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PRODUCTIVITY MEASUREMENT AND ENHANCEMENT IN NAVAL AIRCRAFT INTERMEDIATE MAINTENANCE DEPARTMENTS: A STUDY OF THE METHODOLOGY FOR GENERATING

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United States International University, 1989

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PRODUCTIVITY MEASUREMENT AND ENHANCEMENT IN NAVAL AIRCRAFT INTERMEDIATE MAINTENANCE DEPARTMENTS: A STUDY OF THE METHODOLOGY FOR GENERATING EFFICIENCY AND EFFECTIVENESS MEASURES

A Dissertation

Presented to the

Graduate Faculty of the

School of Business and Management

United States International University

In Partial Fulfillment

of the Requirements for the Degree of

Doctor of Business Administration

---

by

Frederick Charles Orton

San Diego, 1989

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THE RESEARCH PROBLEM

One of the key dimensions of the strength of the United States Navy is the readiness of its Naval Air Forces. Readiness is dependent, in large part, on the effectiveness of shore-based Naval Aircraft Intermediate Maintenance Departments (AIMDs). The AIMDs are activities that provide repair support to shore-based aircraft squadrons in the continental United States and provide in-depth backup support for the Carrier Air Groups (CAGs) based on deployed aircraft carriers around the world.

The purpose of the present study was to test the Methodology for Generating Efficiency and Effectiveness Measures (MGEEM) introduced and tested by the Air Force Human Resources Laboratory (AFHRL) of the United States Air Force in the Communication and Navigation Equipment Repair Branch of a shore-based AIMD under the Commander, Naval Air Force, United States Pacific Fleet. The intent of the research was to determine whether the use of the MGEEM increased the effectiveness of the Communication and Navigation Equipment Repair Branch of a shore-based Naval AIMD, and to determine whether there is inter-service transportability of the MGEEM by comparing the results of this study performed in the Navy with an independently-conducted productivity study in an Air Force shop with an identical organizational mission.

To achieve these two purposes, the following research questions were asked:

1. What changes in effectiveness of the Communication and Navigation Equipment Repair Branch of a shore-based Naval Aircraft Intermediate Maintenance Department (AIMD) were observed during and after implementing the MGEEM?

2. How closely did the Key Result Areas (KRAs), indicators and the subsequent changes in effectiveness obtained from this Navy study compare with those of an independently-conducted implementation in an Air Force shop with an identical organizational mission?

Delineation

The cost of modern weapons systems and the limitations of budget and material resources make it imperative that industrial activities, such as the shore-based Naval AIMDs, are run as effectively as possible. The administration realized that productivity is an important issue and, in 1985, issued Executive Order 12552, which directed that all major governmental agencies increase productivity by 20 percent by 1992.

A standardized method of defining, quantifying and improving mission effectiveness would allow for a continuous and uniform method of measuring the relative standing of each AIMD and offer a procedure for improving its overall productivity. This research was primarily concerned with finding a standardized method to increase mission effectiveness, and hence the productivity, in the

Communication and Navigation Equipment Repair Branch of a shore-based AIMD. Additionally, the research was designed to determine the inter-service transportability of the MGEEM by comparing it with an independently-conducted implementation in an Air Force shop with an identical organizational mission.

Because of a policy of decentralization of authority in the Navy, each AIMD is managed by an AIMD Officer with a specific leadership style, and the individual leadership style, to a large extent, determines an activity's performance. The relative standing of an AIMD with other AIMDs was not an issue at the time of this study, since there had been no standardized yardstick developed to measure productivity in an AIMD. In fact, finding a standardized method of defining, quantifying and improving mission effectiveness that, with minor modifications, would function in similar shops in all services would greatly decrease the cost of establishing such an organizational productivity measurement and enhancement program for the entire Department of Defense.

Variables and Relationships

The research question contains two variables that are under investigation. The independent variable, Methodolgy for Generating Efficiency and Effectiveness Measures (MGEEM), is a tool developed and tested by the United States Air Force (1986) to establish a standard method of measuring and enhancing organizational productivity.

A paradigm of two observable elements (phases) defines the independent variable as follows:

Methodology for Generating Efficiency & Effectiveness Measures:

Element One (Development Phase): Once familiar with the target organization, the measurement coordinator worked with a group of workers and their immediate supervisors in a structured group process called the Nominal Group Technique (NGT) developed by Delbecq, Van de Ven and Gustafson (1975) to formulate and prioritize the organization's principal intended accomplishments, called Key Result Areas (KRAs).

Using the same NGT process, those supervisors, together with their immediate subordinates, then worked with the measurement coordinator to identify effectiveness indicators. The effectiveness indicators are measures used to determine the degree to which a specific KRA is being accomplished. They then used their judgment, based on knowledge of the job requirements, to scale the indicators in terms of their importance as measures of the KRAs on graphs called Mission Effectiveness Charts (formerly called Contingency Charts). A computer-generated report consisting of graphically-displayed measures of the indicators on Mission Effectiveness (ME) Charts was then devised to provide feedback to management and workers. That feedback served to inform all concerned just how effective the target organization was in performing its principal objectives, or KRAs, provided information to managers to help them do their jobs better and provided performance information to motivate workers.

Element Two (Implementation Phase): Mission Effectiveness (ME) Charts were then published and distributed to the target organization. Monthly measurements of those indicators were gathered from the existing maintenance data collection system to monitor any changes in effectiveness in the organization, and feedback reports containing monthly results were distributed to both management and workers. After the feedback-only cycle was complete, the additional productivity enhancement of goal-setting with feedback was added to observe its effect on mission effectiveness.

The dependent variable is mission effectiveness, which is defined as the extent to which the outputs of the target organization fulfill the needs of the customers.

The Research Approach

The research approach used was descriptive-correlational, employing the Communication and Navigation Equipment Repair Branches in two major shore-based Naval AIMDs under the Commander, Naval Air Force, United States Pacific Fleet and the Communication and Navigation Equipment Repair Shop at an Air Force base located in the southwestern United States. The research sought to determine whether the MGEEM would increase the overall effectiveness in the Communication and Navigation Equipment Repair Branch of a Naval AIMD. The research concurrently sought to determine the degree of relationship between this study's KRAs, indicators and subsequent changes in effectiveness and those

obtained in an independently-conducted implementation in a Communication and Navigation Equipment Repair Shop at Bergstrom Air Force Base.

Using the NGT, the KRAs were determined, listed and prioritized, and indicators and ME Charts for those KRAs were originated. A computer-generated feedback report consisting of the ME Charts was then developed.

During the Development Phase of the MGEEM process, four months of past data were collected to establish a baseline, and then four months of measurements were made to observe any changes in mission effectiveness during development of the MGEEM. After that, feedback alone and then feedback with goal-setting were introduced. The KRAs, indicators and ME Charts that had been developed were published monthly and distributed as feedback for workers and management of the branch. The essential research question was to determine whether this feedback alone and then feedback with goal-setting would motivate workers to increase their effectiveness and would facilitate as well as improve the decision making of managers.

Criteria for the Data Source

To qualify as a data source, the shore-based Naval AIMD had to be under the Commander, Naval Air Force, United States Pacific Fleet and had to be classified as a major AIMD. A major AIMD, for purposes of this study, is one that:

1. Serves at least eight squadrons.

2. Employs at least 275 technicians.

3. Processes an average of at least 300,000 maintenance actions per year consisting of processing at least 25.000 repairable items.

Definitions

The following definitions are listed to clarify terms used throughout this paper. These terms pretain to the Naval organization under study and the MGEEM process.

Aircraft Intermediate Maintenance Department (AIMD) : a Navy organization that performs intermediate-level maintenance on aircraft-related avionics, airframes, power plants systems and components, ground support equipment and other items needed to support Naval Aviation.

AIMD officer: a department head on a naval air station or ship having the responsibility of managing the intermediate-level repair of aircraft components.

Production control officer: a division officer who directs the efforts of the production divisions in an AIMD.

Division officer: the person in charge of the functioning of a division of an AIMD.

Work center supervisor: the senior enlisted person on a shift within a given work center.

Key Result Areas (KRAs): the principal measurable aspects of an organization's mission: the prime reasons that the organization exists.

Indicators: the measurements used to determine the degree to which KRAs are being accomplished.

Methodology for Generating Efficiency and Effectiveness Measures (MGEEM): a series of technologies by which complete productivity measurement and enhancement systems can be developed for any organization.

Measurement Development Team (MDT): a team of members of the organization to be measured who are knowledgeable about the organization, have good communication skills and are opinion leaders by virtue of formal or informal power.

Nominal Group Technique (NGT): a proven method used by groups to generate and reach consensus about a complete set of ideas or specifications on a given subject or question. The method was developed by Delbecq, Van de Ven and Gustafson.

Force-field analysis: a method of displaying the forces in favor of and opposed to a specific topic.

Mission effectiveness measures: measures of the capacity for doing the specific job in question.

Target organization (branch): the organization under study.

Mission Effectiveness Charts (formerly Contingency Charts): a method of graphically displaying organizational performance, which is designed to increase motivation when given as feedback to workers and to improve decision making when given as feedback to managers.

Weighted score: any score weighted proportionately to indicate the degree to which it is perceived to be important as a measurement tool.

Implementation plan: a step-by-step written procedure to implement a given change in an organization.

Measurement plan: an outline of steps required to be accomplished to implement a study of an organization.

Background

Aircraft readiness factors are vitally important and are reviewed daily at various levels of command to monitor the current status of the Naval Air Forces and to determine the nature and the extent of deficiencies. Productivity, as a measure of the effective use of resources, is an important factor in readiness, since low productivity will degrade aircraft readiness.

Aircraft maintenance has become more crucial to aircraft readiness as aircraft systems have become more complex. As these systems become more sophisticated, the personnel resources used to repair them have to be used more effectively. Proper utilization of the available personnel is a challenge for the AIMD Officer.

since the performance of the AIMD has a immediate and direct bearing on aircraft readiness of the squadrons served by the AIMD.

At the time of this study, no objective method existed for evaluating the effect of local management on AIMD productivity. The administration had detected a decrease in federal productivity and, in 1985, President Reagan stated his view on the importance of productivity improvement to the nation when he asked Congress to pass a joint resolution declaring productivity improvement as a national goal.

The United States Air Force has long recognized the importance of productivity improvement, as evidenced by Air Force Regulation 25-3, the Air Force Productivity Enhancement Program (PEP). This regulation establishes productivity improvement as a priority in the Air Force, and it acknowledges the fact that the responsibility for productivity improvement in Air Force organizations rests squarely on the shoulders of the managers.

Using resources in the most effective way possible to accomplish an assigned mission is a manager's primary responsibility. Meeting this responsibility with limited budgets and expanding mission requirements places a premium on management excellence. Productivity growth is essential if these management challenges are to be met. The MGEEM evolved in the Air Force as the recommended solution to the productivity measurement and enhancement problem. That methodology was tested in many Air Force organizations, including a Communication and Navigation Equipment Repair Shop in a maintenance squadron at Bergstrom Air

Force Base, and significant increases in mission effectiveness were documented. In January 1987, the MGEEM was incorporated into Air Force Regulation 25-5 as the measurement component of the Performance Measures Document (PMD). This regulation empowers the Air Force Management Engineering Agency (AFMEA) to evaluate the Management Information System (MIS) in place in every Air Force functional area. For those found to have an inadequate MIS, the MGEEM is recommended for use. On every United States Air Force base in the world, it was expected that there would be a cadre of Management Engineering technicians trained to implement and modify, as needed, the MGEEM systems on the local base.

Since both the Navy and Air Force were faced with the same mandate to increase productivity by 20 percent by the year 1992, and since the Air Force had already field-tested the MGEEM and found it effective in measuring and increasing organizational productivity, it followed that the Navy should test the viability and transferability of this proven methodology in its own organizations. The information gathered by this research should provide strong evidence in answering the question of the inter-service transportability of the MGEEM and may significantly contribute to designing a multi-service productivity measurement and ennancement program for the Department of Defense. The findings of this study should also be useful to AIMD Officers in increasing their ability to manage effectively and, thus, increase the productivity in their facilities.

Summary

This chapter presented the background for the research problem, the research problem itself, and the research questions. The research problem was then delineated and the need for standardized measurement of organizational productivity in Aircraft Intermediate Maintenance Departments was stated. The variables were then named and defined.

The research approach was outlined and use of the Nominal Group Technique to determine Key Result Areas (KRAs), indicators and Mission Effectiveness (ME) Charts was discussed in that outline. The criteria for the data source were then given, and definitions of terms used in the study were stated.

The background of the study supported the purpose of the study, which was to determine whether the use of the Methodology for Generating Efficiency and Effectiveness Measures (MGEEM) results in an increase in mission effectiveness in the Communication and Navigation Equipment Repair Branch of a shore-based Naval AIMD. A concurrent purpose of the study was to determine the degree of inter-service transportability of the MGEEM by determining whether there was a comparable relationship between KRAs, indicators and subsequent changes in effectiveness in an independently-conducted implementation in a Communication and Navigation Equipment Repair Shop at Bergstrom Air Force Base.

The research approach used in the study was considered descriptive-correlational, using the Communication and Navigation Equipment Repair Branches of two shore-based Naval AIMDs and the

results of a previously conducted study in an Air Force Maintenance Squadron. The KRAs, indicators and resultant changes in mission effectiveness documented in this study were compared with the corresponding relationships obtained from the Air Force study. This comparison will serve as a basis for a decision making process involving the establishment of a multi-service productivity measurement and enhancement program.

Chapter 2

REVIEW OF SELECTED LITERATURE

This chapter presents an overview of the literature related to the current study. The material discussed is associated with one or more of the following areas of emphasis explored in this research effort:

(1) The background literature leading to the development of the Methodology for Generating Efficiency and Effectiveness Measures (MGEEM) introduced by Tuttle (1981) and

(2) The background literature leading to the development of the Contingency (or Mission Effectiveness) Measurement System developed by Pritchard, Jones and Roth (1987) in conjunction with a study funded by the Air Force Human Resources Laboratory (AFHRL).

The research has been organized as outlined in these two general areas in order to provide a comprehensive presentation of published findings that have addressed problems in the areas explored in the current study.

Background for the Methodology for Generating Efficiency and Effectiveness Measures

The measurement of work effort has long been considered an effective way to increase productivity (Klug, 1962). In a 10-year study of an Air Force work measurement program, as applied to aircraft maintenance and supply functions, Klug found that labor efficiency rose from 55 to 89 percent in maintenance and 61 to 88 percent in supply. Newburn (1972) pointed out that productivity feedback reports to workers stimulate innovation and competition within an organization, and even an imperfect measure is worth the effort as long as it stimulates these responses.

Mollenhoff (1977) summarized that the development and implementation of a work measurement system based on sets of performance indicators for Key Result Areas (KRAs) and refined productivity standards was suitable for use with workers performing complex jobs. He further subdivided KRAs into measurable units and used numerical goals, ratios, rating scale target scores and performance ranges to reflect reasonable and achievable quantitative standards for productivity measurement.

Stewart (1978) developed a multiplicative multi-attribute utility measure of productivity using a structured group process. The resulting measures were used in an aggregated form to represent overall

organizational productivity or in a disaggregated form to monitor individual factors. As long as the organization accepted the measure, it appeared to be an excellent tool for complex, difficult-to-measure situations.

After refining numerous attempts at developing Key Result Areas (KRAs) and indicators for those KRAs, the Nominal Group Technique (NGT) developed by Delbecq, Van de Ven and Gustafson (1975) emerged as an efficient method for completing that process when working with groups that could communicate and discuss items together in one setting. The NGT is a group consensus-seeking strategy consisting of the following steps (Delbecq, Van de Ven and Gustafson, 1975:11-13):

1. Silent generation of ideas in writing;
2. Listing of ideas, one at a time, in round-robin fashion, that were generated by individual group members;
3. Discussion and clarification of the "raw" list of ideas presented;
4. Individual voting to prioritize items from the list;
5. Further voting and classification of items and voting patterns;
6. Revoting to generate the final list.

The first documented research application of the NGT to productivity measurement was in a research program by Sink (1977), conducted under the auspices of the Ohio State University Productivity Research Group. Another researcher subsequently discussed and demonstrated the applicability of the NGT to the

development of efficiency and effectiveness indicators (Tuttle, 1981).

In order to access organizational performance accurately, a set of measurement criteria including efficiency and effectiveness is required. In order to have maximum utility for research purposes, criteria should also meet the following standards:

1. Criteria should, as a whole, possess the following characteristics (Kearney, 1978:11-13):

> Completeness. All significant facets of the organization's mission should be covered:
> Comparability. Measures should remain applicable from one time period to another:
> Input Coverage. The output indicators should cover all significant results obtained from all controllable inputs to the production process (e.g., the results produced by the work hours of all people working in the organization):
> Comparability with existing data sources. Measures should make maximum use of existing data sources:
> Cost-effectiveness. The costs of measurement should not exceed the benefits obtained:
> Acceptability. The indicators should be meaningful and acceptable to those whose performance is being measured.

2. Criteria should, as a whole, have the following properties (Tuttle, Wilkinson and Matthews, 1982: 2-3):

> Consistency. Be consistent across organizations that perform similiar functions:
> Comprehensiveness. Cover all key facets of mission performance:

Meet Efficiency and Effectiveness Components. Include multiple indicators of both efficiency and effectiveness.

3. Individual indicators should possess the following characteristics (Hurst, 1980: 43-49):

Validity. Indicators should accurately reflect changes in the organization's performance:
Uniqueness. Indicators should be relatively independent of each other:
Understandability. Individuals being measured should understand how their performance is reflected in the indicator being used:
Controllability. Organizational members should be able, through their actions on the job, to produce changes in the indicators that are related to their performance:
Reliability. Indicators should yield information that is repeatable over time, assuming that performance levels remain the same.

Many research studies in the field of productivity have been conducted in the Air Force and Navy. A research study conducted by the Air Force (Pritchard, Montagno and Moore, 1978), which explored the effect of various forms of job perfomance feedback on productivity, suggested that feedback regarding job performance has considerable potential for improving productivity. Fears are generated by productivity measurement (Tuttle and Sink, 1984), but strategies and techniques have been developed to minimize fear. Those strategies, if followed and managed properly, can assist in effectively handling the change associated with the introduction of a productivity measurement

process: managed poorly, they can become a disaster (Brown, 1984).

A useful technique for helping managers understand the change process is called force-field analysis (Mahler, 1974). Force-field analysis is a process of analyzing the forces for and against a change in behavior by an individual or group. A strategy for increasing the forces for a change in behavior is to develop and communicate a collective vision of the organization's purpose, philosophy and values. Sink (1984) argued that one approach is a strategic productivity planning process that involves organization members at all levels in defining future organizational goals.

Two companion strategies to increase the forces for a change in behavior are (Tuttle and Sink, 1984:28):

(1) Simply share previously undisclosed business information. The purpose of this information-sharing is to create a sense of trust, to educate subordinates to economic realities and to subtly suggest that survival of the organization and continued job security depend on maintaining competitiveness.

(2) Top management leadership must communicate the message that productivity is important, and it must explain why.

Once the mood has been set, the measurement implementation methodology is ready to begin. For over

five years. the Maryland Center for Productivity and Quality of Working Life carried out research to develop and test a Methodology for Generating Efficiency and Effectiveness Measures (MGEEM) (Cordry and Tuttle. 1984: Tuttle, 1981: Tuttle, Wilkinson and Matthews. 1982:). This methodology is highly participative and makes extensive use of the NGT (Delbecq. Van de Ven and Gustafson. 1975: Sink. 1983).

Measurement is a process that involves assigning numbers to objects. events or attributes according to specified rules or procedures. More precisely, a measurement operation is a standardized rule that maps each of a set of objects into one. and only one. of a set of categories of numbers (Hays. 1967). According to Nunnally (1967:3). "one of the primary aspects of standardization requires that different people who employ the measuring instrument. or supposedly alternative measures to the same attribute. should obtain similar results." Hays (1967) concurred by arguing that the concept of standardization is critical to the measurement process and implies that different people who apply the same rule to particular events or situations obtain very similar results.

In the definition of measurement. it is important to note that numbers are assigned to attributes or objects or events. Strictly speaking. one does not

measure objects, one measures their attributes (Emory, 1985; Kerlinger, 1973; Nunnally, 1967). Emory (1985) argued that the implication of this point for organizational measurement is that one or a few measurements of an organization (e.g., size, productivity, etc.) should not be used to characterize or evaluate the whole organization. He insisted that many attributes must be measured if one is required to describe in quantitative terms an entity as complex as an organization.

