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**A PERFORMANCE MANAGEMENT FEASIBILITY STUDY
FOR A DEFENSE BASED ELECTRONICS
MANUFACTURING ORGANIZATION**

by

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1. INTRODUCTION AND RESEARCH DESCRIPTION

1.1 PROBLEM DESCRIPTION

Companies today are facing a multitude of challenges. Global competitors and demands by customers for higher quality products are forcing organizations to review and change their business practices. Nowhere is this more true than in the defense electronics sector where budget reductions and increased competition are causing significant problems, including shrinking profits and reduced capital for R&D and modernization investments. At the same time, DOD funding organizations are requesting product quality and productivity improvements (Stuelpnagel,1988). Defense companies are being compelled to find methods to decrease production costs, reduce production and design lead times and increase product quality in order to stay competitive.

To meet this challenge, Total Quality Management (TQM) has emerged in the DOD and defense industry as the predominant solution to the quality improvement challenge (Stuelpnagel,1988). TQM is the most recent stage in the quality evolution movement that historically has included inspection, statistical quality control, and quality assurance (Garvin,1988). While in the past, quality improvement has been emphasized through techniques such as Quality Circles, or programs such as Zero Defects, TQM is a philosophy rather than a single technique or program. TQM makes quality an organizational strategic goal and emphasizes every employee's responsibility to quality. Key principles include training, cultural change, internal and external customer satisfaction, statistical thinking, robust design, variability reduction, statistical quality control, individual participation, supplier integration, congressional interface, continuous improvement, management commitment, and teamwork. Fully embracing these principles is a primary factor in the success of any TQM implementation.

As the implementation of TQM in the defense sector increases, the need to study its effectiveness becomes important. The principle focus of TQM is quality. The question arises,

however, whether quality alone should be emphasized to ensure improved performance in an organization. Sink defines performance in terms of seven organizational criteria: productivity, efficiency, quality, effectiveness, innovation, profitability, and quality of worklife (Sink, 1985). From this perspective, quality is only one measure of organizational performance. Thus, in order for an organization to reach its full performance potential, development of a system that addresses not only quality, but other areas of performance improvement is desirable.

To meet this need, the design, implementation, and evaluation of a comprehensive organizational performance management system is required. Organizational performance management systems can be based on the same philosophical principles as TQM. Cultural support mechanisms, measurement and evaluation processes, organizational process intervention mechanisms, planning, training, continuous improvement emphasis and customer satisfaction can be integral elements of the performance management system as they are in TQM. The fundamental advantage of the performance management system, however, is emphasis on more than one performance criterion.

In addition to measuring, evaluating, controlling and improving a set of organizational criteria, a performance management system provides a capability to track criteria interrelationships. For example, an organization might increase the quality of its product to meet specific customer requirements but in the process adversely affect productivity and profitability. Garvin in his book Managing Quality describes the difficulty in identifying and measuring these associations without the existence of appropriate data (Garvin, 1988).

The first objective of this research is to describe an initial high level conceptual design and implementation strategy of a generic performance management system using systems engineering concepts (Blanchard and Fabrycky, 1990), performance and productivity management concepts and techniques (Sink and Tuttle, 1989) and TQM principles (Malcolm Baldrige Award (1991), President's Award for Quality and Productivity (1990), Deming (1986), Garvin (1988), DOD Total Quality Management Guide (1990)). The second objective is to implement this design within an

organizational unit of analysis in a defense electronics manufacturing facility. The organizational unit of analysis selected for the design implementation is a white collar department primarily involved with engineering design and engineering drawing activities. The need for a performance management system design and implementation for this department arose primarily from initial technical and market assessment findings that external market pressures could be met only by improvement of organizational performance.

As a consequence of this implementation, a preliminary descriptive assessment of the conceptual design and actual implementation will be achieved by addressing some basic questions. For example, what are some of the critical design components that increase the probability of system success? What are the performance management system implementation factors and difficulties in a defense electronics organization, white collar environment, or at the department level? Lessons learned from the implementation will also provide feedback to help improve both the initial conceptual design and the implementation process for this and other performance management systems.

1.2 RESEARCH IMPORTANCE

The evolution of the quality movement from inspection, to statistical quality control, to quality assurance, and now to TQM has broadened the organizational view of quality. New tools and techniques have been developed to further quality improvement. Quality is rapidly becoming a key strategic factor in many markets. Some companies have been forced into the quality improvement evolution in order to survive. Others have stepped forward voluntarily in an effort to move beyond their competitors. The evolution, however, is not over (Garvin, 1988).

The next step of the quality evolution may well be towards comprehensive performance management systems. Since a performance management system emphasizes additional performance criteria in addition to quality, it is an attractive management system alternative that

offers the potential for greater control and improvement of organizational performance. The design of a performance management system, however, presents a tremendous challenge for any organization. Identifying critical elements such as planning, measurement, assessment, improvement, control and cultural change and understanding cultural and environmental impacts on system design and implementation is essential.

In addition, the choice of design methodologies is an important issue. This research proposes the use of several design input methodologies including systems engineering, performance and productivity management, and TQM. The use of multiple design methodology inputs provides a broader range of conceptual ideas that will potentially lead to a more robust performance management system conceptual design.

Understanding the difficulty of implementing performance management systems is also important. Variability in organizational structure, level, culture, environment, and market affect the performance management system implementation. Studying performance management system design implementations in a realistic environment is critical to identifying key design components and implementation factors for varying organizational types. In addition, this initial performance management system implementation will help determine a baseline conceptual design that can be evaluated and modified as new information is received.

1.3 METHODOLOGY

1.3.1 RESEARCH FORMAT

This research project uses a case study organization for the performance management system conceptual design implementation. A case study is advantageous because it provides realistic, first-hand data and information about the research topic. This information can then be used directly to establish guidelines for practical applications. A case study format also yields valuable

information through the type of unit of analysis selected. Correct selection of the unit of analysis highlights specific environmental and cultural attributes. For example, this research highlights the cultural and environmental factors in a white collar, defense contracting organization.

Figure 1.3-1 outlines the methodology used in this research. This methodology begins with the selection of a unit of analysis based on the desired areas of focus. Next, an initial, high-level conceptual design of a performance management system for the organizational unit of analysis is presented. The performance management system design is then implemented within the case study organization. Finally, the organization's design and implementation is evaluated and lessons learned are presented. The following sections discuss the methodology in more detail.

1.3.2 ORGANIZATIONAL UNIT OF ANALYSIS SELECTION

The first phase of this research was the selection of an organizational unit of analysis. The selection process involved identifying specific environmental and cultural conditions that could impact the performance management system. Three conditions were considered important. First, a military contracting environment was desirable because of the defense industry's interest in TQM and performance improvement concepts and techniques. Second, a white-collar environment was important to determine its cultural impact on the performance management system. In many cases, white collar workers and managers are skeptical about the capability of quality and performance improvement systems in their information and paper oriented systems. Finally, a department level organization was chosen to identify the impact of a performance management system on a small group of managers and workers. To address each of these conditions the organizational unit of analysis selected was a design/drafting department operating within a military electronics manufacturing facility. The department is white collar oriented, consisting primarily of engineers and Computer Aided Design (CAD) terminal operators.

