots.

The depots, even ones that had little contact with JTEG, were not opposed to using JTEG and saw utility in an organization like it. However, they did not want to expend much energy in tapping its resources. It was generally felt that JTEG could be a central source of information, maybe not having specific details, but knowing what relevant research and development activities were going on, so it could give depots quick feedback on potential solution resources.

E. SUMMARY

How does the depot community benefit as a whole because of an insertion? This is a central question. This chapter provided some background on the main activities involved in a technology exchange.

These characteristics are used in the following chapter to identify metrics that JTEG can employ to ensure it is effective in making the DoD depots more efficient from a corporate viewpoint. Chapter IV uses the concepts of technology transfer within the context of the DoD depot environment and applies relevant metrics that capture the performance of JTEG.

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IV. METRICS ANALYSIS

This chapter uses the concepts from Chapter II and the conclusions from Chapter III to derive performance metrics for the JTEG organization. The usefulness of metrics lies in their ability to make characteristics more visible to the organization, and the metrics in this chapter were developed with this in mind. This chapter demonstrates how some obvious and some more-obscure measures can be linked to JTEG's organizational goals. For a metric to be effective, its link to the organization's ultimate goal must be clear. After suggesting areas on which measurements should concentrate, the chapter discusses the benefits that JTEG currently offers the depot community, as well as its potential benefits. These benefits or value-added features could be exploited, creating stronger incentives for depots to use JTEG's services. Before discussing metrics, the chapter presents a short section on JTEG's competencies and goals.

A. JTEG'S COMPETENCIES

Every organization has core competencies—they are, in fact, the organization's reason for existing. Chapter III showed, through various interviews, that JTEG considers its main competency to be as a communicator of technology information between a variety of activities, ranging from depots to industry developers. This is reflected in JPEG's mission statement, quoted in Chapter II, which states that JTEG should improve coordination in the introduction of new technologies and avoid unnecessary duplication. It is important to measure the activities of an organization to determine if daily operations are contributing to goal accomplishment.

Outcomes are the result of any organization's actions and efforts. Whether general or specific, outcomes are indicative of the effectiveness of the organization. The mission statement is an example of desired outcomes. Outcomes are different from inputs and outputs in that the latter are measurable units (such as number of projects, number of briefers, amount of funding), whereas outcomes relate to whether the organization is achieving its desired objective (e.g., has it made depots more efficient?).

Performance measures should relate the organization's activity to its effectiveness and efficiency. Effectiveness is how well the organization is meeting its goals. As a service organization, JTEG's ultimate objectives depend on how the external environment perceives it; therefore, JTEG's effectiveness depends on how it relates to the external environment. Efficiency has to do with the use of resources, or how well inputs are converted to outputs. An important feature of performance metrics is that they link effectiveness or efficiency to desired outcomes.

Linking the measurement to a desired outcome is one of the most essential elements of performance metrics (Kaplan and Norton, 1996). One of the pitfalls of implementing metrics is measuring current activities without first determining whether those activities are contributing to the organization's efficiency or effectiveness. Without basic understanding of the underlying processes, the result is just more data collection workload without illuminating how well the organization is operating. Measuring efforts that have no definitive links shows merely that the activity occurred; it does not measure whether the activity furthered the organization's goals.

1. Outcomes

One of the primary outcomes that JTEG seeks is to support the JDMAG charter of fostering a stronger corporate entity of the DoD depot system. This is a large, broad-brush outcome that cannot be precisely measured; having depots cooperate across organizational boundaries is a difficult goal to accomplish. However, the efforts of JDMAG and JTEG should aim toward this outcome.

JTEG has some more specific outcomes to attain, such as improving coordination and identifying depot requirements. JTEG also requires a communication network among depots (the adopters) and developers (other depots, labs, logistics, headquarters). This objective defines an outcome of having a functional information exchange process.

Another outcome that JTEG desires is reducing redundancy in the depot system. This outcome is related to the products (the technologies) themselves. Using data on the projects that other depots have implemented or tried reduces the possibility of dual implementation. One depot may have economies of scale that others do not, so it can do the work more efficiently for the entire depot system.

2. Inputs and Outputs

Because most outcomes are very difficult to measure directly, outputs and inputs that can be related to outcomes are used. The following sections examine the specific outputs and inputs that JTEG can use. Care must be used in choosing what to measure; not every activity or effort should be measured. Chosen correctly, a metric can drive activity in a positive way towards organizational goals; some measures can have unintended, negative effects if not applied correctly. While the members of JTEG may do other things, only the activities that contribute to JTEG's effectiveness need the visibility that metrics provide. The following section discusses activities contributing to JTEG's organizational goals.

B. METRICS

The basic methodology follows the discussion of performance metrics in Chapter II. The methodology incorporates the balanced scorecard concepts, although it modifies the specific categories suggested by Kaplan and Norton to fit the structure of JTEG. The metrics generated by the Technology Transfer Society (Proceedings, 1997), as well as various studies of performance in technology transfer (Spann, Adams and Souder, 1995; GAO/NSIAD-99-169) and logistic organizations (Klapper, et al, 1999) are used to develop the valuable metrics JTEG can use to monitor its performance.

It is important to remember that JTEG, in terms of technology transfer, is an intermediary in information exchange and has no funds for either developing or implementing new technologies. Having a broadly defined mission statement with limited funds creates significant constraints, but the use of metrics ensures the best use of JTEG's resources.

Two major categories are used to describe JTEG's activities. The first, processes, includes the information exchange and communication methods used between various participants, without regard to the technology itself. The other major category is projects, which relates to the actual technologies tracked by JTEG.

C. PROCESS METRICS

Table 4-1 lists metrics to capture the effectiveness of the process of information exchange and communication. These metrics are elaborated on in the following sections.

PROCESS METRICs		INPUTS	OUTPUTS	OUTCOME
JTEG Meetings				
	JTEG members (JDMAG staff/service Principals)		Number in attendance	Service connectivity
	JTEG POC (depots)		Number in attendance, which depot	Connectivity of depots
	Other DoD		Number in attendance, which activity	Other commands and depot representatives indicating connectivity
	Other		Number in attendance, which activity	
	Briefers			
	Depots	Needs	Number	Meeting the needs of common depot issues
	DoD		Number	Needs of depots increase capability, reduce redundancy
	Industry		Number	
	Web page	Projects	Hits	Connectivity
Points of Contact				
	Depots		Number of depots represented; Frequency of contact	Connectivity achieving better communication
	Other Technology Groups		Number, Types represented; Frequency of Contact	Connectivity to potential solutions
JTEG visits				
	Depot Visit		Percentage of depots visited	Connectivity, Activeness of depots

Table 1. Metrics For Exchange Process.

1. JTEG Meetings

JTEG meetings are a primary method used to communicate information. How well do they contribute to JTEG's goals of creating networks, deducing redundancy and making depots more efficient? One way to determine how well these meetings are helping JTEG meets it goals is to measure attendance in different ways. Doing this can provide information that links effectiveness of the meetings to the goal of exchanging information. In the past, JTEG recorded meeting attendance without breaking down the attendees' list into sub-categories other than JTEG members and non-members.

Knowing how well the depot community is represented gives useful insights. If, for example, the subject of a meeting is shipyard applications, and only one shipyard representative attends, then tracking the attendance will immediately reveal the absence of the intended audience. This is important since the depots are currently not interested in attending every meeting. Putting together a meeting—i.e., supplying a product—without the presence of the potential consumers—i.e., the depot audience—is not productive. Keeping track of the audience and topic indicates whether supply is meeting demand.

Meetings are designed to highlight certain technology issues, which may hold more interest for some depots than for others. For instance, light metal processes used on aircraft may not have much applicability to shipyards or tank depots. The ideal audience for a meeting on light metal techniques would be representatives from the air depots.

Attendance by the Depot-level personnel, POCs and others, is important. This relates back to the value of information at different levels and how information is lost without direct communication, especially when there is no market device (price) to transmit that information, as is the case in the technology transfer arena. A depot may choose to rely on its service principal or sister depot to relay relevant information. However, no matter how well intentioned, a third party can neither have the appropriate level of information nor understand the needs and wants of the non-attending depot. The most effective way of ensuring communication is for depots to send representatives directly and for JTEG to track attendance. By tracking trends and, thereby, determining which depots are more active, JTEG can focus its efforts on enhancing communications with active depots and finding ways to engage less-active ones.

Briefers at the JTEG meetings should also be broken out and tracked. These meetings offer an excellent opportunity for depots to brief their new projects so that other depots can evaluate them. Through networking at JTEG meetings, depots can benefit from seeing what is going on at related sites with similar concerns. These briefings should not just review local problems, but also should demonstrate the projects' common applicability.

Industry briefers, which, in this context, include anyone outside of DoD, should be tracked for the relevance of their presentations to the depots' needs. Were the depots with the needs in attendance? Tracking the briefers and attendees allows JTEG to assess the effectiveness of the meetings in reaching their target audience.

The JDMAG website offers another avenue for transmitting information, much of which is related to the JTEG meetings. The website contains announcements of upcoming meetings, minutes from past meetings, as well as general information about

JTEG. It is difficult, if not impossible, to ascertain the value of the information transfer process via the website. Web hits can be recorded, but whether the site visitor gained any information from the visit cannot be determined without some formalized feedback, such as a survey. Currently, briefs can be viewed by visiting the minutes of the meeting or using an index. This is useful, although navigating through two or three sub-pages to reach information can be enough discourage a user. Cross-referencing briefs by standardized subjects would make the website more user-friendly and may entice more people to visit the website. Although the Web can indicate an approximate level of interest in the site, it does not clarify the quality of the interaction.

2. Points of Contact

Points of contact at the depots and organizations involved with depot technologies are an important element of JTEG's mission. Each of the depots visited in the study expressed the desire for an effective network of contacts. Maintaining direct contact with the depots improves the quality of the information JTEG is using. Information coming directly from the depot is more useful than the same type of information passed through two or more intermediaries.

The number of contacts maintained with resource providers, whether technology developers, funding sources or industry consortia, shows how well JTEG is staying abreast of technology trends. This, in turn, reflects how well JTEG can provide a network to its depot users and respond to their needs.

This category can be tracked a number of different ways, such as by organization type (e.g., university, private industry, or consortia); however, the best way is probably by type of technology or service provided by that organization.

3. JTEG Visits

JTEG should track its visits to its customer depots by either staff or principals. Doing this indicates JTEG's confidence in the POCs and how well in tune JTEG is with the concerns of the depots. Tracking certain facts—e.g., if a depot has not been contacted or visited for the purposes of JTEG or if a depot has not sent any representatives to JTEG meetings—illuminates a lack of connectivity.

Visits to other organizations should be tracked, as well. Attendance at symposiums and industry conferences that pertain to active projects or depots' needs highlights the connectivity JTEG is providing to the depots.

Visits also offer a feedback opportunity for JTEG, verifying that POC are current and correct, and increasing the information flow to JTEG members. This will enhance JTEG's ability to speak for and find new technologies that could benefit the depots. For instance, a visit by JTEG personnel to Ogden ALC would reveal Ogden's approach to new technology capabilities in its "science programs," thus giving JTEG feedback on what the depot is most concerned with.

4. Newsletters

Another source of information exchange used by JTEG are newsletters, which have recently been sent via e-mail and which have easy-to-use feedback features built in (JDMAG website). These newsletters are a good way of disseminating information, but, like the website, they are primarily one-way communication. The utility of the newsletter as a tool for information dissemination increases as the level of readership increases. It is hard to determine whether the person who received the newsletter was the correct person at that organization (is he the current JTEG POC?) and whether the information was internalized the way JTEG intended. Feedback hyperlinks help, but it is up to the receiver to use those devices.

With feedback that shows that people do read and use the newsletters, they can be an excellent way to disseminate information. It is important to remember, too, that feedback must come from the intended audience and not necessarily from the people who received the newsletter, as they may not be the same.

5. Demonstrations/Validations

Another method of tracking information is demonstration/validation (dem/val). This involves demonstrations for potential users and a limited install/implementation at a site to validate the developer's claims. JTEG has facilitated some of these dem/vals, which show a definite connection between their customers. Measuring the number of dem/vals facilitated by JTEG provides a direct link to connections, and it may indicate an outcome of more efficiency for depots.

Tracking who attended dem/vals (some are between developer and adopter only, while others have a number of potential adopters) is important, as well. This leads to the realization that the technology will provide community-wide benefits—a primary goal of JTEG.

6. Feedback

New forms of feedback should be considered. JTEG has recently attempted to get feedback from JTEG meeting attendees by sending them electronic newsletters with feedback responses built in. However, feedback from these sources is too narrow because it comes from people who are already active in JTEG. More-valuable feedback would be from JTEG's depot customers—the process improvement, engineering and tech transfer offices—to see if any of JTEG's products are reaching their intended audience. In the course of this study, it was apparent that the points of contact are no longer current at many of the depots. A feedback mechanism, either a periodic survey or a dedicated, specific, point-to-point contact between JTEG and the depot POC, will eliminate many of the problems associated with the current one-way communication. Answers from its intended audience to questions such as "did you receive the newsletter, the announcement for the meeting, and the request for depots needs list?" gives JTEG a feel for how successful its communication media are. Feedback measures could come in the form of requests for information, quality of depot needs requirements. Indicators such as these indirectly reflect the communication net's effectiveness. A source for guidance in developing a questionnaire survey is on the Office of Management and Budget website.

7. Not Every Activity is a Metric

Certain activities that take up a significant part of the staff's time, such as phone calls and e-mail, are not good candidates for metrics. Metrics should be used in conjunction with certain goals in mind. Trying to capture a current activity without first assessing its value to the organization's goals may produce metrics that do not achieve their purpose; in fact, attempting to measure activity not linked to performance goals can drive adverse behavior. For instance, the volume of phone calls or e-mail may indicate a level of communications activity. However, without linking the phone calls and e-mail to specific projects, this measure does nothing to illuminate the nature of the communications and, if employed, may drive behavior to maximize this metric at the expense of a more meaningful measure. This highlights one of the perils of metrics: they should not attempt to measure every effort, but, instead, should capture the elements that show progress towards organizational goals.

D. PROJECT METRICS

The other major category of technology transfer is the technologies themselves, which are the project part of the transfer. The best processes of communication and exchange are irrelevant if there are no valuable projects to track. This section shows how projects can be tracked to provide value to the depots that use them.

1. Project Inputs from Depots

Inputs to JTEG regarding needed technologies (see Table 4-2) are extremely important. A structured way of receiving inputs is necessary because the small staff does not have time to work on every project that comes its way. Having inputs in the form of depot needs lists and/or consolidated service needs from materiel or systems commands (through the principals) provides a mechanism for prioritization. Because of no systematic approach, JTEG has not consistently been aware of the depot needs.

PROJECTS METRICs	INPUTS	OUTCOME
Depot Needs list	Number of depots, types of depots	Relates JTEG efforts to needs of community

Table 2. Metrics For Technology Inputs.

The JTEG staff has recently received needs lists from three activities, and compiled a list of most beneficial areas of new technologies to concentrate on (e-mail from Siens, 2001; e-mail from Adams, 2001). These included:

1. Halon replacement.
2. Lead-free soldering.

3. Cadmium alternatives.
4. Non-Destructive Inspection (NDT) equipment.
5. Welding fume emissions.
6. Laser engineering net shaping.
7. Telemaintenance.
8. Honeycomb floor paneling.
9. Intelligent near net-shape manufacturing cell.
10. Portable miniaturized residual stress measurement system.
11. Enhanced digital corrosion detection system.
12. Automated paint applications.

This "needs" list, a wish list of sorts, from individual depots can be compared with others to see if there are commonalities among depots. The level of priority should be established to maximize the benefit of JTEG's time and effort. One way is determine applicability among depots. For example, honeycomb floor panels apply to large transport jets, and while this may be a high priority for the Air Force, it may not have much relevance to other depots, hence may not be a high priority for JTEG when other projects have more universal applicability. Another way is to determine the potential pay-off. In the honeycomb example above, even if it had limited applicability, it might have high potential pay-offs that would result in greater macro benefits to the depot system than some of the smaller projects. These common needs, once prioritized, can be tracked as a depot's leading issues, such as a "top ten" or a "top five" issues list. This "top ten" list would focus JTEG's efforts, which can be compared with outputs to determine overall effectiveness. These needs lists should be tracked for each depot that has submitted one, thus making clear which depots are participating with JTEG.

If JTEG comes across a technology without a related need, it should track it only after determining depots' level of desire for that technology. If a sufficient level of interest is indicated, the need that drove the desire for the technology should be added to the list of depots' needs.

2. Projects

Projects vary in size and scope. The point of tracking them is to be able to provide the depot community with information regarding new technologies. By making data on projects easily accessible, JTEG moves closer to its objective of making the depot system more efficient and less redundant.

The current method of organizing technology projects at JTEG is to categorize them as active or inactive. Inactive projects are listed in alphabetical order by their project title, and information on these can be obtained by contacting a staff member at JTEG, who will pull the file up.

Active projects can be viewed on the web page. Active projects are listed alphabetically and contain the title, a short narrative, a chronology of events since the project became active, and various points of contact for the project. Interviews with the depots indicated that they rarely used this resource.