According to Nunnally (1967), the use of a standardized organizational measurement procedure offers many benefits to both researchers and managers. One benefit is objectivity. Use of standardized measurement procedures takes much of the guesswork out of observations and allows independent verification of organizational attributes. Secondly, numerical indices provided by measurement procedures allow reporting of results in finer detail and more precisely than would be possible with subjective descriptions. These numerical indices also permit use of mathematical and statistical analysis procedures. Without such analytical tools, organizational research would be seriously impaired. Nunnally went on to say that measurement results facilitate communication between researchers, managers, members of the organization and

others who influence or are affected by the organization's activities. He argued that unless standardized measurement procedures exist, it is virtually impossible to evaluate an organization's performance and to communicate to an interested audience that progress has been made.

The type of measurement operations selected or developed depends on the attribute to be measured and the purpose of the measurement. Four levels of measurement are typically identified by statisticians: nominal, ordinal, interval and ratio (Emory, 1985: Hays, 1976). Nunnally (1967:13-16) defined the four as follows:

> NOMINAL. In nominal level measurement, numbers are used either as labels or as a means of assigning people, objects or events to categories. The use of numbers in this way does not imply any quantitative meaning in terms of amount of an attribute.
>
> ORDINAL. In ordinal measurement, (1) objects of measurement are rank-ordered from most to least with respect to some attribute, (2) there is no indication of how much of the attribute the measurement object possesses and (3) there is no indication of how far apart the objects are on the attribute being measured.
>
> INTERVAL. Interval measurement procedures lead to a precise ordering of objects of measurement with respect to an attribute when the distances between objects are known; however, interval procedures do not provide any information about the absolute magnitudes of the attribute for any object of measurement.

RATIO. Ratio measurement includes all the characteristics of interval measurement, but the quantities are expressed in relation to an absolute zero, so that absolute magnitudes can be inferred.

When developing and interpreting measures of productivity, the level of measurement produced by a particular measurement operation is significant. If a particular measurement produces only ordinal measurement, but ratio interpretations are attempted, they may easily lead to inaccurate conclusions.

In addition to the level of measurement, there are also important attributes of productivity measures. Hurst (1980: 44-45) described nine characteristics, which he listed as desirable for measures of organizational performance.

1. CONTROLLABLE. The person or group being measured should have control over the aspects of performance measured by the indicator.

2. CONGRUENT. The performance measure for a sub-system should be compatible with the overall mission and objectives of the larger organization system of which it is a part.

3. MEASURABLE. The characteristics should be quantifiable through procedures that are feasible. In addition, a measurable characteristic should be:

   a. Unequivocal. Not subject to misinterpretation and sensitive to actual changes in performance that occur;

   b. Reproducible. Similar performance changes will produce similar measures repeatedly;

c. Accurate. Not subject to random or systematic biases that will introduce measurement error: and

d. Objective. Multiple observers of the characteristics should agree on what is good performance and what is bad performance.

4. UNDERSTANDABLE. The relationship between the level of performance and the measure is understood by the individual.

5. CHOOSABLE. The people being measured have a say in the measures by which their organization will be judged.

Hurst (1980) acknowledged that not all of these attributes of good measures can be achieved at the same time. Common trade-offs discussed by Hurst (1980) included trade-offs between accuracy and understandability and trade-offs between congruence and measurability.

Adams (1968): Ammons (1965): Chobbar and Wallin (1984): Crawford, White and Magnusson (1983): Dockstader, Nebeker and Shumate (1977): Jones (1985): Pritchard, Bigby, Belting, Coverdale and Morgan (1981): Pritchard and Montagno (1978): and Pritchard, Montagno and Moore (1978) argued that, in addition to measurement, two of the most established techniques for enhancing productivity are feedback and goal setting. They insisted that their research has shown that, when task-related feedback is given to individuals or groups who are performing a task, performance increases as a

result. Similarly, when performance goals are set that are acceptable, specific and challenging, performance also increases (Latham and Yuki, 1975; Locke, 1967; Locke, Shaw, Saari and Latham, 1981; Steers and Porter, 1974; Taylor, Fisher and Ilgen, 1984; Tubbs, 1986).

During the 10 years prior to this study, the Air Force funded a series of research and development efforts focusing on the use of feedback and goal-setting to enhance productivity. The study by Pritchard, Montagno and Moore (1978) investigated the effect of various forms of job performance feedback on productivity. The results suggested that feedback regarding job performance has considerable potential for increasing productivity. Tubbs (1986) clearly indicated that worker participation in goal-setting further increased productivity, and Pritchard, Jones and Roth (1987) demonstrated that, when feedback and worker participation in goal-setting are used together, productivity is even further enhanced.

Performance Measurement Research Associated with the Contingency (or Mission Effectiveness) Measurement Methodology

A study by Pritchard, Jones and Roth. (1987) examined the effects of group-level feedback, goal-setting and incentives on productivity in Air Force jobs. The study represented a more sophisticated procedure than previous studies, which demonstrated the positive effects of feedback and goal-setting. Moreover, it dealt with more complex jobs having a higher degree of independence. Research questions that were investigated were: (a) Can a new system of productivity measurement be effectively implemented? (b) Can feedback and worker participation in goal-setting be used in complex operational Air Force jobs to enhance productivity? It was also of interest to determine how these feedback and goal-setting systems affect work attitudes and how well users liked the system.

Pritchard, Jones and Roth (1987) constructed a productivity measurement system in two steps, which enabled them to deal with complex, interdependent jobs. First, the researchers guided organizational members in defining the major tasks each organization was responsible for carrying out. The members jointly determined how to measure performance of each task

using the Methodology for Generating Efficiency and Effectiveness Measures as described by Tuttle and Weaver (1986a, 1986b). This effort resulted in 13 measures for a Communication and Navigation Equipment Repair Shop and 33 measures for four sections of a supply-related task. All of these measures allowed managers and workers to track the major elements of productivity, but did not provide for integration of the various measures of productivity to produce a "big picture" of how effectively either organization was functioning. This would have necessitated combining all of the productivity measurement data, and combining such large amounts of productivity data is difficult (Meehl, 1965).

The issue of combining the measurement data led to the second step. A method was developed to combine the different types of measures into one overall measure of how effectively the organization was functioning. This was done by constructing a graph called a Mission Effectiveness (ME) Chart. An ME Chart relates each measure of productivity, called an indicator, to how much that measure contributes to overall mission effectiveness. Each measure of productivity was represented by an ME Chart, and each ME Chart was developed through group discussions with supervisors and managers.

Pritchard, Jones and Roth (1987) discovered that, although a curve on an ME Chart could theoretically be a linear relationship between a productivity measure and overall effectiveness, curves on ME Charts for the five organizations measured were usually curvilinear. They demonstrated that this was an indication that tasks do not contribute equally to overall effectiveness throughout the range of performance. To account for the fact that all tasks are not equally important, curves on ME Charts are able to be adjusted for relative importance. An ME Chart with a steep slope represents an important task, whereas a flat slope represents a relatively unimportant task.

Pritchard and his colleagues (1987) argued that the ME Chart approach does not attempt to remove interrelationships among the various productivity measures; use of such charts is intended to maximize motivation. Discussions with supervisors and managers during Pritchard's field test suggested that the ME Charts they constructed represented the way that they actually felt about the relationship between performance and mission accomplishment.

Pritchard, Jones and Roth (1987: 3-4) found that ME Charts are useful for several reasons:

(1) They permit the translation of different measures of productivity into a common scale labeled "Mission Effectiveness."

(2) They capture management policy since they indicate the relative importance of various areas of work done by the organization.
(3) They add an evaluation dimension to productivity measurement since they specify how good each level of performance is on each indicator.
(4) They allow comparison of productivity across organizations.

Pritchard's effort used a process of consensual judgment to construct ME Charts. Supervisors and workers constructed and proposed ME Charts for management's review and modification to reflect organizational policy and goals. Any modification was completed in a discussion session between management and workers, and this session was found to be extremely informative for management and workers alike. During Pritchard's study, an average correlation level of .95 was obtained between ME Charts developed for different shifts. The correlation demonstrated that this type of productivity measurement system developed by one group of workers is in extremely good agreement with that of another group of workers doing a similar set of jobs at the same location.

Information from the measurement system was put together in monthly feedback reports and given to all workers, supervisors and management personnel by the researchers. These reports by Pritchard, Jones and Roth (1987: 4) contained information including:

1. What the important functions of the unit are:

2. What should be focused on to accomplish these functions:
3. What level of performance is expected in each area:
4. How much the unit has done in the last month on each of the important indicators:
5. How good that level of performance is on each of the indicators compared to the previous month:
6. What an overall index of productivity resembles when aggregated for each of the important functions:
7. What an overall index of productivity resembles when aggregated for the unit: and
8. How a specification of the areas can be determined where productivity could be increased. and how the priority for each can be set showing the overall effect on productivity.

Tuttle and Sink (1984) argued that practically any effort to measure and enhance productivity can expect to be met with some resistance because of the perceived threats inherent in being monitored. They outlined two initial fears: The first was a fear of staff reductions and the second fear was a concern that the researchers would try to tell them how to do their jobs better. Once the personnel in the target organization understood that this undertaking was not a manpower study designed for staff reductions. that the productivity measurement system was to be completely custom-fitted to their organization and that they would be given information about how well they were doing rather than advice on how to do it. these fears were greatly reduced.

According to Pritchard, Jones and Roth (1987), the results of giving feedback on this productivity measurement system showed an average increase of 50 percent across five organizations compared with pre-feedback baseline levels. After five months of receiving feedback, worker participation in goal-setting was added (each organization set its own productivity goals). The average increase in productivity across five organizations with the addition of goal-setting was 74.5 percent above baseline.

In addition to focusing on the productivity effects, Pritchard, Jones and Roth (1987) also assessed the effects of feedback on job attitudes. There were significant increases in job satisfaction and morale from baseline to feedback conditions. In addition, attitudes toward the feedback system were very positive for both workers and supervisors. Seventy-two percent of the respondents to a questionnaire assessing attitudes toward the system reported that the productivity measurement system was very well liked overall.

Pritchard, Jones and Roth (1987) reported that this effort proved extremely informative concerning both major research questions. The results showed that the new method of measuring organizational productivity

is effective and that feedback and goal-setting offer a number of important benefits in complex operational organizations. Pritchard, Jones and Roth (1987: 7-8) reported that benefits include:

1. The system yields a wealth of productivity information. It tells how well (how good or how bad) an organization is functioning on each measure of productivity, how well one part of an organization is functioning and how effectively the entire organization is functioning.

2. Building the system causes an examination of current practices. Throughout system construction, discussion of priorities and decisions about work procedures are necessary to build the contingencies and assemble them into a working productivity measurement system. This can stimulate changes in current practices.

3. The system clarifies policy. Various levels of an organization have input into each contingency and understand the views of other parts of the organization concerning what is considered good and bad performance.

4. Workers see the "expected" level of performance and what performance is considered good.

5. Workers receive positive feedback. Management and the workers themselves see when they increase productivity or maintain high levels of productivity. They usually find this very motivating.

6. Workers and mangers see the precise impact of changes (increased effort or new ways of doing old tasks) on organizational effectiveness.

7. Management can easily monitor the performance of the organization.

The results of this research by Pritchard and his associates showed that feedback and goal-setting can increase productivity, since the effectiveness increased impressively in operational Air Force jobs that involved both logistics and electronics maintenance. In fact, Pritchard, Jones and Roth (1987: 8) stated that the results of the research represented "the largest increase in productivity as a result of feedback and goal-setting ever obtained by them in any work environment."

In summary, this research showed that a productivity measurement system had been developed that contained maximum motivational properties and that feedback and goal-setting used by the system increased productivity impressively.

Summary

This chapter summarized the literature selected as a basis for the research. The available material was screened and selected for its applicability to military and related industrial applications. Its usefulness to the researcher and its relevance to other research explored in productivity studies involving military and related industrial facilities.

The section of this chapter that reviewed the background research on which the Methodology for

Generating Efficiency and Effectiveness Measures (MGEEM) model was based featured the findings published by Tuttle (1981). Tuttle and Weaver (1986a. 1986b). and Pritchard. Jones and Roth (1987).

Chapter 3

METHOD

To obtain the data required for this study, two major Aircraft Intermediate Maintenance Departments (AIMDs) were chosen as the target organizations to be examined. The AIMD at Naval Air Station North Island, Coronado, California was chosen as the facility to implement the Methodology for Generating Efficiency and Effectiveness Measures (MGEEM). The AIMD at Naval Air Station Lemoore, Lemoore, California was selected as the facility to be used as the control group.

The data obtained as a result of the 16-month Navy study and an examination of the changes in effectiveness observed in the Communication and Navigation Equipment Repair Branch were used to answer the following research questions:

1. What changes in effectiveness of the Communication and Navigation Equipment Repair Branch of a shore-based Naval AIMD were observed during and after implementing the MGEEM?

2. How closely did the Key Result Areas (KRAs), indicators and subsequent changes in effectiveness obtained from this Navy study compare with those of an independently-conducted implementation in an Air Force shop with an identical organizational mission?

Collection of Data

The research was concerned with evaluating a standardized method of increasing mission effectiveness and thus organizational productivity in shore-based Naval AIMDs. Two fully-functional major AIMDs under the Commander, Naval Air Force, United States Pacific Fleet were used in the study.

Data Sources

The research required three data sources: One experimental facility and one control facility for the Navy study and an independently-conducted study performed by the Air Force. The MGEEM process that was investigated is a multi-step procedure employing a measurement facilitator who leads a target organization through a structured group process called the Nominal Group Technique (NGT), which was developed by Delbecq, Van de Ven and Gustafason (1975). The NGT was used to define and prioritize the principal intended objectives

of the target organization, which are called Key Result Areas (KRAs). A Measurement Development Team (MDT) consisting of top level managers along with their subordinates was used to develop the KRAs. Once the KRAs were defined, the MDT was used to identify indicators, which were used to periodically assess whether the KRAs were being accomplished, and Mission Effectiveness (ME) Charts were then developed and programmed on a computer to periodically provide feedback on the organization's performance on indicators to both the management and the workers. This feedback alone, and later feedback coupled with goal-setting, were studied for their impact on mission effectiveness.

The entire MGEEM process was implemented in the Communication and Navigation Equipment Repair Branch located at Naval Air Station North Island, Coronado, California AIMD. The KRAs and indicators developed at the Naval Air Station North Island AIMD were published and distributed as policy and implemented in the Communication and Navigation Equipment Repair Branch. A computer-generated feedback program to display ME Charts and provide productivity enhancement was developed, and feedback reports were made to both managers and workers to observe changes in mission

effectiveness based on feedback. After the Feedback Phase was completed, goal-setting was added as an additional enhancement to observe changes in mission effectiveness based on feedback coupled with goal-setting.

The Naval Air Station Lemoore, Lemoore, California AIMD acted as the control group and was not involved with any phase of the MGEEM process. The KRAs and indicators developed at Naval Air Station North Island were used as items to be measured at both locations so that the gathered data were able to be compared. Four months of historical data were gathered at both AIMDs initially to establish a baseline. Monthly measurements were then taken at the AIMDs for four months during the Development Phase. for four months during the Feedback Phase and for four more months during the Goal-Setting Phase.

The data from both Naval AIMDs and the Air Force shop were then analyzed to determine (1) whether the MGEEM process was associated with a change in mission effectiveness at Naval Air Station North Island and (2) whether the KRAs, indicators and resultant changes in effectiveness obtained from this Navy study were similar to those obtained in an independently-conducted

implementation in an Air Force shop with an identical organizational mission. The AIMDs used in this study are described in Table 1.

Table 1

Description of the Aircraft Intermediate Maintenance Departments (AIMDs) That Constitute The Research Population

MAJOR AIMD	Number of Squadrons Supported	Number of Technicians Employed	Annual Repair Actions Performed
Lemoore	13	653	27.279
North Island	21	705	35.979

The study design specified a 16-month evaluation period to minimize inaccuracies caused by the supported squadrons' differing missions, deployment schedules and operating environments. Some unavoidable influences, such as geographic operational area and specific mission of the supported squadrons, were kept to a minimum, but were not considered to be relevant factors, due to the fact that only changes in mission effectiveness from a given baseline for each AIMD were being observed.

Instrumentation

The measurement method used to assess organizational productivity is the result of applying the MGEEM process to identify KRAs, indicators and develop their resultant Mission Effectiveness (ME) Charts. The methods used as enhancements were feedback and goal-setting.

This approach to measuring productivity was developed as a result of funding supplied by the Air Force Human Resources Laboratory (AFHRL) and was field-tested in 1986 in a Communication and Navigation Equipment Repair Shop and in four branches of a Supply Squadron at an Air Force base located in the southwestern United States. The evaluation of the productivity measurement system was a part of a larger project, which focused on interventions of feedback, goal-setting and incentives as techniques for enhancing organizational productivity.

To assess interventions, four months of historical data were gathered to establish a baseline before the interventions were implemented. If no historical data were present, the most current month's data were used to establish the baseline from which mission effect-

iveness changes due to the interventions were able to be evaluated.

The frequency for reporting mission effectiveness data for indicators within each KRA was established as one month in order to parallel the work cycle. The data were obtained monthly primarily from the in-place maintenance data collection system. The computer-generated feedback program developed to report results was capable of taking raw input data and producing a weighted feedback chart called a Mission Effectiveness (ME) Chart. ME Charts display the judgments of members of the work center concerning the impact of various levels of performance, displayed as indicators, on the work center's overall mission effectiveness. Thus, there is one ME Chart for each indicator. Each ME Chart shows a given indicator on the X-axis and always shows mission effectiveness on the Y-axis: see Figure 3.

Curves on ME Charts account for the fact that some indicators of productivity are more important than others: therefore, the computer-generated feedback report could aggregate to obtain the total effectiveness score by adding the effectiveness scores for each ME Chart. This score was compared with baseline and

the previous month's effectiveness score to determine the extent of change in mission effectiveness, hence productivity.

Procedure

To obtain permission to conduct the study and to schedule on-site visits with the AIMDs selected as data sources, the researcher was assigned in a Temporary Additional Duty (TAD) status as the measurement facilitator for productivity in the Productivity Branch of the Aircraft Maintenance Department assigned to the Commander, Naval Air Force, United States Pacific Fleet Staff. Telephone calls to the AIMD Officers established the initial consent to conduct the study: a follow-up call established a mutually convenient date for conducting the Development Phase of the MGEEM process. The procedure followed throughout this study parallels the procedure suggested by Tuttle and Weaver (1986a, 1986b) in their guides for measurement facilitators in the use of the MGEEM process.

At the pre-arranged time, date and place, an initial meeting with the target Naval Air Station's AIMD Officer marked the formal beginning of the MGEEM implementation. At that meeting, time was devoted to establish a rapport with the AIMD Officer and to assure

him that the purpose of the MGEEM implementation was to develop a tool that would measure and improve the productivity of the AIMD. The structured interview in Appendix A employed by Tuttle and Weaver (1986b) was used for assistance in the initial meeting. In the meeting, the AIMD Officer also received an overview briefing on the MGEEM Development and Implementation Phase, and the major steps of the process were explained along with a suggested timetable for implementation. All questions were answered and the AIMD Officer was assured that the MGEEM measurement facilitator was there to benefit the organization, not to evaluate or threaten it.

A review of existing in-house documentation was then made to ensure that the measurement facilitator was familiar with the target organization. Examples of documentation included in this review are listed in Appendix B.

Another source of information about the target organization was obtained through a site visit equivalent to the one suggested by Tuttle and Weaver (1986b). The measurement facilitator's primary concern in this site visit was to learn more about the target organization. Examples of specific items included in

the site visit are included in Appendix C. The facilitator then focused on identifying the work center's major products and services, as well as developing a general understanding of the work flow involved.

It would have been possible for the facilitator to do an adequate job of conducting the MGEEM implementation without having seen the work site, but there were distinct advantages to such a visit. One advantage was the opportunity to establish a rapport with members of the work center. If the facilitator was seen as caring enough to understand how the organization worked, members tended to cooperate more fully and were more willingly to cooperate with the requirements of the research. Another advantage is that, through seeing the work site, the facilitator was able to communicate more effectively in the group sessions to follow and was able to better understand participants' comments because he had become familiar with the pattern of the work flow.

The facilitator then used a systems diagram, or input-output approach, suggested by Tuttle and Weaver (1986b) to illustrate the multiple organizations that were involved when determining the mission effective-

ness of the target organization. A system is a set of interrelated components that have a common purpose or goal. A Navy organizational system could be an air wing, a squadron, a maintenance department or even a branch within a maintenance department. Systems can be small or large, but they all have a set of interrelated components, such as people, materials, equipment and organizational entities that share a common mission. Systems are defined in terms of their inputs, outputs, goals and interactions with their environment across system boundaries. Figure 1 pictures a system defined by its boundary, which separates it from its environment.

As a general rule, inputs to any organization can be grouped into labor, material, capital and energy. Outputs are defined as the products or services that the system produces to achieve its purpose. The main outputs of a maintenance organization are the number of pieces of equipment repaired, personnel trained, parts fabricated and reports submitted.