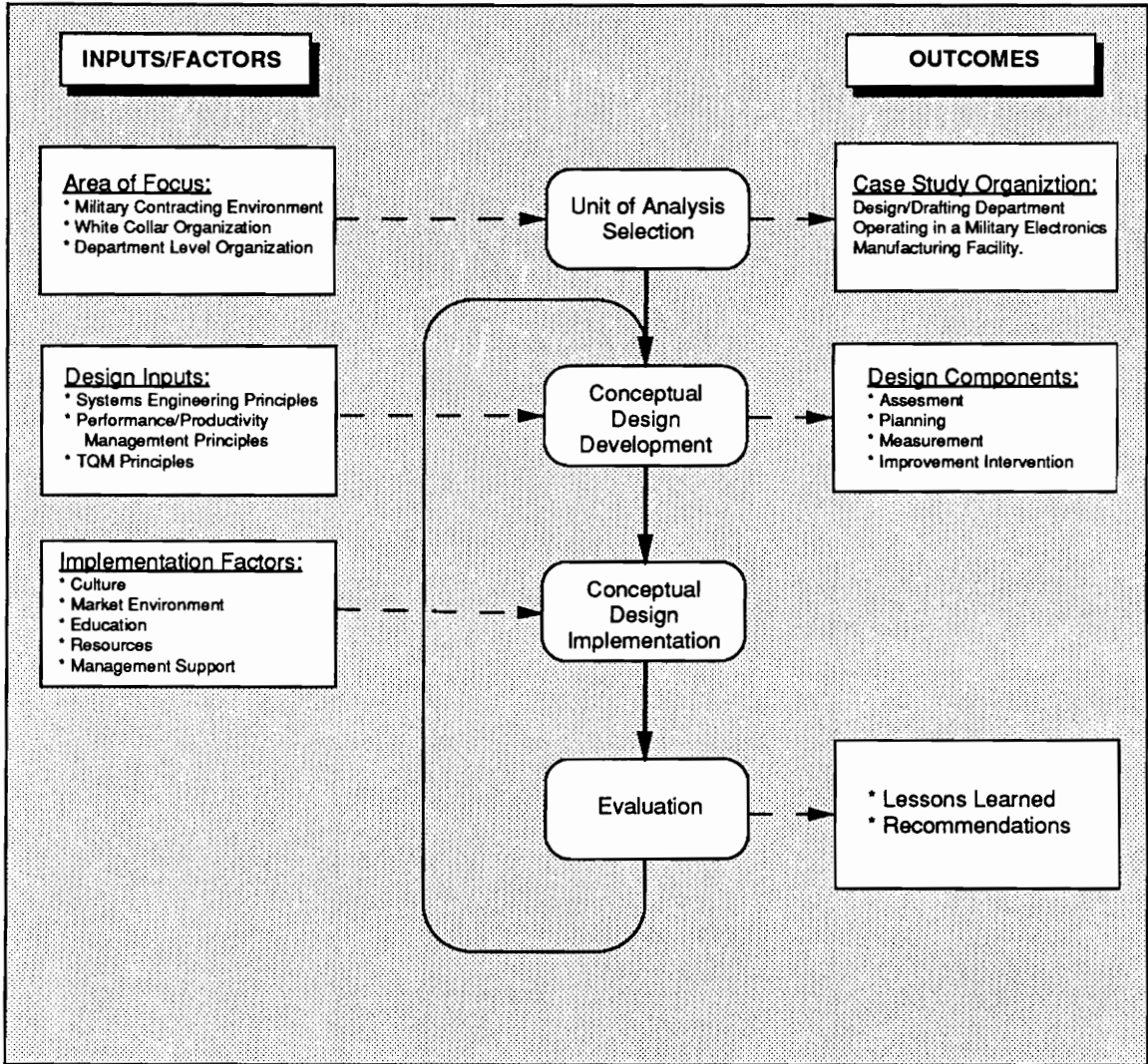


Figure 1.3-1 Research Methodology

1.3.3 CONCEPTUAL DESIGN

The second phase of this research involves the description of the main characteristics of a high-level conceptual design of a performance management system. This conceptual design process focuses on three areas. First, viable design concepts and methodologies are identified for use as design inputs. Principles and concepts of systems engineering, performance management, and total quality management are considered. Second, key design components of the initial performance management system are identified. These components are selected to help ensure the system meets its goal of continuous organizational improvement. Third, critical factors affecting the implementation of a performance management system, especially for the selected organizational unit of analysis, are presented.

1.3.4 IMPLEMENTATION

The third phase of this research is the implementation of the performance management system conceptual design for the case study organization. For this research the performance management system conceptual design was implemented within the selected organizational unit of analysis. The impact of organizational, cultural, and environmental constraints, however, prevented the department from fully considering or implementing all aspects of the conceptual design. To help evaluate this problem, the design and implementation steps taken by the unit of analysis are described. In addition, the successes, failures, and problems encountered by the department during these steps are also presented.

1.3.5 EVALUATION

The final phase of this research is the evaluation of the performance management system

conceptual design and implementation. The evaluation is based on several criteria including how well the system met its initial objectives, whether the design components were necessary or sufficient to achieve these objectives, how well individual design components contributed to the overall system goals and to organizational performance improvement, and how well factors affecting the system implementation were identified and addressed.

Comparison of the department performance management conceptual design implementation and the literature based conceptual design will be made. An analysis of the successful steps taken by the department as well as the problems and failures encountered will provide feedback about what components are critical to the performance management system design and what factors affect its implementation. The output of this analysis will be a set of additional guidelines for performance management system design and implementation for this type of organization.

1.4 PROJECT AND REPORT ORGANIZATION

This report is organized as follows. Chapter 2 provides the background and description of the selected organizational unit of analysis, including its structure, composition, primary and secondary activities, and cultural and environmental issues.

Chapter 3 presents a literature based performance management system design concept. Concepts, methodologies, and principles from areas such as TQM and systems engineering will be used. Key components of the performance management system that ensure its goal of continuous organizational performance improvement will be identified. Critical factors affecting the successful implementation of the system will also be discussed.

Chapter 4 describes the implementation of the performance management system within the organizational unit of analysis. The implementation process successes, failures, and problems encountered will be described. Data generated by the performance management system will also be examined, including NGT session results and productivity and quality measurement data.

Chapter 5 evaluates the effectiveness of the organizational unit of analysis performance management system design implementation process. The contribution of design components to the initial performance management system requirements and objectives will be examined. How well implementation factors such as planning, education and cultural support were addressed by the unit of analysis will be discussed. Reasons for successes, failures, and problems encountered will be identified. Comparisons between the literature based design concept and the design and implementation process of the unit of analysis will be made.

Chapter 6 draws some conclusions about performance management system design and implementation for the selected unit of analysis. Theoretical design and implementation guidelines for organizations of this type will be presented. Lessons learned from the case study will be discussed and areas for further research identified.

2. ORGANIZATIONAL UNIT OF ANALYSIS BACKGROUND

There are a number of organizational elements that are associated with or directly affect a performance management system design and implementation. Understanding the organization's activities, inputs and outputs, environment, culture, and composition is a necessary part of the performance management system development. The following discussion provides a description of these elements for the selected unit of analysis.

2.1 DEPARTMENT HIERARCHY AND COMPOSITION

The organizational unit of analysis for this research is a design/drafting department operating within a defense electronics manufacturing facility of approximately 330 employees. The department itself consists of approximately 40 employees. The department is a white collar organization consisting of approximately 60% engineers, 30% draftspersons, and 10% supervisory or administrative personnel. Experience level within the department varies. Approximately 35% have less than 5 years of experience, 40% have 5-10 years experience, and approximately 25% have over 10 years experience with the company.

Department employees are divided into two groups, engineering and drafting. The engineering section is composed of electrical engineers, mechanical engineers and one standards employee. The drafting section is predominantly composed of CAD operators responsible for drawing generation, drawing changes, and limited design work. Other drafting section personnel perform special activities, including drawing checking, drawing administration and storage, and development and maintenance of electrical cable and wiring drawings. A drafting supervisor oversees the drafting section and reports directly to the department supervisor. Members of the engineering section report directly to the department supervisor. The department hierarchy is shown in figure 2.1-1.

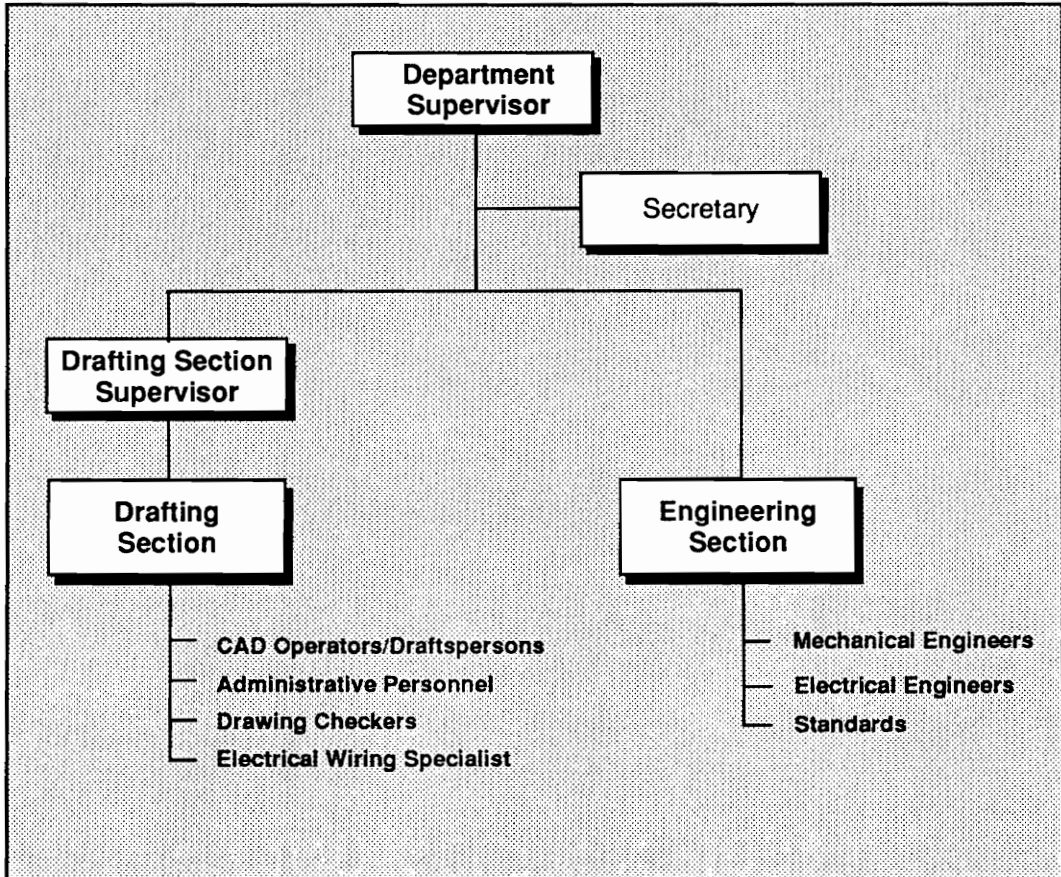


Figure 2.1-1 Design/Drafting Department Hierarchy

2.2 PRIMARY AND SECONDARY DEPARTMENT ACTIVITIES

The design/drafting department performs many primary and secondary activities. As with most white-collar organizations, these activities involve a great deal of information manipulation, making input and output identification difficult. Primary activities, i.e. activities the company identifies as the department's principle responsibility, include design of mechanical and electrical assemblies, drawing generation and management, documentation generation, hardware research and development functions, engineering analysis, preliminary mechanical and electrical testing of new designs, and some software/firmware development.