To make the active projects more attractive to the depots, the JTEG staff, with very little extra effort, can categorize information in standardized ways to make information retrieval much easier for users, such as heavy metal applications, light skin applications, etc. Table 4-3 displays the metrics for measuring projects. To get this information, the new technology developer should be able to provide test data or reasonable estimates for the standardized categories.

PROJECTS METRICs		INPUTS	OUTPUTS	OUTCOME
Characteristics				
	Safety	Developer	Hard data if available; "high, medium, low" characterizations	Reduces redundancy, increases capability of depots
	Start-up (install) costs	Developer		
	Environmental Reductions	Developer		
	Resource Savings	Developer		
	Productivity	Developer		
	Quality	Developer		
	Maintenance	Developer		
	Logisitics	Developer		
Type of Technology		Depot Needs	Link to Depot Needs	Reduces Redundancy
Type of Depot Affected		Depot Needs	Number of depots	Reduces Redundancy
Current Status				
	Disseminated	Depot Needs	Number of active projects	Progression of active projects increases depot efficiency
	Implemented			
Success Stories		Projects	Number of projects disseminated, implemented	Demonstrates the worth of JTEG to chain of command, depot users

Table 3. Metrics For Technology Projects.

Other than start-up (install) costs, these are non-monetary measures. Most can be related to monetary equivalents, but it subjective and differs from user to user. As discussed in Chapter II, providing hard numbers for emerging technologies may be difficult, but a rating scale of "high, medium or low" or "better, same, or worse" than current practices can be done. This allows users, who are the potential depot adopters, to gain succinct, quick data to decide whether or not to pursue the project. There have been attempts to come up with rating scales to determine the usefulness based on a range of factors (Rose, 1995; Crutcher and Fieselman, 1994; Bozeman and Coker, 1992), but these were applicable to specific situations and could not easily be adapted across multiple organizations. This rating is done implicitly by JTEG, if value wasn't perceived the technology wouldn't be tracked. Employing a simple rating scale by using basic information about the product formalizes the benefits JTEG sees in the technology without requiring complex scales that users wouldn't understand. Appendix E is an example of a simple rating system already in use. This satisfies the depots that desire a centralized information source with usable data to narrow their search for new technologies.

The categories mirror the factors NADEP North Island used in assessing new technologies and representation of factors other depots use. By rating different areas, with estimates or qualitative assessments, JTEG provides initial data to depots for their own analysis. Depots have different relative priorities on different factors, having information presented in a standardized way, can assist their staff in performing an analysis of benefits to the specific depot.

In addition to being organized with standardized characteristics, the projects should be tracked with three additional factors: types of technology, the depot affected, and the current JTEG status. If JTEG tracks an active project, it should be one that benefits more than one depot and should be related to the "top ten" list.

Tracking by type of technologies and depots affected shows the areas in which the JTEG organization has been working. Thus, JTEG can continue or change course as deemed necessary. For instance, if eight out of ten active projects relate to stripping protective coatings (i.e., paint), but the depots' needs list says this is not a priority, JTEG can re-evaluate which projects it should actively track.

Current status currently is tracked in the active projects list. This should continue. Active projects should lead towards adoption to benefit the depot community; otherwise it should be discontinued. Measuring a project's progress can help determine whether to keep it as an active project or whether to no longer devote any time to it. Structured milestones can be set up in this regard. For instance, a goal of having all depots exposed to a technology in one year can be a milestone, and after that, if there is no interest, discontinue the project. This will prevent open-ended projects from hanging on with little purpose.

3. Success Stories

Success stories validate the organization's mission. Projects transfers that have been implemented and shown beneficial to the adopting depot should be followed up with detailed data, most of which can be provided by the adopting depot.

Success stories relate to both projects and processes. JTEG is about transferring information that is useful to at least one, preferably multiple depots. It should depict examples of good processes (in order for the transfer of information) and useful projects (a technology project that meets a depot's need), which contributed the entire depot organization becoming more efficient or capable. These success stories should be ones to hang your hat on, demonstrating how JTEG's efforts are producing desired outcomes.

Developing some of JTEG's more beneficial activities will allow depots to see the usefulness in JTEG services. In addition, industry can have another link to depot problems and systems commands can have visibility on programs, which saves them sustainment costs. Putting success stories in high profile areas on the web page, briefing them at JTEG meetings as an agenda item, and including them in the newsletters give credibility to the organization with developers and adopters. The developers can be satisfied that their involvement results in positive implementations, and the adopters can see that JTEG has provided technologies that can be applied to their problems.

E. VALUE ADDED

JTEG offers the depot community some advantages by creating a means to increase efficiencies at little cost. JTEG, by measuring what it is tracking and how it is communicating with its constituents, can exploit its capability to collect, collate, and distribute information at lower costs than individual depots.

Using JTEG as a source of information about new technologies is low cost from the depots' perspective, the primary cost being time, which is not insignificant. The metrics discussed can bring visibility to the efforts that are either effective or ineffective at meeting the depots' needs, and they can help JTEG identify information that the depots do not value. Depot use of JTEG services are made visible by employing these metrics, and steps to improve overall or targeted areas can be taken.

JTEG provides is a conduit of information, which, of course, is valid only when communications links (networks) are established and vibrant. Establishing and maintaining communication links take work. But having a functioning network can mean taking advantage of the search costs, failed implementations, and dubious technologies.

By using its leverage as a united voice of depots, JTEG can offer the following advantages. It has a certain power of monopsony. Monopsony is the power of a single buyer over suppliers—the reverse of a monopoly. Many technologies that depots are interested in are unique; by leveraging a developer with multiple depots instead of one, JTEG can obtain lower prices from developers and purchasers. Without shared information, individual depots would pay a collectively higher price than if they combined forces (through JTEG) to strike a better deal.

JTEG also can be a screener for quality. Depots can be assured that if a developer has gone through JTEG, it has demonstrated reliability in business practices. In essence, JTEG could provide a "Good Housekeeping Seal" on products or projects for the depot community. A technology having a stamp of approval is not the main point, but having up-front credibility by being sanctioned by JTEG is.

By helping depots become more efficient, new technologies can lower support costs of weapon systems—contributing to lower life-cycle costs. Therefore, beyond the depot community, a JTEG that is contributing to depot efficiency contributes to weapon system efficiency. If materiel commands and DoD labs cooperate with JTEG, other potential weapon systems sustainment cost savings can be realized. A product developed for one DoD system (e.g., a better way to produce ICBMs) may also benefit, say, aircraft depots, which could use the system to lower support costs for aircraft.

F. SUMMARY

Formulating measurable characteristics of its environment, JTEG can assess how well it is achieving its goals. This chapter presented the areas that are the most beneficial in reaching those goals. A distinction was made between measures that capture effort and measures that capture activity that was linked to a desired outcome.

The two major categories of metrics—processes and projects—were presented. These capture the two greatest challenges of a technology exchange organization: having the information to meet the customers' needs; and being able to effectively communicate that information.

Understanding how measures are linked to their outcomes is extremely important and enlightening. Once they see this connection, managers can make better decisions. Effort not tied to organizational goals can be eliminated or reduced, and goals can be adjusted to fit the organization's capabilities. Having measures to assess how well the organization is working can enable these decisions. If the organization does change, the performance metrics should be re-visited to ensure that they are still effective.

The visibility that metrics provide can reveal whether or not JTEG is effective and successful. This is important to building future relationships with outside organizations and to allowing buy-in of the services by depots. Values such as time savings, buying power, and quality standards can be enhanced by effective use of JTEG.

Keeping abreast of current activities in the depots requires work, but to be effective and to make the participating depots' time worthwhile, JTEG must do this. Implementing metrics make that connectivity visible. Creating stronger ties between and among depots ultimately has the effect of making the entire depot system more efficient and effective.

V. CONCLUSIONS AND RECOMMENDATIONS

The process to derive performance measures can be as valuable as the metrics themselves. The self-evaluation it takes to arrive at appropriate measures reveals the critical aspects of an organization; and, if appropriately applied, these measures allow the organization to concentrate on activities that contribute to organizational success. This thesis examined the environment of the JTEG organization and its primary customers, the DoD maintenance depots. It explored the areas that performance metrics of JTEG activities should highlight. The subsequent visibility gained by the organization can reveal strengths and weaknesses not previously appreciated by its members.

Metrics for JTEG were derived using the principles of balanced scorecard and theories on technology exchange. The thesis identified two major categories for metrics. The first was processes, which describe the transactions JTEG uses to receive and transmit information. The second was projects, which describe the new technologies JTEG tracks. The two categories are interrelated; one without the other is ineffective.

A. CONCLUSIONS

From this research, the following can be concluded:

1. The Service JTEG Supplies Must Match the Demand of its Target Customers, the Depots.

There is a lack of incentives in JTEG to adapt to the depots' needs because a market has not been established for what they do. The consumer depots are not demanding the product JTEG is providing. Hence, as providers of a service, JTEG lacks the information normally found in a market environment, resulting in the following: a gap between what depots desire and what JTEG provides, and a loss of connectivity between the depots and JTEG. There are few intrinsic incentives currently in place to compensate for the lack of information; JTEG receives an annual budget regardless of who uses their product. Operating in an environment of new technologies in a depot setting, a true market may never come to fruition, but without changing the incentives of JTEG, this disparity between service offered and demand will continue. Identifying and implementing performance metrics are a means to information a market naturally lends itself, indicating the demand of customers and performance of the organization. Metrics also offer a critical link between effort and desired outcomes, creating the incentives for JTEG to adapt its service to meet or create demand for its services. JTEG members (staff and principals) defined success as having a strong networks among depots and facilitating technological information to help depots solve pressing problems. Only with heightened visibility of its activities can success be determined. The lack of involvement by depots in this study indicates that JTEG is supplying a service that is not in demand.

2. More Effective Two-Way Communication Needs to be Established.

Communication requires constant work and feedback to ensure the message sent is the same message received at the other end. JTEG and many of the organizations it deals with underwent significant organizational changes that broke down lines of communication, and those have not been re-established. JTEG uses a lot of communication media that are one-way in nature and that do not easily allow for feedback. More effective two-way communication needs to be established and maintained. Process metrics heighten visibility of exchange media's (meetings, newsletters, visits, etc.) successes and failures. Feedback on these media should come from the people who receive the communications (e.g., through links on newsletters) and

JTEG. JTEG's targets are the depots' industrial engineering or environmental divisions. These groups must have separate contact to ensure that they have received other forms of communication. People who never receive a newsletter will, naturally, never provide feedback on it.

3. Projects Tracked should be linked to Common Depot Needs.

Having metrics that make the depots' needs more visible will lead JTEG to track more beneficial projects. This addresses the low incentive depots currently have to participate in meetings, use the website, and otherwise interact with JTEG. With numerous demands on their time, depot personnel do not have time to participate in an activity that does not address immediate concerns. Dealing with technologies that affect future issues is not in the management scope of depots right now. Without depot participation, a vicious cycle is started, in that the technologies depend on depot participation, but depots don't want to participate without meaningful (to them) technology issues being addressed.

4. If More Fully Used, JTEG Offers Value to Depot Organization in Time and Search Costs.

A centralized unit of the depots has the possibility of capitalizing on combined needs and powers of a large system. The value that JTEG provides to the depot community includes the power of monopsony, establishing quality standards, and reducing depots' search time. Taking into account the time that depots spend on research, JTEG, as long as it is focused, can help make the depots more efficient in both their research and process improvements. JTEG recognizes that it can't track every potential project, but technologies of those that it does track and monitor should apply to multiple depot users. With focused effort, JTEG can best choose the technology information exchange to create more efficient depots and potentially lower sustainment costs for weapons systems.

B. RECOMMENDATIONS

1. Implement the Performance Metrics Proposed in Chapter IV.

The state of an organization and how it is meeting its market demand cannot be assessed without some measure of its activity. Implementing the metrics outlined in Chapter IV will give visibility to the quality of JTEG's information transfer process and benefits of the projects JTEG tracks. Items that depots need should be enhanced and promoted; while activities that do not contribute to JTEG's organizational goals should be modified or discontinued. To most effectively assess progress towards organizational objectives, intermediate goals (e.g., annual goals) should be established. Some examples of intermediate goals could be to have two JTEG projects implemented by depots, or 100 percent depot input on their technology needs. Metrics derived for an organization should not be viewed as static. As the organization and its environment change, the metrics should as well.

2. JTEG Needs to Establish Additional Feedback Channels.

JTEG staff and principals should establish feedback mechanisms in addition to the newsletters and meetings on which it primarily relies. Regular depot contact, with means such as JTEG visits to depots, establishes and reinforces communication links. In the face of many organizational changes, the depot relationships require continual maintenance to keep the information flowing. Contacting targeted audiences can also display how well other forms of communication are being used. To encourage depot participation, depot POCs might be given expanded roles in the JTEG organization, such as making them a formal JTEG committee with formal responsibilities (similar to the principals' oversight committee).

3. JTEG Should Actively Track Depots' Needs.

JTEG should systematically collect depot needs, and those needs should be reflected in the technologies JTEG tracks. This has not occurred at JTEG with any consistency. The lack of information about depots' needs—combined with weak depot POC links—has widened the gap between what depots need in technology and what JTEG is providing. JTEG needs input from the depots in order to link the projects it is tracking to its objective of making depots more efficient. Compiling these needs into a "top ten" issues list can help JTEG focus its energies and provide a standard for judging its ongoing projects. Tracking depots' needs results in success stories, which create more interest in JTEG, which, in turn, creates a self-reinforcing cycle.

4. Success Stories will Demonstrate Value.

JTEG is a small organization with no funds for sponsoring technology developers or depot adopters; therefore, the metrics it uses will be mainly non-monetary. JTEG is in the position of offering the depot community value and can demonstrate that value by having one or two success stories a year. Using metrics derived in Chapter IV, JTEG can quickly evaluate how it is meeting goals and make meaningful changes to improve performance. A strong, interlinking depot system can help reduce sustainment costs. However, JTEG has not tracked information exchanges to their ultimate conclusions.

The use of metrics will clarify which technologies facilitated by JTEG are in place. From there, the cost savings or reductions in sustainment costs can be obtained or estimated, bringing to light the benefits to the weapon system program managers.

C. SUGGESTED FURTHER STUDIES

This exploratory study investigated the circumstances surrounding the JTEG organization. Other potential studies, which can build on the ideas presented here, have applicability across many functional areas of logistics, acquisition and system management.

One primary area of research would be to relate benefits of depot-level technology insertions to life cycle cost reduction. This would close the loop that JTEG starts by providing information and assisting in new technologies for a depot. Once that technology is installed, it is typically lost among the general costs of doing business. By isolating the benefits of a specific technology in the depot system after implementation, lower total life cycle cost savings for weapon systems can be reflected back as a monetary benefit of JTEG.

Developing metrics to evaluate an organization, its objectives, and how best to track its progress can benefit any organization. Future studies could apply non-monetary measures to other organizations to highlight the organization's benefits. Many of the organizations observed in this study have significantly restructured over the last five to ten years, which is, at least in part, why the inefficiencies in JTEG are occurring. Re-evaluating core competencies should be an ongoing process that can be applied to any organization.

APPENDIX A. JTEG PROJECTS

The following is a list of active and inactive projects currently tracked by JTEG (JDMAG Website, Mar. 2001):

A. ACTIVE PROJECTS:

PROJECT NUMBER: 000901
TITLE: ADSIL Anti-Corrosion Coating (AD30)

NARRATIVE: About twenty years ago NASA began research on a chemical process that 'grows' glass at room temperature. Aptly named *Ambient Temperature Cured (ATC) Glass*, the invention was modified for commercial use as AD30 manufactured by ADSIL. AD30 is impervious to all corrosives – especially salts, acids, and alkalis. General types of coatings lay large molecules over the surface of metal substrates that merely stick; they do not chemically bond. Degradation of the coating creates pockets of air allowing corrosives to build up under the coating. AD30 utilizes covalent bonding to bond to metal substrates like an atomic welder. AD30 does not degrade and therefore no pockets of air are created to begin corrosion. AD30 has a five year guarantee, stops corrosion, and provides a surface that will not support mold, mildew, or algae growth.

PARTICIPANTS: Mike Hanson, USCG/ARSC, 252-335-6451; Andy Greg, NAVSEA, 703-416-0161; NAVAIR PMA 290; Charles Smithson, TACOM, 810-753-2370 (DSN 786); Ken Kilbilko; MCLB Albany, 912-439-6805.

STATUS: Active

Sep 00 Marine Corps is investigating use on the AAAV Program.

Nov 00 Coast Guard is testing and evaluating applications on wing slats of Falcon Jets.

Dec 00 NAVSEA is testing and evaluating select on shipboard applications. NAVSEA has directed that Bath Iron Works investigate use on 9 cost savings programs. NAVAIR is testing and evaluating test coupons. If results are favorable, plans are to field test on the S-3 Viking aircraft. TACOM is looking into the possibility of applications with the LAV and M1 Programs. NAS Jacksonville in partnership with the Depart of Energy has been working an energy savings program for the entire Air Station.

Feb 01 NAVAIR reports that preliminary test results are not as favorable as anticipated.