The system's boundary separates the system from its environment. Although the concept of a boundary is theoretical, it has practical implications, since a manager is able to control what goes on in the system

while having little control over what occurs outside the system. Once a system is defined by specifying its boundaries, its environment consists of anything that is not contained within the system. More detailed systems diagrams than shown in Figure 1 can be prepared after going through an organizational familiarization process.

The facilitator used the concept of a systems diagram to better understand the target organization. The diagram for the system under study is shown in Figure 2. It can be seen that inputs are derived from the environment, and the system uses these inputs to produce outputs, which are then disbursed to the environment.

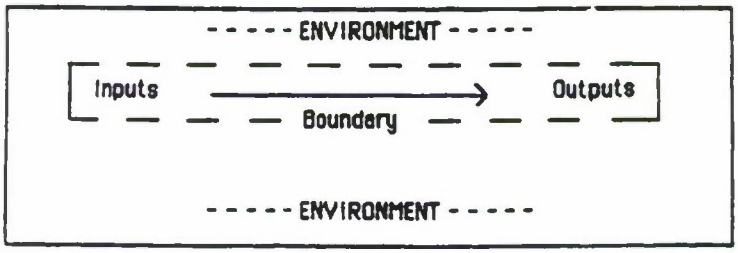


Figure 1

Systems Diagram

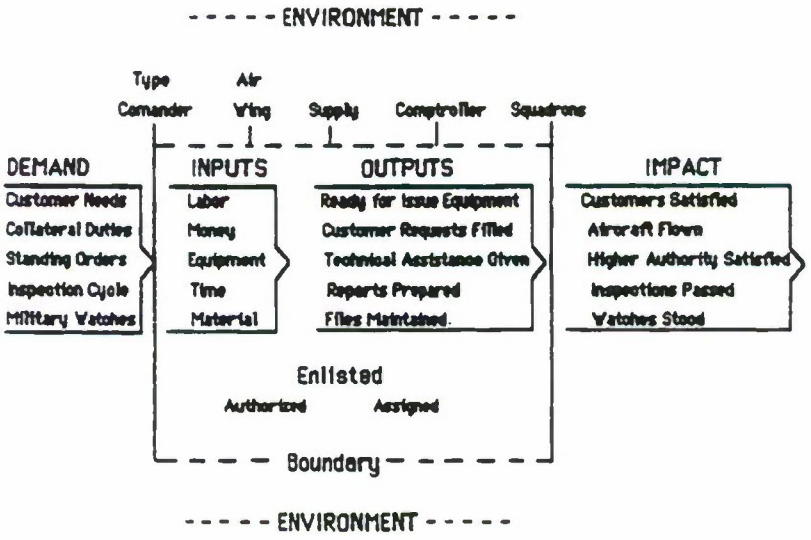


Figure 2

Organizational Diagram for the Communication and Navigation Equipment Repair Branch

After developing the systems diagram, it was explained to the AIMD Officer that there are many reasons why organizations decide to measure their productivity. In general, these motives are either organizational control or organizational improvement. The motive of organizational control is that organizations want to generate measures to satisfy someone else, such as a higher command or a controlling agency. The motive of measurement for organizational improvement has a different focus in that the managers themselves create measures as guides to assist in identifying methods to improve organizational effectiveness. Thus, control-oriented measurement is used by organizations to justify themselves to other organizations in their environments, while improvement-oriented measurement provides information to enable organizations to better manage themselves. (This distinction is made here, since it was explained that the MGEEM process should be seen as an improvement-oriented approach to management.)

A basic purpose of developing improvement-oriented measurement is that it provides an organization with a method of initiating productivity improvement. It was explained by the researcher to the AIMD Officer and MDT

that the relevant measures to be developed by the MGEEM would not be those that fall under the control of external organizations, but would be those controlled by the AIMD itself. Through use of improvement-oriented measurement, it was shown that the AIMD Officer and his subordinates could assess current performance and take corrective action.

The facilitator then worked with the AIMD Officer and appropriate branch personnel to identify potentially helping and restraining forces associated with the goal of implementation of the MGEEM. Tuttle and Weaver (1986b) also suggested this process in their facilitator's guide. The reason for outlining these forces is to enable the facilitator to put together a strategy to strengthen the forces for success and to minimize forces working against success. A sample of these forces is shown in Table 2.

Table 2

Analysis of the Forces For and Against MGEEM Implementation

Forces For implementation of the MGEEM process	Forces Against implementation of the MGEEM process
AIMD Officer's support ----->	<--Fear of more paperwork
Desire to improve---------->	<--Fear of more workload
Division Officer's support-->	<--MGEEM process unknown
Supervisor's support-------->	<--Fear of monitoring
Desire to have a voice------>	<--Fear of losing freedom

Once the force field analysis summarized in Table 2 had been completed, the results served to guide the development of an implementation plan. A sample implementation plan format is presented in Appendix D.

The implementation plan was then communicated over a short period of time to all members of the Communication and Navigation Equipment Repair Branch of the AIMD from the top down as suggested by Tuttle and Weaver (1986a). Tuttle and Weaver (1986b:9) also suggested that caution should be taken to avoid certain common misconceptions and errors:

1. The perception by the workers that the measurement effort was being forced on the organization and does not have the full support of branch and/or section chiefs. To avoid this misconception, strong, continuous and visible management support for the MGEEM process was essential.

2. The perception that the process was designed to require more work from members of the organization. To avoid this misconception, it was emphasized that improvement, not control, is the main purpose of the MGEEM. Management made their endorsement of this purpose to all members of the organization. Management also stressed that the MGEEM would identify areas where performance could be improved by working smarter, not harder.

3. Neglecting to recognize the legitimate organizational concerns and limitations during the implementation of the MGEEM process. For instance, it is a mistake not to pay enough attention to the fears of organization's members. Implementation had to include a sincere effort to give people a chance to voice their fears and concerns and to have those concerns answered honestly. However, implementation was not allowed to drag on until each minor issue was resolved.

4. Failure to ensure that the target organization had been clearly defined by the measurement facilitator. To avoid misunderstandings, the facilitator had a clear conception, displayed in a systems diagram, of what organizational units and functions were within and beyond the scope of the measurement activity. This understanding was shared and agreed to by the commander and management of the target organization.

The next step involved forming a Measurement Development Team (MDT) similar to that suggested by Tuttle and Weaver (1986a, 1986b). Since the MGEEM

involves participative methodologies. the facilitator worked with the AIMD Officer to ensure that the MDT members were carefully selected. MDT members needed sufficient knowledge of the organization and its primary work process to contribute ideas and make meaningful judgments. Furthermore, they had to be able to communicate their ideas to those with whom they work and were required to be key members or opinion leaders by virtue of their formal or informal power.

Two MDTs were formed by Tuttle and Weaver (1986a. 1986b): however, it was found beneficial to form only one MDT in this Navy study, since the Communication and Navigation Equipment Repair Branch is a relatively small part of the AIMD. The MDT members, consisting of the division officer, senior personnel and opinion leaders in the work center, first defined the broad measurable facets of the branch's mission (called the KRAs). Once the KRAs were developed, the specific indicators and Mission Effectiveness (ME) Charts for each indicator were developed.

From the viewpoint of the external environment. KRAs are the reasons that the organization exists. The MDT needed to be briefed on the meaning of a KRA. This

initial briefing paralleled the one suggested by Tuttle and Weaver (1986b) and is outlined in Appendix E.

The facilitator used the NGT to simplify the KRA development process. The following question was asked: "What output or results does the Navy expect this branch to accomplish?" Members of the MDT were asked to write answers to this question on a sheet of paper. Once written, all of the answers (proposed KRAs) were posted on chart paper around the room. The proposed KRAs were discussed, modified and consolidated until a preliminary listing of KRAs had been generated. The primary reason that all of the ideas were listed, discussed, modified and consolidated was to attempt to consider everyone's inputs; a further reason was to reduce, consolidate and refine the KRAs, which set the stage for voting to reach consensus on the final set of KRAs among members of the MDT.

The listing was then discussed and voted on to reduce and prioritize the number of KRAs on the list. As a result of the first vote, the KRAs began to emerge that were considered the most important by members of the MDT. The condensed list is shown in Appendix F. After more discussion and modification, a second vote was conducted to further reduce and prioritize the list

of KRAs in order of their importance. The final KRAs are shown in Table 3. The MDT needed to vote only twice to reduce the KRAs to a managable number, but another vote would have been used if necessary.

Table 3

Final KRA Listing of the Communication and Navigation Equipment Repair Branch

KRA # 1. Customer Satisfaction Describes the organization's primary means of measuring the service it is required to provide.
KRA # 2. Motivation Describes the organization's ability to meet the needs of the assigned workers.
KRA # 3. Training Describes the organization's ability to meet its training needs.
KRA # 4. Safety Describes the organization's ability to conduct its job in a safe manner.

After the KRAs were developed, the MDT developed what they considered the best performance indicators for each KRA, as suggested by Tuttle and Weaver (1986a, 1986b). While deciding on the best indicators for each KRA, use of existing statistical data available from the maintenance data collection system was encouraged. This proved extremely helpful, since the MDT members were familiar with the meaning of the maintenance data that were presently being collected, and new data collection burdens on the organization were kept to a minimum.

The first KRA for which indicators were to be developed was purposely chosen to be the easiest one. This served to familiarize MDT members with the process of developing indicators. Formulating indicators for other KRAs was then patterned after the process used on the first one.

While developing indicators, members of the MDT were asked to write down all the potential indicators that they could think of for the KRA. The indicators were then listed and discussed, modified, consolidated and voted on in the same manner as the KRAs were in their development stage, until the number of indicators for each KRA was reduced to no more than six per KRA.

This was done to ensure that the measurement system measured only the most important indicators: measuring more than six indicators per KRA was considered to be a paperwork burden by the MDT. The final KRAs and indicators are listed in Table 4.

Table 4

Final KRA and Indicator Listing for the Communication and Navigation Equipment Repair Branch

KRA # 1.	Customer Satisfaction
Indicator A:	Y-Code rate: Percentage of repaired equipment that did not function immediately after installation.
Indicator B:	Backlog: Number of items that were awaiting maintenance (AWM) or awaiting parts (AWP).
Indicator C:	Exrep backlog items: Number of items that were AWM or AWP for expeditious repair.
Indicator D:	RFI rate: Percentage of equipment brought in for repair that was actually repaired.
Indicator E:	Turn around time: Average processing time taken to repair items.
Indicator F:	Broad Arrow/TED reports: Number of test benches that were inoperative or operating in a degraded condition.
KRA # 2.	Motivation
Indicator A:	Recognition: Number of people formally recognized or rewarded per month.
Indicator B:	Morale Index: Average of feedback scores on a quarterly morale survey.
Indicator C:	Production Effort: Percentage of work accomplished by assigned personnel.
Indicator D:	Negative personnel indicators: Number of negative reports received on personnel in the work center.
Indicator E:	Quarterly Retention: Percent of those eligible who reenlist or extend.

Table 4 (continued)

KRA # 3. Training	
Indicator A:	OJT: Average number of on-the-job training hours documented per month per person.
Indicator B:	PQS: Percent of assigned Personnel Qualification Standards that have been completed.
Indicator C:	Rate Training: Average hourly amount of training completed in Navy professional jobs.
Indicator D:	Formal Billet Training: Average hourly amount of training received in specific job assignment.
KRA # 4. Safety	
Indicator A:	Accidents: Number of reported accidents at work.
Indicator B:	Safety Violations: Number of safety violations reported at work.
Indicator C:	Repeat Discrepancies: Number of repeat discrepancies on the Safety Audit.

The next phase of the measurement process captured the MDT's judgment on the relative importance of each indicator and on its impact on the Communication and Navigation Equipment Repair Branch's overall level of performance. The resulting graph is referred to as a Mission Effectiveness (ME) Chart. ME Charts were developed by the Air Force Human Resources Laboratory (AFHRL) specifically for this purpose.

Each ME Chart employs a two-dimensional (X,Y) axis and creates a unique transformation for each indicator. On the Y-axis, overall mission effectiveness is measured on a scale in increments of 10 from 0 to +100 on the top and 0 to -100 on the bottom. There is one ME Chart for each indicator, and the different levels of possible performance on the indicator are relected on the X-axis of the graphs. For each given indicator, the relationship between performance on the indicator and its impact on mission effectiveness is plotted.

To construct each ME Chart, group discussion was used by the MDT to determine points on the graph. The first point determined was the expected level of performance (or zero point), which was determined by asking the question, "What is the level on this indicator that has no impact on mission effectiveness?" Another way to put the question was to ask, "What is the level on this indicator that will not cause management to commit more resources in order to affect mission effectiveness?" The coordinate for this is zero on the Y-axis and it represents the expected level or zone of performance on the X-axis.

Once the expected level or zone was determined, the points of possible maximum and minimum performance on the indicator were determined, which "anchored" the values on the graph.

Intermediate points of effectiveness were then determined by discussion, and the resulting graph was a possibly non-linear representation of the effectiveness produced by different levels of performance on each indicator. Consensus through discussion was then used to rank the maximum of each indicator in terms of its contribution to the overall productivity of the unit. The maximum with the greatest contribution was automatically given an effectiveness value of +100, and the group rated the other maximum values relative to the most important one. For example, if the maximum of a given indicator was only half as important to the effectiveness of the unit as the most important maximum, it was given a value of +50. An analogous process was then completed for the minimum values of each indicator. Since, by going through this procedure, each indicator for a given KRA had been weighted according to its relative value or importance as a measure of its contribution to the effectiveness

of the unit, the values of each indicator were able to be mathematically summed to yield the total effectiveness contribution for each KRA.

Since it is probable that all KRAs do not contribute equally to mission effectiveness, each KRA had to be weighted using a procedure similar to the procedure used to weight the indicators for the KRAs. This was necessary since weighting the KRA scores allowed the individual weighted KRA scores to be aggregated in a manner similar to the weighted indicator scores to produce a single number to represent total mission effectiveness.

The facilitator then scheduled a review of the KRAs, indicators and their ME Charts with the division officer, as was done in the study by Tuttle and Weaver (1986a, 1986b). In reviewing the KRAs, indicators and their related ME Charts, the division officer had several options: He could delete the item, modify the item, retain the item or defer action on the item until further research was done to determine the feasibility of using it. The facilitator then prepared a report of the results. A sample ME Chart and indications of how ME Charts can be used by management are shown in Figures 3 through 5.

Figure 3 presents the general form of an ME Chart. The horizontal axis represents the amount of an indicator ranging from the possible worst to the possible best level of performance. The vertical axis of the figure, which ranges from a maximum effectiveness of +100 to a minimum effectiveness of -100, illustrates the effectiveness values of the various levels of the indicator. The zero point or zone on the vertical axis is defined as the expected, or neutral, level of effectiveness.

As indicated in Figure 4, the MDT considered between 8 and 11 repaired items returned per month the expected level of performance. Once the zero or expected level of performance had been established by the MDT, the next task was to determine the possible best and worst levels of performance to "anchor" the values on the graph.

Figure 4 shows that the MDT indicated that, in their view, it is not possible to do better than 5 Y-Codes (repaired items returned) per month and they consider 20 repaired items returned the worst possible level of performance. From Figure 4, it can also be observed that personnel in the MDT considered the Y-Code (return rate) an important aspect of their job.

since the maximum possible effectiveness is +100 and the minimum possible effectiveness is -90. Although the MDT considered a return rate of between 8 and 11 items per month an expected level of performance. It can be observed that the decrease in effectiveness is not linear as the number of returned items per month increases beyond 11.

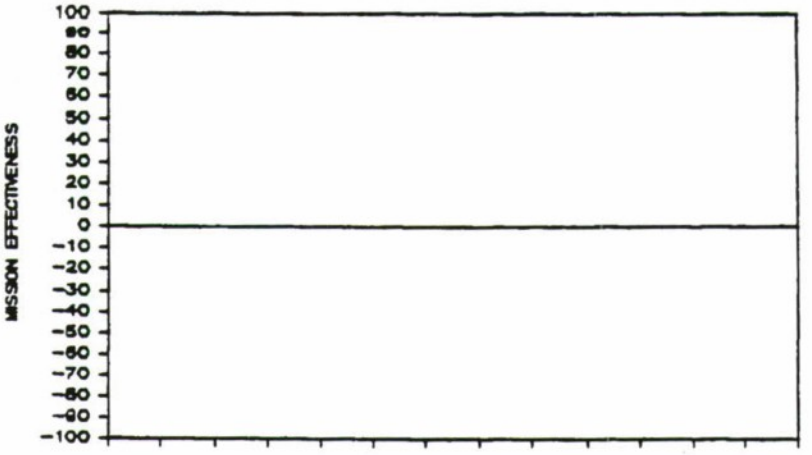


Figure 3

General form of a Mission Effectiveness (ME) Chart

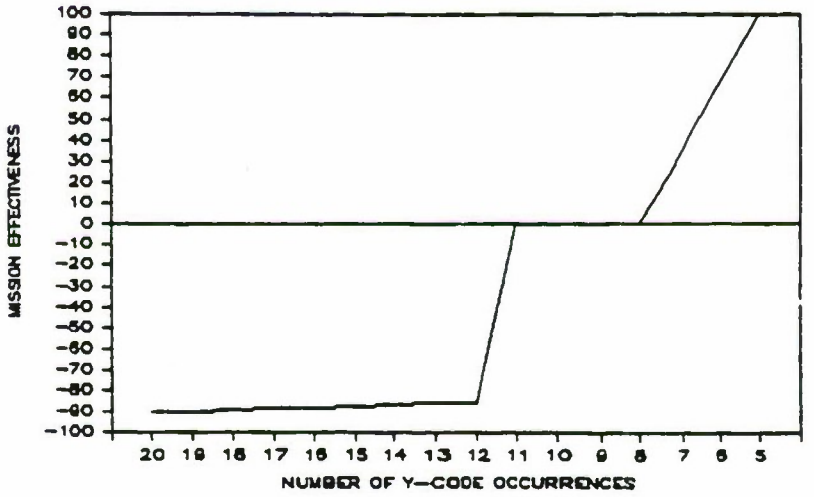


Figure 4

How to interpret the ME Chart
Y-Code Rate

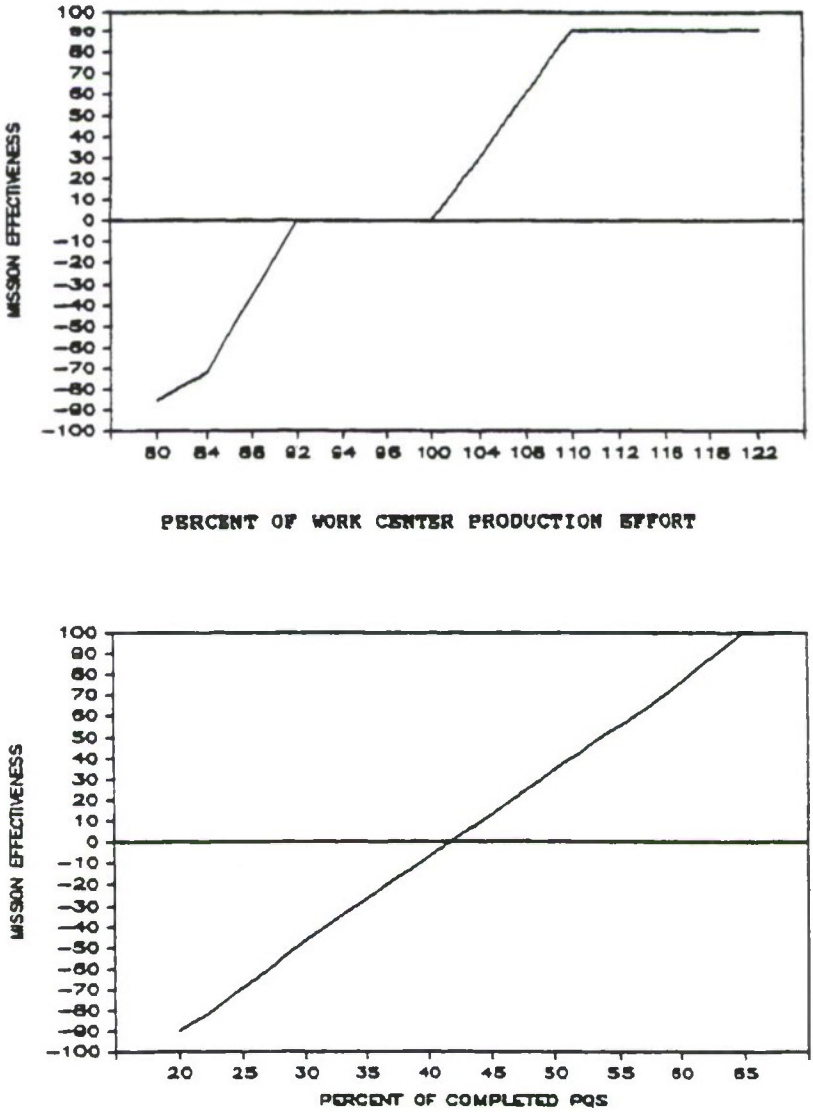
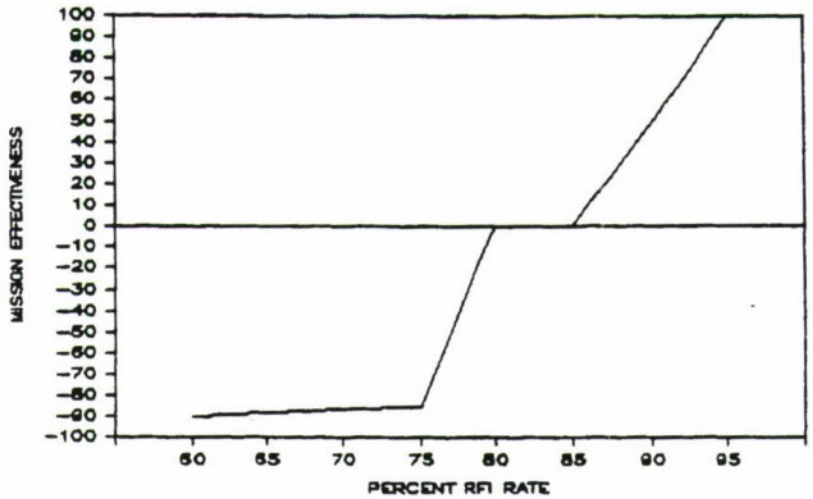