Of these primary activities, electrical and mechanical assembly design, drawing generation, drawing management, and drawing maintenance are most significant to the department. Electrical and mechanical assembly design includes both system and detail design functions. System design functions include activities such as product trade studies, vendor search and comparison studies, specification development, and conceptual design development. System design activity inputs are predominantly information oriented. Vendor and customer data, project management office and customer requirements, product specification requirements, military specification requirements, and engineering data are examples. System design outputs are also information oriented, including items such as reports, design decisions, and specifications. Figure 2.2-1 shows the system design activity tasks, inputs and outputs.

The detail design activity is also information oriented. Detail design functions include detailed test and analysis consisting of engineering analysis, data gathering and analysis, design approach determination, component research, specification development, mechanical layout and design feasibility testing. Inputs include decisions generated in the system design activity, data, project management office and customer requirements, military specification requirements and software requirements and information.

The primary output of the detail design activity is the drafting work order (DWO) package.

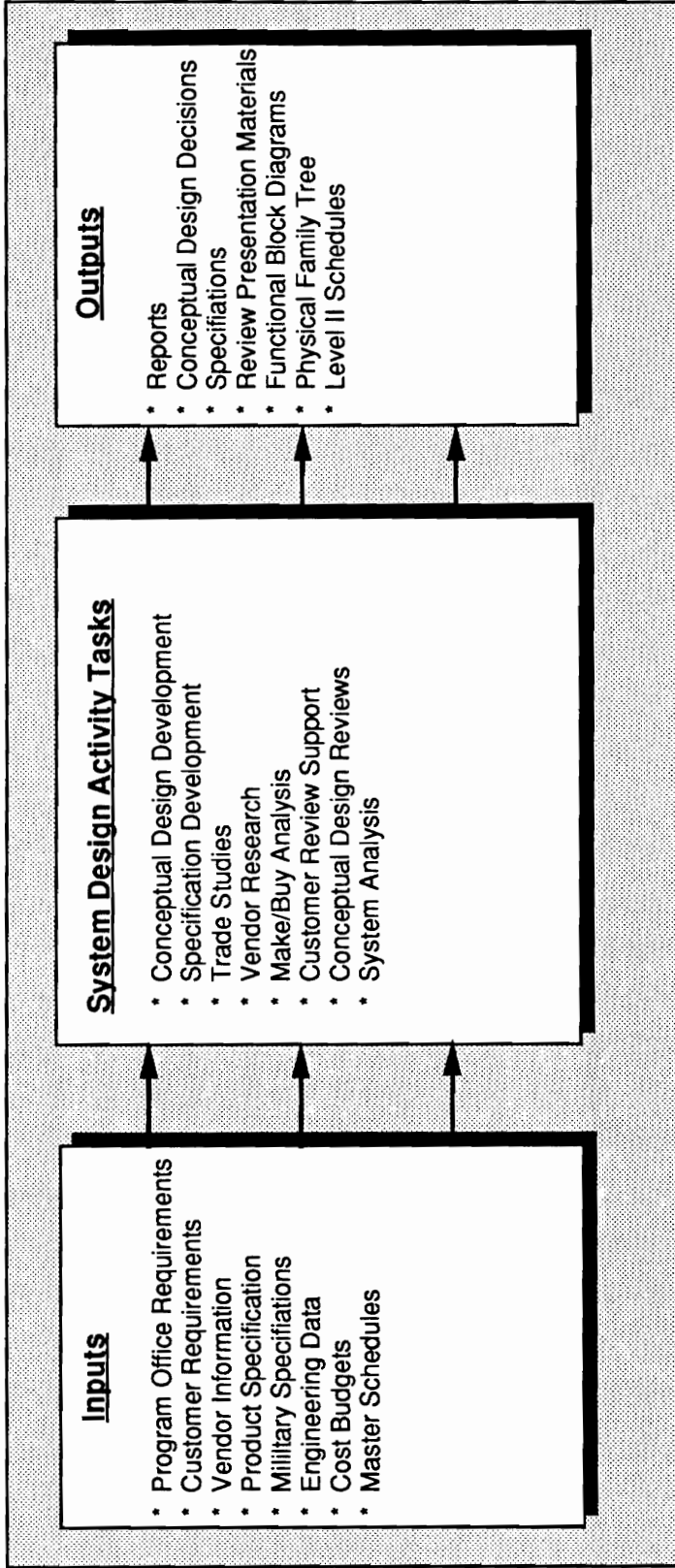


Figure 2.2-1 System Design Activity

Generated by an engineer, the work order package contains instructions and information for drafting personnel to create drawings for new mechanical and electrical assemblies. Submitting the work order package to the drafting section initiates the drawing generation activity. Figure 2.2-2 shows the detail design activity tasks, inputs and outputs.

Drawing generation and management is another important department activity. The DWO package generated in the detail design activity is the primary input. Drafting work order packages are submitted to the drafting section lead. The drafting section lead reviews the incoming drafting work order package and assigns it to a CAD operator. The CAD operator then creates all drawings required by the work order package. If information is insufficient, unclear, or missing from the work order package, the CAD operator either researches and gathers the data himself/herself or requests engineering assistance. The CAD operator may also perform design functions such as mechanical layout and parts selection.

Upon completion, drawings are sent to a drawing checker for review. The checker is responsible for correcting drafting errors, adding missing items, and checking for military standard compliance. When the checker has finished reviewing the drawing, the engineer responsible for the drawing may also review the drawing and make changes. The drawing is then returned to the CAD operator for incorporation of these changes.

After correction, the drawing is returned to the checker for review and signoff. Review and signatures are required from the draftsman, checker, engineer, and representatives from the reliability, logistics, and standards departments. If more corrections are identified, the drawing is returned to the CAD operator, otherwise the drawing is signed off and officially released. The drawing original is sent to the drawing storage area where it is photographed on microfiche, recorded, and stored. Figure 2.2-3 shows the drawing generation activity.

Drawing maintenance is another important department activity. The primary vehicle for this activity is the Engineering Change Notice (ECN) form. The ECN form is used by the company to formally initiate and document changes to released drawings. Reasons for change can include