COMMENTS:
ADSIL LC
1 rgrove Grade, Suite 1-K
Palm Coast, FL 32137
905-445-8239; 800-549-2539; DoD rep is Mr. Tony Gedeon
Email: info@adsil.com
Website: www.adsil.com

PROJECT NUMBER: 000102
TITLE: Aircraft Applique'

NARRATIVE: Aircraft coating systems perform a variety of functions including corrosion prevention, erosion control, marking, camouflage, electromagnetic shielding, and other special functions. An environmentally friendly topcoat replacement system requiring less maintenance is required. Appliqué is one of the few technologies currently available which appears to provide topcoat performance with reduced organizational maintenance level (O-Level) requirements and reduced maintenance impact. The use of appliqué as a paint substitute could provide substantial cost savings; however, the benefits are not purely economic. The implementation of appliqué will enable the Navy to reduce the level of hazardous material generated by means of source reduction, which is the preferred method of current environmental legislation. Increases in aircraft readiness coupled with sizable reductions in maintenance labor-hours are expected. Anticipated benefits of appliqué are the reduction of painting requirements, reduction in repair time compared to touch up painting and the ability to perform appliqué repair concurrent with other aircraft maintenance. Appliqué material has been observed to behave as a system. If the primer, adhesive or polymeric film is changed, appliqué may not perform as expected. Coupon testing of the system is required prior to flight clearance based on this conclusion. Surface preparation is of major importance. The primer must be completely cured, properly sanded and cleaned prior to appliqué installation. Aircraft with a pressurized cockpit/cabin present additional issues. Adhesives tested to date have not been able to withstand the forces of a pressurized cockpit/cabin without appliqué disbondment. The solution is to use perforated appliqué allowing the air leaks to escape. However, perforated material may allow moisture to come in contact with the primer. Temperature limitations of appliqué have been observed around engine and accessory power unit (APU) exhausts. Economic issues of material cost, material application and material removal rates must be considered during the evaluation of appliqué for legacy aircraft. Although concerns, these factors are not an issue at the O-Level due to increased durability and corrosion protection which greatly reduce the requirement for replacing current topcoat material replacement. The increased performance characteristics of appliqué material may provide substantial O-level savings in both manpower and material.

ASSOCIATED INITIATIVES/ORG: AFLMA/LGM Project # LM922167, Alternate Aircraft Surface Finishes; JTEG Project 56346, Alternate Aircraft Surface Finishes; ESTCP Project Applique' Coatings.

PARTICIPANTS: Dave Pulley, NAVAIR 4.3, 301-342-8050, GySgt Pablo Sanchez, NAVAIR 3.6.3.1, 301-757-3094 (DSN 757); Mike Spicer, AFRL, DSN 785-0942

STATUS: Active

Mar 99 Appliqué technology has been previously trial used on the F/A-18B Hornet, the F-15 Tomcat, the S-3B Viking, and the C-130 Hercules aircraft. Appliqué has been demonstrated to reduce organizational maintenance in the F/A-18B Hornet and S-3B Viking programs. Future programs for trial use of appliqué are the KC-135 Refueling Tanker, the AV-8B Harrier, the P-3 Orion, and the F-16 Falcon. Replacing aircraft paint with film is not ready on a wide scale as yet. Long-term performance factors need to be evaluated. Areas of concern are corrosion impact, adhesive properties, material durability, and edge sealer materials.

Apr 99 The Joint Appliqué Initiative between the Navy and Air Force currently includes the AV-8B, E-2, F/A-18, P-3, C-130, and S-3 aircraft platforms. Additional appliqué efforts underway or completed include the F-16, F-15, F-18 aircraft platforms. The AV-8B, Harrier platform has completed coupon testing at Boeing, St. Louis.

- The E-2, Hawkeye platform has applied appliqué material on the rotordome, January 2000. The platform has received full flight clearance from NAVAIR, March 2000. The aircraft will return to the squadron for the period of one year. The material will then be removed to evaluate both the appliqué and substrate. Appliqué material will be reapplied and monitored for an additional period of one year.

- The F/A-18, Hornet platform has determined the locations of the appliqué coupons for testing. Draft Statements of Work for the appropriate activities have been created. Squadron test aircraft have been identified.

- The P-3, Orion platform has considered appliqué as a solution for wing area corrosion problems. A test work document is being developed.
- The Air Force C-130, Hercules platform is a replacement for the KC-135. Laboratory testing is underway to perform adhesion comparison tests, optimum primer cure time and corrosion effects of both the perforated and non-perforated materials. The contract to cover C-130 aircraft with appliqué in the year 2000 has been awarded to the Boeing Company.
- The S-3, Viking platform has created a Test Work Document for coupon testing. Coupon testing is planned for March/April, 2000. Full aircraft coverage will be based on the results of the coupon flight tests.
- The F-16, Falcon platform has completed the installation of 336 square feet of coupon material.

Jul 99 Testing is underway with seventy of the planned two hundred flight hours complete.

- The results to date indicate that appliqué behaves as a system. The appliqué system consists of five elements; the aircraft skin, metallic or composite, pretreatment, primer, appliqué adhesive layer and the appliqué polymeric film. Aircraft surface preparation is critical in the application of appliqué. It is desired that a freshly primed aircraft have a surface roughness less than 65 micro inches. A surface roughness greater than 65 micro inches but less than 100 micro inches is marginal. Surface roughness with measurements greater than 100 micro inches will not provide the surface area required for proper adhesion. The peaks and valleys are too many. The primed surface must be smoothed with a light abrasive, such as scotchbrite, to increase the contact area of the adhesive.
- Testing appliqué material has also indicated that there are temperature and pressurization limitations. Perforated appliqué will be used on pressurized aircraft allowing the aircraft cabin/cockpit leaks to pass. Current appliqué material has demonstrated expansion and wrinkling in the presence of high heat from the Auxiliary Power Unit (APU) and direct turbine engine exhaust.

Aug 00 The Joint Appliqué Project has made significant strides. The purpose of the project is to evaluate appliqué material as an aircraft topcoat replacement in an operational environment. The types of appliqué material available have been studied. The selected versions of appliqué have been purchased from the manufacture. The material has also been evaluated in laboratory conditions representing the operational environment. Tests performed to represent the environment include impact resistance, material flexibility, corrosion resistance, and adhesion. These tests are performed with various stresses and weather conditions simulated.

- The results of laboratory testing have provided confidence in the material's abilities to proceed to small coupon testing. Small coupons, 3"x3" to 6"x6" squares, of appliqué material have been placed on the S-3 Viking aircraft. The small coupon flight evaluation results were positive. The small coupon test evaluation results support advancing the appliqué project to the next step. Large coupon testing of appliqué material on the S-3 Viking aircraft is that next step. Appliqué material, FP-500 and FP-1500 with 52-4 adhesive, has been selected for large coupon testing. Large coupons vary in size from a 1'x 1' square to a 2'x4' rectangle. A flight test program has been generated and executed for the testing of FP-500 material with 52-4 adhesive both perforated and non-perforated. A separate flight test program has been generated and executed for the testing of FP-1500 material with 52-4 adhesive both perforated and non-perforated. The large coupon appliqué testing is complete.

- The F/A-18 platform is considering the use of appliqué material. Appliqué material properties regarding P-static are currently a point of discussion. Testing criteria for appliqué material peculiar to F/A-18 requirements have been developed by F/A-18, AIR - 4.3 and AIR-3.6 team members.
- The Air Force has selected the C-130 aircraft as the test platform for appliqué material. Boeing Corporation has been contracted to develop training material/documents for appliqué material application and repair. The C-130 wheel well area has been laser mapped, by Boeing, to develop patterns for the appliqué material. Boeing Corporation will perform the installation of appliqué material to the C-130 aircraft.
- The P-3 program office has expressed interest in using appliqué material on the aircraft to reduce corrosion. The top and underside of the wing, not to include the engine nacelles, are the current target areas for appliqué material. The FP-500 material and 52-4 adhesive have been selected as the appliqué material for this purpose.
- The E-2 platform has applied appliqué material, FP-500 material and 52-1 adhesive, to the TRAC-A roto-dome. The appliqué material is used to cover the fiberglass to aluminum seam on the roto-dome. The material is scheduled to remain on the aircraft for one year. The material will then be removed and the area inspected. The material will be reapplied to the aircraft for an additional year. The aircraft is a squadron asset not a test platform.
- The Joint Appliqué Project plans to continue the evaluation of appliqué material to the extent of covering the external surface of an aircraft. The material shall remain on the aircraft for a time period equivalent to an Integrated Maintenance Concept (IMC). Scheduled inspections will be conducted to monitor both the operational and maintenance characteristics of appliqué in the operational environment.

Sep 00 The test results of large and small scale coupon testing on both laboratory and aircraft did not meet the minimum requirements for AIR-4.3 to approve the use of appliqué in the S-3 full-scale flight test plan.

Feb 01 AIR-4.3 will continue to study and compare large area application and removal methods of appliqué material with studies being conducted through SBIR and Repair Technology efforts. Air-4.3 is also continuing to investigate additional appliqué materials to include P-Static testing to understand the lightning strike survivability of appliqué material. AIR-4.3 will pursue working with the manufacture of appliqué material to meet the established requirements, and further recommends that Naval Aviation postpone additional demonstrations of appliqué technology on full-scale aircraft until this is resolved.

- Air Force has completed laser mapping of the C-130 aircraft, via Boeing Corporation, and is having appliqué gores and boots made. Air Force has identified the O Level training required for inspection and repair appliqué material, which will be conducted prior to and during the application process on the C-130 aircraft.

PROJECT NUMBER: 72524
TITLE: Catalytic Extraction Process

NARRATIVE: The Catalytic Extraction Process (CEP) is hoped to eliminate disposal fees for some hazardous wastes handled by DRMO. CEP uses a molten metal bath to convert wastes to useful rew materials. Wastes are injected into the molten metal bath, where the catalytic properties of the moten metal dissolve molecular bonds and reduce compounds to single elements. The elements can then be used as building blocks to form commodity gases, ceramics, and metals for disposal, recycle,or sale to established markets. CEP completely destroys hazardous compounds, exceeding regulatory standards for missions and residuals. Upon introduction to the bath, the catalytic effect of the metal, selective reactants, and appropriate reaction engineering cause waste materials fed into the system to dissociate into their constituent elements and be incorporated into the molten metal. The CEP reactor is designed for continuous operation and is comprised of process components currently used widely by the metallurgical and chemical communities. CEP has been demonstrated successfully on many materials ranging from simple compounds (like paraffins, alcohols, and water), to complex material containing toxic metals, halogens, cyanides, PCBs and polyaromatic hydrocarbons. Based on these tests, high-level feed destruction and high-value product syntheses have been proven experimentally. Benefits to DOD include the elimination of waste disposals, manifesting, reduction of TRI numbers, usable by-products and cost comparable or equivalent to disposal costs without CEP.
PARTICIPANTS: Don Black, DRMO/UIMB, DSN 339-7033, dblack@oklahoma-ex.drms.dla.mil
STATUS: Active

Feb 97	No update.
Sep 97	Treatability Tests I, II, & III are completed. Regulatory reviews to follow.
Nov 97	Planning Phase II.
Nov 99	The contractor declared bankruptcy. The new contractor, Quantum Catalytic, is nearing completion of required research for Phase III.
Aug 00	No update.
Mar 01	No update.

PROJECT NUMBER: 72543
TITLE: Cleaning Formulations Based on Lactate Esters

NARRATIVE: The Argonne National Laboratory (ANL) has developed four formulations of Lactate Esters that can possibly be utilized as a drop-in replacement for many of the solvents and cleaners used by DoD. Some physical properties of Lactate Esters include: non-toxic, FDA approved, non-ozone depleting, non-carcinogenic, semi-aqueous, low volatility, compatible with all metallic materials and most plastic polyermers, recyclable, and completely biodegradable (typically within 24 hours).
ASSOCIATED INITIATIVES: DoE Project "Novel Membrane Technology Applications and Green Product Development"
PARTICIPANTS: Mary Nelson, CTC, 803-637-2534; Tom Landy, TACOM, 810-574-8818, Richard Beckman, NTEC, 814-337-7296; Rathin Datta, Argonne National Lab, 630-252-6478; Carl Adams, JDMAG, DSN 986-2771; Carrie Roque, NADEP Jacksonville; Elaine Lambert, CCAD, DSN 861-4663; Ron Hagler, AMCOM.
STATUS: Active

Mar 97	ANL and the Corpus Christi Army Depot (CCAD) are constructing a proposed ESTCP Project "Demonstration and Validation of Cleaning Formulations Based on Lactate Esters". This project will test the feasibility Lactate Esters for use in Honey

Comb Structure Repair and Hydraulics Cleaning applications.

Apr 97 Project proposal submitted to ESTCP.

Aug 97 Proposal not selected by ESTCP. Pursuing other possible funding avenues.

Oct 97 Investigating possible funding/project with the National Center for Manufacturing Sciences (NCMS).

May 98 ESTCP and NCMS did not select as a project.

Dec 98 New Technology Inc. (NTEC) has 5000 tons of lactate ester available for project use at little to no cost to the military.

Jan 99 OC-ALC showing interest in starting a project.

Aug 99 EPA has given Versol (lactate ester) the Green Chemistry Award. Corrosion testing needs to be addressed. Dynamold Solvents produces DS108 which is 70% ethyl lactate. DS108 is not corrosive. NTEC and Dynamold are investigating the additional testing needed for corrosion testing of lactate ester. AMCOM is requesting that a demonstration project be accomplished for cleaning aircraft engines at CCAD.

Nov 99 MCLB Albany showing interest in starting a degreasing project.

May 00 Crane Naval Weapons Station tested and evaluated degreasing capabilities for railroad boxcars. Results were very successful.

Jul 00 NADEP Jacksonville to begin test and evaluation for degreasing capabilities. The Army Missile Command is planning a cleaning project.

Oct 00 OSD funded the Control Technology Center (CTC) with a tasking to begin testing and evaluation of lactate esters as a Non-Toxic Chemical Depainting and Cleaning Agent. This Tasking is CTC Sub-Task 024), and the Project Manager is Ms. Mary Nelson, 803-637-2534. The primary stake-holder and technical monitor is the Army Tank and Automotive Command (TACOM). The TACOM POC is Mr. Tom Landy, 810-574-8818.

Jan 01 The JDMAG mailed letters to the depot maintenance community requesting interest and participation in CTC Sub-Task 024.

Mar 01 Showing interest in participating are CCAD, ANAD, MCLB Barstow, and the USCG Elizabeth City.

PROJECT NUMBER: 72526

TITLE: Direct-to-Metal Primerless Topcoat (DTM)

NARRATIVE: The Marine Multi-Commodity Maintenance Centers (MC3) at Albany, GA, at Barstow, CA, and Fleet Marine Forces are seeking to reduce Volatile Organic Compound (VOC) emissions. Switching from a primer coating operation to a primerless coating operation will reduce VOC emissions by approximately 45% and enable the Marine Corps to comply with local Air Quality Management Control Board regulations. DTM is a one step application, has excellent adhesion to MIL-C-29475 type coatings, which will remove one shop floor coating process. DTM has potential for improved corrosion protection. DTM requires one hardner and therefore will reduce material inventories. DTM is expected to meet or exceed MIL-P-22750, MIL-P-53030A, and MIL-P-53022. Application color is Seafoam Green.

PARTICIPANTS: Ken Kilbilko, MCLB Albany, GA, DSN 567-6805

STATUS: Active

Dec 96 DTM application to USMC test vehicles at MC3 Albany, cold weather application at MC3 Barstow.

3Qtr97	DTM application to USMC test vehicles at MC3 Albany, hot weather application at MC3 Barstow.
Feb 97	Cold weather applications for MCLB Albany and Barstow have been completed. Application tests for maritime conditions have been added to the field testing.
Jun 97	The maritime application is scheduled for Blount Island.
FY97	Field monitoring will be conducted for coating performance.
Aug 97	Maritime Preposition Ship Equipment scheduled for painting in Oct 97. Due to enhanced DTM corrosion resistance, the reformulated hot weather test is now scheduled for the first temperature permitting opportunity or Summer 1998.
Oct 97	Applied DTM to 50K lbs Rough Terrain Cargo Handlier (RTCH). The RTCH will be secured topside bow of an MPS ship and will be exposed to long durations of ocean salt water environment.
Nov 97	Scheduled to apply a new zinc rich primer and DTM (a two coat system) on a RTCH that will be loaded on board a different MPS ship. The new zinc rich primer is exhibiting excellent results with over 4500 hours in the salt fog lab tests.
Feb 99	Maritime applications were completed. The Naval Surface Warfare Center (NSWC) Carderock is conducting site surveys to evaluate application performance.
Nov 99	Last year, DTM applications were made on Camp Pendleton 5 ton trucks and HUMMVs at MC3 Barstow. 18 month evaluations at Camp Pendleton are proving that DTM coating is an excellent coating and corrosion control package. NSWC Carderock is developing a report on the results. The evaluation on the RTCH is still in process.
Jul 00	Project is still on-going. RTCH evaluation is still in process.
Mar 01	Awaiting site surveys report from NSWC Carderock.