Figure 5

Different-Shaped ME Charts



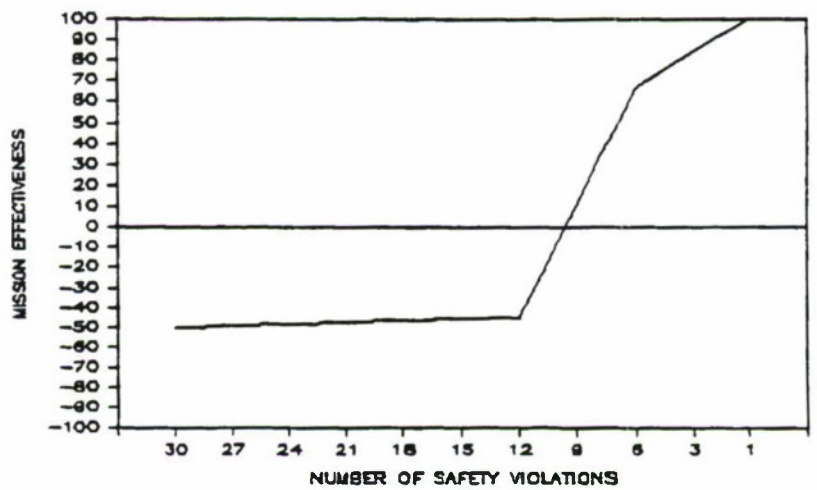


Figure 5 (continued)

Different-Shaped MB Charts

Four representative ME Charts are presented in Figure 5. For each indicator, there is an ME Chart with its possible maximum, possible minimum, expected level or zero point, and a function relating to effectiveness. The first ME Chart represents percent of Work Center Production Effort. Note that, for this ME Chart, the expected level of performance is between 92 and 100 percent production effort. If the percent of Work Center Production Effort increases to 110 percent, the maximum effectiveness of +90 is attained. Once maximum effectiveness is attained at 110 percent, further increases in effectiveness are not possible. The minimum level of effectiveness of -85 is not achieved until percent Work Center Production Effort decreases to 80 percent: however, the function describing the drop from the expected level of Work Center Production Effort to the minimum possible level of Work Center Production Effort is not linear.

The second ME Chart describes the percent of completed Personnel Qualification Standards (PQS). Note that the expected level of performance is 41 percent of the PQS completed. The maximum level of effectiveness of +100 is not reached until the percent of completed PQS is increased to 65 percent, and the

minimum level of effectiveness of -90 is not reached until the percent of PQS has decreased to 20 percent. Note also that there is a linear relationship throughout the range of completed PQS as would be expected, since there is no specific level of training given that would produce a disproportionate increase or decrease in effectiveness of the work center personnel. With that in mind, management would be aware of the fact that effectiveness gained through this type of training yields a linear return throughout its range.

The third indicator, monthly Ready For Issue (RFI) Rate, has an expected range of between 80 and 85 percent. The maximum level of effectiveness of +100 is not reached until the RFI Rate has increased to 95 percent. The minimum level of effectiveness of -90 is not reached until the RFI Rate has decreased to 60 percent: however, once the RFI Rate has decreased from 80 to 75 percent, the majority of the effectiveness has been lost. This information allows managers to see that the largest gains in effectiveness can be made in this zone, since once effectiveness has dropped to 75 percent, little more can be lost beyond that point.

The last indicator, number of monthly Safety Violations, has an expected value of 10 per month. The

maximum effectiveness of +100 is reached when the number of Safety Violations has decreased to one per month, and the minimum effectiveness of -50 is reached when the number of Safety Violations has increased to 30 per month. Note especially that there is a non-linearity between number of Safety Violations per month and effectiveness, and that the greatest increases in effectiveness per unit of change can be achieved as the number of Safety Violations decreases from 12 to 6.

Two things are particularly noteworthy about the four ME Charts shown in Figure 5. The first is that the ME Charts permit non-linearities to exist between performance on indicators and mission effectiveness. A linear relationship means that to improve a given amount at the low end of an indicator yields an increase in effectiveness as great as improving that same amount at the high end or anywhere else on the X-axis. In the work environment, this is not always the case, since it is very common for values in the mid-range of an indicator to represent large improvements in productivity and the values at the high end (or low end) to represent a point of diminishing returns. When an organization achieves a fairly high level of product-

ivity in one given indicator, it might prove more productive to try to improve on another indicator that is not doing well, rather than to expend the extra effort to continue improvement on an indicator that is already at a high level.

The second item worthy of note is that the slope of the function expresses the relative importance of the indicator. For example, the overall slope of the third indicator (RFI Rate) is steeper than the fourth indicator (Safety Violations). This reflects the fact that, although it is important not to have any safety violations while working on an item, it is more important to actually complete the repair and have the item Ready For Issue (to the customer).

It is necessary to recognize what these two properties of an ME Chart can reveal to the manager. First, since the slopes can be non-linear, they accurately reflect the realities of how an organization functions. In many cases, linear relationships between indicators and mission effectiveness do not exist. Secondly, the charts reflect different levels of importance for different indicators, since all indicators are not equally important to the productivity of an organization. Aspects of the job that are very

important get steeper slopes than aspects of a job that are less important: therefore, a small increase in a critical aspect of a job could realistically produce a larger increase in effectiveness than a larger increase in a non-critical aspect of the job. Thus, the relative importance of each aspect of the job is incorporated during the development of the ME Charts.

Since monthly feedback of performance on the ME Charts was necessary, the Data Analysis Division of the AIMD assisted in generating a program that would provide a monthly computer-printout to reflect mission effectiveness for both managers and workers. The computer-generated feedback system that was created was able to provide feedback in a graphical form, show the current status of each indicator, and aggregate all effectiveness information to a single measure of productivity for the AIMD Officer.

To aggregate effectiveness scores, it was necessary to weight the summed effectiveness scores to reflect the relative importance of the KRAs. This was accomplished by asking the division officer and the petty officer supervisors in the MDT to assigned ranks and percentage-of-100 weights to the four KRAs. These were 40 percent for customer satisfaction, 20 percent

for motivation, 30 percent for training, and 10 percent for safety. To create the monthly aggregated score for the feedback, a weighted mean was computed with the following equation: KRA #1 summed effectiveness score (KRA #1 weight) + KRA #2 summed effectiveness score (KRA #2 weight) + KRA #3 summed effectiveness score (KRA #3 weight) + KRA #4 summed effectiveness score (KRA #4 weight).

An alternate to this double-weighting procedure is to ask the MDT to evaluate the possible worsts and possible bests of each indicator relative to all the others in terms of its contribution to the overall mission. To not evaluate possible worsts and bests within each KRA permits the effectiveness scores to be summed across all KRAs and avoid the second weighting for KRA importance. The problem with the single weighting, however, is that the MDT may resist or find it too difficult to evaluate a large number of possible worsts/bests. This was the case in this field test.

Once the computer-generated reports were completed, the Implementation Phase of the MGEEM process began. The KRAs, indicators, and ME Charts were published and distributed to all personnel in the branch. Management support was evident and all key

persons showed strong support for the system. The initial monthly ME Charts, reflecting changes in effectiveness in the branch during the Baseline and Development Phase, were distributed to both management and workers. The results were posted, as shown in Appendix G, to ensure they could be viewed frequently.

During the first enhancement of monthly feedback, the researcher did not interact with the target organization, since interaction with branch personnel could have possibly caused increases in organizational productivity due to the workers' knowing that they were being observed. During the second enhancement of monthly feedback and goal-setting, the researcher interacted with the MDT personnel for only a few hours to assist them in setting meaningful goals. A sample of two ME Charts showing mission effectiveness is shown in Appendix H. Feedback was intended to motivate the target organization's personnel to increase their productivity.

Analysis of Data

A description of the analysis of data is presented in this section. The process included listing KRAs, charting the monthly values of the indicators on ME Charts, and producing a graph showing overall mission

effectiveness. The ME Charts displayed a baseline of historical data that were collected to show a standard of mission effectiveness from which changes in productivity could be calculated. The charts of monthly values on the indicators, individual ME Charts, and the aggregate productivity graph were capable of displaying data for a report of findings.

Included in this collection of data for analysis was an overlay of overall aggregated productivity data on a single graphic display, which was able to show the combined changes in mission effectiveness during the term of the research on both the experimental and control facility. Comparisons of the graphic display contributed to answering the research question posed by the study.

Statistical data obtained from the monthly measurements of effectiveness indicators for each KRA provided the basic input for each ME Chart, which indicated monthly performance in a graphical format. Numerical comparisons were made between the effectiveness scores of the previous month's productivity data.

The data collected from the Air Force study at Bergstrom Air Force Base are also listed for comparison with the data collected during this study. The comparisons between KRAs, indicators and resultant productivity changes at both facilities were made to determine the feasibility of inter-service transportability of the MGEEM.

Research Assumptions and Delimitations

The following research assumptions and delimitations are discussed. Items not listed as assumptions or delimitations were not considered relevant to this study.

Research Assumptions

In designing the study, it was assumed that the adoption of a descriptive-correlational research approach using Mission Effectiveness (ME) Charts and an overall mission effectiveness graph along with tables listing KRAs, indicators and changes in mission effectiveness would facilitate in the collection and analysis of the data required to answer the research questions. It was also assumed that the research findings that were limited to the Communication and

Navigation Equipment Repair Branch might be more broadly applied to the entire AIMD.

As is the case with any performance improvement strategy, there were potential dangers and problems associated with the process. Among the problems, three fears were referred to by Tuttle and Weaver (1986b). One fear is the fear of being measured. Since concerns are often expressed when performance is measured, these concerns had to be addressed. The second fear, the fear of failure, was dealt with by encouraging groups to set goals that were challenging but attainable. The third fear, the fear of repercussions from higher authority, was frequently grounded in a history of having been confronted by a superior for a performance problem, but this fear was minimized by discouraging micromanagement. That was accomplished by sending only aggregated data to the AIMD officer.

Goals can be seen as ceilings, but the goals used in this study were designed to serve as targets that encouraged performance improvement. The key to avoiding ceiling effects was to establish in the organization attainable goals and a mind-set of continual work on performance improvement.

One normally obtains improvements in the results that one measures; therefore, the MDT tried to consider only the important facets of the organization's performance. The NGT assisted in this process, since it necessarily reduced the KRAs and indicators to a small number, which eliminated the measurement of less important results.

Delimitations

The research concentrated on identification of KRAs and indicators combined with measuring the overall effectiveness of the Communication and Navigation Equipment Repair Branch of major West Coast shore-based Naval AIMDs under the Commander, Naval Air Force, United States Pacific Fleet. The specific KRAs measured did not represent a universal measure of total productivity, but were intended to be representative of areas in which it was most desirable that mission effectiveness be measured. The non-critical areas of productivity were eliminated in the voting process used by the MDT.

The curves representing mission effectiveness were generated by consensus of the MDT. As branch priorities and MDT membership changed, the curves on the Mission Effectivenss Charts were held constant so that

the study would be consistent with the Air Force study. That consistency was required to satisfy the restrictions of Research Question 2. In the real world, managers would want to change the slopes of the ME curves to reflect different priorities as the environment changes.

Summary

The Methodology for Generating Efficiency and Effectiveness Measures (MGEEM) is a multi-step process that enables any organization to create a complete productivity measurement and enhancement system. The use of a feedback procedure consisting of Mission Effectiveness (ME) Charts allows the organization to incorporate command policy and goals into the measurement process by constructing possibly non-linear feedback charts used in conjunction with the productivity measurement system that has been created specifically for that organization. The total productivity measurement system so created contains significant motivational properties, since it has been created by the workers themselves to measure their own productivity. It also provides motivation, since it gives the workers an opportunity to discuss their constraints as a group, formulate solutions to those

constraints, and attempt to work smarter, not harder. Once the worker-created total productivity measurement system had been designed, feedback alone and then feedback coupled with goal-setting were used to determine the effects on mission effectiveness.

This chapter described the participative productivity measurement and improvement process called the MGEEM. It described the method used for the collection of data, outlined the data sources, and described the instrumentation design that was used as a feedback mechanism to managers and served also to answer the research questions. The procedure used to collect the data was then described, along with specific preliminary steps that were used to facilitate the introduction and acceptance of the MGEEM process at the site being tested. The discussion of the need for advance preparation by the measurement facilitator demonstrated how acceptance of the MGEEM process could be either hindered or facilitated. The instrument used to collect the data was then discussed. The analyses of the data included calculating changes in mission effectiveness and examining the similarities between the productivity measurement and enhancement system designed at Naval Air Station North Island and at an

Air Force base located in the southwestern United States. The assumptions and delimitations of the study were listed.

Chapter 4

FINDINGS

This chapter presents the findings of the study. The first part of the study consisted of identifying Key Result Areas (KRAs) and indicators, and constructing Mission Effectiveness (ME) Charts to record performance on each indicator. The study then obtained statistical data related to mission effectiveness, hence productivity, using four months of historical data to establish a baseline, four months of current data during development, four months of data while feedback alone was used, and four months of data while both feedback and goal-setting were used. The second part of the study used the KRAs, indicators and resultant changes in effectiveness produced in the first part of the study and compared them with the findings of a similar study of an Air Force facility having the same operational responsibilities. Section One of this chapter deals with data relating to the first research question, and Section Two deals with data relating to the second research question.

First Research Question

What changes in effectiveness of the Communication and Navigation Equipment Repair Branch of a shore-based Naval Aircraft Intermediate Maintenance Department (AIMD) were observed during and after implementing the Methodology for Generating Efficiency and Effectiveness Measures (MGEEM)?

These results will be presented in three sections: (1) measures of organizational productivity recorded from historical data, which constituted the baseline period and four month's current data for the period when the system was under development, (2) measures of productivity during the feedback period that followed, but before the goal-setting period began, and (3) measures of productivity after goal-setting began.

Results During the Baseline and System Development

A Measurement Development Team (MDT) consisting of the Division Officer, Work Center Supervisor and eight other work center personnel was used in identifying the various KRAs, indicators and constructing ME Charts. While developing the KRAs, a total of 36 potential KRAs were initially listed using the data-gathering phase of the Nominal Group Technique (NGT). After discussion,

clarification, modification and consolidation of the 36 initially-listed KRAs, 7 remained, and these were then voted on to further reduce the list and identify priorities. The seven candidate KRAs are listed in Appendix F.

Each of the 10 members of the MDT selected 5 of the 7 remaining KRAs, which were considered most important, and ranked them in order of their perceived importance (5 being the most important). Total scores were then calculated to determine the items that were considered the most important measurable aspects of performance or KRAs. For example, if 9 of the members of the MDT each assigned a rank of 4 to represent the relative importance of a specific candidate KRA, then that KRA would be assigned a total score of 9 X 4 or 36. The KRAs having the highest total scores from the rankings and the highest "N." or number of the MDT members voting for them, were considered to be the most important measurable aspects of the organization's mission: the remaining KRAs, having received a significant drop in total score in the voting, were eliminated by consensus of the MDT. Table 5 lists the final voting score of KRAs that were selected.

Table 5

Final Voting Score on
Key Result Areas
(N= 10 Members of the MDT)

Key:
Total Score = Number points received (1-5 points per vote)
Scale: 1 = least important: 5= most important

Key Result Area	N	Total Score
Customer Satisfaction	10	50
Motivation	10	33
Training	10	27
Safety	9	24

Tables 6 through 9 list the indicators that were determined by the NGT to be the factors that would give the best evidence that the specific KRA was being accomplished. Each KRA was considered separately and, using the NGT referred to earlier, an initial set of indicators for that specific KRA was listed. Those initial candidate indicators were then discussed, modified and consolidated to reduce the total number for the specific KRA. The

reduced list of possible indicators was then voted on by the 10 members of the MDT. They ranked the resulting seven indicators in terms of importance (7= most important). The results were totaled, where N represents the number of members of the MDT who considered the indicator important and total voting score represents the total number of points each indicator received. Only the indicators with the highest N and total voting score (prior to a significant decline in N and total voting score) were selected as indicators: the lower-scoring indicators were eliminated by consensus of the MDT.

Table 6

Indicators Chosen to Measure the KRA
Customer Satisfaction

Key:
Total Score = Number points received (1-7 points per vote)
Scale:1 = least important: 7= most important

Indicator	N	Total Score
Ready For Issue rate	10	63
Turn Around Time	9	51
Y-Code rate	9	39
Exrep backlog items	7	34
Backlog	9	28
Broad Arrow/TED reports	7	27

Table 7

Indicators Chosen to Measure the KRA
Motivation

Key:
Total Score = Number points received (1-7 points per vote)
Scale:1 = least important: 7 = most important

Indicator	N	Total Score
Recognition	9	42
Retention percentage	10	40
Negative personnel indicators	8	35
Morale Index	7	34
Production effort	6	32

Table 8

Indicators Chosen to Measure the KRA
Training

Key:
Total Score = Number points received (1-7 points per vote)
Scale:1 = least important: 7= most important

Indicator	N	Total Score
On-the-Job Training	9	41
Personnel Qualification Standards	9	39
Rate training	7	35
Formal billet training	7	34

Table 9

Indicators Chosen to Measure the KRA
Safety

Key:
Total Score = Number points received (1-7 points per vote)
Scale:1 = least important: 7= most important

Indicator	N	Total Score
Accidents	9	55
Safety violations	7	38
Repeat safety discrepancies	8	30

After identification of the most important KRAs and indicators, the ME Charts were were developed for each indicator: these are shown in Figures 6 through 23. To develop each ME Chart, group discussion was used to determine several points before smooth lines were used to connect the points. The first point that was determined was the zero point or "neutral" zone, which represents an expected level of performance. This level of performance was seen as neither causing management to commit more resources for increasing productivity nor causing management to praise the group for its performance. Once the expected level or zone of performance was determined, both the best and worst possible levels of performance envisioned by the MDT for the branch were ascertained. This "anchored" the extreme points of the horizontal axis of the ME Chart. Intermediate points of performance were then determined by discussion, and a line was then drawn connecting those points.