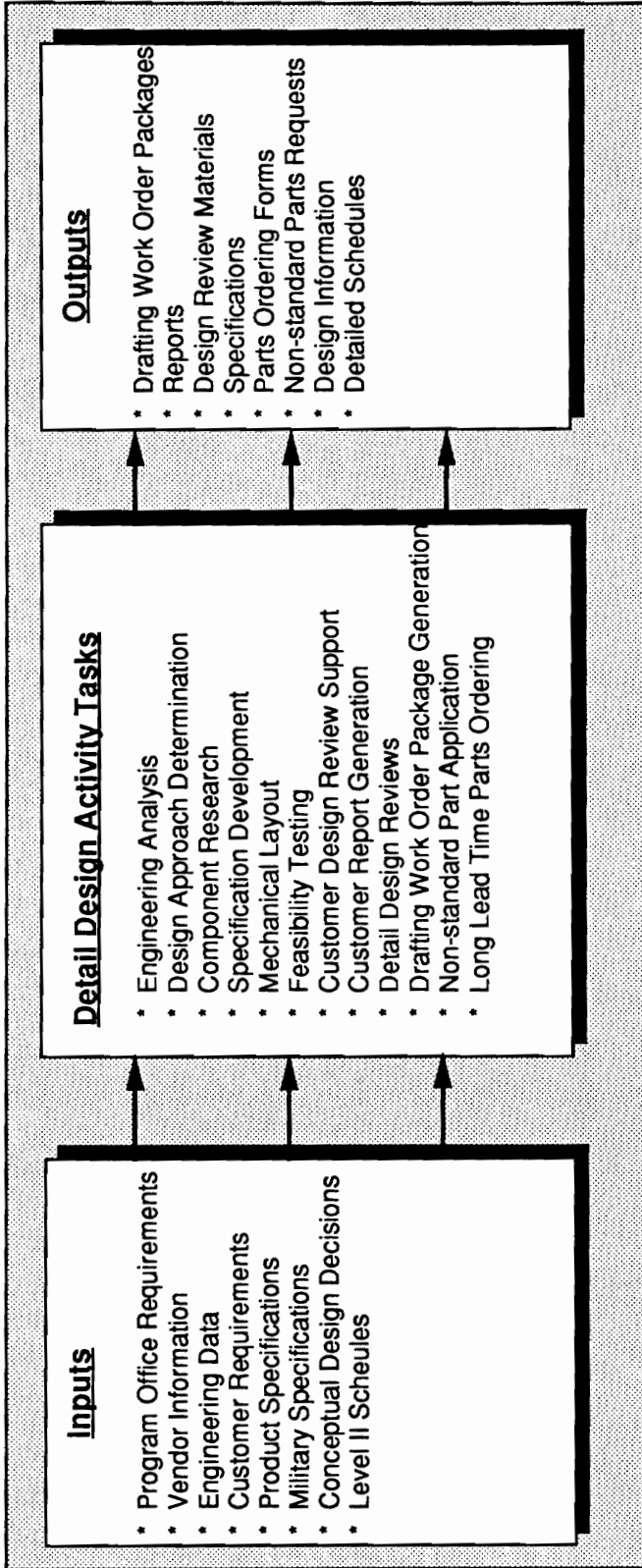


Figure 2.2-2 Detail Design Activity

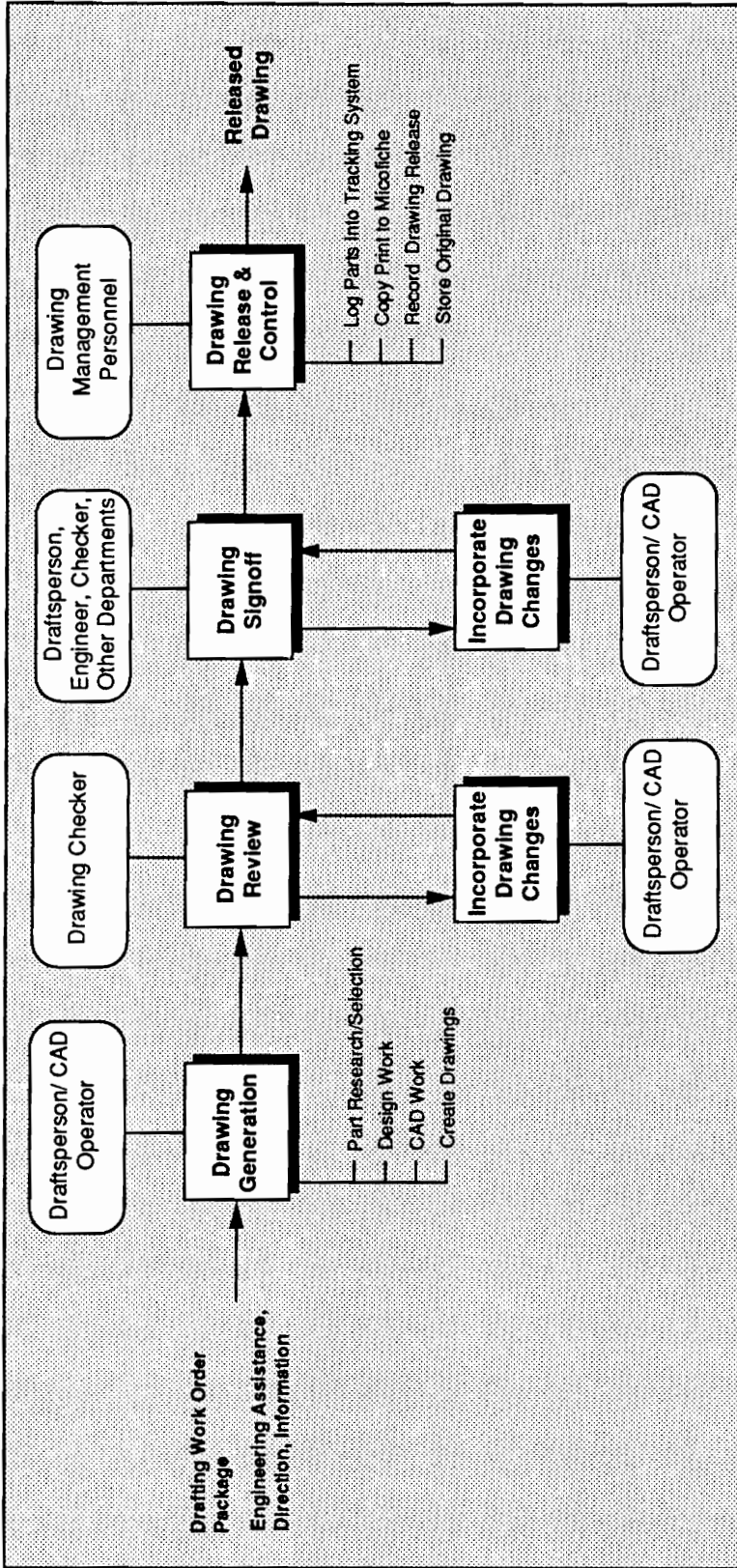


Figure 2.2-3 Drawing Generation Activity

anything from typographical errors, to design changes, to drawing discrepancies noted during test or inspection. An example of the ECN form is shown in Appendix A.

The ECN form requires a signoff process similar to drawing signoff. A description of the drawing change and signature of the originator are required. Additional signatures include representatives from the production control, logistics, configuration management and quality assurance departments. A signature is also required from a project engineer or project manager, and standards. With some exceptions ECNs are reviewed and signed at Configuration Control Board (CCB) meetings held by the configuration management department. Review, approval, and signoff of the ECN occurs at these meetings. Approved ECNs are recorded and filed by drafting administrative personnel. The drawing changes are periodically distributed to CAD operators for incorporation. Figure 2.2-4 shows the drawing maintenance activity.

Secondary department activities involve support activities for other departments and project management groups in the company. A majority of these activities consist of providing technical assistance or information. For example, an engineer assists test personnel in analyzing problems with an assembly or provides design information to project management for a customer design review. Engineering responsibility for these secondary activities is not always clearly defined. Often the engineer or department supervisor must determine if support is justified.

The extensiveness of these support activities is indicated by the number of other departments the design/drafting department interfaces with. These include purchasing, quality control, quality assurance, production control, software, technical publications, logistics/reliability, configuration management, manufacturing, test, and project/contract management offices. Support activities for these organizations contribute significantly to daily workload.

Although most of the department's activities appear well defined, many activities do not have written guidelines or well defined responsibilities. For example, specific steps and responsibilities in the engineering design and drawing generation activities are "understood" rather than identified by consensus or recorded. Inconsistencies and misunderstandings are a problem. Engineers