PROJECT NUMBER: 970701
TITLE: FLASHJET Coating Removal System

NARRATIVE: FlashJet is a coating removal Boeing-patented depainting process to address the difficult problem of removing paint and specialty coatings from aircraft and aircraft components. The process employs pulsed light energy to pyrolize organic coating and, simultaneously, a stream of CO_2 particles which cools the substrate and removes the coating residue. The process involves an integrated stripping head that has a xenon flash-lamp to ablate the paint; a stream of frozen carbon dioxide pellets to clean and cool the surface; and an effluent capture system that collects the CO_2 and coating that is being removed. The energy source is an electrically energized, xenon-filled, quartz tube that emits pulses of light. The surface coating absorbs photon energy, heats to the point of pyrolysis, and changes into fine ash particles and previously trapped volatiles. At the same time the dry ice system applies a particle stream to the surface to offset potentially damaging pyrolysis heating, maintains flash-lamp window cleanliness for constant maximum light transmission, and sweeps away coating residue from the surface. FlashJet is a synergistic combination of two technologies that allows the advantages of each to cancel out the disadvantages of the other to achieve effects that neither could by itself. These effects include high strip rates, damage free coating removal, finite process control, and significant reductions in maintenance man-hours, stripping cycle time, and stripping costs. The benefits include: a significant reduction of hazardous materials and wastes, selective coating stripping, and reduced turn-around-times. This technology is offered as mature, commercial off-the-shelf, technology in the form of a FlashJet Gantry system for small tactical military aircraft.

PARTICIPANTS: Steve Hartle, NAVAIR 4.3.4.E, DSN 342-8006, Tom Cowherd, NAVAIR 6.3, DSN 942-0516x123, Edward Cooper, CCAD/SIOCC-ES-IE, DSN 861-2214, Mike McMillan, AFMC/ENB, DSN 787-6484, Randy Ivey, WR-ALV/TIEDM, 912-926-4489.
STATUS: Active

May 96 FlashJet Gantry system is operational at Boeing Mesa, AZ. Since this time, 139 AH-64A Apache Helo's have been stripped.

Jul 97 NAVAIR approved the Flashjet technology on all metallic, fixed-wing aircraft surfaces. NAVAIR T-45 aircraft program awarded contract to Boeing, St Louis to procure and install a Flashjet System at NAS Kingsville, Texas.

May 98 A Mobile Manipulator Prototype System was jointly developed by the Air Force and the Navy as a pollution prevention technology project, funded by SERDP (note: SERDP transitioned technology to ESTCP in Sep 97). This system was developed by Mercer Engineering Research Center and The Boeing Company and was successfully demonstrated at NADEP Jacksonville during the summer of 1998. Demonstration of the technology at NADEP Jacksonville funded primarily by CNO/N-45.

FY99 ESTCP Project funded for tri-service certification, and demonstration/validation of Flashjet on rotary wing aircraft.

Mar 99 Boeing Aerospace developed their version of a Mobile FlashJet System for large aircraft. This system was sold to Singapore Airlines and is currently depainting C-130 and C-141 aircraft in Singapore.

Mar 99 FlashJet Gantry System operational at NAS Kingsville supporting T-45 depainting efforts. To date 20 aircraft have been depainted since its commissioning.

Nov 99 The FlashJet Gantry System has been constructed at CCAD for depainting UH60, SH-60, AH-64, and CH-47.

Apr 00 FlashJet demo for the EA-6B conducted at NAS Kingsville Texas T-45 facility and was a major success. Enabled NADEP Jacksonville and others within the DOD to "Test Drive" the system and assess FJ Gantry capability to meet production requirements and to strip fighter aircraft.

May 00 Boeing St. Louis and NAVAIR enter into contract for the next generation Mobile Manipulator FlashJet System for NADEP Jacksonville. The project consists of 4 phases:

Phase I requires JOINT contracting for modeling/simulation of a new mobile manipulator, Preliminary Design, Critical design review, Final Design Review, and Demonstration/Acceptance Test at the Vendor's Test Site on simulated P-3 aircraft section. This phase will take approximately 12-15 months.

Phase II will consists of a practical demonstration of that mobile manipulator (less an operational FJ system) at NADEP Jacksonville on a Navy P-3 aircraft.

Phase III upgrades NADEP Jacksonville facilities and FJ equipment and support systems and ends with an actual strip demo on a P-3 aircraft.

Phase IV consists of procurement of Contractor Furnished Equipment, namely the Boeing Mobile Manipulator.

Jun 00 FlashJet Gantry System is operational at WR-ALC for off aircraft parts/components.

Jan 01 CCAD operational. First UH-60 Blackhawk programmed and stripped.

Feb 01 The Boeing Company continues under contract for Phase I Mobile Manipulator System with Framatone and PAR Systems as subcontractors. Modeling/simulation study by Framatome is completed. PAR Systems has completed final design review, and has begun manufacture of the Manipulator. Manufacture demonstration of manipulator is scheduled for early August. Phase II tentatively scheduled for Cecil Field.

PROJECT NUMBER: 000103
TITLE: Laser Cladding

NARRATIVE: Laser cladding is using laser energy delivered down a fiber-optic cable to a work piece for the purpose of depositing surface materials onto a substrate. Typically, a laser cladding process will utilize an industrial 3.0 Kilowatt Yittrium Aluminum Garnet (YAG) laser to fuse metal powder into areas affected by corrosion or other types of damage. YAG is the type of crystal used as the gain medium in the laser. The YAG crystal is surrounded by flashlamps that produces the laser energy. The YAG laser energy is delivered to the repaired part via a fiber optic umbilical, manipulated by a robot. The robot also directs a powder feed nozzle into the beam to provide filler material for the repairs. The major benefit of the laser cladding process is that repairs can be made on expensive aluminum components which cannot be repaired using more conventional processes – such as 7000 series aluminum alloys used in torpedo components. Approximately 1/3 less heat is transferred into the part base material compared with conventional welding processes - greatly reducing undesirable affects such as thermal distortion, cracking, and large heat affected areas. Even materials which can not be welded such as K-monel, can be cladded with a laser.
PARTICIPANTS: Nick Eutizzi, PSNS 138.3 DSN 339-9941, eutizzin@psns.navy.mil; Mike Lehman, NUWC Keyport, DSN 744-7173, mlehman@kpt.nuwc.navy.mil
STATUS: Active

Aug 99 The PSNSY started development of laser cladding technology in 1994. PSNSY is not in a full production mode but some repair of shafts and industrial control valves is being accomplished. A primary focus for laser cladding has been in development of laser repair methods for shafts, valve discs, and catapult trough covers from aircraft carriers. Inconel 625 and Stellite 6 are the primary materials for laser cladding. Some welding has been accomplished with carbon steel and nickel al bronze (NAB).

\- The NUWC Keyport designed and installed Laser Processing Facility became operational. The basic cladding process was developed and proven at the Penn State Applied Research Laboratory (ARL) working under a MANTECH funded project. The newly installed system is being phased into production to make repairs on torpedo shells, target shells, fuel tanks, and a variety of Inconel components.

Mar 00 Plans are underway to begin in Sep 00, building a second processing room to double the capacity of the NUWC Laser Cladding facility.

Jul 00 At NUWC a "Q" Switched stripping laser and a second robot will be added to enable torpedo shell paint and anodize to be laser stripped. The laser stripping capability will provide labor savings and a reduction in hazardous waste by enabling operators to only selectively strip areas needing laser clad repair. Using timeshare fiber optic systems on both the cladding and stripping lasers, NUWC will be able to clad and strip in each Processing Room.

Mar 01 No update.

PROJECT NUMBER: 72553
TITLE: Lead and Antimony Free Solid Film Lubricants

NARRATIVE: Solid Film Lubricants (SFL) find wide use throughtout DoD. SFLs in use now are both hazardous, due to the presence of lead and antimony, and costly, because used containers of these SFLs are a hazardous waste. DoD policy regarding P2 has caused many installations to bar use of SFLs high in lead and VOC content. Since OSHA considers antimony to be a carcinogen, many users are also concerned because current SFLs contain antimony. The objective of this effort is to develop and field SFLs that do not contain lead or antimony compounds, reduce the VOC content to current environmental standards, and meet performance requirements for MIL-L-46010 and MIL-L-46147.

PARTICIPANTS: TACOM - Tom Landy, AMSTA-TR-E, DSN 786-8818; Ft Belvoir - Ralph Mowery, MTC-B, 703-704-4220, DSN 786; - Luis Villahermosa 703-704-4207, DSN 786

STATUS: Active

Mar 97 Program Plan developed and sent to Belvoir Center for review and comment.

May 97 Sandstrom Products and E/M Corporation are the industry partners involved with this project. They are still developing candidate SFL formulations meeting the lead and antimony-free requirements. When completed, both companies will submit samples to the TARDEC Fuels and Lubricants Research Facility for laboratory testing.

Feb 99 Southwest Research Institute (SWRI), reported limited success with the initial product submissions from Sandstrom Products and E/M Corporation, among others. All products failed either the salt fog resistance requirements or had problems with the endurance life and load capacity tests. Three new products are about to undergo the same screening tests -- one molybdenum disulfide product from Sandstrom, and two products (Alseal 380 and Urethabond W119U) from Coatings for Industry. Unfortunately, these products were designed to be applied at five times the current mil thickness specified under MIL-L-46167, so if they successfully pass all testing requirements, they could only be used for applications where thickness was not an issue. A Type III classification under MIL-L-46167 may have to be developed for these products.

Nov 99 The focus of this project has narrowed to the identification of lead- and antimony-free solid film lubricants meeting MIL-L-46147, Type II requirements. SWRI concentrated on molybdenum disulfide-based materials for this investigation and was able to test the following 10 products: MoS2-900 (McGee), MoS2-108L (McGee), MoS2 (Sandstrom), Tiolube 75/75 (Tiodize), Lubribond K (E/M), Alseal 380 Air Cured (Coatings for Industry, Inc.), Alseal 380 Heat Cured (Coatings for Industry, Inc.), Urethabond W119U Air Cured (Coatings for Industry, Inc.), and Urethabond W119U Heat Cured (Coatings for Industry, Inc.) The products were tested against the technical requirements identified in MIL-L-46147, which included endurance life/load carrying capacity, fluid resistance, thermal shock sensitivity and corrosion resistance. Bottom line -- none of the materials tested could meet all of the specification's requirements, with corrosion (salt spray) resistance being the common failure among all of the materials.

Nov 99 Review of the results is in process. It appears that none of these materials meet the specification requirements for salt spray, that does not necessarily mean the products cannot be used. The TACOM-TARDEC Fuels and Lubes Technology Team is re-visiting the current salt spray resistance requirement. The team is determining as to how 100 hours per ASTM B117 was developed and whether it is still applicable. Technical requirements are reviewing many different applications to insure materials and technologies are not rejected, which may meet some (if not all) requirements for specific applications.

Mar 01 A draft of a Final Report of results has been distributed. TACOM is evaluating the results.

PROJECT NUMBER: 970801
TITLE: Next Generation Transparency Program (NGT)

NARRATIVE: The objective of this program is to demonstrate and validate the ability of Injection Molded Frameless transparency Technology to be incorporated in an integrated design that meets the future mission requirements for an advanced strike aircraft. Technologies to be integrated into the frameless transparency concept under this program include advanced abrasion resistant coatings, mission compatible optics, 500 kt bird impact protection, emergency egress through the canopy, rapid transparency change-out, manufacturing processes and combat hazard protection. The products of this program will be: a validated set of design criteria necessary to combine injection molded frameless transparency technology as part of an integrated system; and a full scale injection molded frameless canopy that has demonstrated manufacturing scale-up and the ability to satisfy mission requirements. The payoff of this program will be: an order of magnitude reduction in transparency manufacturing costs, mission compatible durability, combat hazard protection, and optics; improved supportability through reduced spare parts and a less than one hour replacement time. Because of the AFRL team approach to validating the Next Generation Transparency, the technology will be ready for direct implementation. Two cooperative agreements have been awarded to Boeing Information, Space and Defense Systems for a total of $6M.

PARTICIPANTS: Bob McCarty, AFRL/MLMP, DSN 785-2598; Mike McMillan, AFMC/ENS, DSN 787-6484; Ron Wimmer, NAVAIR 6.3.4.2, DSN 757-3062

STATUS: Active

Aug 97 Bob McCarty, NGT Program Manager briefed the JTEG and requested funding support for FY99/00.

Sep 97 A NGT kickoff meeting was hosted by Boeing. Boeing presented the IPPD process overview on the first day (10 Sep 97).

Jan 98 Customer requirements and down-select criteria for demonstration platform have been developed.

Nov 98 Initial selection of F-22 canopy as NGT demonstration platform.

Jun 99 F-15 based cost studies completed.

Sep 99 Final selection of Advanced Fighter configuration as NGT demonstration platform.

Jul 00 Deep Optical Element Part articles successfully injection molded at Salt Lake City.

Aug 00 Deep Optical Element Parts were molded in Salt Lake City. Generally good results with regard to optical distortion; however, orange peel on the steel molds (by-product of polishing) was manifest on the surface of the plastic parts. OML surface was worst. It corresponds to the cavity.

Oct 00 Demonstrated that Deep Optical Element Parts exceed F-16 & F-22 specs for optical distortion. The design of the Full-Scale Demonstration Article was reviewed and approved.

Jan 01 Deep Optical Element Mold Cavity surface being re-worked at Delta Tooling using 2 different methods to demonstrate that an orange peel free surface can be produced. This activity is in-progress and will be complete in March/April 01.

Feb 01 NGT team met on 21 Feb to review and select available mold materials and mold manufacturing concepts prior to ordering steel for full-scale demonstration article and to make a decision regarding what tool steel will be ordered. The decision was based on the performance of the steels (primarily corrosion resistance, machinability and polishing), but with the decision was constrained based on the available NGT program budget and schedule. The team concluded that the FSDA mold will be fabricated from P-20 tool steel (same as Deep Optical Element Mold) due to budget and schedule constraints. However, for the EMD program, the steel of choice may very well be stainless steel because it is now available in large enough billets to manufacture a monolithic mold (as well as other options for providing a SS surface).

Jun 02 Full Scale Development Article injection operations.

Sep 02 Complete demonstration testing of Full Scale Development Articles.

PROJECT NUMBER: 001001
TITLE: Non-ODC Oxygen Line Cleaning

NARRATIVE: This project is a Joint Group on Pollution Prevention (JG-PP) Project J-99-CL-015. The purpose of this project is to demonstrate and qualify a portable unit for onboard cleaning of oxygen systems and two off-aircraft oxygen line cleaning systems that use non-ozone depleting chemicals (ODC) to clean oxygen lines on Department of Defense (DOD) and National Aeronautics and Space Administration (NASA) aerospace vehicles.

Currently, once an oxygen system becomes contaminated, all lines and components must be removed and cleaned, then re-installed. To remove these lines, many other aircraft systems equipment must be removed to gain access to the oxygen lines. This is very labor intensive and requires all disturbed equipment to be functionally checked prior to the aircraft flying again.

The Air Force, Navy, and Northrup Grumman have independently developed viable and complimentary alternative cleaning processes that do not use ODC cleaners. This JG-PP project is a partnership with a current Environmental Securities Technology Certification Program (ESTCP) sponsored project "On-Board Oxygen Line Cleaning System for use with DOD Weapon Systems".

Additional information and status of this project can be found on the JG-PP web site: www.jgpp.com

ASSOCIATED INITIATIVES/ORG: FASTT Team project EDWARD_412CRS_FEH03, Replacement for Freon-113 in LOX Shop; JTEG Projects 72528 Liquid Oxygen Technical Orders, 72529 Liquid Oxygen Tube Cleaning, and 72530 Oxygen Gauge Cleaning.

PARTICIPANTS: Ron Wimmer, NAVAIR 6.3.4.2, DSN 757-3062

STATUS: Active

May 96 SA-ALC began testing the Navy Oxygen Cleaner (NOC) for cleaning liquid oxygen lines and hydraulic lines.

May 99 Off-aircraft and space vehicle cleaning and other applications are also being evaluated under JG-PP project J-99-CL-015.

Jan 00 Draft Joint Test Plan (JTP) for JG-APP Non-ODC Oxygen Line Cleaning Project J-99-CL-015 is being developed.

Mar 00 Draft JTP for JG-APP Non-ODC Oxygen Line Cleaning Project J-99-CL-015 finalized and distributed.

Apr 00 This project will not be updated by the JTEG because it updated by the JASPPA. This project may be found on the JASPPA website at www.jgpp.com The JTEG will keep the status of this project as Active until it is closed by the JASPPA.