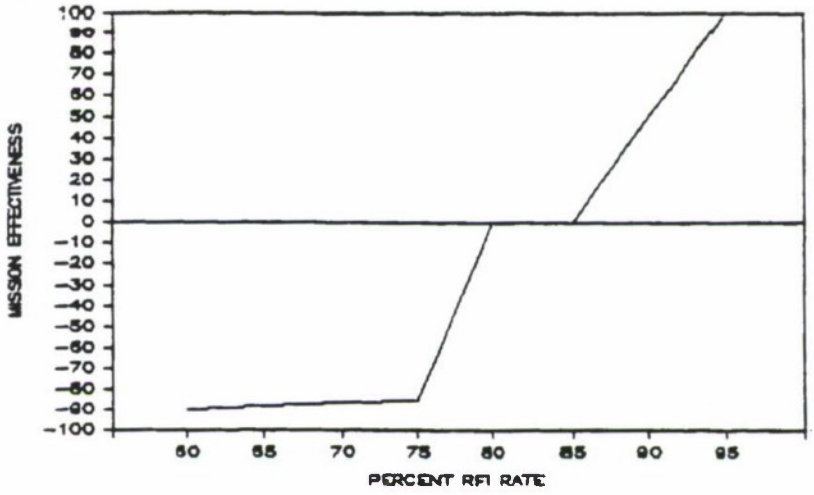


Figure 6

Mission Effectiveness Chart for the Indicator
Ready For Issue (RFI) Rate

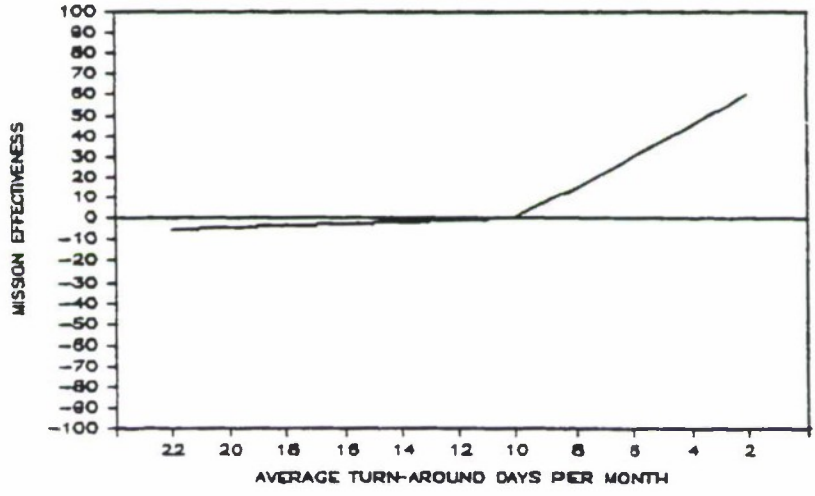


Figure 7

Mission Effectiveness Chart for the Indicator
Turn-Around Time

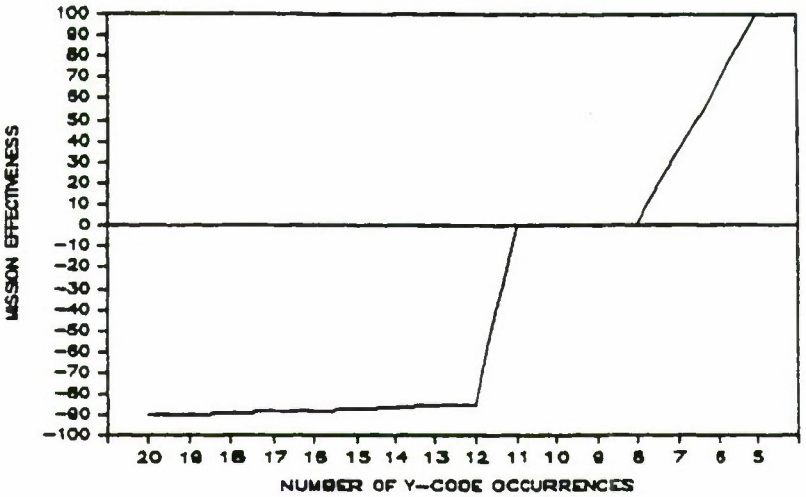


Figure 8

Mission Effectiveness Chart for the Indicator
Y-Code Rate

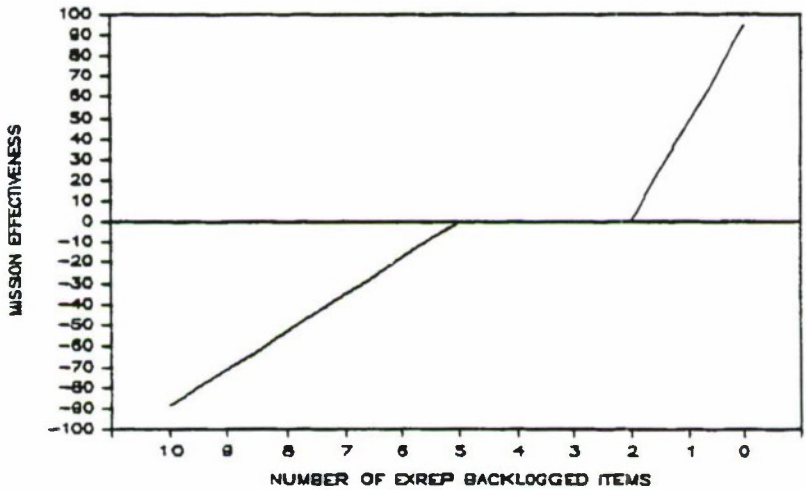


Figure 9

Mission Effectiveness Chart for the Indicator
Exrep Backlog

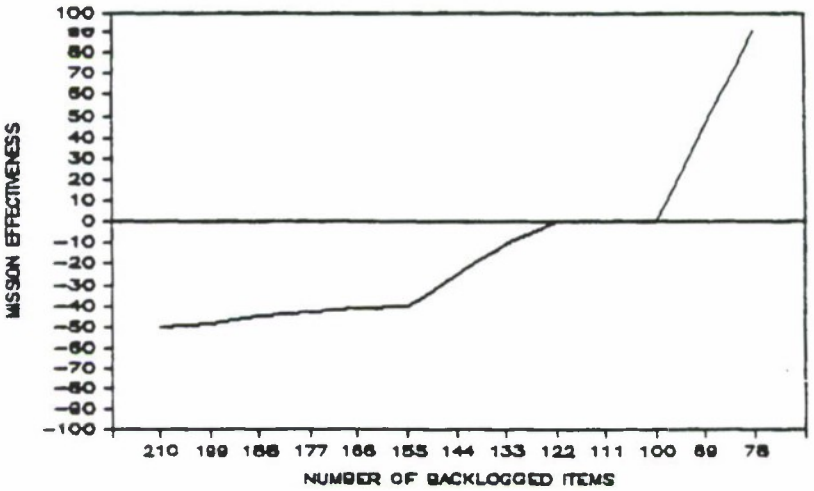


Figure 10

Mission Effectiveness Chart for the Indicator Backlog

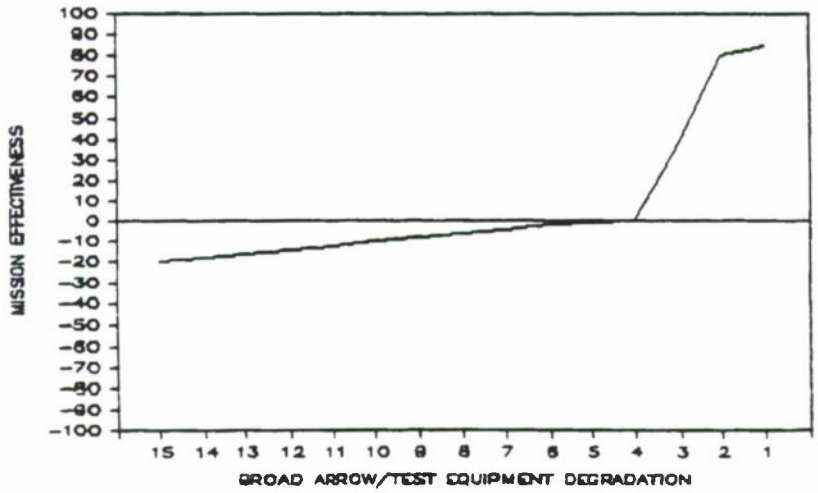


Figure 11

Mission Effectiveness Chart for the Indicator Broad Arrow / TED Reports

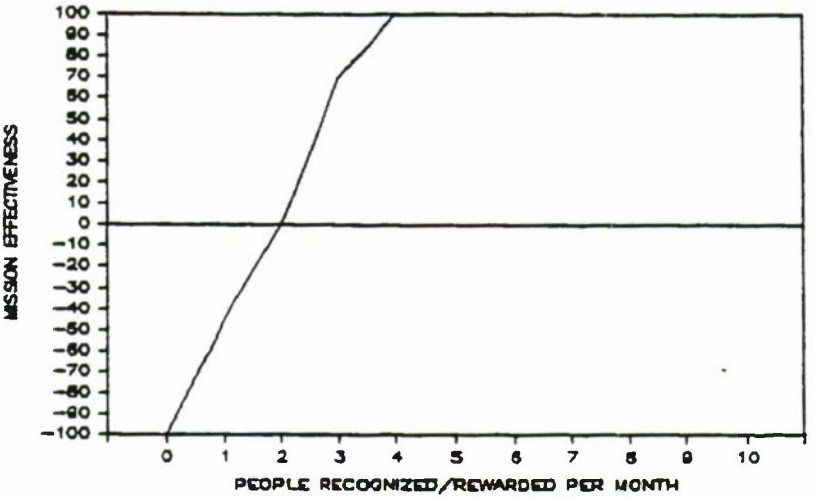


Figure 12

Mission Effectiveness Chart for the Indicator Recognition

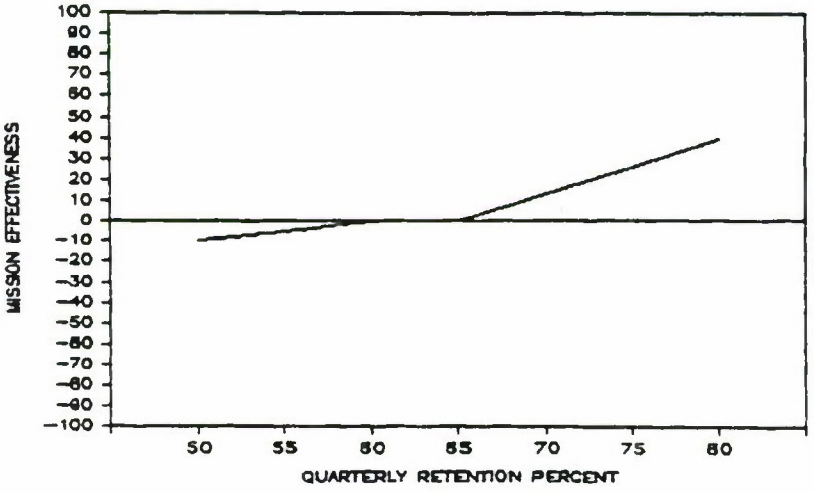


Figure 13

Mission Effectiveness Chart for the Indicator Quarterly Retention

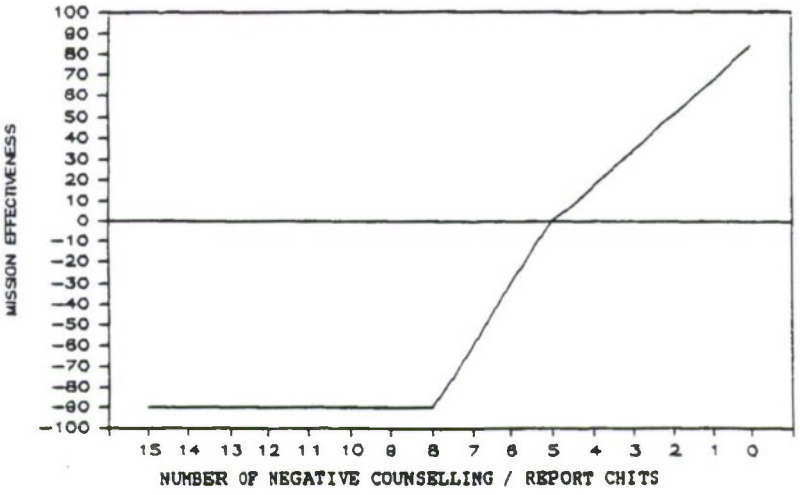


Figure 14

Mission Effectiveness Chart for the Indicator
Negative Personnel Indicators

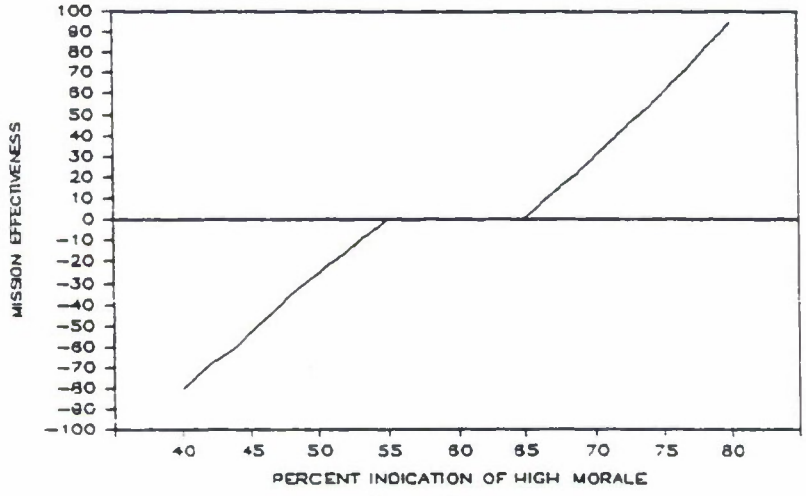


Figure 15

Mission Effectiveness Chart for the Indicator
Morale Index

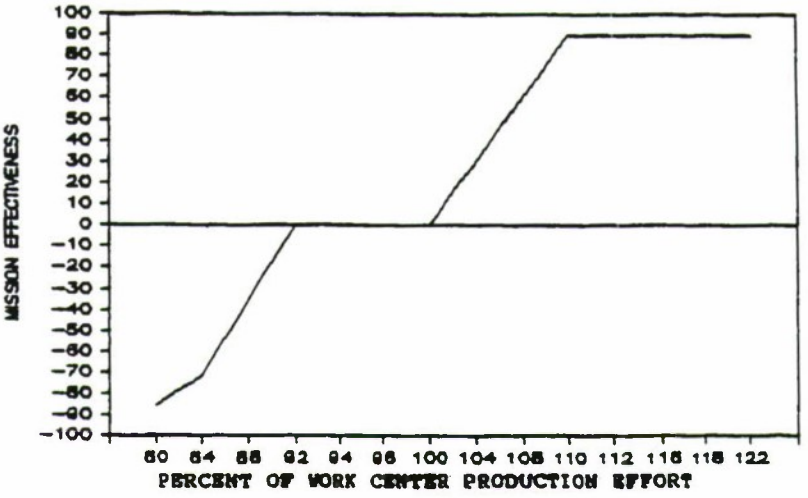


Figure 16

Mission Effectiveness Chart for the Indicator Production Effort

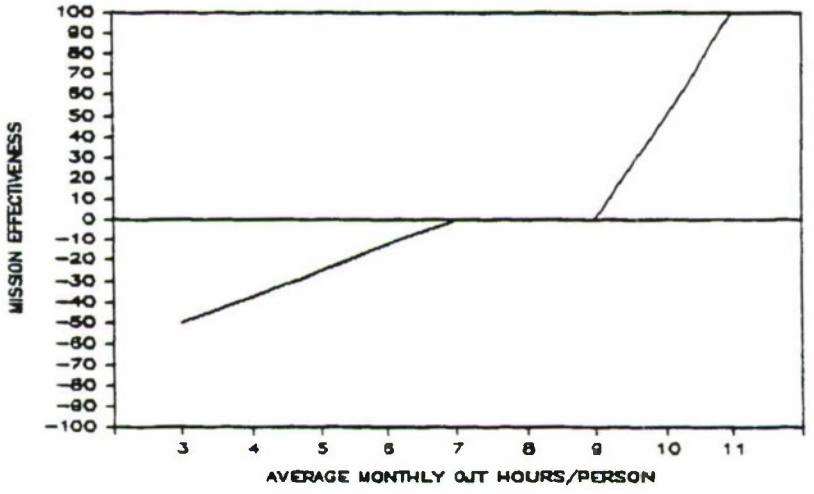


Figure 17

Mission Effectiveness Chart for the Indicator On-The-Job (OJT) Training

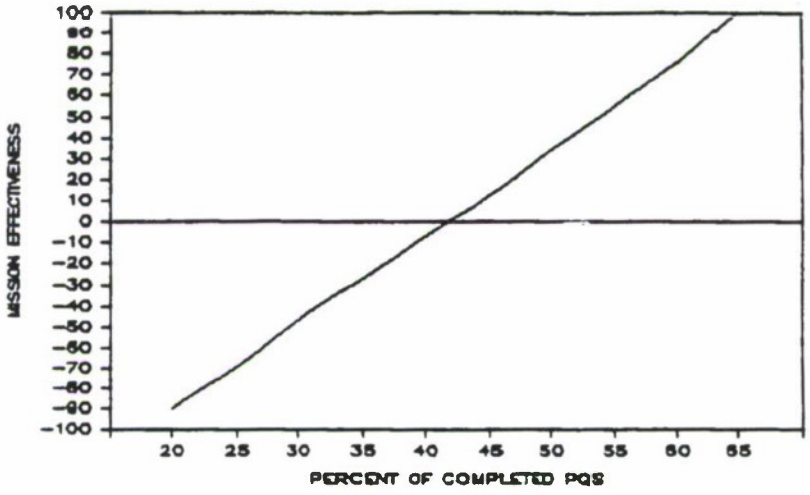


Figure 18

Mission Effectiveness Chart for the Indicator
Personnel Qualification Standards (PQS)