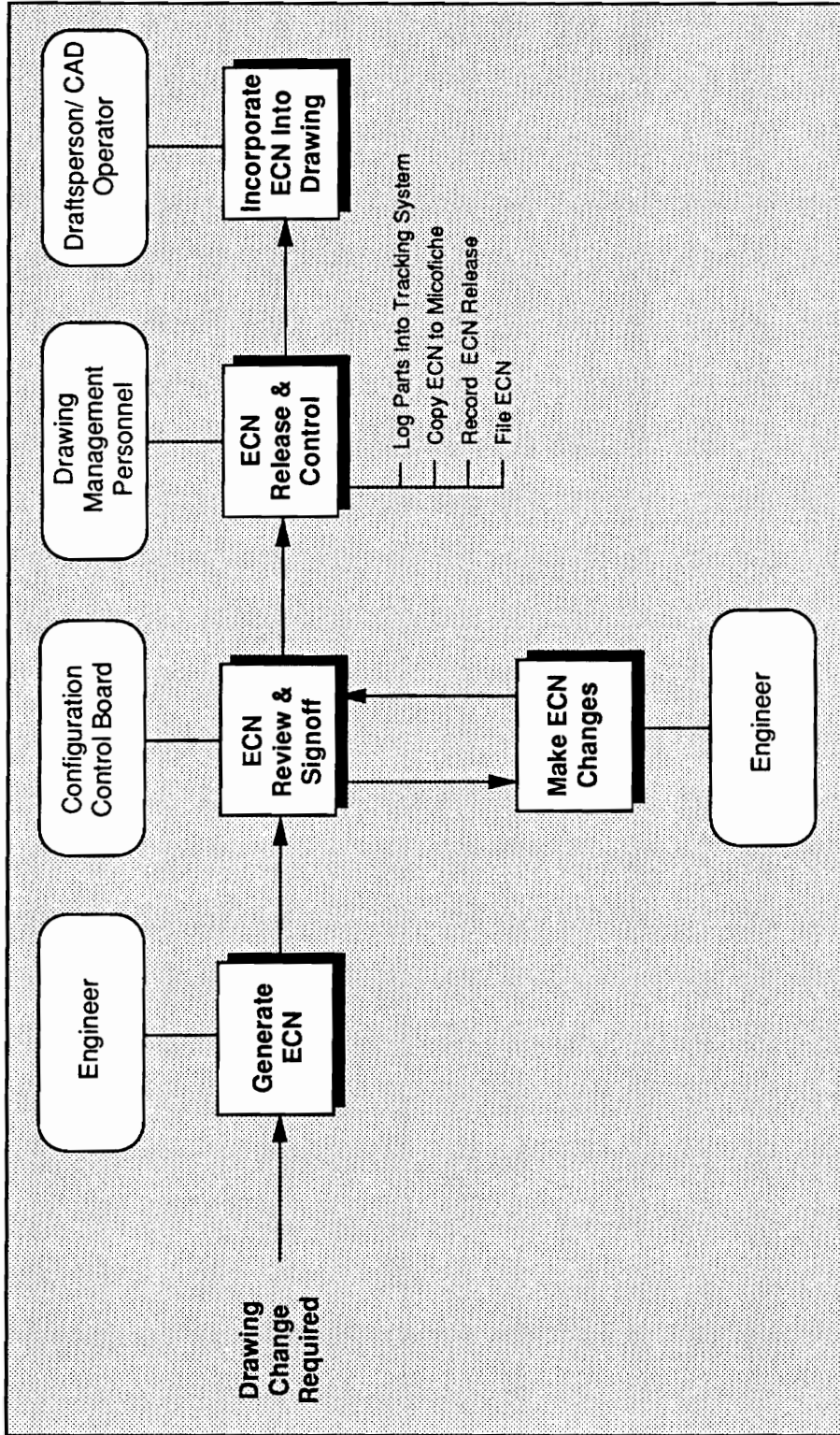


Figure 2.2-4 Drawing Maintenance Activity

sometimes assume that certain design tasks are the responsibility of drafting personnel. Drafting personnel, however, are not always aware of this assumed responsibility. Such instances such as reduce the efficiency of the drawing generation process.

Support activities performed by the department also have the same problem. Lack of consensus guidelines and responsibility definition between departments creates conflicts. Other departments may assume the design/drafting department is responsible for a specific support task and request an engineer to provide this support. The engineer or department supervisor, however, may feel differently and refuse to perform the work. At times, the engineer simply agrees to perform the task, realizing that the work is necessary and will not be completed if he refuses. This environment places a significant burden on the department and contributes greatly to the crisis work ethic. Work patterns are frequently interrupted by requests for assistance, making planning difficult.

Standardization is also missing from department activities. For example, creation of formal engineering design notes for use in later designs is rarely performed and CAD drawings are often generated from scratch and without regulation because guidelines and standard databases do not exist. In general, department members determine their own approach to meeting day to day work requirements.

2.3 DEPARTMENT CULTURE AND ENVIRONMENT

In their book Planning and Measurement In Your Organization of the Future (1989), Sink and Tuttle identify the importance of cultural support systems for effective performance management systems. In order to identify areas requiring cultural change and support, the organization must understand its operating environment and the attitudes and culture of its people. Difficulties encountered during the implementation of the department's performance management system and its effectiveness relate directly to these issues. This section describes some of the cultural and

environmental aspects of the department.

2.3.1 MILITARY CONTRACTING ENVIRONMENT

The design/drafting department is part of a defense electronics organization, and operates under DOD contractor requirements. This environment constrains and influences work procedures, inputs and outputs, and work activities within the department. Designs, drawings, and work procedures such as drawing signoff and correction are directly affected by military specifications. Auditing, tracking, and inspection activities are required. Although these constraints serve a purpose, flexibility of the department to make changes is hampered.

These environmental constraints also affect worker attitudes. Even though a desire for change exists within the department, military restrictions and requirements create a perception that change is difficult. Workers view some activities as constrained and complex. Military specifications and procedures make correction of mistakes and problems laborious. As a result, the quickest, easiest solution to a problem is often exercised instead of a quality, long term solution. Workers are often frustrated when a more cost effective approach exists but military requirements restrict or prevent the change. These problems foster an attitude of complacency with respect to changes.

2.3.2 DEPARTMENT CULTURAL ASPECTS

In addition to cultural attitudes generated by the military environment, other department cultural attitudes exist. For example, many department employees are skeptical of upper management support for improvement programs. Part of this attitude stems from an unsuccessful attempt to implement quality circles within the company. During this period, quality circle projects occasionally received negative emphasis by management. Instead, emphasis was placed on company production work. When quality circles presented change proposals to management,

recommendations were often rejected. Eventually the quality circle phase died out through lack of enthusiasm and support. At this time employees viewed quality circles as the industry "flavor of the month", receiving lip service but no firm management commitment.

In addition to skepticism generated by the quality circle events, many department members perceive labor cost and schedule issues as management's only concern. Quality and performance improvement work are less emphasized, adding to department member skepticism that a performance improvement system would be fully supported. In addition, upper level management ideas, goals, objectives, actions, and commitments are often not visible or communicated to department members, further degrading employee impressions of upper management.

Another department cultural aspect is the highly analytical attitude present in the department. Department personnel, particularly the engineers, tend to apply analysis skills and techniques to any problem encountered. With this cultural characteristic a danger exists of micro-engineering performance management system components and measures. For example, the department might overspecify the measurement process or try to measure activities too precisely, resulting in a cumbersome and ineffective management system.

Another cultural issue is problems with department communication and teamwork. Internally, department communication is fair. Engineers and drafting personnel communicate freely to work out problems, however there are problems with determining and communicating responsibility for specific activities. A limited amount of teamwork also occurs. Engineers and drafting personnel meet informally to work out designs or solve technical problems but formal design teams do not exist. Inter-department communication and teamwork also occurs, but less often. Design/drafting department members often do not have a clear understanding of the activities and requirements of other departments.

The crisis work ethic existing in the department is another cultural issue. Unscheduled requests for technical support by other departments, production crises requiring immediate attention, and shifting work priorities create a difficult work environment. Long term planning is difficult and

normal work patterns are often disrupted.

Another cultural issue is department member views of formal planning and goal setting. Formal plan development is typically viewed as a management function. Department employees are usually not involved in planning processes and therefore do not view themselves as responsible or accountable for plan progress. There is also little exposure to goal and objective setting at the worker level. Department and company goals are not well communicated and workers are typically not involved in their generation. As with planning, department members view goals and objectives as management responsibility and not a significant aspect of their work.

These issues form serious cultural roadblocks to performance management system implementation and organizational improvement. Positive cultural aspects, however, also exist in the department. A significant cultural impact was made on the department by a performance improvement project sponsored by upper management. The project objective was to identify and implement improvements in department activities. The project was a one time effort, beginning prior to the department's performance management system design and implementation efforts and concluding approximately the same time this research was initiated. The cultural impact of this project was significant in bringing about the development and implementation of the department's performance measurement system and merits discussion.

The project began with the formation of a "Process Enhancement Team" composed of representatives from both the drafting and engineering sections. The team convened in a series of meetings and identified department activities and procedures most in need of change. Identification of the changes occurred informally rather than through a structured group approach.

The first change identified involved evaluating and modernizing current forms used by the department. Forms selected for change included the Engineering Change Notice (ECN) form (used for making formal changes to drawings), the Engineering Release Authorization (ERA) form (used to order parts and assemblies), and the Drafting Work Order (DWO) form (used to initiate new drawings). The team concluded that these forms did not provide proper information nor did they

accurately reflect department and company value adding activities.

To correct the deficiencies, team members met with representatives from all organizations who used the forms to identify the changes required. In addition, the team developed guidelines describing form use. Written guidelines were a particularly important change since prior to this project none existed.

The second change the Process Enhancement Team identified was the generation of written guidelines for value adding processes within the department to increase department standardization. The team proposed the development of three reference materials including a set of design guidelines, a set of drafting guidelines, and a parts standardization database.

The design guidelines included items such as instructions for the new ECN, ERA, and DWO forms, and the description of a new cost saving approach for releasing major mechanical and electrical assembly drawings. The design guidelines also initiated formal design folder requirements for all major electrical and mechanical assemblies. This concept was intended to provide better documentation and standardization of electrical and mechanical designs and facilitate the use of past designs on future projects.

Drafting guidelines were developed from current department drafting practices and corporate drafting guideline documents. The guidelines included the establishment of standard practices for CAD model generation and use, drawing layouts, and identification of standard drawing notes. The goal of these guidelines was to reduce drafting errors and increase drawing generation efficiency.

A parts standardization database was developed to provide engineers and drafting personnel with a list of commonly used parts and materials. Part selection for designs would come from this database. The team anticipated that the database would increase design commonality and standardization, resulting in cost reduction and efficiency improvement.

The department Process Enhancement Project provided positive cultural impact in several ways. First, the department became motivated to look for performance improvement changes. By supplying an avenue for change, interest in improvement had been stimulated. Second,

department members began to perceive that change was possible. Third, the project helped stress the need for teamwork and communication in improvement projects.

While the Process Enhancement Project cultural impact was largely positive, one negative aspect existed. Resource problems toward the end of the project slowed the publishing and distribution of forms and documents, resulting in a significant reduction in department enthusiasm and sense of accomplishment.

Company interest in TQM prior to and during the department performance management system development and implementation also provided significant positive cultural impact. Exposure of department members to these concepts was small, but interest in performance improvement among a few department members increased, establishing a small cultural support base for further performance improvement work.