PROJECT NUMBER: 72530
TITLE: Oxygen Gauge Cleaning with HFEs

NARRATIVE: 3M™ Hydrofluoroether (HFE)-7100 is currently being investigated by the Naval Sea Systems Command (NAVSEA) and NASA as a CFC-113 replacement for oxygen gauge cleaning and as a wipe solvent for oxygen life support applications. Aqueous cleaning systems and the Navy Oxygen Cleaner (NOC) will not clean gauges and other components adequately due to the complex geometric components that are part of oxygen gauge assemblies. The Air Force is also investigating the use of HFEs for cleaning of precision missile and aircraft guidance components. Several Naval Aviation Depots are also considering evaluation of HFEs for certain uses such as precision bearing cleaning. HFEs are also being considered for electrical contact cleaning (where nonflammable cleaners are necessary, such as on energized equipment), certain high performance electronics cleaning applications, and as a carrier solvent for high performance lubricants. HFEs are designed for specialized industrial and manufacturing processes across many, varied industries. These applications include precision cleaning of high value, complex parts used in electronic, computer, aerospace, and medical products and equipment, and in automotive systems. Other key applications are in: 1) heat transfer and low temperature cooling systems including secondary loop refrigeration in equipment such as supermarket freezer cases; 2) as a carrier for specially lubricant deposition on computer hard disks; and 3) as a key component in spray contact cleaners used in electrical maintenance and repair.

PARTICIPANTS: Neil Antin, NAVSEA, (703) 602-5552, Ext. 508, antinne@navsea.navy.mil or Dennis W. Schroll, Wright-Patterson AFB, (937) 255-7953/dSN 785-7953, Dennis.Schroll@wpafb.af.mil

STATUS: Active

Jun 96 3M is initially introducing 3M HFE-7100 and 3M HFE-71DE and is continuing research and development on providing a family of 3M HFE products for an even broader range of applications. A third 3M HFE is scheduled for commercialization in early 1997. Initial screening and applications research are proceeding on additional products in the family. Detailed technical information on the new 3M(Tm) HFEs is available from 3M Engineering Fluids & Systems, Dept. CH96-10, 3M Center 223-6S-04, P.O. Box 33223, St. Paul, Minnesota 55133-3223, or by calling 800/455-2972.

Aug 96 A partnership agreement is planned with the 3M corporation and NADEP Cherry Point.

Dec 96 Testing is underway at NADEP Cherry Point. Testing indicates that non-flammable, low pressure, non-VOC HFEs may perform as desired. From May 96 through Sep 98, NASA and NAVSEA accomplished testing to qualify HFE-7100 as an Oxygen Gauge Cleaner for NAVSEA. The qualification testing was for cleaning performance, compatibility analysis for piping system materials, compatibility with gaseous and liquid oxygen systems, solvent removal, and toxicity analysis (The Navy Health and Environmental Center was a participant in the toxicity studies).

Jan 00 NASA's report concluded that HFE-7100 is an acceptable cleaner for oxygen gages. NAVSEA is planning to start using HFE-7100 sometime in FY 2000. The Naval Air Systems Command (NAVAIR) has decided not to use HFE-7100 only because its cleanliness cannot be verified with infrared analysis in a process called the Non-Volatile Residue (NVR) method.

Jul 00 Based on previous testing, NAVSEA is drafting an Oxygen Requirements Technical

Manual for Oxygen Gauge Cleaning, NAVSEA ST700-AM-GYD-020-OYCR. The draft of this manual should be released sometime this fall. NAVSEA is also testing a new analysis method for HFE 7100 to replace the NVR analysis method.

Feb 01 For oxygen gauges, the Navy has completed its testing of HFE-7100, and has also tested and evaluated a new cleanliness verification method. The Navy will replace IR analysis with Optically Stimulated Electron Emission (OSEE) using a device called a surface quality monitor (SQM).

All of this is being incorporated in a revised technical manual that will be issued this year. The SQMs will be implemented over the next 4 years. The technical manual allows use of either CFC-113 or HFE-7100. The SQM can analyze both solvents. Currently all T&E results of HFE-7100 cleaning and the SQM is in draft form. Because of lack of funds, the results will not be coordinated into a final report for some time (probably years). The major effort has been in preparing the applicable technical manual and the implementation plan.

PROJECT NUMBER: 970401
TITLE: Paint Carrier Agent Formulations Based on Lactate Esters

NARRATIVE: The Argonne National Laboratory (ANL) has developed four formulations of Lactate Esters that can possibly be utilized as a drop-in replacement for many of the solvents and cleaners used by DoD. Some physical properties of Lactate Esters include: non-toxic, FDA approved, non-ozone depleting, non-carcinogenic, semi-aqueous, low volatility, compatible with all metallic materials and most plastic polymers, recyclable, and completely biodegradable (typically within 24 hours).

ASSOCIATED INITIATIVES: DoE Project "Novel Membrane Technology Applications and Green Product Development"

PARTICIPANTS: Mary Nelson, CTC, 803-637-2534; Tom Landy, TACOM, 810-574-8818, Richard Beckmann, NTEC, 814-337-7296; Carl Adams, JDMAG, 937-656-2771, DSN 986.

STATUS: Active

Apr 97 Communications between JDMAG/MAT and the Argonne National Laboratory revealed the possibility of a No-VOC and a Ultra Low-VOC Paint formulation from lactate esters.

May 97 JDMAG/MAT proposed the project to ANL. This project will seek to demonstrate the feasibilty of using lactate ester as a carrier agent for paint coatings. This technology application could produce a No-VOC or a Ultra-Low VOC paint coating.

Jul 97 ANL communicating with industry and academia to prove the No-VOC and Ultra Low-VOC formulations. JDMAG/MAT communicating with the depot community and Service laboratories for funding and resource participation.

Aug 97 Interested participants are GSA, NFESC, NADEP Jacksonville, NAWC Patuxent River, Wright Laboratories, New Technology Inc. (NTEC), a California university, and an industrial paint company.

Oct 97 Investigating possible funding/project with the National Center for Manufacturing Sciences (NCMS).

May 98 NCMS was very interested but did not select as a project.

Dec 98 New Technology Inc. (NTEC) has 5000 tons of lactate ester available for project use at little to no cost to the military.

Jan 99 No interest is shown in starting a project. This proposed project has been cancelled due to lack of interest. ANL is now concentrating on cleaning and stripping processes.

Jan 00 Project reopened. TACOM showing interest in starting a No-VOC Coating Project.

May 00 The National Defense Center for Environmental Excellence (NDCEE) is to evaluate several applications of lactate ester, paint solvents is one of the applications.

Jul 00 No change.

Oct 00 OSD funded the Control Technology Center (CTC) with a tasking to begin testing and evaluation of lactate esters as a Non-Toxic Chemical Depainting and Cleaning Agent. This Tasking is CTC Sub-Task 024), and the Project Manager is Ms. Mary Nelson, 803-637-2534. The primary stake-holder and technical monitor is the Army Tank and Automotive Command (TACOM). The TACOM POC is Mr. Tom Landy, 810-574-8818.

Jan 01 The JDMAG mailed letters to the depot maintenance community requesting interest and participation in CTC Sub-Task 024.

Feb 01 Showing interest in participating are Redstone Arsenal, DLA Mechanicsburg, OC-ALC, CCAD, ANAD, MCLB Barstow, and USCG/ARSC.

PROJECT NUMBER: 72536
TITLE: Paint Stripping With Lactate Esters

NARRATIVE: The Argonne National Laboratory (ANL) has developed four formulations of Lactate Esters that can possibly be utilized as a drop-in replacement for many of the solvents and cleaners used by DoD. Some physical properties of Lactate Esters include: non-toxic, FDA approved, non-ozone depleting, non-carcinogenic, semi-aqueous, low volatility, compatible with all metallic materials and most plastic polymers, recyclable, and completely biodegradable (typically within 24 hours).
PARTICIPANTS: Mary Nelson, CTC, 803-637-2534; Tom Landy, TACOM, 810-574-8818, Richard Beckman, NTEC, 314-337-7296; Rathin Datta, Argonne National Lab, 630-252-6478; Carl Adams, JDMAG, DSN 986-2771; Elaine Lambert, CCAD, DSN 861-4663; Ron Hagler, AMCOM
STATUS: Active

Feb 97 ANL and the Corpus Christi Army Depot (CCAD) are constructing a Paint Stripping Project Utilizing Lactate Esters. This project will test the feasibility Lactate Esters for use in (1) Epoxy Paint Primers, (2) Chemical Agent Resistant Coating Applications, (3) Solvent Borne Systems, and (4) Equipment Cleaning.

Mar 97 Project proposal submitted to SERDP.

Aug 97 Project not selected by SERDP.

Oct 97 Investigating possible funding source/project with the National Center for Manufacturing Sciences.

May 98 SERDP and NCMS did not select as a project.

Dec 98 New Technology Inc. (NTEC) has 5000 tons of lactate ester available for project use at little to no cost to the military.

Jan 99 OC-ALC showing interest in starting a project.

Aug 99 Radome stripping testing at OO-ALC was very successful. CCAD is planning a project to paint strip honeycomb structures. NSWC Crane has requested for NTEC to help them start a paint stripping project on railroad cars.

Nov 99 USCG is planning a project to paint strip an aircraft. Lactate ester has excellent stripping potential for CARC paint. ANAD is planning a project to paint strip a tank.

May 00 The National Defense Center for Environmental Excellence (NDCEE) is to evaluate several applications of lactate ester, paint stripping is one of the applications.

Jul 00 The Army Missile Command is planning a paint stripping project.

Oct 00 OSD funded the Control Technology Center (CTC) with a tasking to begin testing and evaluation of lactate esters as a Non-Toxic Chemical Depainting and Cleaning Agent. This Tasking is CTC Sub-Task 024), and the Project Manager is Ms. Mary Nelson, 803-637-2534. The primary stake-holder and technical monitor is the Army Tank and Automotive Command (TACOM). The TACOM POC is Mr. Tom Landy, 810-574-8818.

Jan 01 The JDMAG mailed letters to the depot maintenance community requesting interest and participation in CTC Sub-Task 024.

Feb 01 Showing interest in participating are Redstone Arsenal, DLA Mechanicsburg, OC-ALC, CCAD, ANAD, MCLB Barstow, and USCG/ARSC.

PROJECT NUMBER: 72534
TITLE: Plasma Arc Destruction of Hazardous Materials

NARRATIVE: This is a DOD project approved under the Environmental Security Technology Certification Program (ESTCP) to investigate the application of plasma arc technology (PAT) for the treatment of high-priority DOD waste streams. The project will establish a plasma arc hazardous waste treatment facility (PAHWTF) at the Norfolk Naval Base that will have the capability of destroying mixed solid and liquid hazardous materials on a production basis. A cost study has indicated that use of the PAHWTF for treating most of the hazardous waste generated at the base would result in a savings of approximately $30 million over the next 20 years.
PARTICIPANTS: Bruce Sartwell, NRL Code 6170, 202-767-0722, DSN 297, sartwell@nrl.navy.com
STATUS: Active

Dec 94 Identified candidate waste materials and selected four materials. Identified a subcontractor who can treat these four materials.

Jul 95 Conducted testing and analysis of selected materials.

Oct 95 Prepared video depicting operation applicability and benefits, and procurement and design guide.

Feb 96 Obtaining RCRA RD&D and NESHAP Air Permits.

Mar 96 RFP out for design/construction of Plasma Arc Hazardous Waste Treatment Facility (PAHWTF)

Aug 96 Permitting process continuing with EPA. NRL evaluating a submitted proposal and negotiating for possible construction contract. Possible contract award in Oct 96.

Dec 96 Prepare cost estimate to install PAT system at a DOD facility. Submit final report.

3Qtr 97 Environmental Impact Statement (EIS) must be completed prior to installation of the system. EIS will be based on performance tests of unit at the contractors site.

May 97 No update.

Aug 97 EIS and permit submittals are on-going. Expect permits by Spring 98. The Plasma Arc unit is under construction at the contractor and is currently planned for installation during Summer 98.

Nov 97 No Change in status.

Jun 99 Construction of plasma arc system completed at contractor's site.

Oct 99 Testing of plasma arc system on paint, paint cans, dirt, and liquid solvents successfully completed.

Nov 99 Still awaiting finalization of draft EIS. Expect publication in Federal Register and conducting hearing early in 2000.

Feb 01 A production-scale plasma arc hazardous waste treatment system (PAHWTS) has been designed, constructed and tested at a contractor site in California. The types of materials introduced into the system during testing included paint, paint cans, oily rags, and a mixture of non-chlorinated and chlorinated solvents. The results indicated that all of these materials can be successfully treated in the plasma arc system, with emissions that will meet regulatory requirements. The PAHWTS has been disassembled and shipped to the Norfolk Naval Station where it is currently in storage until permits are obtained. The Naval station is currently preparing an Environmental Assessment related to installation of the system at the base and a Title V Permit Application under the Clean Air Act has been submitted to the state of Virginia. An application for a RCRA Research, Development, and Demonstration permit is being finalized and will be submitted to Virginia in February 2001. Once the EA is completed and the permits obtained, the system will be assembled on the Naval Station and will be used to destroy a substantial fraction of the hazardous waste generated on the base.

PROJECT NUMBER: 72538

TITLE: Replacement of Hard Chrome Plating Using Advanced Thermal Spray and PVD Techniques

NARRATIVE: This is a joint Service project sponsored by the ESTCP Office. Driving forces for this project are toxicity levels of hexavalent chromium and regulatory requirements. The current permissible exposure limit for hexavalent chromium in air is 51 micrograms per cubic meter. Preliminary test results from John Hopkins University show excessive male deaths at this limit. Planned new regulatory requirements set the new limit at 0.5-5.0 micrograms per cubic meter. The planned new regulatory requirements will have a significant impact on chromium plating operations. Some operations will require expensive air handling equipment and some operations may be completely shut down. The objective of this project is to demonstrate and validate high-velocity oxygen-fuel (HVOF) thermal spray coatings as cost effective and technologically superior alternatives to electrolytic hard chromium in maintenance operations at DoD aviation depots and private companies.

PARTICIPANTS: Bruce Sartwell, NRL Code 6170, 202-767-0722, sartwell@nrl.navy.mil

STATUS: Active

Mar 96 ESTCP funding first received. Hard Chrome Alternatives Team (HCAT) formed which is consortium of DOD aircraft depots, military aircraft manufacturers, DOD research laboratories, and other private organizations.

Nov 96 Initial assessment has determined that HVOF and PVD coatings have potential to replace the majority of chrome plating at repair depots and manufacturers. Preliminary cost evaluation indicates that HVOF coatings are less expensive than hard chrome.

Fall 97	HCAT teams with Joint Group on Pollution Prevention to execute separate projects to qualify HVOF coatings on aircraft components.
Jul 98	Initial stakeholders meeting held on establishing requirements for qualifying HVOF coatings as replacement for chrome on landing gear.
Mar 99	Project Arrangement formally signed between DOD and Canadian Department of National Defense to cooperate on program to qualify HVOF coatings on landing gear.
Summer 99	Decision to proceed with projects on qualifying HVOF coatings on propeller hubs, hydraulic actuators, and helicopter dynamic components.
Jun 99	Final Joint Test Protocol (JTP) for landing gear issued for signature.
Oct 99	Signatures obtained from Navy, Air Force, and most landing gear manufacturers endorsing landing gear JTP.
Nov 99	Project approved for joint project between HCAT and Propulsion Environmental Working Group (PEWG) on qualifying HVOF coatings as replacement for chrome on gas turbine engine components.
Feb 01	This effort is principally related to chrome plating replacement on aircraft components and is divided into five separate projects depending on the types of components on which the chrome is currently being plated. The five project areas are: (1) Landing Gear, (2) Propeller Hubs, (3) Hydraulic Actuators, (4) Helicopter Dynamic components, and (5) Gas Turbine Engine Components. An overarching organization, designated the Hard Chrome Alternatives Team (HCAT), consisting of DOD organizations and aircraft manufacturers, is coordinating the execution of the projects. For the first four projects, the HCAT is collaborating with the DOD Propulsion Environmental Working group. Within each project a Joint Test Protocol has been or is being developed that delineates all of the testing required to qualify the thermal spray coatings as a replacement for chrome. This usually includes materials testing (fatigue, wear, corrosion, etc.), rig testing on coated components, and flight testing. The principal types of coatings being investigated are those deposited using high-velocity oxygen-fuel (HVOF) thermal spray technology, with WC/Co, WC/CoCr, and Tribaloy 400 as the principal coating materials. To date, most of the testing has shown that the HVOF coatings possess superior or equivalent wear, fatigue, and corrosion performance compared to hard chrome plating. Initial cost analyses have indicated that military depots should be able to reduce their repair and overhaul costs and decrease turnaround times by replacing chrome with the thermal spray coatings.

PROJECT NUMBER: 61959
TITLE: Supercritical CO2 Spray Coating Application

NARRATIVE: Aircraft and aircraft component parts must meet appearance requirements and must have maximum protection from corrosion. In general, this is provided by application of a chromated epoxy primer and a polyurethane topcoat. These coatings contain Volatile Organic Compounds (VOCS) and are under scrutiny by the US EPA. The Aerospace National Emission Standard for Hazardous Air Pollutants (NESHAP) requires the level of VOCs in these coatings to be reduced from an average of 600 g/L (5.0 lb/gal) to 350 g/L (2.9 lb/gal) for primers and 420 g/L (3.5 lb/gal) for topcoats. there are coatings available that meet these proposed limits; however, they have prolonged drying times, are difficult to apply, and have questionable performance.