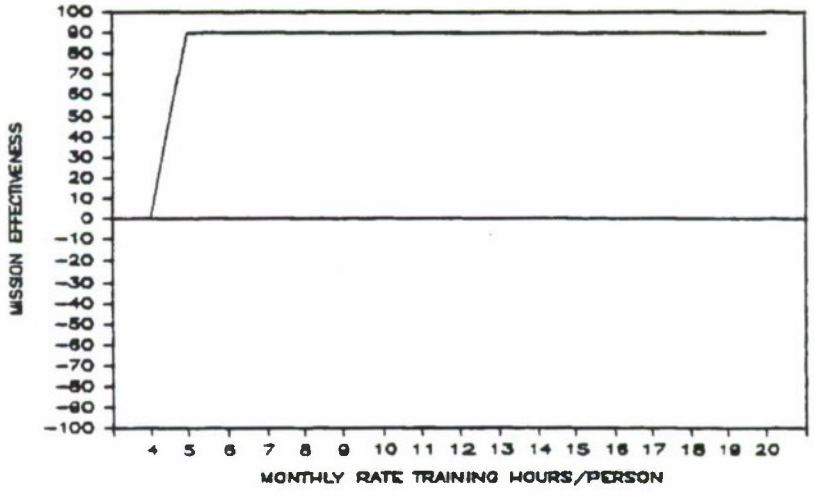


Figure 19

Mission Effectiveness Chart for the Indicator
Rate Training

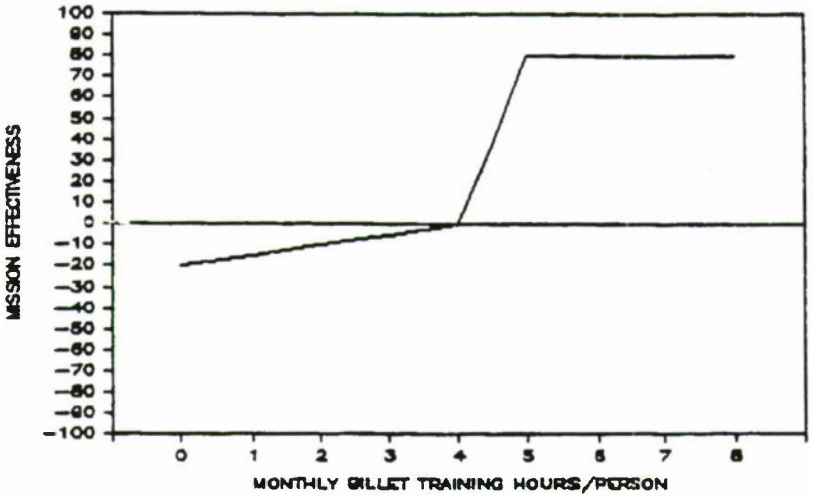


Figure 20

Mission Effectiveness Chart for the Indicator Formal Billet Training

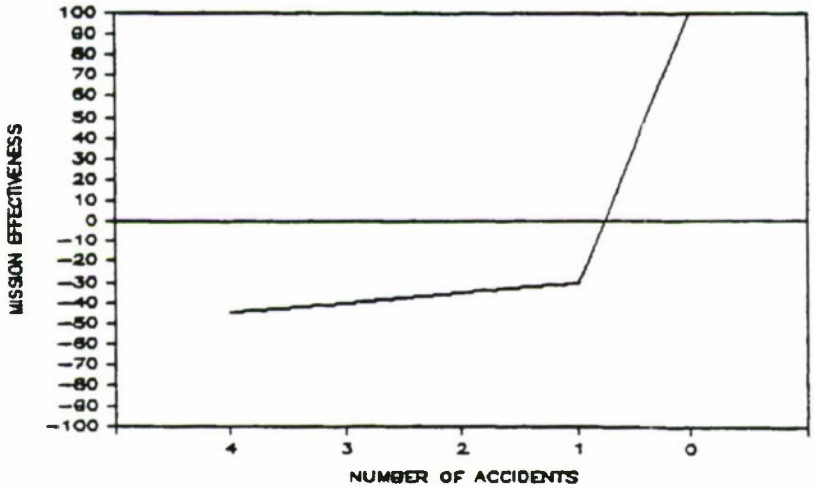


Figure 21

Mission Effectiveness Chart for the Indicator Accidents

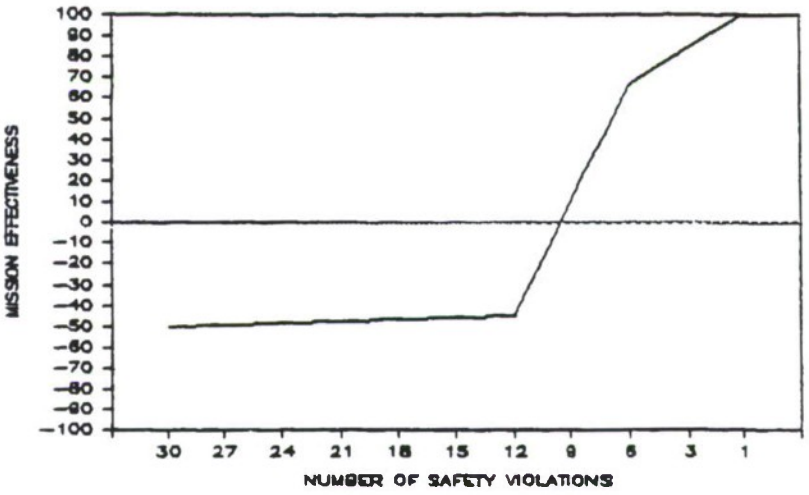


Figure 22

Mission Effectiveness Chart for the Indicator
Safety Violations

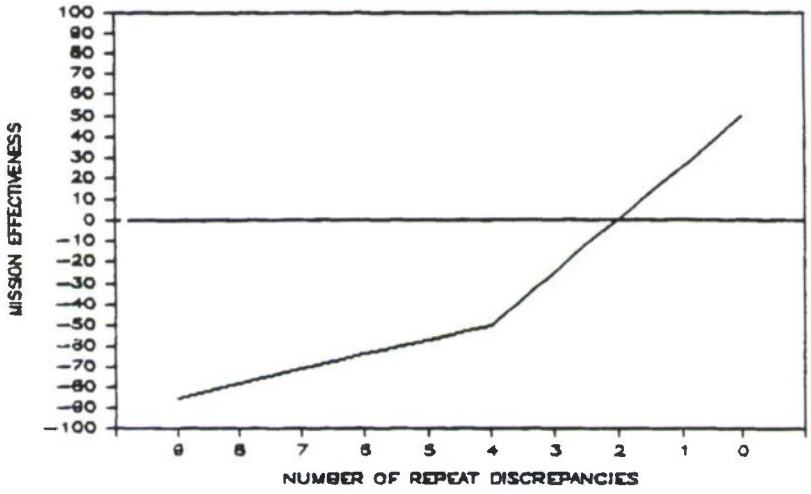


Figure 23

Mission Effectiveness Chart for the Indicator
Repeat Discrepancies

After the entire framework of the productivity measurement and enhancement system had been developed, the indicators were again considered by the MDT. During this discussion, the indicators were weighted based on their perceived importance as measures of mission effectiveness. The indicator selected by the MDT to have the highest level of importance for its contribution as a measure of productivity for the specific KRA was automatically given the value of +100, the highest possible effectiveness value. The effectiveness values were assigned in increments of five units to more easily enable the MDT to reach a consensus on a value. The MDT then rated the other indicators relative to the most important indicator. For example, if by consensus of the MDT the maximum for a given indicator was only considered half as important to the effectiveness of the unit as the most important maximum, it was given a value of +50. This procedure weighted the indicators of each KRA relative to each other as measures of effectiveness. Table 10 lists the indicators for each KRA and their respective weights.

Table 10

Relative Weights of the Various Indicators as Measures of Mission Effectiveness

KRA *	Indicator **	Weighted Score	
Customer Satisfaction	Ready For Issue rate	100	
	Y-Code rate	100	
	Exrep backlog items	95	
	Backlog	90	
	Broad Arrow/TED reports	85	
	Turn Around Time	60	
		530	Total
Motivation	Recognition	100	
	Morale Index	95	
	Production effort	90	
	Retention percentage	40	
	Negative personnel indicators	85	
		410	Total
Training	On-the-Job Training	100	
	Rate training	90	
	Formal billet training	80	
	Personnel Qualification Standards	100	
		370	Total
Safety	Accidents	100	
	Safety violations	100	
	Repeat safety discrepancies	50	
		250	Total

* Detailed descriptions of KRAs may be seen in Table 3 (Chapter 3).
** Detailed descriptions of indicators may be seen in Table 4 (Chapter 3).

Once each of the indicators was weighted, the KRAs had to be weighted in a manner similar to that used to weight the indicators, so that a single number representing overall productivity could be generated. The relative weights of each KRA were used in the formula: KRA #1 summed effectiveness score (KRA #1 weight) + KRA #2 summed effectiveness score (KRA #2 weight) + KRA #3 summed effectiveness score (KRA #3 weight) + KRA #4 summed effectiveness score (KRA #4 weight). The weights are listed in Table 11.

Table 11

Relative Weights of the KRAs as Measures of Mission Effectiveness

KRA	Maximum Score	X	Weight	=	Weighted Score
Customer Satisfaction	530	X	.40	=	212
Motivation	410	X	.20	=	82
Training	370	X	.30	=	111
Safety	250	X	.10	=	25
			Total	=	430

Once the KRAs and indicators had been identified and weighted and ME Charts had been constructed, a computer feedback program was designed that would incorporate the KRA weighting formula and print out individual graphs for each KRA and a composite graph for overall productivity. While the computer feedback program was being developed, four months of baseline data were gathered from historical files. and four months of current data were collected for both the experimental and control facilities at North Island and Lemoore, California, respectively. Those data points are presented in Tables 12 through 15.

Table 12

Naval Air Station North Island, Coronado, California
Effectiveness During the Four-Month
Baseline Period
(Experimental Facility)

Scale: Higher values indicate greater effectiveness. Any value above zero indicates performance better than level set by Measurement Development Team.

KRA *	1987 Baseline Jan	Feb	Mar	Apr
Customer Satisfaction	-189.0	- 71.0	-165.0	- 95.0
Motivation	- 73.2	- 15.2	21.8	26.8
Training	90.0	95.0	- 12.0	- 27.0
Safety	250.0	250.0	198.0	250.0
Total Effectiveness	77.8	258.8	42.8	154.8

* Detailed descriptions of KRAs can be found in Table 3 (Chapter 3).

After a baseline had been established using four months of historical data, four months of current data were collected during the Development Phase.

Table 13

Naval Air Station North Island, Coronado, California
Effectiveness During the Four-Month
Development Period
(Experimental Facility)

Scale: Higher values indicate greater effectiveness.
Any value above zero indicates performance better
than the level set by Measurement Development Team.

KRA *	1987 Development May	Jun	Jul	Aug
Customer Satisfaction	-116.0	49.0	123.0	146.0
Motivation	- 81.2	52.8	31.0	70.8
Training	90.8	- 13.3	- 49.6	- 14.0
Safety	250.0	115.0	243.0	250.0
Total Effectiveness	143.6	203.5	347.4	452.8

* Detailed descriptions of KRAs can be found in Table 3 (Chapter 3).

At the Control Facility in Lemoore, California, a baseline was also established using four months of historical data.

Table 14

Naval Air Station Lemoore, Lemoore, California
Effectiveness During the Four-Month
Baseline Period
(Control Facility)

Scale: Higher values indicate greater effectiveness.
Any value above zero indicates performance better
than the level set by Measurement Development Team.

KRA *	1987 Baseline Jan	Feb	Mar	Apr
Customer Satisfaction	135.0	31.3	19.3	103.0
Motivation	- 93.2	- 54.2	- 24.2	- 54.2
Training	61.3	289.0	370.0	289.0
Safety	- 26.0	250.0	120.0	242.5
Total Effectiveness	77.1	516.1	485.1	580.3

* Detailed descriptions of KRAs can be found in Table 3 (Chapter 3).

After a baseline had been established using four months of historical data, four months of current data were collected during the Development Phase.

Table 15

Naval Air Station Lemoore, Lemoore, California
Effectiveness During the Four-Month
Development Period
(Control Facility)

Scale: Higher values indicate greater effectiveness.
Any value above zero indicates performance better
than the level set by Measurement Development Team.

KRA *	1987 Development May	Jun	Jul	Aug
Customer Satisfaction	273.7	351.5	206.3	143.5
Motivation	- 54.2	- 54.2	- 54.2	23.8
Training	347.9	289.0	156.4	370.0
Safety	250.0	250.0	250.0	226.0
Total Effectiveness	817.4	836.3	558.5	763.3

* Detailed descriptions of KRAs can be found in Table 3 (Chapter 3).

During the Development Phase, a Morale Index survey was administered quarterly to the branch personnel by the branch supervisor at each location. The Morale Index survey is shown in Appendix G. Its variables were Job Satisfaction, Morale, Reenlistment Intentions, Role Clarity and Clarity of Objectives. These variables were scored on five-point Likert scales. The scores were added to produce a single number to be used as a Morale Index, and then the

number was entered as an indicator called Morale Index in the KRA Motivation.

Once the productivity measurement and enhancement system was constructed and a baseline of four months of historical data plus four months of development data were plotted, it was calculated that overall average productivity at Naval Air Station North Island increased 14.6 percent over baseline during the Development Phase, as shown in Figure 24.

Results During the Four-Month Feedback (Enhancement I)

During the Feedback Phase, the researcher deliberately avoided interacting with the target organization. This was for the purpose of eliminating any possible increases in organizational productivity due to the workers' knowing that they were being observed. Feedback graphs, however, were placed in high traffic areas and were seen by all work center personnel. The results of the data collection during the Feedback Phase are listed in Tables 16 and 17 for the experimental and control facilities, respectively.

Table 16

Naval Air Station North Island, Coronado, California
Effectiveness During the Four-Month
Feedback (Enhancement I)
(Experimental Facility)

Scale: Higher values indicate greater effectiveness.
Any value above zero indicates performance better than the level set by Measurement Development Team.

KRA *	1987 Feedback Sept	Oct	Nov	Dec
Customer Satisfaction	191.3	- 46.4	142.6	16.7
Motivation	-108.3	30.9	198.6	189.4
Training	- 34.9	86.5	23.2	90.5
Safety	250.0	120.0	250.0	250.0
Total Effectiveness	298.1	191.0	614.4	546.6

* Detailed descriptions of KRAs can be found in Table 3 (Chapter 3).

At the Control Facility in Lemoore, California, four months of data were recorded during the Feedback Phase.

Table 17

Naval Air Station Lemoore, Lemoore, California
Effectiveness During the Four-Month
Feedback (Enhancement I)
(Control Facility)

Scale: Higher values indicate greater effectiveness.
Any value above zero indicates performance better
than the level set by Measurement Development Team.

KRA *	1987 Sept	Feedback Oct	Nov	Dec
Customer Satisfaction	- 27.7	161.3	101.8	70.0
Motivation	-171.2	57.8	86.8	23.8
Training	370.0	370.0	370.0	370.0
Safety	244.0	120.0	238.0	250.0
Total Effectiveness	415.1	709.1	796.6	713.8

* Detailed descriptions of KRAs can be found in Table 3 (Chapter 3).

Results During the Four-Month Feedback and Goal-Setting (Enhancement II)

During the Feedback and Goal-Setting Phase, the researcher interacted with the Measurement Development Team (MDT) approximately one hour per month to set goals and discuss the previous month's performance data for each of the indicators in each KRA. Roadblocks that stood in the way of increasing mission effectiveness during the previous month and anticipated roadblocks for the coming month were

discussed. These discussions assisted the Measurement Development Team in setting more realistic goals and in overcoming or finding ways around occasional roadblocks. The data collected for the experimental facility and the control facility are presented in Tables 18 and 19, respectively.

Table 18

Naval Air Station North Island Effectiveness
During the Four-Month Feedback and
Goal-Setting (Enhancement II)
(Experimental Facility)

Scale: Higher values indicate greater effectiveness.
Any value above zero indicates performance better
than the level set by Measurement D
evelopment Team.

KRA *	1988 Feedback and Goal-Setting Jan	Feb	Mar	Apr
Customer Satisfaction	86.3	37.3	54.4	187.3
Motivation	183.7	103.4	244.4	120.4
Training	122.6	290.0	370.0	370.0
Safety	250.0	243.0	250.0	115.0
Total Effectiveness	642.6	673.7	918.8	792.7

* Detailed descriptions of KRAs can be found in Table 3 (Chapter 3).

At the Control Facility in Lemoore, California, four months of data were recorded during the Goal-Setting Phase.

Table 19

Naval Air Station Lemoore Effectiveness
During the Four-Month Feedback and
Goal-Setting (Enhancement II)
(Control Facility)

Scale: Higher values indicate greater effectiveness.
Any value above zero indicates performance better
than the level set by Measurement Development Team.

KRA *	1988 Feedback and Goal-Setting Jan	Feb	Mar	Apr
Customer Satisfaction	282.4	138.0	249.5	227.2
Motivation	69.8	86.8	69.8	- 23.2
Training	370.0	370.0	370.0	370.0
Safety	120.0	120.0	250.0	250.0
Total Effectiveness	842.2	714.8	939.3	824.0

* Detailed descriptions of KRAs can be found in Table 3 (Chapter 3).

After applying the proper weights to each KRA's summed effectiveness score, the weighted mean effectiveness scores were determined for each four-month phase of the experiment. Those weighted mean effectiveness scores are listed in Table 20.

Table 20

Weighted Mean Effectiveness Scores
for each Four-Month Phase
of the Experiment

Phase	Weighted Mean Effectiveness Score
Baseline	- 19.3
Development	46.4
Feedback	80.1
Goal-Setting	177.0

During feedback, average mission effectiveness increased 22.1 percent over baseline. In calculating percent increase in effectiveness, the ratio of the gain in effectiveness to the maximum possible gain in effectiveness was used. The gain in effectiveness is calculated by subtracting the mean baseline effectiveness (-19.3) from the mean effectiveness during the given period: the maximum possible gain in effectiveness is calculated by subtracting the mean baseline effectiveness from the maximum possible effectiveness (430). For example, since the mean effectiveness during feedback was 80.1, that was a gain of 99.4 over mean baseline

effectiveness (80.1-(-19.3)). The percent gain in effectiveness of the maximum possible gain in effectiveness is 99.4/ 449.3, or 22.1 percent. Other increases in mission effectiveness were calculated in a similar manner. This approach to calculating change is, in some ways, conservative, in the sense that the maximum possible increase in effectiveness is limited to 100 percent.

During goal-setting, average mission effectiveness increased 43.7 percent over baseline, as shown in the graph in Figure 24. The overall changes in mission effectiveness during the term of the study for the control facility at Lemoore is shown in Figure 25. An overlay showing the comparison of mission effectiveness during the 12 months of data collected in the study between the experimental and control facility is shown in Figure 26. A Trend Line comparing mission effectiveness of the experimental and control facility during the same 12-month period is shown in Figure 27.

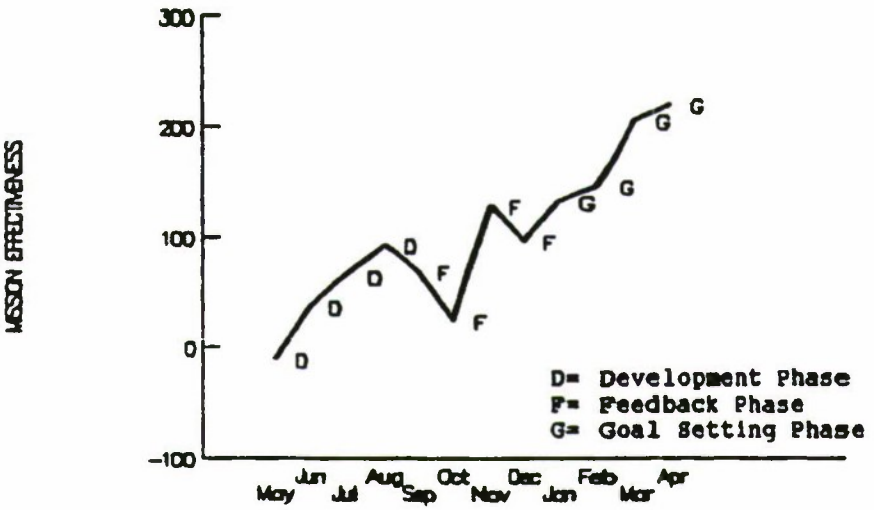


Figure 24

Total Productivity
NAS North Island

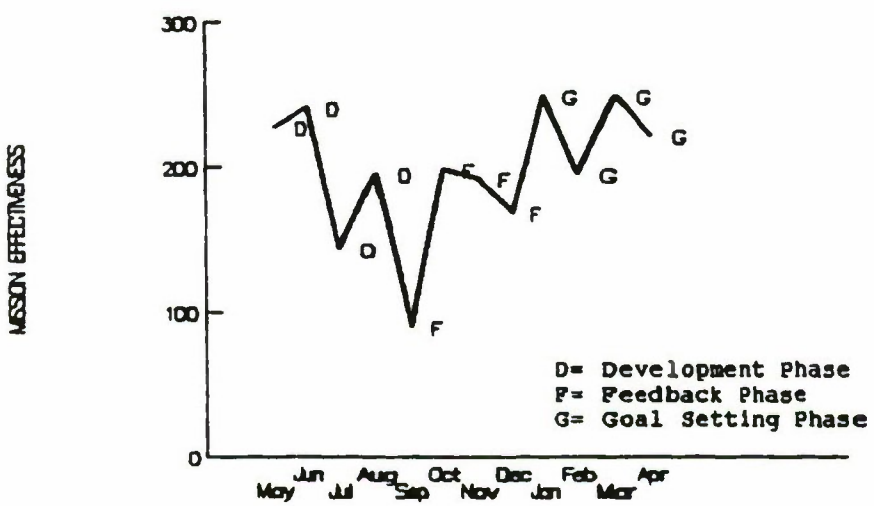


Figure 25

Total Productivity
NAS Lemoore

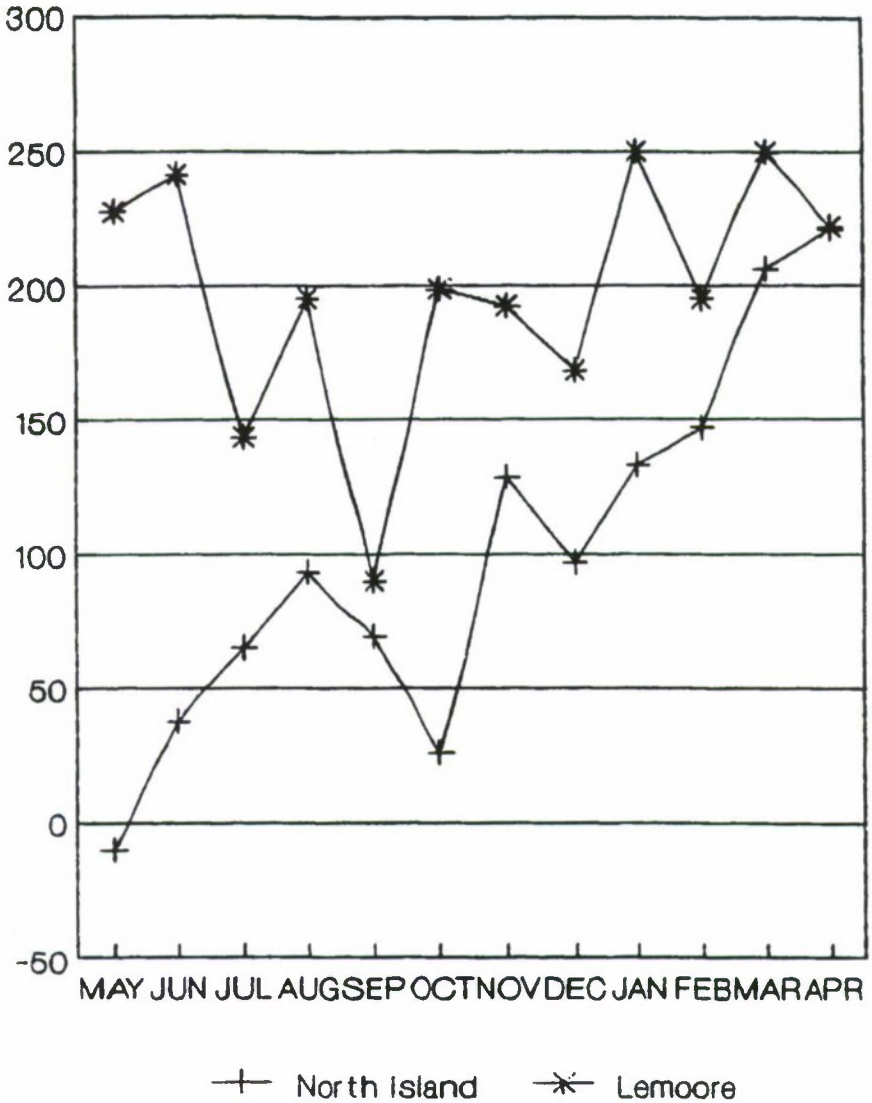


Figure 26

Twelve-Month Comparison of Mission Effectiveness of Naval Air Stations North Island and Lemoore