3. PERFORMANCE MANAGEMENT SYSTEM CONCEPTUAL DESIGN

The objective of this chapter is to present a preliminary performance management system conceptual design for the organizational unit of analysis based on current concepts, techniques, and philosophies of quality, productivity, and performance management. The conceptual design presented here forms a basis for comparison and evaluation of the department performance management system design implementation.

The primary objective of the performance management system is to provide a management structure which promotes and ensures continuous performance improvement within an organization. To meet this objective the conceptual design must identify key design components and address specific system implementation issues that will ensure sustained performance improvement in the organization.

The methodologies used include the systems engineering methodology proposed by Blanchard and Fabrycky (1990), the performance management system concepts and philosophies proposed by Sink and Tuttle (1988), and the general TQM principles and methodologies established during the recent TQM evolution (Malcolm Baldrige Award (1991), President's Award for Quality and Productivity (1990), Deming (1986), Garvin (1988), DOD Total Quality Management Guide (1990)). These three sources provide the conceptual design inputs that contribute information, concepts, techniques, and principles applicable to the performance management system.

3.1 DESIGN INPUTS

3.1.1 SYSTEMS ENGINEERING

Systems engineering provides input to the performance management system conceptual design through the system design process. The phases of the system design process include conceptual

design, preliminary design, detailed design, construction, and system utilization and support. In addition, each phase involves essential activities in the system development such as system functional analysis, system synthesis, and system design. Figure 3.1-1 shows the system design process (Blanchard and Fabrycky, 1990).

The system design process offers an organized design approach adaptable to performance management systems design. The design process also encompasses the entire lifecycle of the system from conceptual design through system utilization and support. This approach is important for performance management system design as well. The management system requires evaluation, support, maintenance, and corrective action mechanisms to ensure its effectiveness well after initial implementation. The system design process stresses this lifecycle support philosophy and requires addressing these issues early in the system design process.

While specific system design process activities relate better to the design of physical systems, many of these activities can still be adapted to the performance management system conceptual design. For example, the system conceptual design phase includes three important activities. First, a feasibility analysis is required. This assessment function includes the identification and analysis of organizational needs and system operational requirements. This is an important step in a performance management system conceptual design. Understanding organizational needs and requirements is necessary to develop accurate specifications and objectives for the management system design. Organizational needs and requirements are also fundamental in establishing system objectives.

Next, the conceptual design phase requires advance planning. Advance planning involves the development of planning documentation for the system design, implementation, evaluation and support. This activity is also applicable to performance management system design. A quality plan forms a guideline for management and employee actions and decision making, imposes accountability, and provides a scale to measure system design and implementation progress.

Last, the conceptual design phase requires the development of a system maintenance concept.

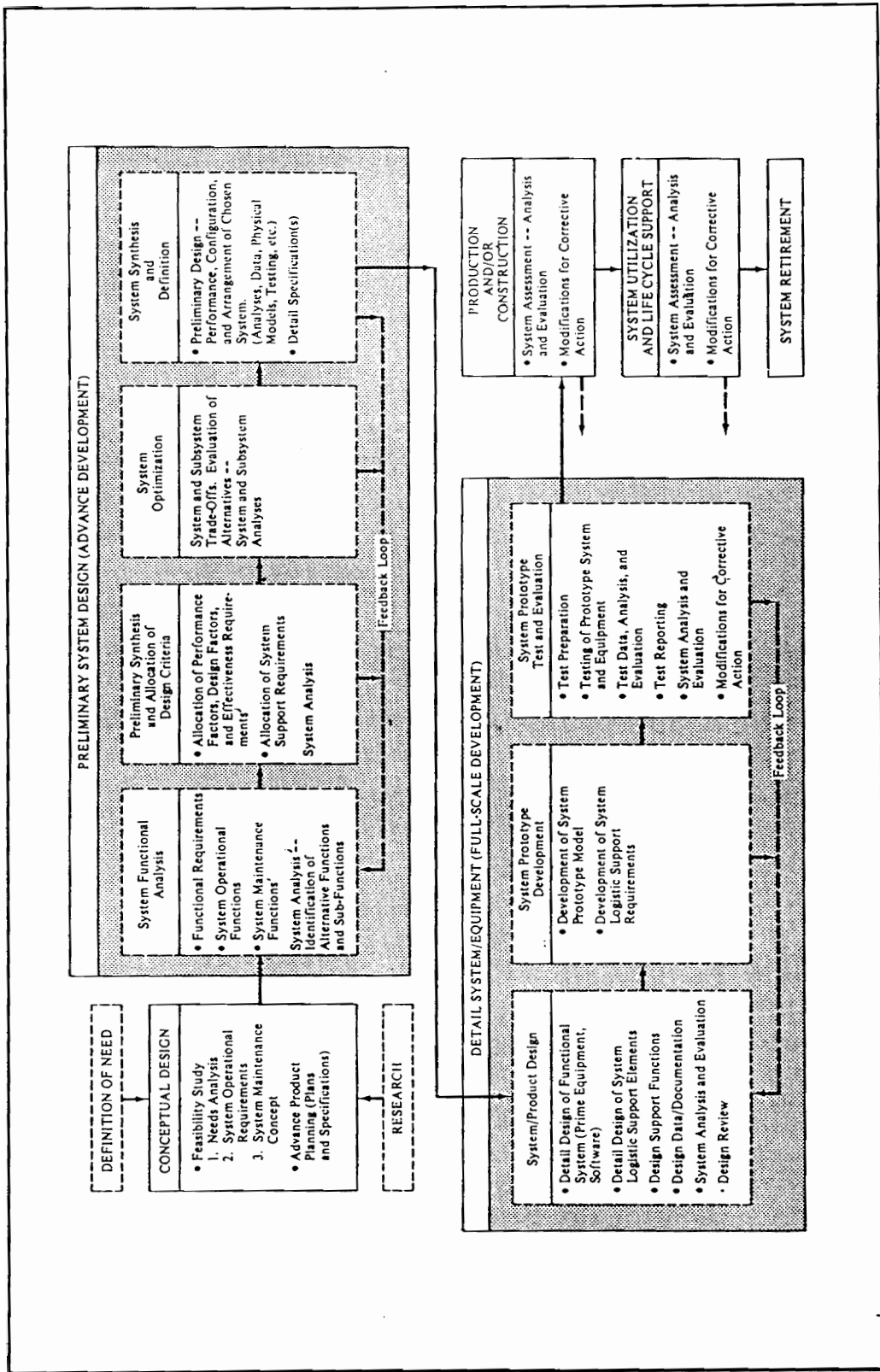


Figure 3.1-1 System Design Process

While a maintenance concept appears more relevant to physical systems, it can also be a critical support element of performance management systems. To ensure continuous performance improvement, the system must be capable of adapting to changing requirements, environment, and culture. Periodic system assessment determines if the system is meeting organizational objectives. Problems can be addressed and changes made to ensure system integrity and quality operation.

Specific activities of the system design process preliminary design phase also apply to the performance management system conceptual design. Identifying system functional components and requirements ensures the performance management system meets established organizational requirements and objectives. Identifying system maintenance support functions and requirements is also critical. Alternative configurations and approaches should be evaluated to ensure optimum system performance as specified in the system optimization activity. In addition, system synthesis through component configuration, modeling and detail specification establishes component interfaces, assists in planning, and generates a comprehensive description of each system component. Representational modeling of system components provides a clear visual picture of each component for analysis and evaluation.

Several activities of the detail design phase are adaptable to the performance management system design process. The system design function includes system component detail design with respect to system goals such as maintainability, manability, supportability, economic feasibility and social acceptability. Addressing these issues in both the system and the component design increase the likelihood of the performance management system success.

System prototype test and evaluation function and the system utilization and support phase activities also apply to the performance management system conceptual design. Activities include system testing, measurement, analysis, evaluation, and corrective action. These concepts can be continuously applied in the performance management system during its initial implementation and throughout its life. Continuous system measurement and periodic evaluation contribute to a flexible management system, capable of adapting to changing organizational requirements, culture, and

environment.

In conclusion, the system design process primarily identifies the performance management system design implementation strategy, focusing on elements such as assessment, planning, system analysis and synthesis, measurement and evaluation, and support function identification. Utilizing these system design process concepts can help produce a more robust performance management system design with greater chance for success.

3.1.2 PERFORMANCE AND PRODUCTIVITY MANAGEMENT CONCEPTS

The second area of performance management conceptual design input includes the principles and concepts of productivity and performance management. By definition (Sink & Tuttle, 1989), performance management involves the following:

- Creating a vision of the desired future state of the organization.
- Assessment of the organization's current state and capabilities.
- Planning and establishing strategic objectives that will move the organization towards its desired future state.
- Design and implementation of improvement interventions that will move the organization towards its goals.
- Design, redesign and implementation of measurement and evaluation systems to tell the organization where it is and if it is meeting its objectives.
- Implementation of cultural support systems that reinforce and reward progress and improvement.