Supercritical carbon dioxide has shown to be an effective replacement for VOCs while imparting superior process and performance for coatings. Tinker AFB has purchased a unit for prototyping and will be coordinating with coating manufacturers on solvent substitution of targeted coating.
PARTICIPANTS: Kevin O'Conner, OC-ALC/LALEP, DSN 336-3074; Mike Spicer, WL/CTIO, DSN 755-0942
STATUS: Active

May 95 Request made to Environmental Security Technology Certification Program (ESTCP).

Mar 96 OC-ALC has obtained a prototype unit. The supercritical CO2 spray process is envisioned for use on large military aircraft (B-52, B-1, E-3, and C-135) painted at OC-ALC.

Jan 00 OC-ALC discovered that the coating formulations had to be designed for the specific equipment. OC-ALC had no funds to continue this project. Project and equipment was reassigned to WL/CTIO.

Aug 00 No update.

PROJECT NUMBER: 9108
TITLE: Two Bay Large Aircraft Advanced Corrosion Control Facility

NARRATIVE: Provides a functional and environmentally safe facility with separate paint strip and paint applications bay to perform corrosion control on various aircraft. The facility will incorporate the most modern paint processes, strip technologies, and eliminate the use of methylene chloride as a stripping agent. Shortfalls in depot aircraft paint stripping and paint capacity already exists with present and future aircraft workload. Tinker AFB has been forced to incur additional cost by contracting out the FY94 paint shortfall (15 aircraft) and defer aircraft stripping until future years. This situation will become intolerable when the Clean Air Act Amendments of 1990 requires a zero methylene chloride emission from paint stripping after 1998. Plans are underway to replace methylene chloride stripping with high-pressure water jet technologies such as the Large Aircraft Robotic Paint Stripping (LARPS) system. LARPS will strip B-1 and C-135 aircraft by 1996 in Bldg 3105. Existing stripping facilities, Buildings 2122 and 3105 are not large enough to accommodate E-3 and B-52 aircraft with LARPS technology and still must use methylene chloride stripping. There continues to be a shortage of strip and paint capacity at Tinker AFB. This project will fully implement LARPS for E-3 and B-52 aircraft; completely eliminate methylene chloride as a paint-stripping agent; and provide capacityto strip and paint all the projected workload. Continued use of methylene chloride will result in penalties (i.e. jail or fines). The methylene chloride restrictions also have a dramatic effect on private industry which will impact constraint painting capability as well. Critical depot level corrosion control of aircraft will be deferred. Estimated annual savings is $7.9M.
PARTICIPANTS: Jerald Terrell, OC-ALC/LA, DSN 336-7757, Jerald.Terrell@tinker.af.mil
STATUS: Active

- Two MILCON projects are planned. FY96/97/98, WWYK890040, $11.4M, and FY00, WWYK983156, $12.6M. A two phase project to construct a two-bay corrosion control hanger.
- Congress approved one paint bay as a FY96/96 MILCON. The strip bay is currently programmed as a FY00 MILCON for one LARPS strip bay.

Jan 00 Funding authorization keeps sliding. President Clinton directed Congress to place this on the Defense Budget for FY 2002.

Mar 01 Paint bay is complete. Contracted. Test & eval. phase will be awarded in a month or two.

PROJECT NUMBER: 000104
TITLE: Wastewater Solids Recycling (Biosolids)

NARRATIVE: The Naval Aviation Depot Cherry Point (NADEP CP) is committed to reducing the solid waste generated at the facility and transported offsite for disposal each year. The waste totaled 1.46 million pounds of material removed from the depot in FY 98. The waste disposal results in a yearly expense of over $300K. The largest component of the waste stream generated at the NADEP is sludge or wastewater solids from the industrial water treatment plant (IWTP) and process applications. At this time part of the sludge is considered hazardous and part non-hazardous due to the contents of the wastewater stream. Post-treatment of the industrial sludge can produce a Class A or B soil conditioner that can be recycled for land application. Wastewater, which contains hazardous metals, can be treated to remove these hazardous contaminants. The metals must be removed from the wastewater stream to prevent contamination of the wastewater solids. Elimination of the metals from the wastewater stream will change the hazardous sludge material to a non-hazardous solid waste classification. Benefits resulting from this project impact all Naval Aviation weapons systems supported at NADEP CP. Combining wastewater and sludge treatment methods can reduce the solid and hazardous waste streams at the NADEP CP. The total pounds of waste disposed each year could be reduced or eliminated resulting in potential savings of nearly $150K per year in disposal costs. These changes could prevent approximately 1 million pounds of waste from entering solid and hazardous waste landfills, reducing the environmental liability associated with Navy operations at NADEP CP.
PARTICIPANTS: Ron Wimmer, NAVAIR 6.3.4.2, DSN 757-3062; Robert King, NADEP CP Code 830, 252-464-7841; Dr. Brad Striebig, PennState ARL, 814-863-9911
STATUS: Active

Jan 00 Project proposed with PennState Applied Research Laboratory (ARL).

Mar 00 Project agreed upon and accepted by Pennsylvania EPA, ARL, and NADEP CP. The Technical Plan will be in three phases.

Phase 1: Identification of available technology. Laboratory testing and evaluation of technologies. Laboratory and pilot evaluations will be conducted to determine treatability and estimate the economic benefits.

Phase 2: Demonstration of a pilot scale sludge treatment process will be conducted at the Cherry Point Depot. Analysis of the sludge prior to and post treatment will be carried out. In addition the off gases from the process will be characterized and uses for the reusable material will be identified. The pilot scale data will provide detailed sizing information for a full-scale sludge treatment unit, which may eliminate up to 70% of the solid waste disposed of by NADEP CP.

Phase 3 will support efforts such as writing specifications and evaluating proposals in order to implement these technologies at NADEP Cherry Point. NADEP Cherry Point has taken the proactive step of submitting a proposal for acquisition fund for this equipment in FY 03, which will be coordinated with this project.

Mar 00 Attempts in process to obtain research information from a similar RepTech project and obtain Capital Funding to acquire the needed equipment. NADEP CP is working to reduce heavy metals in the industrial sludge, and then dry the sludge. This reduces the waste hazard category and can be disposed as dry waste instead of wet waste.

B. Inactive JTEG Depot Maintenance Projects:

Project Number	Project Title
8996	1,1,1 Trichloroethane Dryer
9046	2000 HP Computerized Dynamometer System
165	4 Axis NC Machining Center with Pallet Changer
9172	5-Axis Robotic Water Jet Abrasive Cutting Workcell
333	5526A Measuring System
57959	Abrasive Blasting
125	Abrasive Flow Machine
9156	Abrasive Water Jet Cutter
41392	Accelerate Development of Usable Volatile Organic Compound (VOC) Coatings
41405	Addressing Environmental Issues in the Acquisition World
173	Adhesive Bonding of Avionics Modules
220	Advanced Bonding Techniques (Honeycomb Repair Center)
254	Advanced Circuit Card Repair
32	Advanced Composite In-service NDE System
269	Advanced Computed Tomography NDI System
37902	Advanced High Temperature Graphite Polyimide Repair
224	Advanced Neutron Radiography (Advanced Mobile Neutron Radiography)
374	Advanced Laser Balancing Machine for the AGT 1500 Turbine Engine
34	AEP Coating Equipment
226	AFLC Robotics Application Study
137	Air Assisted Airless Paint System
61949	Air Compressor Signaling and Monitoring System
55718	Air Force Paint Spray Booth Flow Reduction
246	Air Force Video Teleconference Network (VTCN)
41408	Air Quality Utilities Information System (AQUIS)
8997	Air-Water Spray Guns/Electroplating Operation
9026	Aircraft Coating by Air-Assisted Electrostatic Paint Spray with Component Mixing
1917	Aircraft Corrosion Control Chemical Dispensing System
11773	Aircraft Exterior Paint Stripper
8961	Aircraft Fuel Tank Foam Drying, Phases 3, 4
179	Aircraft Robotic Paint System
283	Aircraft Wash/Paint Preparation System
11803	Aircraft Washrack Water-Blast Recycling System
261	Aircraft Wheel Inspection Improvements
9132	Allison Electrophoretic Process (AEP)
56346	Alternate Aircraft Surface Finishes
45802	Alternate for Cynanide Based Corrosion Removing Compound
8986	Alternative Chemical Paint Strippers for CARC
58013	Alternative Coolant for Minuteman Missile Guidance Set
57957	Alternative Solvent for PD-680 Type II
37925	Aluminum Conversion Coating (CCC) Proposal
9104	Aluminum Ion-Vapor Deposition
233	Analog Circuit Simulator
184	Analytical Industrial Measuring System (AIMS)
72519	Anti-Freeze Recycler
70	Application of Group Technology (GT) for Rotary Wing Aircraft
69	Application of Robotic Painting to Rotary Wing Aircraft
9151	Artificial Intelligence-Neural Network X-Ray Image Analysis System
37866	Artificial Neural Test Station (ANTS)
45801	Asbestos Alternatives in Packings and Gaskets
326	Auto Collimating Laser Alignment System
327	Auto Collimating Laser Alignment System
9137	Auto Prompting Inspection Station (APIS)
26	Automated Aircraft Canopy Refinishing System
267	Automated Aircraft Paint Removal
52	Automated Aircraft Painting System (AAPS)
9165	Automated Aircraft Painting System (AAPS)
9111	Automated Aircraft Wheel Blast Machine
119	Automated Blade Measurement System
113	Automated Blade Removal
47	Automated Blade Repair Center
9036	Automated Engine Crankshaft Grinding (Tooele Army Depot)
5	Automated Disassembly of Double Pin Track (Phase I)
141	Automated Electron Beam Welder for Combustion Chamber Repair
378	Automated Electronic Cable and Harness Assembly
156	Automated Filing System
298	Automated Flourescent Penetrant Inspection System

303 Automated Guided Vehicle Material Handling System
55 Automated Infrared Test and Inspection System (AITIS)
237 Automated Large Cordage System
1[illegible] Automated, Laser Corrected, Dynamic Balance
377 Automated Laser Paint Stripping (ALPS)
9145 Automated Phosphoric Acid Anodize System (PAAS)
266 Automated Physical Properties Test Station
142 Automated Plasma Spray Cell
39 Automated Plasma Spray Cell (APSC)
9106 Automated Plating and Solution Monitoring for Plating
320 Automated Propeller Optical Measurement System (APOMS)
321 Automated Propeller Optical Measurement System (APOMS)
9146 Automated Rework Grinding Cell
268 Automated Screw Removal, Deriveting, and Drilling Cell
291 Automated Shot Peen Machine
37903 Automated Stencil Cutting System
112 Automated System for Cleaning Jet Engine Fuel Manifolds
205 Automated Test Equipment Expert Aid
258 Automated Tube Bender
241 Automated Ultrasonic Inspection System
176 Automated Wire Harness Manufacturing System (AWHMS)
53110 Automated X-Ray Inspection System (AXIS)
9161 Automatic Bearing Washer
11792 Automatic Cleaning of Paint Equipment
9097 Automatic Dynamic Laser Balancing of Gryo Rotors
9159 Automatic Match Grinder
120 Automatic Penetrant Application System
206 Automatic Test Equipment Software Support Environment (ATESSE)
102 Automating the Autoclave Process
238 Automation of Electronic Cable and Harness Assembly
96 Automation of Engine Dynamometers
9166 Automation of Instrument Sealing
63 Automation of Plating Operations
9119 Automation of Water Jet Cutting System
11794 Aqueous Ultrasonic Cleaning
41402 Army MANTECH/EAMTP
352 Bar Code Laser Scanner
349 Bar Code Reader System
247 Bead Blast Paint Removal
389 Bead Blasting MM Computer Chassis
27 Bearing Vibration Analysis System
37898 Bench Level Reconfiguration Automatic VXI (BRAV) Tester Development
56344 Benzyl Alcohol Paint Remover
11795 Bicarbonate Abrasive Stripping System (BASS)
57577 Bilge and Oily Wastewater Treatment System (BOWTS) to Replace DONUTS
42563 Biodegradeable Cleaner
72541 Bioremediation of Oil Spills
9133 Blade/Disk Disassembly
122 Blast Cleaning With Dry Ice Pellets
56345 Blast Media Dust Disposal (Repelletizing Plastic Media Blast)
57565 Boric/Sulfuric Acid Anodizing
183 Bottom Quench Furnace
293 Broad Capability Laser Cutting
11790 Burn Waste Oil in Base Boilers
11793 Butylene Oxide as a Solvent Inhibitor
57958 By-Pass Oil Filtration System
9013 C-130 Prop Water Jet Cleaner
41374 Cadmium Plating Bath Substitution
45682 Cadmium Plating Reduction
9087 Calder Testers
9014 Calibration Fluid Recovery
42557 Carbon Dioxide Blast
8 CAM Application of Robotics to Shelter Refinishing
42566 Carbon Dioxide Pellets
41421 Carbon Dioxide Technology
108 Case Resizing Machine
61943 Casting Emission Reduction Program (CERP)
311 Catapult Expert Laser Alignment
11802 Central Hazardous Waste Processing Facility
41400 CFC Recycling
41398 CFC Substitution Recycling
41404 Changes to TOs, TMs, & DMWRs
84 Chassis Dynamometer
57549 Chemical Digestion of Paint Blast Waste
9019 Chemical Cleaning Solution Treatment System
8993 Chemical Material Management System (CMMS)
186 Chemical Reclamation
57866 Chemical Stabilization of Blasting Media
8988 Cleaning Tank Filtration
37908 Chemical Tank Rejuvination
57553 Chemical Tank Rejuvenation System (CTRS)
9120 Chrome Plating Line Automated Monitoring System
41375 Chrome Product Substitution
57581 Chromium Emissions Reduction
9093 Close in Weapons Study (CIWS) Milling Machine
8982 Closed Loop for Rinse Tanks Used in the Chemical Conversion of Aluminum
11779 Closed-Loop Backflow Rinse for Chromium Plating
11775 Closed-Loop High Pressure Solvent Detergent Cleaning
111 CNC Automated Fabrication Center
170 CNC Automated Grinder
9078 CNC Burning Center
9079 CNC Fabricating Center

37894 CNC Horizontal Machining Center
375 CNC Laser Cutting Machine
9138 CNC Laser Drilling/Cutter
81 CNC Machining, Gantry Mounted, Six Axis
37890 CNC Plasma Cutter Controller
37895 CNC Slant Bed Universal Turning Center
9077 CNC Tube Bender
37891 CNC Turret Punch Press with Plasma Arc Cutter
353 CNC Turret Punch with Laser
9086 CNC Shaft Lathe
37893 CNC Slant Bed Chucker Lathe
37892 CO2 Blasting
14 CO2 Pellet Blast for Aircraft Applications
8977 Coal Fired Fluidized Bed Boiler Plant
41385 Coatings and Cleaners: Reformulations and Substitutions
218 Coherent Microwave Moisture Detector System
9022 Cold Vaporization
42559 Compliant Chemical Strippers
221 Composite Repair Center (Advanced Composite Repair Center)
281 Composite Repair Facility
37 Composite Structures Repair Study (Phase I)
38 Composites Structures Repair (Phase II)
315 Compulaser KLM 3E Marking System
133 Computer Aided Design & Drafting (Graphics System)
253 Computer-Aided Design (CAD) for Artwork Layout
255 Computer-Assigned Data Integration for W.R. MANN Optical Comparator
20 Computer Assisted Ultrasonic C-Scan
301 Computer Controlled Fluorescent Penetrant Line
9101 Computer Monitored Plating Station
148 Computerized Control for Heat Treat
9045 Computerized Dynamometer System
278 Computerized Maintenance Management System
257 Computerized Theodolite Optical Alignment System
72520 Concrete, Rock, and Rubble Crusher
215 Conformal Coating System
59979 Conformal Coatings Removal Technology
86 Conforming Anode Hard Chrome Plating
9047 Conforming Anode Hard Chrome Plating
57760 Contaminant Removal From Plating Baths
11801 Contaminated Rag Laundering Equipment
59980 Contaminated Soil Vapor Extraction
8983 Control Recycle of Sand Blast Media
24 Controlled Laser Surface Vapor
66 Conversion of Existing NC Equipment to DNC
8979 Conversion of Robotic Paint System
9018 Coolant Recovery System
55720 Corona Destruction Process
262 Correlation for Absorbed Hydrogen and Embrittlement Damage in Steel
10233 Corrosion and Entrapped Liquid Detection