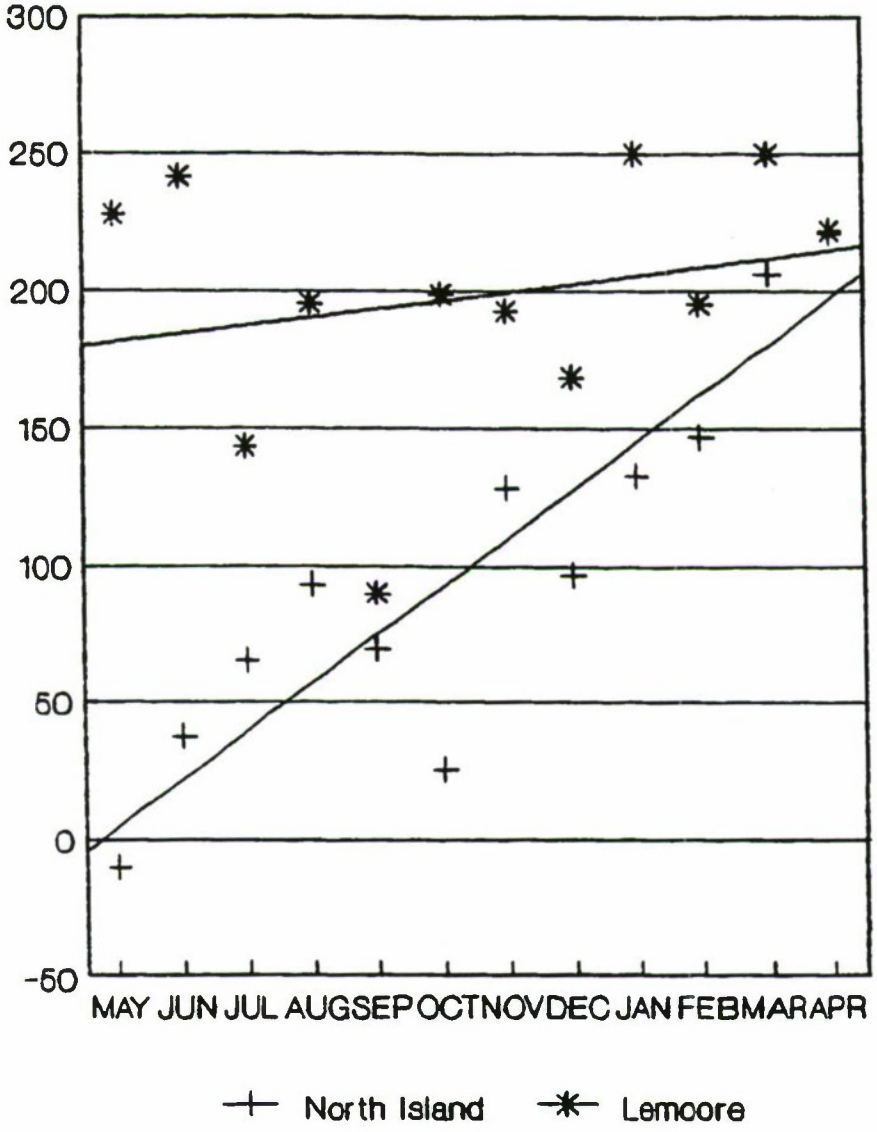


Figure 27

Twelve-Month Trend Line Comparison of Mission Effectiveness of Naval Air Stations North Island and Lemoore

Second Research Question

How did the KRAs, indicators and the subsequent changes in effectiveness obtained from this Navy study compare with those of an independently-conducted implementation in an Air Force shop with an identical organizational mission?

The KRAs and indicators from Tables 5 through 9 have been consolidated by branch of service and are presented in Tables 21 and 22 to facilitate the comparison.

Table 21

Final Key Result Areas and Indicators for this Study Done in the United States Navy

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KRA # 1. Customer Satisfaction

Y-Code rate: Percentage of repaired equipment that did not function immediately after installation.

Backlog: Number of items that were awaiting maintenance (AWM) or awaiting parts (AWP).

Exrep backlog items: Number of items that were AWM or AWP for expeditious repair.

RFI rate: Percentage of equipment brought in for repair that was actually repaired.

Turn Around Time: Average amount of time taken to repair items in the repair process.

Broad Arrow/TED reports: Number of test benches that were inoperative or in a degraded condition.

Table 21 (continued)

KRA # 2. Motivation

Recognition: Number of people formally recognized or rewarded per month.

Moral Index: Average of feedback scores on a quarterly morale survey.

Production effort: Percentage of work accomplished by work center personnel.

Negative personnel indicators: Number of negative reports received on assigned personnel.

Quarterly Retention: Percent of those eligible who reenlist or extend on active duty.

KRA # 3. Training

OJT: Average number of On-The-Job Training hours documented per month per person.

PQS: Percent of assigned Personnel Qualifications Standards that have been completed.

Rate training: Average hourly amount of training completed in Navy professional jobs.

Formal billet training: Average hourly amount of training received in specific job assignment.

KRA # 4. Safety

Accidents: Number of reported accidents at work.

Safety Violations: Number of safety violations reported at work.

Repeat Discrepancies: Number of repeat discrepancies on the Safety Audit.

The KRAs and indicators determined by the Air Force study are listed in Table 22.

Table 22

Final Key Result Areas and Indicators for the Previous Study Done in the United States Air Force

KRA # 1. Equipment Repair

Bounces: Percentage of repaired equipment that did not function immediately after installation.

Percent QA (Quality Assurance) inspections passed: Rate of QA inspections that were passed.

AWM: Number of units awaiting maintenance.

AWP: Number of units awaiting parts.

Demand Met: Percentage of equipment brought in for repair that was actually repaired.

KRA # 2. Training

STS Tasks Completed: Mean number of standard (more basic) training tasks completed for personnel in training.

Percent Qual Tasks Completed, Comm: Mean percent of advanced training tasks completed for personnel repairing communications equipment.

Percent Qual Tasks Completed, NAV: Mean percent of advanced training tasks completed for personnel repairing navigation equipment.

Scheduled Training Tasks Overdue: Total number non-technical (e.g., military) training requirements not met on time for all shop personnel.

Table 22 (continued)

KRA # 3. Other Duties

Mobility Equipment: Number of pieces of equipment used for mobility exercises that were not calibrated by the shop on schedule.

PMEL Overdue: Number of pieces of shop calibration and test equipment that were not calibrated by the shop on schedule.

Percent 349 Errors: Percent of errors on a major manpower documentation form.

Missed Appointments: Number of formal on-base appointments missed.

The percent increases in mission effectiveness for the Air Force base during the feedback and feedback with goal-setting periods of the study are compared with those obtained from the Navy study in Table 23. The main observation is that effectiveness increased in both organizations during feedback and further increased in both organizations during feedback with goal-setting. The differences between the increases in the two organizations may be explained, at least in small part, by the fact that the Air Force facility figures are based on a five-month feedback and a five-month goal-setting period, while the Navy facility figures are based on a four-month feedback and a four-month goal-setting period. More

Importantly, the Navy facility underwent a major command inspection during the second month of the Feedback Phase. During that month, overall effectiveness decreased to below average Development Phase effectiveness.

Table 23

Mission Effectiveness Increases of Navy and Air Force Facilities During MGEEM

Military Branch of Service	Percent Increases During Feedback	Percent Increases Feedback & Goal-Setting
Navy	22.1%	43.7%
Air Force	30.0%	65.0%

Summary

This chapter presented the findings of the study. The results of analyses conducted to answer the research questions were presented in individual and composite formats to aid in visual analysis. The first section of the chapter listed the changes in effectiveness of two Communication and Navigation Equipment Repair Branches of shore-based Naval Aircraft Intermediate Maintenance Departments (AIMDs) that were

documented during and after the use of the Methodology for Generating Efficiency and Effectiveness Measures (MGEEM). The second section of the chapter reported findings pertaining to Key Result Areas, Indicators and subsequent changes in mission effectiveness obtained in the Navy study and compared them with the results from an independently-conducted implementation in a shop with the same organizational mission in the Air Force.

Chapter 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The information included in this chapter summarizes the findings that resulted from the implementation of the research design specified for the study. Also included are conclusions drawn from data gathered during the study. The chapter concludes with recommendations for further research related to the study.

Summary

The following paragraphs discuss the research problem, delineate the research population and specify the theoretical framework of the study. The background leading up to the study and the method of analysis employed in the study are also outlined.

The Research Problem

Studies of methods to increase mission effectiveness emphasize either feedback and goal-setting or using worker participation in designing measurement criteria. The improvements resulting from combining these two approaches, when applied in the military services of the United States, have been supported and

demonstrated in studies and reports by the Air Force Human Resources Laboratory (AFHRL) (Pritchard, Jones and Roth 1987; Tuttle and Weaver 1986a; 1986b).

Because of the Navy's traditional use of strict chain-of-command and strict junior-senior relationships, worker participation in management decisions has historically received little attention. In the modern environment of decreasing resources, increasing costs and increasing complexity of weapons systems, a reconsideration of command relationships and conditions required investigation if productivity targets established by Executive Order 12552 were to be realized by 1992.

This study examined the use of a participative management approach to measure and enhance mission effectiveness in a Navy facility called the Methodology for Generating Efficiency and Effectiveness Measures (MGEEM). The MGEEM approach to measuring and enhancing productivity was field-tested in numerous Air Force settings (Pritchard, Jones and Roth 1987; Tuttle and Weaver 1986a; 1986b) and was found to increase mission effectiveness, to be well-liked by workers, and to be a cost-effective method for measuring and enhancing productivity. The changes in mission effectiveness of

two Navy facilities, one an experimental facility and one a control facility, were monitored during and after implementation of the MGEEM in the experimental facility. Additionally, the Key Result Areas (KRAs) and indicators generated in the Development Phase of the MGEEM and the subsequent changes in mission effectiveness observed in this Navy study were compared with those from a similiar implementation conducted earlier by the AFHRL in an Air Force Communication and Navigation Equipment Repair Shop with an identical organizational mission.

Two major objectives were specified for this study. The first was to document the changes in mission effectiveness of the Communication and Navigation Equipment Repair Branch of a shore-based Naval Aircraft Intermediate Maintenance Department (AIMD) during and after implementation of the MGEEM. The second objective was to determine the inter-service transportability of the MGEEM by observing how closely the KRAs, indicators and subsequent changes in mission effectiveness obtained in this Navy study compared with those that resulted from an independently-conducteo implementation in a similiar organization in the Air

Force. In view of these objectives, the study was designed to answer the following questions:

1. What changes in effectiveness of the Communication and Navigation Equipment Repair Branch of a shore-based Naval Aircraft Intermediate Maintenance Department (AIMD) were observed during and after implementing the Methodology for Generating Efficiency and Effectivenes Measures (MGEEM)?

2. How closely did the Key Result Areas (KRAs), indicators and subsequent changes in effectiveness obtained from this Navy study compare with those of an independently-conducted implementation in an Air Force shop with an identical organizational mission?

Delineation

This study focused on a system designed to measure and enhance mission effectiveness and investigated the transportability of that system. Only shore-based Naval AIMDs were studied while attempting to enhance mission effectiveness in the Navy; however, the results of an Air Force productivity enhancement effort in a shop with an identical organizational mission were used to investigate the transportability of the system. It was proposed in this study that changes in mission

effectiveness occur when interventions of feedback and goal-setting are used in conjunction with a worker-generated measurement system. It was also proposed that inter-service transportability of the system might be feasible. The system under study for measuring and enhancing productivity emphasized the initial use of worker and supervisor participation in generating the initial measurement system itself. Subsequent interventions of feedback and goal-setting were then applied to investigate their effects on overall mission effectiveness. The system requires participative management during construction of measurement parameters, and it then emphasizes the use of feedback alone as an intervention and still later emphasizes the use of both feedback and goal-setting to increase mission effectiveness.

Theoretical Framework

The theoretical framework of this study was drawn from the Air Force Human Resources Laboratory (AFHRL) reports on the use of the Methodology for Generating Efficiency and Effectiveness Measures (MGEEM) by Pritchard, Jones and Roth (1987) and Tuttle and Weaver (1986a; 1986b). Integration of the results of the two reports supports the use of active participation of

workers and supervisors when designing a productivity measurement and enhancement system. Interventions of feedback alone and then goal-setting coupled with feedback were investigated to determine their influence on increasing mission effectiveness.

Background

Productivity was among the most important issues facing the nation: however, this area had not been adequately addressed in the United States Navy. Since the AFHRL had conducted several studies and produced numerous reports on productivity measurement and enhancement projects in the Air Force, it followed that the methods that were successful for the Air Force should be examined in the Navy.

The Communication and Navigation Equipment Repair Branches of Naval AIMDs were used for this Navy study since they have the same operational mission as an Air Force Communication and Navigation Equipment Repair Shop that recently was used to field test the MGEEM methodology. By examining the resultant KRAs, indicators and the corresponding changes in mission effectiveness in this Navy study, the inter-service transportability of the system could be tested simultaneously.

In view of the need for the development of an accurate method for measuring and enhancing productivity in a Navy setting and considering that no published study had yet focused on measuring and enhancing productivity in a Naval AIMD, this study filled a need.

Method

The sample for this study was composed of the Communication and Navigation Equipment Repair Branches of two major West Coast Naval AIMDs. Additionally, the AFHRL report concerning the use of the MGEEM at the Communication and Navigation Equipment Repair Shop at an Air Force base located in the southwestern United States was used to compare results of the Navy study for determining the inter-service transportability of the MGEEM system.

This sample represented two of the seven major West Coast Naval AIMDs, which serve numerous squadrons that have various types of aircraft and avionics equipment. The Communication and Navigation Equipment Repair Branch of the Navy AIMD at Naval Air Station North Island, Coronado, California was chosen to implement the MGEEM methodology, while the Communication and Navigation Equipment Repair Shop at

Naval Air Station Lemoore, Lemoore, California was used as the control group.

This study used a descriptive-correlational approach. The approach was considered appropriate because a descriptive procedure was needed to describe the effects of feedback alone and then goal-setting coupled with feedback on productivity. For investigating relationships between this Navy study and the Air Force study, correlational procedures were required to determine if there were similarities between the KRAs, indicators and resultant changes in mission effectiveness in this Navy study and a previously-conducted implementation completed by the AFHRL in an Air Force shop with an identical organizational mission. The comparison would help in determining the feasibility of the inter-service transportability of the MGEEM.

Conclusions

Two research questions were formulated for the purpose of the study. The major findings related to these two questions are summarized in the succeeding section.

Research Question One

What changes in effectiveness of the Communication and Navigation Equipment Repair Branch of a shore-based Naval AIMD were observed during and after implementing the MGEEM?

One of the effects of the development of the MGEEM system was that it produced an opportunity for the organization to carefully examine its objectives, possible measures of those objectives, and obtain a true feeling of the productivity expectations of management. This process led supervisors to examine present procedures and discover numerous places where improvements could be made in the overall operation of the organization during the Development Phase of the productivity measurement and enhancement system. Naturally enough, the supervisors began to implement these changes. but this created a dilemma for the researcher. While it was clearly worthwhile for the organization to improve its effectiveness during the development of the measurement system, this improvement occurred prior to the intervention of the first enhancement of feedback. If, because of this, the Development Phase showed a higher effectiveness than it otherwise would have, this

would tend to decrease the size of any effect due to the feedback and goal-setting interventions.

There was little that the researcher could do about this dilemma. The supervisors of the organization felt strongly that such changes should be made, and they made them. The supervisors also felt that these changes were increasing their effectiveness, and this indeed seemed to be the case, since mission effectiveness increased 14.6 percent over baseline during the Development Phase of MGEEM. In interviews with the supervisors, it was ascertained that a substantial portion of this improvement was due to the process that the work center personnel went through while developing the productivity measurement system. This suggests that the improvements in productivity that were evidenced in the later interventions were, in fact, underestimates of the overall impact of the enhancements of feedback and goal-setting on overall mission effectiveness.

Once the MGEEM was developed and a baseline of four months of historical data were plotted, the results indicated that productivity increased 22.1 percent over baseline when feedback alone was used during the Feedback Phase, as indicated in Figure 24.

As the figure indicates, overall effectiveness continued to increase substantially over baseline. During the Feedback and Goal-Setting Phase, average productivity increased 43.7 percent over baseline. These percent increases are percent gain in effectiveness over baseline compared with the maximum possible gain.

A 12-month trend line shown in Figure 27 (Chapter 3) compares the changes in mission effectiveness at the experimental facility at Naval Air Station North Island, Coronado, California with those of the control facility at Naval Air Station Lemoore, Lemoore, California. From the trend lines it can be observed that the overall increase in mission effectiveness at the experimental facility was clearly greater than changes that were occurring without the planned intervention of both feedback and feedback with goal-setting activities in a similar organization.

Research Question Two

How closely did the KRAs, indicators and subsequent changes in effectiveness obtained from this Navy study compare with those of an independently-conducted implementation in an Air Force shop with an identical organizational mission?

The number of KRAs in this Navy study was four: the Air Force only used three. Since "Safety" was considered the least important KRA in the Navy study, and since a parallelism must be established with the Air Force study to facilitate making a comparison, the KRA "Safety" (with its corresponding indicators) was eliminated from the analysis. The remaining KRAs are compared in Table 24, and it can be observed that two of the three KRA areas coincide. The Navy KRA "Motivation" did not appear in the Air Force report as a KRA since the Air Force did not consider "Motivation" to be one of its KRAs. The Navy KRA "Customer Satisfaction" included most of the indicators used in the combined Air Force KRAs "Equipment Repair" and "Other Duties," and the Navy and Air Force KRA "Training" included highly similiar indicators.

Table 24

Comparison of Key Result Areas in
The Navy and Air Force Study

NAVY	AIR FORCE
Customer Satisfaction	Equipment Repair
Customer Satisfaction	Other Duties
Training	Training
Motivation	[Air Force did not choose as a KRA]

The indicators for the the Navy KRA "Customer Satisfaction" are compared to the parallel indicators for the Air Force KRAs "Equipment Repair" and "Other Duties" in Table 25. It can be observed that five of the six Navy indicators have equivalent Air Force indicators for the KRAs under inspection.

Table 25

Comparison of Customer Satisfaction Indicators
for Navy and Air Force KRAs
(from Table 24)

NAVY KRA Customer Satisfaction	AIR FORCE KRA Equipment Repair and Other Duties
Y-Code Rate (Repaired equipment that did not function after installation)	Bounces (Repaired items that did not function after installation)
Backlog (Number of items that were Awaiting Maintenance (AWM) or Awaiting Parts (AWP) for repair)	AWM (Number of items Awaiting Maintenance) AWP (Number of items that were Awaiting Parts)
Exrep Backlog (Number of items that were Awaiting Maintenance (AWM) or Awaiting Parts (AWP) for expeditious repair)	AWM (Number of items Awaiting Maintenance) AWP (Number of items that were Awaiting Parts)
Ready for Issue Rate (Equipment brought in for repair that was actually repaired)	Demand Met (Equipment brought in for repair that was actually repaired)
Broad Arrow/Test Equipment Degradation Reports (Number of test benches operating in a degraded condition or inoperable)	PMEL Overdue (Shop calibration and test equipment working in a degraded condition due to lack of calibration)
Broad Arrow/Test Equipment Degradation Reports (Number of test benches operating in a degraded condition or inoperable)	Mobility Equipment (Pieces of equipment used for mobility exercises in a degraded condition due to lack of calibration)

Table 25 (continued)

NAVY KRA Customer Satisfaction	AIR FORCE KRAs Equipment Repair and Other Duties
Turn Around Time (Average time taken to repair items in the repair process)	[Air Force did not choose as an indicator]
[Navy did not choose as an indicator]	Percent Quality Assurance Inspections Passed (Rate of QA inspections passed)
[Navy did not choose as an indicator]	Percent 349 Errors (Rate of errors on a major manpower documentation form)
[Navy did not choose as an indicator]	Missed Appointments (Number of formal on-base appointments missed)

The indicators for the Navy and Air Force KRA "Training" are compared in Table 26. It can be observed that all four of the Navy indicators coincide with the Air Force indicators for the KRA "Training." However, the Air Force had an additional indicator (Scheduled training tasks overdue) that the Navy did not use.