Many of these concepts are similar to the system engineering concepts including planning, assessment, measurement and evaluation, and implementation of support systems. Performance

and productivity management concepts, however, offer several new ideas suitable for the performance management system conceptual design. Creating a vision of the organization's desired future state solidifies the desires and objectives of the organization and provides a focus for performance improvement efforts. The design and implementation of improvement interventions is the process whereby an organization implements changes in order to reach its performance goals and objectives. The implementation of cultural support systems motivates, educates, and supports the continuous improvement process. Through cultural support systems the organization becomes biased towards performance improvement.

The performance and productivity management concepts also offer detailed assessment, measurement, and planning function descriptions which relate well to management system design. Additional requirements for these functions are also specified. For example, the organizational assessment described by Sink and Tuttle (1989) requires the identification of organizational strengths, weaknesses and roadblocks to improvement. The implementation of a measurement system is emphasized rather than simply specifying the need for measurement. In planning, the use of a structured, strategic planning process is recommended. The planning process outlined by Sink and Tuttle includes organizational system analysis, creation of planning assumptions, development of strategic goals, development of action items, formation of action teams and plans of action, project management, development of measurement and evaluation systems, and the continuous implementation of the system.

These concepts and requirements further contribute to the performance management system conceptual design, identifying both system implementation strategies and identifying critical system components. Utilization of these concepts will potentially increase the performance management system's effectiveness and overall success.

3.1.3 TQM PRINCIPLES

The final area of conceptual design inputs comes from the principles and philosophies associated with Total Quality Management. Basic concepts of TQM include continuous improvement emphasis, education and training, teamwork emphasis, and cultural support (Stuelpnagle, 1988). These concepts are considered crucial to TQM implementation because they help ensure the success of the quality management process.

Similarly, these concepts apply to performance management. Continuous improvement emphasis is a primary objective of the performance management system. If the organization is to use the performance management system to improve performance and reach its performance objectives, the system must promote continuous organizational improvement.

Education and training also apply to the performance management system. Members of the organization must understand performance improvement concepts to ensure successful system implementation. If employees do not understand why or how the organization is implementing the performance management system, there will be lack of support for the system and a greater chance of failure.

Emphasizing teamwork in the performance management system produces several desired effects on the system and the organization. Members of the organization exchange ideas more freely, cooperation is more prominent, and support for decisions and activities is elevated. Decisions made by a team or structured group process establish a sense of unification and accomplishment. These factors can help achieve support for the performance management system and performance improvement activities.

Finally, the establishment of cultural support systems is a desirable input to the performance management system conceptual design. The cultural change required for the performance management system is difficult. To achieve organizational support for performance improvement concepts and objectives, all members of the organization must be supportive to the performance

improvement cause. Performance improvement must become an integral part of everyone's day to day work. A desire to improve must be instilled within all participants. To achieve these changes, cultural support systems are needed.

3.2 PERFORMANCE MANAGEMENT SYSTEM COMPONENTS

The concepts and principles identified in the three design input areas provide the basic framework of the performance management system conceptual design. From this framework, the key design components and factors affecting the performance management system implementation can be identified.

Comparison of the systems engineering and productivity/performance management concepts results in the identification of several common system components and implementation activities desirable for the department performance management system conceptual design. First, an initial assessment of the organization to identify items such as the state of the organization, and organizational goals and objectives is required. Second, strategic planning must be implemented. Third, a measurement and evaluation system must be developed to provide information and data about the organization's performance and the performance management system itself. Fourth, an improvement intervention process or mechanism must be included in the performance management system conceptual design.

In addition to these basic components, all three design input areas address factors that can affect performance management system component design, implementation, and support. These factors include cultural support mechanisms, education and training, environment assessment, resource commitment, and system maintenance. The following sections discuss these key design components and implementation factors of the conceptual design in more detail.

3.2.1 ORGANIZATIONAL ASSESSMENT

Before an organization can begin a detailed design of the performance management system, an assessment of the organization is required. The assessment should define several aspects of the organization, including current organizational operation and performance, organizational boundaries, the desired future state of the organization, the needs and requirements driving the organization to implement a performance management system, and constraints affecting system implementation and effectiveness. The organization should perform these activities in a structured manner to ensure a useful, quality output. The Organizational System Analysis process presented by Sink and Tuttle (1989) is an example of a structured, step by step process for organizational assessment.

The first step of the assessment process defines the organization's current state. This includes identifying organizational activities, inputs, outputs, suppliers and customers. Boundaries for the performance management system are established and system interfaces identified. Organizational characteristics such as structure and available technology are examined. If possible, current organizational performance levels are determined to establish a baseline for performance improvement measurement and evaluation. Organizational strengths are also identified so that they can be built upon during system design and implementation.

Once the current state of the organization is established, organizational needs and requirements are defined. Understanding the reasons for implementing a performance management system will lead to a strong, comprehensive system design that specifically addresses these issues. Well defined needs and requirements also facilitate the development of organizational and performance management system goals and objectives.

Next, the organization develops a vision of its desired future state. Establishing the organization's future state provides input for the performance management system design and for organizational and performance management system goal and objective development.

Characteristics of the future organization are identified such as the role of participative management, teamwork, communication, measurement, customer service and performance improvement work. If possible, future organizational performance levels are also established.

With an understanding of organizational needs and requirements, and a picture of the organization's future state, organizational and performance management system goals and objectives can be established. This step is critical. Goals and objectives crystallize the organization's vision of its future state and provide focus for employee improvement efforts. Assumptions for achieving organizational goals and objectives should also be stated so that the organization can work to avoid conditions that will negatively impact performance management system effectiveness.

Finally, the organization must identify potential roadblocks to performance improvement such as problems created by organizational culture, environment, management style, communication deficiencies, or other organizational weaknesses. By identifying these roadblocks, the organization can address these issues during planning, design, implementation, and operation of the performance management system to help ensure its effectiveness and success.

3.2.2 PLANNING

The initial organizational assessment is the first stage of a strategic planning process. Strategic planning is a well emphasized requirement in TQM, systems engineering, and performance and productivity management. A well defined performance improvement plan is essential for the organization to meet its performance goals and objectives. The plan covers activities throughout the lifecycle of the performance management system from system conceptual design through system utilization and support. Plan activities include education and training, identification of system components and support functions, establishment of requirements and objectives, system synthesis, component and support function design, performance measure development and

implementation and support actions. Emphasizing long term commitment, developing measures to monitor plan progress, and establishing accountability for the organization's improvement process are also required.

In order to develop a successful plan, however, a quality planning process is essential. The planning process should be well defined to avoid developing a plan that is narrow in focus, too theoretical, or unintegrated (Sink, 1985). Planning process activities include organizational assessment, development of organizational goals and objectives, and performance plan development. The planning process should utilize group participation, stress teamwork, and effectively communicate activities and results to the organization to ensure ownership and support for the improvement plan.

The performance improvement plan should also receive equal emphasis with other business plans. Committing too few resources or establishing a lower priority for performance improvement work will send the wrong message to employees. Support for the performance management system will decline and successful implementation will be difficult. A well structured planning process can help avoid these problems.

The eight step planning process proposed by Sink and Tuttle (Sink & Tuttle, 1989) is an example of a structured planning process. This planning process has steps such as organizational assessment, identification of planning assumptions, development of strategic goals and objectives, and development of measurement and evaluation systems. Emphasis is on group participation and teamwork. Such a planning process helps build commitment of organizational members to the performance management system through participation, goal setting, and team building. It also provides a step by step approach that is organized and properly emphasizes the preparation and long term horizon necessary for performance management system implementations.

3.2.3 MEASUREMENT AND EVALUATION SYSTEM

Measurement is stressed in each of the three design input areas. In the system design process, measurement provides data to evaluate the system design and operation. This data provides system performance level information, identifies whether the system is meeting established organizational requirements and objectives, and determines what system changes are required. In TQM measurement is emphasized through the use of statistical process control. This measurement approach provides information about organizational activity performance and process control. Data informs management and employees how well processes are operating and where improvement interventions can be targeted. Similarly, performance management concepts describe measurement and evaluation as integral parts of the management system. Sink and Tuttle in Planning and Measurement In Your Organization of the Future identify the single most important reason for measurement is to support and enhance improvement. Measurement supplies feedback about system capabilities, performance levels of organizational processes and systems, where to target resources, and where to focus improvement interventions (Sink & Tuttle, 1989).

From this analysis it is clear that a measurement and evaluation system is a necessary component of the performance management system. Sink and Tuttle's expanded presentation of Kurtstedt's management systems model (Kurtstedt, 1986) provides an excellent guide for measurement system development. Figure 3.2-1 shows this model.