270 Corrosion Manangement Expert System
41381 Cost of Compliance
11778 Counter Current Double Rinse Tanks for Plating
214 Crew Module Pressure Source Inspection System
9109 Critical Component Generation System (GENESYS)
22 Cryogenic Hardening of Austenite Materials
9027 Cutting Oil/Grinding Coolant Recycler
41373 Cyanide Plating Solution Substitution
41426 Cyanide Stripping Solution Product Substitution
157 Dabber Tig Welder
8963 Delisting of Metcolite C Media as Hazardous Waste and Recycling the Spent Media
71 Depot Analysis of Resources and Technology (DART)
41407 Depot Maintenance Hazardous Material Management System
45804 Develop Closed Loop for Sampling of Petroleum Test
41393 Develop VOC Control Technologies
37896 Dewatering of Paint Waste Slurry (Sludge)
88 Diamond Bond Honing Stone
9124 Diffusion Bonding
37897 Digital Fault Isolation Probe (DFIP)
9147 Dimensional Inspection of Blades
136 Direct Proportioning and Mixing Paint System
31 Disk Surface Eddy Current Inspection System
42561 Disposal of Empty Containers
10232 DNC Manufacture of Bonded Structure Components
9121 Drop-Bottom Heat Treating Furnace
8968 Drum Compactor
8992 Drum Pickup and Delivery Service
37899 Dual Energy Real-Time Microfocus X-Ray System
212 Eddy Current Signal Acquisition System (ECSAS)
290 Electrical Discharge Machine
41396 Electroless Nickel Solutions
8966 Electrolytic Treatment Systems
56352 Electromagnetic Plating
195 Electron Beam Welder
48533 Electronic Board and Tester Simulation Software (EBATSS)
200 Electronic Component Screening
292 Electronic Readout Machine (EROM)
222 Electronic Repair Center
99 Electronic Supply Data Card (Scheduled Removal Component Card)
42 Electronics Repair Center (SM-ALC)
160 Electrostatic Air Assisted Airless Paint System
9100 Electrostatic Discharge (ESD) Failure Analysis Laboratory
17 Electrochemical Deburring

72555 Elimination of Clay Absorbent (Speedy Dry)
41410 Elimination of EPA Targeted 17 Chemicals
45803 Elimination of Fuel System Icing Inhibitor (FSII) Contaminated Tank Waters
41397 Emerging Technologies
77 Engine Block Machining
73 Engine Container Sealing
40 Engine Repair Process Stations
328 Engineering Data Management Information and Control System (EDMICS)
287 Engineering Services Contract
9082 Enhanced Tool Repair Techniques/Processes
132 Enhancement of NC Interactive Graphics System
9099 Environmental Stress Screening Station
41383 Environment and Acquisition Working Together
41379 Environmental Law
251 ESS/EDS for Electronic Repair Capability
9116 Equipment for Aging and Surveillance of Missile Components
37921 Evaluation of Brymill Corporation Crygun Component Cooler
37919 Evaluation of Corrosion Potential of Flux Cleaner
37922 Evaluation of EXAIR Component Cooler
37920 Evaluation of Surfactant-Deionized Water Medium to Detect Leaks in Gyroscope Housings.
48534 Explosive Ordnance Planning Aid (EOPA)
9122 Extrusion Stretch Press
9024 Freon Glove-Box Spray Booth
8990 Fuel Blending
8960 Fuel Bowsers
235 F-111 Robotic Fuselage Tanks Desealing System
240 F/FB-111 Cold Proof Load Test (CPLT) Facility Renovation
9174 F-15 Robotic Drilling Cell
217 F-16 Inverter Controller DEPOT Automatic Test System
64 Fabrication and Design Oriented Robotic Welding
9171 Fastener Manufacturing System
213 Ferrite Repair
9091 Fiberglass Patterns
55719 Flame Ionization Detector (FID)
209 Flash Lamp Paint Removal System
152 Flexible Manufacturing Cell (FMC)
9029 Flexible Manufacturing System
172 Flexible Printed Wiring Manufacturing
19 Flexible Welding Work Station Development
41388 Fluidized Bed
9011 Flexible Manufacturing Cell
153 Flexible Manufacturing System
115 Flexible Repair Center (FRC)
194 Fluidized Bed (MAR Quench) Furnace
9148 Fluid Cell Press
9123 Fluoride Ion Cleaning (FIC)
158 Gang Reaming System
37905 Gas Turbine Engine Production Line Production Automation Prototype
131 Gaseous Flow Calibration (GFC) System
201 Gear and Cutter Geometry Measuring System
83 Generator Load Bank Testing
146 Gold-Nickel Furnace Brazing
9125 Grind-Plate-Grind
9098 Gyro Weight Sorter
41399 Halon Replacement
59978 Halon 1301: Recovery and Recycling System
8939 Hard Chrome Plating Retrofit - NSY Charleston, SC
8941 Hard Chrome Plating Retrofit - NUWES Keyport, WA
8940 Hard Chrome Plating Retrofit - NSY Long Beach, CA
8942 Hard Chrome Plating Retrofit - NSY Philadelphia, PA
41422 HAZMAT Tracking and Control
42567 HAZMAT Tracking and Control
8980 HAZMIN Low Pressure/High Volume Paint Spraying Equipment
59888 Hazardous Material Procurement and Tracking System (HazMat PATS)
8972 Hazardous Material Storage Facility (HMSF)
41406 Hazardous Material Tracking for Credit
41401 Hazardous Technical Information Services
000105 Heads Up Display Welding Helmet
37876 HeNe Laser Leveling System
37877 HeNe Laser Leveling System
340 Hewlett-Packard Laser Jet Printer
203 High Cost Expense Items
61951 High Pressure Aqueous Stripping System
72527 High Pressure Removal of Plasma Spray Coatings
93 High Pressure Water Jet Cutting
41378 High Pressure Water Technology
41390 High Performance, Easy to Remove Paints
72525 High Temperature Vitrification
249 High Speed B&W 2000 Frame/Second Video Camera & Recorder
13 High Speed Chromium Plating
9144 High Speed Grinder
344 High Speed/Volume Printer and Disk
8955 High Volume Low Pressure Paint
9083 Hillyer Vertical Machining Center
103 Honing System
9102 Hot Bonding Equipment for Honeycomb Repair
16 Hot Isostactic Press (HIP)
12 Hot Machining of Super Alloys
11772 Hot Tank Paint Stripper
223 Hughes Infrared
11787 HVLP Spray Painting Equipment
228 Hydraulic Pump Automatic Test System

234 Hydraulic Pump and Motor Test Stand (HPMATS)
55713 Hydroblasting Recycling Unit
345 IBM 6670 Laser Printer
37870 Image Scanner
260 Improved Inspection for Hole Cracking
33 Improved Ultrasonic Equipment Reliability
265 Improving Reliability of Ultrasonic Eval of Bonded-Structure Repairs
59887 Immobilized Ligand Technology
9096 In-Circuit Testing of N-16 Modules
37907 Industrial Plant Equipment (IPE)Maintenance Advisor
9118 Industrial Robot System
55712 Industrial Waste Treatment Plant
8952 Industrial Waste Treatment Plant Sludge Filter Press
61948 Infrared Imaging Feasibility Demonstration Program (Formerly: Infrared Imaging Phased ArrayRadar)
248 Installation of Cryopump in Veeco 25-inch Coating System
192 Integral Quench Furnace
35 Integrated Blade Inspection System (IBIS)
57569 Integrated Circuit Model Extraction System
355 Integrated Gas Metal Arc Welding System
117 Integrated Welding and Grinding (IWAG) Cell
288 Interactive Maintenance Aiding System (IMAS)
341 Intermec Portable Laser Reader
282 Investment Casting
18 Ion-Beam Etching
23 Ion-Beam Etching for Composite Bonding
41377 Ion Exchange for Chrome Recovery
11784 Ion Implantation, Nitrogen
89 Ion Nitriding Process
8994 Ion Vapor Deposition
41376 Ion Vapor Deposition
8973 Ion Vapor Deposition (IVD)
8989 Ion Vapor Deposition (IVD)
11800 Ion Vapor Deposition (IVD) of Aluminum
9139 Ion Vapor Deposition (Trade Name: IVADIZE)
8967 IWTP Sludge Dryer
9126 Jet-Kote Hypersonic Spray
243 Just-in-Time (JIT) Manufacturing
37901 Jet Engine Parts Marking
61957 Jig Borer/Grinder Conversion
9021 JP4/5 Purge Emissions Recovery
8948 Lab Analysis of Tank Cleaning Solutions, Recharge Weak Solutions
229 Laboratory Precision Immersion Ultrasonic Inspection System
325 Laser Alignment System
335 Laser Alignment System
337 Laser Alignment System
338 Laser Alignment System
361 Laser Alignment System
286 Laser Application Study
28 Large Area NDI Composites by Thermography
37874 Laser Automated Depainting System (LADS)
306 Laser Balancing System (LABS)
364 Laser Bar Coder
360 Laser Calibration
367 Laser Corrected Dynamic Balance
362 Laser Cutter
354 Laser Cutting Machnine CNC
252 Laser Etching of Lighted Panels
331 Laser Eyepiece
9167 Laser Heat Shrink and Cable Tag Marking
124 Laser Holograph Inspection
9149 Laser Holographic Inspection System
329 Laser Interferometer
330 Laser Interferometer
336 Laser Interferometer
365 Laser Interferometry
366 Laser Interferometry
339 Laser Level
359 Laser Machining Center
373 Laser Machining Center
100 Laser Machining Center (LMC)
90 Laser Marking Machine
180 Laser Marking System
312 Laser Marking System
313 Laser Marking System
317 Laser Marking System
318 Laser Marking System
319 Laser Marking System
357 Laser Marking System
358 Laser Marking System
159 Laser Marking Systems
350 Laser Mass Data Storage
9035 Laser Measurement of Large Parts (MCLB Barstow)
322 Laser Measurement System
323 Laser Measurement System
334 Laser Measurement System
72 Laser Melting of Explosives in Bombs and Projectiles
368 Laser NC Turret Punch
37875 Laser Ordnance Initiation System for Aircrew Escape
372 Laser Particle Counter
351 Laser Photo Plotter
9168 Laser Photoplotting
236 Laser Repair Center
98 Laser Rotor Balancing
41411 Laser Technology
277 Laser Tool Marking
369 Laser Tool Marker
370 Laser Tool Marker
57567 Laser Ultrasonic Inspection System (LUIS)
82 Laser Vibration Depot Inspection System
371 Laser Welder
310 Laser Welding of Clips
48 Lasers for Paint Removal Phase I
57550 Lease and Recycle of Blast Media

75 Letterkenny Evaluation Analysis and Planning Program (LEAP)
72517 Liquid CO2 for Cleaning
72528 Liquid Oxygen Technical Orders
72529 Liquid Oxygen Tube Cleaning
314 Logistics Application of Automated Marking and Reading Symbols (LOGMARS)
8949 Low-Pressure, High-Volume (LPHV) Paint Spray Equipment
57547 Low Temperature Ashing of Paint Blast Waste
41387 Low VOC, High Transfer Efficiency Paint
72531 Low VOC Waterborne CARC Paint
150 Machine Shop In-process Inspection
2 MACI (Phase I) (CAM) Automated Dynamometer Control for Standardized Inspection Testing
57573 Maneuverable Neutron Radiography System (MNRS)
9115 Maneuverable Ultrasonic C-Scan
57574 Maneuverable X-Radiography Systm (MXRS)
36 Manufacturing Technology for Production Integration of Advanced Bonding Techniques (Honeycomb Repair Center)
48535 Match Drilling with Robotic Deriveter
346 McIntosh Model LR49438 Laserwriter
9158 Measurement of Large Parts
305 Metalizing Equipment Automated Plasma Spray
9117 Mechanized Handling System
9012 MEDIA Separator
57568 Medium Pressure Water (MPW) Depainting System
9017 MEK Distillation System
72518 Metal Wire Arc Spray of Industrial Maintenance Stands
57546 Microbiological Digestion of Paint Waste
259 Microcircuit Failure Analysis
9085 Microcomputer Based CAD/CAM System
57575 Microfocus Real-Time and Reverse Geometry X-Radiography
11797 Microseparator for Waterfall Paint Booths
7 Microwave Power Device Performance Analysis Capability
37900 Minor Repair of Single Crystal Turbine Airfoils
279 Missile Nose Cone Robotic Painting
53 Mobile Neutron Radiography System (N-Ray)
9127 Mobile Autoclave for Composites
57566 Mobile CO2 Cleaning System
30 Mobile Neutron Radiography System
55714 Model Facility Program
185 Modernization of Gyro Calibration and Final Test Operations
204 Modular Automatic Test Equipment Software Support/Development System (MATE SS/DS)
198 Modular Electronic Software Engineering Station (MESES)
307 Modular Laser Calibrator (MLC)
95 Molded Plastic Hardware for Two Axis Dry Gyros
107 Molten Salt Furnace
9150 Multi-Station Portable Blending and Deburring System
48536 Multichip Module (MCM) Capability
190 NC 5-Axis Machining Center
196 NC Plasma Punch Press
129 NC Punch Press
155 NC Tool Grinder
191 NC Tube Bending Machine
316 Nd:Yag/180 Laser Marker
37868 NDI of Military Circuit Cards After ESS
37869 Neural Radiant Energy Detection System
9134 Nickel-Boron Process
57579 Nitrite Wastewater Treatment
80 Noise and Vibration Diagnostics of Rotating Components
72532 Non-Chromated Primer for Aerospace Applications
41380 Non-Critical Use of Expired Shelf-Life Material
8991 Non Cyanide Strippers
57551 Non-Cyanide Stripper to Replace Cyanide Strippers
72533 Non-Methylene Chloride Paint Strippers
57578 Non-Persistent Emulsifying Degreasers for Shipboard Use
11788 No-Dump Aluminum Etch Additive
231 Numerical Control/Master Layout System
45644 ODC Electronic Cleaning Alternatives
72521 Oil/Fuel Filter Crusher
8984 Oil Reclamation
42560 Olivine Green Lightning Blast Media
11805 On-Site Solvent Recovery
8944 Optical Waste Minimization - NOSTRA Yorktown, VA
57 One-Part Sealant for Water Integrity
9023 Organic Solvent Recycling Project
309 Outdoor Laser Range Project
9 Overlay Coatings for Gas Turbine Engine Blades
72523 Ozone Technology
55716 Paint Overspray Arrestor Evaluation
11804 Plastic Media Blast Recycling System
11786 Paint Solvent Recycling
41386 Paint Stripping Waste Reduction RDT&E
11785 Paint Waterwash Booth Additive
274 Parts Delivery System
225 Parts Replication System
275 Parts Storage and Retrieval System
37867 Performance Evaluation Equipment for Electro-Optic and Infrared Imaging Systems
78 Performance Specifications
21 Photonitride Coating for Integrated Circuits (IC)
74 Plastic Media Blast
9025 Plastic Media Blasting (Aircraft Airframes)

8965 Plastic Media Blasting (PMB)
11776 Plastic Media Blasting of Components
161 Plastic Media Paint Removal Booth
199 Plastic Particle Paint Removal on Aircraft
9020 Plastic Media Paint Removal Booth
41414 Plastic Media Pellet Blast
37928 Plating - Ion Exchange for Chrome Recovery
37927 Plating - Ion Vapor Deposition
37929 Plating - In Tank Filter Technology
37926 Plating - Porous Filter Technology
11799 Plating Shop Rinsewater Recycling Project
11777 Plural Component Mixing Unit
57545 PMB Paint Waste Biodegradation
11774 Polysulfide Sealant Stripper
11780 Porous Pot Bath Purifier for Chromium Plating
42568 Porous Pot Filter
324 Portable Coordinate Measurement System
271 Portable Hydrogen Determinator
8975 Power and Inertia Simulator (PAISI)
106 Power Flush
308 Precision Measurement Laser System
9034 Precision Measurement of Contours (MCLB Barstow)
9016 Pretreatment of Plating Waste
181 Printed Circuit Board Manufacturing
216 Printed Wire Board-Bare Board Tester
11796 Printed Wiring Board Rinse Water Recycling System
37923 Process Cleanliness Evaluation Using Stable Isotopes
41384 Procurement Actions: Environmental Concerns
8957 Procurement of Paint in Returnable Bulk Containers
59 Production of Boride Coated Long Life Tools
273 Programmable External Gap Grinder
101 Programmable Read Only Memory (PROM) Burning System
9010 Propeller Adaptive Machining System (PROMS)
356 Propeller Automated Welding System (PAWS)
9090 Propeller Plug and Ring Gauge Manufacturing
187 Prototype Microelectronic Repair Project (PACER HYBRID)
8971 Puncturing Aerosol Cans
15 Radiation Curing for Polymeric Coating
208 Radio Automatic Test Equipment (ATE) Network
9141 Radiographic Computed Tomography
9031 Rapid Acquisition of Manufactured Parts (RAMP)
9173 Reaction Injection Molding (RIM for C-130 Propeller Fairings
294 Real Time Microfluoroscopy
285 Real Time Radiography
9129 Real Time Radiography
164 Real Time X-ray for Weld Repair
134 Real-time Microfocus X-ray System
127 Rebuild of Dual Spindle 5-axis
11791 Reclamation of Hydraulic Oil
87 Reclaim M174 Gun Mounts
72535 Recovering Spent Acids at Watervliet Arsenal
105 Recovery of Fuel Cell Sump Residue Fuel
8981 Recycle Sulfide Pretreatment Plant Effluent Study
55715 Recyling/Purification of Plating Baths
45799 Reduce Toxicity of Methylene Chloride and Orthodichlorobenzene Base Cleaners
41391 Reducing Toxicity and Volume of Hazardous Sludge
126 Rejuvenation of Rotating Components
114 Rejuvenation of Static Engine Components
57548 Remediation of Paint Waste
9170 Repair Technology (REPTECH) for Printed Circuit Assemblies (Formerly Laser Soldering/Desoldering of Circuit Boards)
50956 Repair Technology for Infrared Imaging of Phased Array Antennas
8958 Replace and/or Modify Waterfall Paint Booth
41419 Replacing Hazardous Chemicals with Water Base Biodegradable Cleaners
8987 Replacement of Cadmium Plating with Zinc Plating
8985 Replacement of Hard Chrome Plating with Metal Spray
72522 Re-Refined Motor Oil
48532 Resonant Ultrasound Second Harmonic Inspection (RUSHI)
9135 Retirement for Cause/Nondestructive Evaluation Inspection System (RFC/NDE)
41425 Reverse Osmosis
56 Rigid Foam in Helicopter Structures
94 Rim Molded Helicopter Secondary Structures (Bellcranks) for AHIP
37873 RMATS Digital Multimedia Information System
9009 Robotic Adaptive Welding System (RAWS)
9112 Robotic Application of Flame Spray
49 Robotic Application Study for ALCs
79 Robotic Blast Cleaning of Tactical Vehicles
256 Robotic Canopy Polishing System (RCPS)
67 Robotic CARC Paint and Blasting System
376 Robotic Control of Laser Welding
51 Robotic Deriveter
363 Robotic Laser Cutting
178 Robotic Laser Paint Stripper
92 Robotic Metal Spray System (RMSS)
239 Robotic Non-Destructive Inspection, X-Ray and N-Ray System
9142 Robotic Paint Cell
297 Robotic Painting
9163 Robotic Painting
9113 Robotic Painting of Missile Components
280 Robotic Painting of Wing Folds
9028 Robotic Plasma Spray System (RPSS)