Table 26

Comparision of Training Indicators
for Navy and Air Force KRAs
(from Table 24)

NAVY KRA Training	AIR FORCE KRA Training
On-the-Job-Training (Basic training hours documented)	STS Tasks Completed (Basic training tasks completed)
Rate Training (Basic Navy Job training completed)	STS Tasks Completed (Basic training tasks completed)
Personnel Qualification Standards (Advanced job specific tasks completed)	Percent Qual Tasks Complete Comm & Nav (Advanced training completed)
Formal Billet Training (Job specific training received in a formal school)	Percent Qual Tasks Complete Comm & Nav (Advanced training completed)
[Navy did not choose as an indicator]	Scheduled Training Tasks Overdue (Number of non-technical training tasks not met on time)

To answer the third part of Research Question Two, namely, the comparison of the changes in productivity of the Navy and Air Force facilities, the productivity increases previously documented in Research Question One of this Navy Study and the productivity increases previously documented in the Air Force Study are listed in Table 27. It can be observed that productivity increased significantly during both the feedback and the goal-setting period after implementation of the MGEEM.

Table 27

Increase in Mission Effectiveness of Navy and Air Force Facilities During MGEEM (Results from Research Question One and the Air Force Study)

Branch of Service	Mission Effectiveness Increase: During Feedback	Feedback & Goal-Setting
Navy	22.1%	43.7%
Air Force	30 %	65 %

The increases in mission effectiveness recorded in Table 27 present strong evidence to substantiate the viability of using the MGEEM system to increase productivity in the Navy. When comparing this Navy study with the Air Force study, significant similarities in KRAs and indicators were observed; however, from the dissimilarities observed, it is apparent that each local organization has to tailor the set of KRAs and indicators to its own needs prior to using them to gauge mission effectiveness. The transportability of the MGEEM process therefore is accepted, and the transportability of most of the KRAs and their indicators is also evident, although parallelism in all details has not been established. Further study might find that some differences are inevitable, or that greater parallelism should be sought.

Discussion of the Findings

This section is a discussion of the results of the analyses conducted to answer the research questions.

1. Discussion of Findings of Research Question One.

It was found that there was a significant increase in overall mission effectiveness at the Navy facility that incorporated the MGEEM, as indicated in Figures 24, 27, and 28 (Chapter 3). A part of the increase was believed to be due to either the Hawthorne Effect (which states that workers tend to do better when they know they are being observed) or the documented fact that work center personnel obtained true feelings of the productivity expectations of management during the Development Phase and made changes to achieve them before enhancements were used. This was apparent, since average mission effectiveness increased 14.6 percent over baseline during the Development Phase of MGEEM.

During the Feedback Phase there were two events that occurred that may have served to decrease overall mission effectiveness. A major command inspection was held in the month of October, and extensive prep-

arations for the inspections are standard operating procedure in the Navy; consequently, the decreases in mission effectiveness for both September and October could be expected. The amount of preparation and volume of non-productive work that must be completed to prepare for a major command inspection would logically detract from the productivity of the organization in the month of the inspection as well as the prior month. The other such event during feedback, which coincided with a decrease in effectiveness, was the holiday vacation period in December. Historically, military organizations allow up to 50 percent of their personnel to go on leave during that period. Productivity naturally would decrease when a large part of the work force is not available for production.

The trend lines shown in Figure 27 (Chapter 3) and the composite charts showing mission effectiveness for the experimental and control facilities in Figure 26 show clearly that a far greater increase in overall productivity occurred in the Experimental Facility, which used the MGEEM methodology. Although generalizations from a single experiment of this type are not conclusive, there is strong evidence to indicate that use of the productivity measurement and enhancement

technology that is incorporated in the MGEEM was responsible for a significant increase in overall mission effectiveness of the Communication and Navigation Equipment Repair Branch of the Naval AIMD.

2. Discussion of Findings of Research Question Two.

It was found that the Navy used four KRAs, while the Air Force only used three KRAs; therefore, before a comparison was made, the least important Navy KRA and its respective indicators were not considered when a comparison between the studies was made. Those KRAs are listed in Table 28.

Table 28

Key Result Areas used in The Navy and Air Force Study

Navy	Air Force
Customer Satisfaction	Equipment Repair
Training	Training
Motivation	Other Duties
Safety	--------

Of the 13 indicators identified in the Air Force study, 9 indicators from the Navy study were found to coincide with them, as shown in Table 29. Since 66.6 percent of the KRAs and 69.2 percent of the indicators were equivalent for both service organizations, this indicates that there would be a significant opportunity to provide a basic framework of the MGEEM-produced KRAs and indicators. These basic KRAs and indicators could be modified locally by the organizations applying them, thus permitting the organizations to allow for regional policy and operational mission differences.

Table 29

Comparisons of All Indicators from the Navy and Air Force Studies

Navy	Air Force
Y-Code Rate (Repaired equipment that did not function after installation)	Bounces (Repaired equipment that did not work after installation)
Backlog (Number of items Awaiting Maintenance (AWM) or Awaiting Parts (AWP) for repair)	AWM (Number of items Awaiting Maintenance) AWP (Number of items Awaiting Parts)
Exrep Backlog (Number of items Awaiting Maintenance (AWM) or Awaiting Parts (AWP) for expeditious repair)	AWM (Number of items Awaiting Maintenance) AWP (Number of items that were Awaiting Parts)

Table 29 (continued)

NAVY	AIR FORCE
Ready for Issue Rate (Equipment brought in for repair that was fixed)	Demand Met (Equipment brought in for repair that was actually fixed)
Broad Arrow/Test Equipment Degradation Reports (Number of test benches operating in a degraded condition or inoperable)	PMEL Overdue (Shop calibration and test equipment working in a degraded condition due to lack of calibration)
Broad Arrow/Test Equipment Degradation Reports (Number of test benches operating in a degraded condition or inoperable)	Mobility Equipment (Pieces of equipment used for mobility exercises in a degraded condition due to lack of calibration)
On-the-Job Training (Basic training hours documented)	STS Tasks Completed (Basic training tasks completed)
Rate Training (Basic Navy job training completed)	STS Tasks Completed (Basic training tasks completed)
Personnel Qualification Standards (Advanced job specific tasks completed)	Percent Qual Tasks Complete Comm & Nav (Advanced training completed)
Formal Billet Training (Job specific training received in a formal school)	Percent Qual Tasks Complete Comm & Nav (Advanced training complete)
Turn Around Time (Average time taken to repair items in the repair process)	[Air Force did not choose a an indicator]

Table 29 (continued)

NAVY	AIR FORCE
[Navy did not choose as an indicator]	Percent Quality Assurance Inspections Passed (Rate of QA inspections that were passed)
[Navy did not choose as an indicator]	Percent 349 Errors (Rate of errors on a major manpower documentation form)
[Navy did not choose as an indicator]	Missed Appointments (Number of formal on-base appointments missed)
[Navy did not choose as an indicator]	Scheduled Training Tasks Overdue (Number of non-technical training tasks not met on time)

The increases in organizational effectiveness in both the Navy and Air Force studies provide strong evidence of a significant increase in productivity associated with use of the MGEEM in both the Navy and the Air Force.

Implications and Recommendations

A number of implications and recommendations can be drawn from this study. Several relate to the first research question concerning the viability of the MGEEM. The remainder relate to the second research question concerning the inter-service transportability of the MGEEM.

Implications

The results of this Navy study affirm numerous earlier studies concerning the beneficial effects of feedback and goal-setting on organizational productivity. The study also reaffirms that participation of the workers in designing a productivity measurement system motivates the work force, since it engenders a sense of ownership in the measurement system.

In addition to significantly increasing productivity, the MGEEM was found to be highly acceptable to both management and workers. Because no additional money, materials, facilities, and only a token amount of manpower to build and monitor the system were required to realize a significant increase in productivity, the MGEEM proved to be extremely cost effective. The MGEEM also proved to be relatively easy to

understand and implement. It additionally satisfied the common need among commanders for a method to (1) comprehensively measure organizational productivity and (2) facilitate the manager's job, since Mission Effectiveness Charts allow managers to see monthly where extra emphasis should be placed to increase productivity.

The inter-service transportability of the basic MGEEM system was also supported. However, it was clear that local adjustments to a basic MGEEM framework need to be made to custom-fit it to each new activity.

A number of questions were raised as a result of this study. Would the MGEEM technology be appropriate in a wartime environment? To state this question differently, participative management with feedback and goal-setting serves to increase productivity in a peacetime environment, but would it be equally applicable in the life and death situations of a wartime environment? Would the strict requirement for chain-of-command and junior-senior relationships have priority over participative management? How would participative management work in other Navy settings? How would participative management work in other military services?

Recommendations

The results of this study suggest that the Department of Defense should sponsor a full-scale test of the impact of using this measurement and enhancement technology in other organizational settings, and should test the transportability of the MGEEM for use in service components not included in this study. Subsequent tests of the MGEEM should consider enhancements other than feedback and goal-setting to determine whether the participative management techniques alone provide increases in mission effectiveness. Possibly, participative management techniques, when combined with team building (Quality Circles, Juran Teams, etc.) and other enhancements, would provide comparable increases in mission effectiveness.

Further research should be conducted to determine whether a relationship exists between MGEEM and the so-called Deming way (Deming, 1982; 1986). Can MGEEM be the implementation technique used as the vehicle to incorporate Deming's "Fourteen Points" in an organization? How could this be implemented? For example, do the measurement system construction techniques or the feedback sessions used in the MGEEM give workers a chance to participate in two-way communication with

supervisors to a great enough extent to "Drive Out Fear"? Does focusing on mission, KRAs, and indicators achieve a measurable outcome consistent with Deming's "Constancy of Purpose"? What are other ways that the MGEEM could incorporate Deming's philosophy and ideas in a productivity enhancement setting?

Suggestions For Further Research

The findings of this study confirmed the existence of an increase of productivity when participative management is used in coordination with feedback and goal-setting. It also suggested the viability of intra-service transportability of the basic MGEEM.

The areas in which further study would be appropriate include:

1. Determining whether enhancements other than feedback and goal-setting would produce similiar or better results.

2. Researching the possible use of the MGEEM technology to incorporate Deming's "Fourteen Points" in an organization.

3. Testing on a larger scale the inter-service transportability of the MGEEM process.

4. Finding the quickest and most effective way to train facilitators and to reach a consensus in group situations.

5. Investigating the best types of automation to use for processing feedback reports.

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APPENDICES

APPENDIX A

STRUCTURED INTERVIEW

APPENDIX A: STRUCTURED INTERVIEW

Format for Interview with the AIMD Officer

NOTE TO INTERVIEWER

Following introductions and preliminary discussion to establish rapport, the following questions may be used to gather information. These are simply opening questions and should be followed by "probes" to obtain more detail. Examples of probes are: "Tell me more about that." "Could you elaborate?" "Could you give me a specific example?"

The purpose of the interview is to make possible the construction of a systems diagram of the organization. It is helpful to visualize this diagram as the interview is conducted.

---

1. What is the mission of this AIMD?

2. What are the major products/services of the AIMD?

3. Who are the principal customers of the organization?

4. What about staffing levels? How many military and civilian personnel are authorized? Assigned? What is the breakdown by pay grade and experience?

5. What other organizations does this unit depend upon for information or support to get the job done?

6. What degree of control do you, as AIMD Officer, have over:
   Number of personnel hours expended?
   Material and equipment acquistion?
   Capital investment?
   Energy consumption?

7. How is this AIMD evaluated by higher authority?

8. What primary indicators do you use to tell you that the AIMD is doing what it is supposed to do?

9. Do you have a standard briefing for visitors? If so, could I have a copy of your briefing and slides? What other written material would help me better understand your mission and organizational structure?

10. What else should I know?

APPENDIX B

IN-HOUSE DOCUMENTATION

APPENDIX B: IN-HOUSE DOCUMENTATION

Examples of Information Reviewed by Facilitator

---

1. Manning Documents/Manpower Studies

   A. Percent authorized manpower onboard
   B. Number of people possessing required specialty training
   C. Experience level of personnel onboard (pay grade)

2. Organizational Charts

   A. Department Organization Chart
   B. Division Organization Chart
   C. Work Center Organization Chart

3. Division Briefing Package

4. Monthly Maintenance Plans for Three Months

5. Work Center Task Description

6. Diagram Showing Flow of Components Through the Repair Cycle.

7. List of Number of Squadrons/Type Aircraft Supported

8. Instructions and Notices that govern the work of the Target Organization

APPENDIX C

SITE VISIT

APPENDIX C: SITE VISIT

Examples of Items Accomplished During a Site Visit

NOTE

If the visit is to be conducted prior to the implementation of the MGEEM, then the facilitator should be introduced as a visitor. If the unit personnel have been informed about the purpose and events associated with the MGEEM implementation process, the facilitator should be identified as being associated with the process.

---

1. Identify the target organization's major products and services.

2. Develop a general understanding of the work flow.

3. Establish a rapport with the workers of the target organization and become familiar with the organization's structure.

4. Obtain a working Knowledge of present and past history of the work center's production record/ problem areas.

5. Become familiar with the units that target organization has to depend upon to do its job.

6. Become familiar with the customers of the target organization.

APPENDIX D

IMPLEMENTATION PLAN

APPENDIX D: IMPLEMENTATION PLAN

Examples of Items Included on an Implementation Plan

NOTE

After the Measurement Plan is developed, it should be communicated over a short period of time to all members of the target organization from the top down. The communication should be in the form of both face-to-face and written communication. The sequence of communication activities for a branch is outlined below.

0800 (Work Center Supervisors meeting). The division officer introduces the facilitator and discusses the purpose of the MGEEM measurement activity within the work center. The facilitator discusses the steps involved in implementation and proposes a timetable. The work center supervisor is asked for comments, and schedule conflicts are resolved. The division officer and work center supervisor agree on the appropriate time for the facilitator to visit the work center to present the measurement plan.

0900 (Facilitator and Supervisor finalize Memorandum). A memorandum is prepared for later distribution to personnel, summarizing the highlights of the implementation schedule. The memorandum should focus on the purpose of the measurement activity, the schedule, and how members of the organization will be affected.

1300 to 1400 (Work center meeting). The facilitator and division officer go to the work center and hold a brief meeting with work center members. During this meeting, members hear the division officer, division chief, and work center supervisor express support for the MGEEM measurement process. The facilitator gives a general outline of the steps involved in implementation and what will be expected from each member of the organization. Each member of the work center receives a copy of the previously developed memorandum, which summarizes the information presented. Members' questions are answered.

APPENDIX E

INITIAL BRIEFING ON KRA DEVELOPMENT

APPENDIX E: INITIAL BRIEFING ON KRA DEVELOPMENT

Introduction

Introduction of Facilitator and Participants
Purpose of the Measurement Activity (Senior Officer)
Overview of MGEEM Process
Perspectives on Defining Measures (Slide 1)
What are Key Result Areas? (Slide 2)
Purpose of This Meeting
Questions

Productivity Overview

Discussion of Organization Diagram (Figure 2. Chapter 3 made into a slide)
Definition of Productivity for the Target Organization

Defining Measures - Perspectives (Slide 1 example)

. MEASUREMENT IS NOT AN END IN ITSELF

. WHAT YOU MEASURE IS WHAT YOU GET

. MEASUREMENT SYSTEMS FAIL IF THEY LACK ACCEPTANCE

. MEASUREMENT IS A SUBSTITUTE FOR DIRECT OBSERVATION

. MEASUREMENT DATA HAVE THEIR LIMITATIONS

. MOST ORGANIZATIONAL UNITS CAN BE MEASURED

Key Result Areas are: (Slide 2 Example)

. AREAS REQUIRING HIGH LEVELS OF PERFORMANCE

. WAYS TO MEASURE MISSION EFFECTIVENESS

. THE CRITICAL. MAKE-OR-BREAK AREAS OF A JOB

. RESULTS: NOT ACTIVITIES. PROCESS. OR PROCEDURES

. OUTPUTS. NOT INPUTS: ENDS. NOT MEANS: WHAT. NOT HOW.

APPENDIX F

CONDENSED LIST OF KRAS

APPENDIX F: CONDENSED LIST OF KRAs

1. Realistic managerial goals in accordance with OPNAVINST 4790.2D
2. Customer satisfaction through quantity and quality gear to keep aircraft flying.
3. Motivated work force with high morale.
4. Trained personnel.
5. Optimum utilization of production personnel.
6. Safety
7. Maintain real property.

APPENDIX G

POSTING OF ME CHARTS

APPENDIX G: POSTING OF ME CHARTS

Overall Mission Effectiveness Chart

_____

_____

Composite Mission Effectiveness Charts for KRAs 1-4

KRA #1	KRA #2	KRA #3	KRA #4
_____	_____	_____	_____
_____	_____	_____	_____

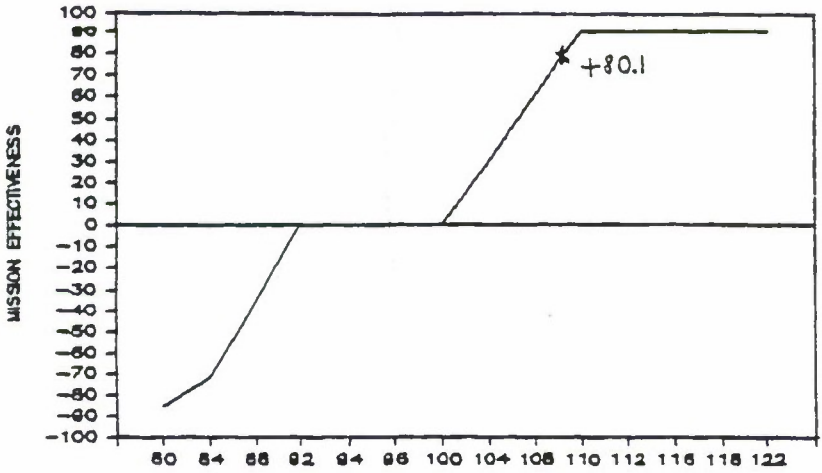
Individual Indicator charts posted by KRA

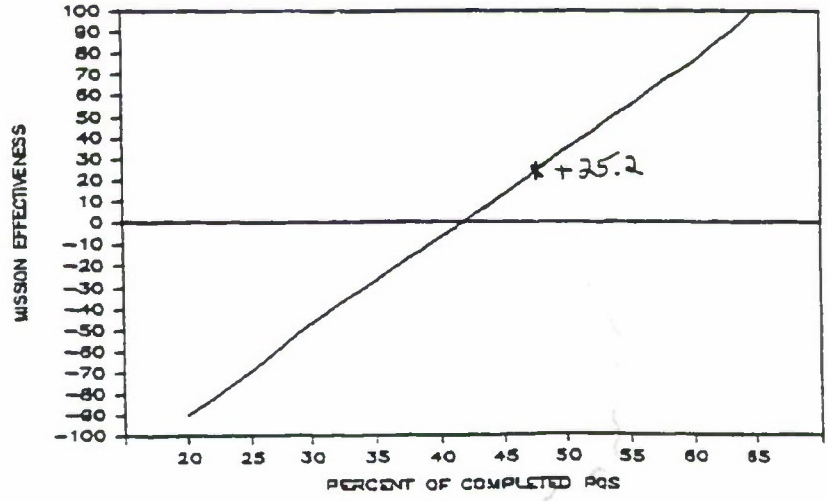
KRA #1	KRA #2	KRA #3	KRA #4
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	
_____	_____	_____	
_____	_____		
_____	_____		
_____			
_____			

APPENDIX H

TWO SAMPLES OF ME CHARTS

APPENDIX H: TWO SAMPLES OF ME CHARTS





APPENDIX I

MORALE SURVEY

APPENDIX I: MORALE SURVEY

W/C 610 Survey

Instructions: For each statement below, mark an "X" in the box corresponding to the answer that most closely indicates your response to how you feel about your work environment.

Statement	Very Satisfied	Satisfied	Not Sure	Dis-satisfied	Very Dis-satisfied
1. The chance to do something that makes use of my abilities.					
2. The way the Navy policies are put into practice.					
3. The freedom to use my own judgement.					
4. The chance to try my own methods of doing work.					
5. The working conditions.					
6. The praise I get for doing a good job.					
7. The feeling of accomplishment I get from the job.					

APPENDIX I (continued)

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. A spirit of teamwork exists betweeo the people in my W/C.					
2. A spirit of teamwork exists betweeo the people io my division.					
3. The people in the W/C work together to accomplish the W/C's objectives.					
4. The people in the divisioo work together to accomplish the division's objectives.					
5. I feel a sense of pride at being a member of this W/C					
6. I feel a sense of pride at being a member of this division.					
1. I plan to reenlist or extend.					
2. I would like to leave the Navy oext year.					

APPENDIX I (continued)

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. I know what my responsibilities are.					
2. I know exactly what is expected of me.					
3. Explanation is clear of what has to be done.					
1. I understand which of my work objectives are more important than others.					
2. The work objectives in my W/C are clear and specific.					
3. The work objectives of the division are clear and specific.					
4. I understand which of my W/C's objectives are more important than others.					
5. I understand which of my division objectives are more important than others.					