9160 Robotic Plastic Bead Blasting Systems
3 Robotic Polyurethane Camouflage Painting
76 Robotic Polyurethane Camouflage Painting of Tactical Wheeled Vehicles (TWV)
60 Robotic Polyurethane Camouflage Painting System
232 Robotic Radome Painting System
61 Robotic Repair of Printed Circuit Boards (PCB)
91 Robotic Rubber Injection Molding of Double Pin Track (Phase I)
9136 Robotic Shotpeening and Grit Blasting
65 Robotic Van Drilling and Printing
9164 Robotic Van Panel Assembly
4 Robotic Water Jet Material Removal System
62 Robotic Welding
6 Robotic Welding of M113A2 Suspension
230 Robotic Wing Desealing System
295 Roboticized Airfoil Grinding Cell
41 Rotor Stacking Process Cell
116 Rotor Straight Stack Processing Cell
242 Router System-Printed Wiring Board (PWB) Facility
202 Scanning Electron Microscope
118 Semi-automated Blade Weighing System
188 Semi-Rigid Coaxial Cable Repair and Manufacture
264 Sensitization Measurement Procedures for Metals
135 Serviceable Stacker Computer Upgrade
8976 Sewage Pretreatment Plant
8951 Shift-to-Shift Paint Carryover System
9153 Shaft and Disk Alignment Center (SADAC)
263 ingle-Step Magnetic Particle Inspection
11781 Sludge Dryer
8998 Sludge Drying Ovens
37906 Small Component Processing Line for Engine Start Systems (ESS) Workloads
128 Small NC Lathe
272 Small Parts Bead Blast System
42556 Sodium Bicarbonate Compound
9033 Sodium Bicarbonate/Water Slurry Blasting for Paint Removal
8945 Solvent Distillation in Vapor Degreasers
8950 Solvent Distillation Unit
8969 Solvent Distillation Units
55717 Solvent Free Surface Cleaning Alternatives
8962 Solvent Recovery System
9015 Solvent Recovery System
8959 Solvent Recycle Program
11783 Solvent Recycling Stills
8954 Solvent Recycling (Stills)
37924 Spare Parts Production and Reprocurement (SPARES) System
332 Spectra Physics Laser Level System
147 Spindle Finishing Machine
9030 Standardized Electronic Repair Station (SERS)
45800 Standards of ODC Strategic Reserves
9157 Stationary Neutron Radiography System (SNRS)
9076 Steel Grit Blasting
211 Surface Quality Unit for Inspection by Nondestructive Testing (SQUINT)
37871 Surface-Mount Technology
56353 Super Critical CO2 for Cleaning
72540 Supercritical CO2 for Spray Coating Applications
8978 Surface Treatment Plant
85 TEAD Foundry Project
9131 Thermal Spray Robot
57580 Thermoplastic Powder Coating
207 Thermoform/Injection Molding System
250 Thermography for Industrial Plant Equipment
37958 Thermoplastic Powder Coating (TPC) System
296 Titanium Forming/Diffusion Bonding Equipment
42564 Trichloroethane (TCA) Solvent Life
9081 Tool Making Enhancements
138 Turbine Vane Restriking
166 Tubing Manufacturing Center
9143 Twin Robot Paint Cell
56351 Twin Wire Flame Spray
302 Ultrasonic C-Scan Inspection System
210 Ultrasonic Cutting Tools
284 Ultrasonic Evaluation of Bonded Structure Repair
29 Ultrasonic I.D. Lathe Turning
130 Ultrasonic Knife
149 Ultrasonic Stripping
25 Ultrasonic Tinning by Immersion
11 Ultrasonic Tube Bending
8970 Underground Storage Tank Removal
175 Urethane Tire Fill
8946 USATHAMA Paint Stripping Fluidized Bed
8947 USATHAMA Plastic Blast Media Study
41394 US Navy Chlorofluorocarbon (CFC) and Halon Program
8995 Upgrade of Purge Fluid Reclamation Facility
8964 Used Oil Disposal Program
56349 UV Oxidation to Breakdown VOCs
276 Vacuum Formed Tool Box Silhouettes
163 Vacuum Furnaces
57552 Validation of Multi-Process Metal Treatment
140 Vane Bending and Checking System
9044 Vane Bending Machine
139 Vane Measurement and Selection System
42562 Vapor Corrosion Inhibitors
144 Variable Ratio, Plural Component Air Spray System
54 Versatile Processing Center
9084 Vertical and Horizontal Machining Centers
189 Vertical Copy Milling Machine
41409 VOC Identification
41382 VOC Source Control Methods
72554 Volatile Solvent Substitution
123 Vibratory Processing for GTE Stators
9095 VM-8 Test Station Modernization

11798 Waste Management of Spent Batteries (Dry and Wet Cell Akaline)
8956 Waste Water Reclamation at Steam Rack Activity
9152 Water Blast Cleaning System
167 Water Jet Cleaning System
9105 Water Jet Cleaning/Stripping System
182 Water Jet Cutting System
299 Water Jet Cutting System
9080 Welding Robot
151 Wire Electrical Discharge Machines
300 Wire Marker
174 X-Ray of Printed Circuit Boards
347 Xerox 4045 Laser Printer/Copier
348 Xerox 4045 Laser Printer/Copier
342 Xerox 4045 Laser Reader
343 Xerox 8044 Laser Printer
56350 Zinc Alloy Plating
11789 Zirconium Alumina Blasting Abrasive

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APPENDIX B. PERFORMANCE METRICS

The following is an excerpt of the consultant report on JTEG (Fox, 2000):

START UP PHASE: ADMINISTRATIVE METRICS

One of the most common requirements for metrics is the need to evaluate the cost effectiveness of a program or service. Looking at "cost effectiveness" as an indicator without having other reliable data and measurements in place can easily produce very unreliable information and results.

Therefore it is recommended that JTEG should first implement a start up phase of administrative metrics in order to provide benchmark information on the overall health and functioning of the program. This will provide very valuable information on the strengths and weaknesses of program activities including critical bottlenecks. This information combined with customer satisfaction surveys will help to identify improvement goals which, if implemented successfully, will contribute to the desired cost effective and value added program results.

The following list of metrics was compiled in conjunction with the JTEG administrators.

Technology Conference Metrics

1. Attendance – totals (depot/ non depot, service principals, others), attendance at other conferences
2. Conference presentations – totals, technologies, speakers, joint service application
3. Technology demonstrations – totals, types, relationship to presentations and theme, joint service application
4. Customer satisfaction level - use customer satisfaction survey feedback
5. Action items – totals, number of new actions, actions completed, % completed, actions pending, location/responsibility, description (purpose, type, deliverables, benefit, target date)

Tracking of Technology Projects

1. Active versus inactive – totals, technology types, location, joint service application, depot project owners, % completion
2. Service principals – number of contacts with project owners, follow-up activities

Technology Information Services

1. Types, status, joint service application, responsibility
2. Depot problems needing technology solutions – number, types, locations
3. Resource referrals
4. Web page visits
5. External conference attendance – Totals, technology type, information shared

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APPENDIX C. INTERVIEW QUESTIONS

The following is a list of the DoD depots and personnel visited during the thesis study.

A. Naval Air Depot, North Island, California (NADEP North Island):

CAPT Emory Chenoweth, USN, Commanding Officer

CDR Fred Cleveland, USN, Executive Director, Product Management

Ray Paulson, Environmental Engineering Office

Mike Holleron, Industrial Engineering Office, New Technologies

B. Marine Corps Logistics Base, Barstow, California (MCLB Barstow):

Randy Spencer, Environmental Division Manager

Luis Alvarez, Production Engineering

Dean Knutson, Customer Service Representative

C. Puget Sound Naval Shipyard, Bremerton, Washington (PSNS):

Jan Brunson, Industrial Engineering Division Manager

Mike Norris, Industrial Engineering Branch Manager

Dave Curly, Plant Equipment Branch Manager

Tim Morris, Fleet Support Business Manager

Jim Colebank, Process Improvement and Benchmarking Manager

Jim Oats, Carrier Program Process Improvement

Frank Turner, Cumbersome Work Practices Reduction

Nick Eutizzi, Welding Engineer

Lon Overson, Industrial Engineering Branch

D. Ogden Air Logistics Center, Hill AFB, Ogden, Utah (OO-ALC):

David Chaston, Senior Engineer, Science and Engineering

Tom Gailey, Office of Research and Technology Applications, Science and Engineering Division

MAJ Bill Endres, USAF, Automated Information Technology Team Leader

CAPT Dave Taylor, USAF, Metrics Team Leader

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APPENDIX D. DEPOTS VISITED

The following is the list of questions posed during each depot visit.

Questions for depots (working level):

1. How do you make a technology insertion decision?

   (Factors to be considered: Cost, Safety, Environmental, Reduced labor, less stress, increased throughput/output, easier, more efficient)

2. Do you have the means to transmit cost/benefit information to JTEG?

   (Are there proprietary issues, and will command allow it?)

3. Is there a vehicle already in place that can be used (i.e., a business plan, annual reports)

4. Are there follow-ups/tracking of technology insertions?

5. What benefits do you glean from working with JTEG?

   (Savings in R&D, or Networking contacts related to your field?)

6. How is information disseminated in Depot?

7. Does depot attempt to send a representative to every JTEG meeting?

8. Are there specific contacts in each division/branch that handle new technologies?

9. Do you ever push information to JTEG? If so, is it possible to do routinely?

10. How often do you pull information from JTEG? Could JTEG have a better structure to make it easier to do so?

11. Does JTEG ever push information (unsolicited) to you? What kind of information would be most helpful?

12. How do labs/engineering services interact with depot operations? Do they ever develop new ways of doing things for the depot? Does/can this work get transmitted back to JTEG?

13. How does the depot work/contact commercial or non-DoD activities? How much of a role does JTEG play in this relationship?

For Senior Level Depot managers:

1. How can technology exchange best help your organization? In what areas? How can your organization help other DoD activities?

2. What are the most important elements of JTEG?

3. How willing is the depot willing to share data or new technology with other DoD activities?

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APPENDIX E. DEPOT RANKING CRITERIA

Criteria Sheet Ranking Form for Input into Matrix

NADEP North Island, Feb 2001

CRITERIA SHEET FOR DETERMINING SIGNIFICANT ENVIRONMENTAL ASPECTS (SEA)

Reference Number (From Environmental Aspect Table): __________ Date: __________
Organizational Unit (OU): ______________________Bldg: _____ POC:__________
ext. __________
Product Activity and Service (PAS): _____________ Alt POC: _______________
ext. __________
Organizational Unit Management Representative (OUMR): ___________________
Proposed Improvement: _______________________________________

Brief Description of Proposal:

____

List Environmental Benefits:

____

List Regulatory and Other Drivers:

____

Project Metrics (i.e., reductions achieved or anticipated):

____

List any identified Equipment or Facility requirements:

____

Estimated Costs:

a. Material ______________
b. Labor ______________
c. Maintenance ______________

Estimated Savings:

a. Material ________________
b. Cost Avoidance ______________
c. Labor (Intangible benefits) __________

Funding Source identified? __ Yes ___ No

Are there NEW chemicals involved? ___ Yes __ No

If Yes, please list CAS Numbers, or chemical names/brand names:

1) ____________ 4) ____________ 7) ____________
2) ____________ 5) ____________ 8) ____________
3) ____________ 6) ____________ 9) ____________

1. REGULATORY COMPLIANCE Check all that apply: Score

• *Compliance with all Federal, Navy, State, and Local Environmental regulations to protect the environment.*

a. This will IMPROVE our regulatory compliance. 3 ☐
b. This has NO CHANGE in our existing regulatory compliance. 2 ☐
c. This will give us MORE BURDEN in meeting all regulatory compliance issues. 1 ☐
d. This will get us into an OUT OF COMPLIANCE situation. 0 ☐

Comments:

____

____

2. SAFETY

• *Ensures safety and protection of human health within NADEP and the community.*

a. This will IMPROVE the existing health & safety of employees. 3 ☐
b. This will have NO CHANGE in the health & safety of employees. 2 ☐
c. This will create MORE BURDEN in maintaining the health & safety of employees. 1 ☐
d. This will cause an UNSAFE working condition for employees. 0 ☐

If you checked (d) in either one of the first 2 criteria, it will be automatically rejected. Otherwise, please proceed with the rest of the checklist.

3. COST TO IMPLEMENT

• *The approximate value of equipment to be purchased (if any), man-hours, and materials.*

a. Less than $ 25,000.00 3 ☐
b. Between $ 25,000.0 and $ 100,000.00 2 ☐
c. Greater than $ 100,000.00 1 ☐

Comments:

____

____

4. FUNDING

• *Availability of funds to implement the proposed improvement.*

a. This will be funded by an OUTSIDE SOURCE. 3 ☐
b. There is internal FUNDING AVAILABLE. 2 ☐
c. There will be FUNDING DIFFICULTIES. 1 ☐

Comments:

____

____

5. POLLUTANT REDUCTION

• *Reduction in the amount of air emissions, containerized hazardous waste, industrial waste, and/or municipal solid waste (garbage).*

a.	There is potential for LARGE REDUCTION.	3	☐
b.	There is potential for SMALL REDUCTION.	2	☐
c.	There is will be NO REDUCTION at all.	1	☐

Comments:

____

____

6. RESOURCE CONSERVATION

• *Conservation of valuable materials or energy resources (i.e., electricity, gas, steam, air, water).*

a.	This will CONSERVE resources.	3	☐
b.	There will be NO CHANGE.	2	☐
c.	This will NOT CONSERVE resources.	1	☐

Comments:

____

____

7. PRODUCTIVITY Check all that apply:

Score

• *Any changes that would affect the efficiency of the process.*

a.	This will IMPROVE PRODUCTIVITY (more efficient).	3	☐
b.	There is NO NET DIFFERENCE in productivity.	2	☐
c.	There will be a DECREASE IN PRODUCTIVITY (less efficient).	1	☐

Comments:

____

____

8. QUALITY

• *Improvement and consistency in quality.*

a.	This will INCREASE QUALITY.	3	☐
b.	There is ESSENTIALLY NO CHANGE in quality.	2	☐
c.	This will DECREASE QUALITY.	1	☐

Comments:

____

____

9. MAINTENANCE

• *Requirements to perform regular maintenance and/or upgrades.*

a.	This will DECREASE MAINTENANCE COST.	3	☐
b.	There is ESSENTIALLY NO CHANGE in maintenance cost.	2	☐
c.	This will INCREASE MAINTENANCE COST.	1	☐

Comments:

---

10. FACILITY LOGISTICS

- *Preparation of site for tie-in of required utilities and pads.*

a. Use of facility with NO MODIFICATIONS. 3 ☐
b. Use of facility with MINOR MODIFICATIONS. 2 ☐
c. Use of facility with MAJOR MODIFICATIONS/NEW FACILITY. 1 ☐

Comments:

---

11. TECHNICAL FEASIBILITY

- *Investigation of technological options.*

a. This is a PROVEN TECHNOLOGY and is applicable. 3 ☐
b. This is NOT WIDELY USED and has indirect applicability. 2 ☐
c. It is UNPROVEN with excessive unknowns. 1 ☐

Comments:

---

(1) 12 INTERESTED PARTIES

- *Stakeholders; NADEP employees, host command, and the community.*

a. POSITIVE stakeholder impact. 3 ☐
b. NO/NEUTRAL stakeholder impact. 2 ☐
c. NEGATIVE stakeholder impact. 1 ☐

Comments:

The TOTAL SCORE is ______ ("check" flag, only when 12c is checked; - click to see comments)

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OO-ALC/TIEH
Attn: Mr. Dave Chaston
5851 F Ave
Hill AFB, UT 84056-5713

10. LCDR Rick Taylor 3
1324 Cedar Lane
Lemoore, CA 93245