The model displays the implementation of the measurement and evaluation system as an integral part of the organization's management system. First, measurement techniques are used in a data collection process to obtain data about organizational system inputs, processes, and outputs. Next, the data is evaluated to determine if it is useful, timely, and accurate. Raw data is massaged, possibly through statistical means, to provide measurement data suitable for presentation and further evaluation. Measurement information is then presented to employees and management for feedback and decision making. Based on this information, decisions are made

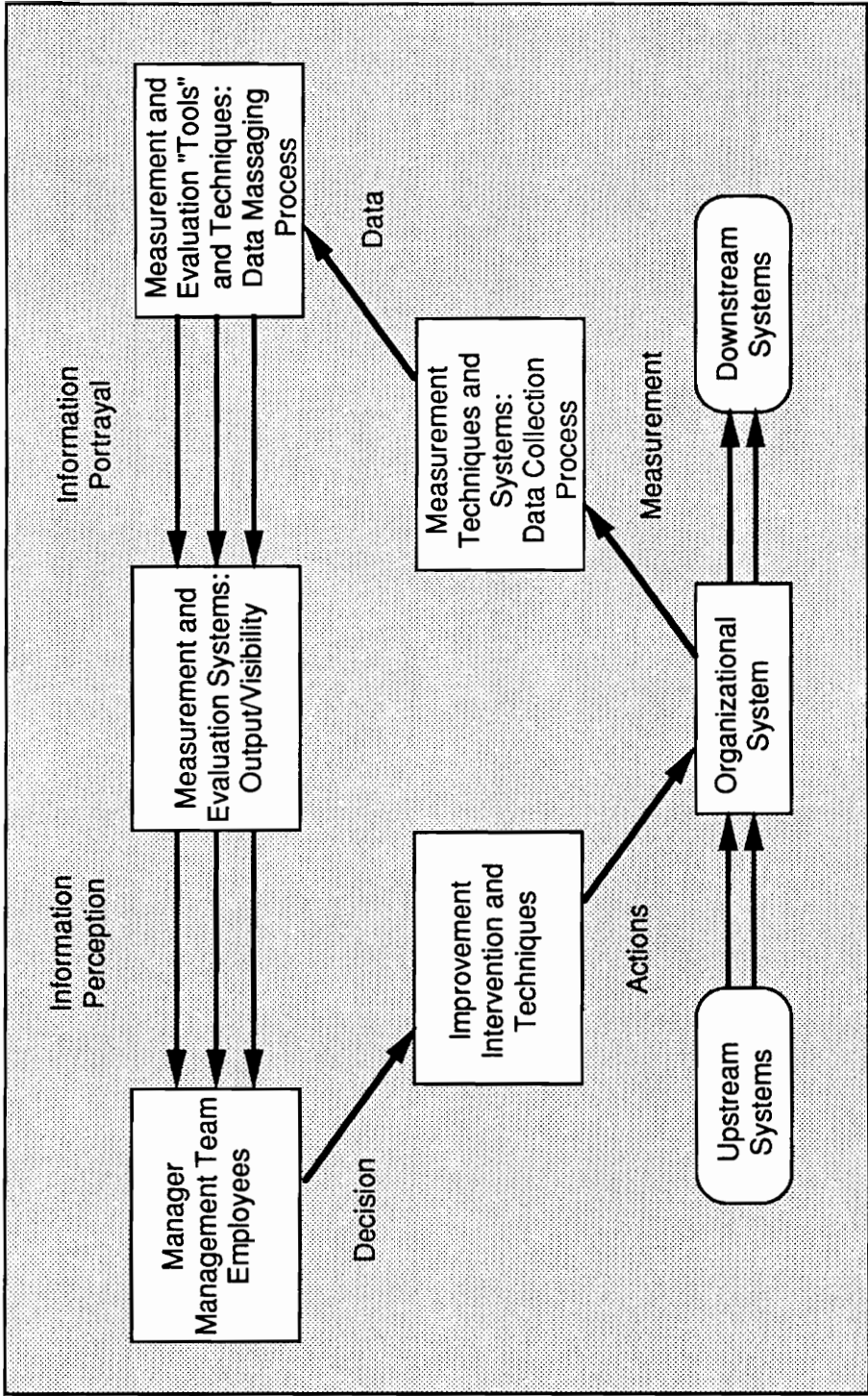


Figure 3.2-1 Management Systems Model

about organizational changes. After changes are implemented, the measurement system provides feedback about the effects of these changes. This data collection, evaluation, and change implementation cycle continues indefinitely.

The measurement and evaluation system is a key component of the performance management system. The measurement system is an organizational tool used for performance information feedback, evaluation and improvement intervention decisions. The measurement system tells the organization how well it is performing and the effectiveness of its improvement changes. The system also helps link performance improvement activities to identifiable organizational improvements and goal achievements.

As part of the measurement and evaluation system implementation, the organization must establish a well defined set of performance criteria. Performance measures are then developed based on this criteria. Definitions of performance criteria can be based on any number of principles, such as Sink's seven performance criteria, Deming's 14 points, or even specific criteria developed by the organization itself. The primary objective is to develop criteria which provide a broad picture of organizational performance. Once these performance criteria are established and measures developed, it is the role of the measurement and evaluation system to provide data and information for the established performance measures.

3.2.4 IMPROVEMENT INTERVENTION SYSTEM

In order to achieve continuous improvement, an organization must continually evaluate itself and make changes. The concept of continuous improvement exists in each of the design input methodologies. In TQM continuous improvement is intended to reduce organizational costs through improved quality. This cannot take place without emphasis on continuous improvement and the availability of change mechanisms. Performance management concepts parallel this thought. Further examination of the management systems model in figure 3.2-1 shows that a key

element of the management process is improvement intervention on the existing organizational system. The system design process also defines the need for corrective action and change to improve system operation and ensure organizational requirements are met. It is clear that improvement intervention mechanisms are needed as part of the performance management system to move the organization towards desired performance levels and the organization's envisioned future state.

In designing the improvement intervention component of the performance management system, the organization should consider an approach which adapts well to organizational culture and environment. The intervention mechanism should also stress teamwork and participation to achieve maximum employee involvement and support. Measurement data from the measurement and evaluation system should be a primary input to the improvement intervention mechanism.

The performance action team (PAT) process (Sink, 1985) is one example of an intervention mechanism. This process uses a participative approach to identify and implement organizational improvement changes. In addition, the process emphasizes team work, measurement, worker/management communication, feedback and reward. The PAT process is well suited to task oriented, problem solving environments such as in technical organizations because teams can focus on solving individual performance problems one at a time. Resources can also be better managed.

3.3 PERFORMANCE MANAGEMENT SYSTEM IMPLEMENTATION FACTORS

The next step in the performance management system conceptual design is identification of factors affecting the implementation and effectiveness of the performance management system components. The identification of these factors is important. Issues such as organizational culture, management support, and market environment have a direct affect on the performance management system implementation and effectiveness. The following sections identify and discuss

the factors most critical to the performance management system conceptual design implementation.

3.3.1 ORGANIZATIONAL CULTURE

The idea that cultural attitudes and behavior directly affect an organization's ability to build effective quality, productivity, and performance improvement systems is pervasive in both TQM and productivity/performance management philosophies. The culture of an organization describes the way members act, react, and deal with the problems and tasks encountered in their environment. In essence these are the values of the organization. Responses to situations and solutions to problems are directly related to what the organization has learned and perceives as the "right" way to operate.

These cultural biases and attitudes directly affect the success of the performance management system implementation and effectiveness. For example, a crisis work ethic creates a reactive rather than a proactive environment. In this type of environment, emphasis can easily shift away from performance improvement objectives to fighting daily crises. If members of the organization believe that performance improvement work is secondary to the rest of their work, the performance management system will not receive the required attention and support.

If, however, cultural biases and attitudes are identified during the planning stages of the performance management system, cultural change can be planned for. Sink and Tuttle confirm this approach by identifying the need for cultural support systems in the performance improvement process. These systems are the mechanisms for cultural change within the organization to ensure continuous attention and support of the performance management system.

Cultural support mechanisms can be simple, such as providing continuous communication and feedback to the organization about improvement efforts and organizational performance changes. The support mechanism can also be more complex such as the development of a reward or gainsharing system for performance improvement contributors. Another example of a support

mechanism is education. Increasing knowledge and understanding of performance improvement concepts reduces skepticism about the performance management system and increases performance improvement support. As part of the performance management system planning process, the organization needs to identify cultural barriers and design support mechanisms to eliminate them.

3.3.2 MARKET ENVIRONMENT

Related to cultural effects on the performance management system components are the impacts from the organization's market environment. This is particularly true in defense contracting firms where military standards, specifications, and requirements impact daily work activities and affect worker attitudes. Examining the culture of the case study organization provides a good example. In the design/drafting department, restrictions placed on department activities by the military contracting environment lead to cases of frustration and even complacency about organizational changes. Military standards and requirements created both real and perceived barriers to change.

As with specific cultural effects on the performance management system, the effects of the marketing environment must also be identified and planned for during the assessment and planning phases. Environmental constraints should be identified and communicated to the organization. Support mechanisms should be planned for. With this approach problems related to environmental barriers can be solved effectively, increasing potential performance management system success.

3.3.3 EDUCATION AND TRAINING

Along with cultural change and market environment assessment is the need for education and training. Both workers and managers of an organization must understand basic management and

performance improvement concepts such as measurement, cultural support, strategic planning, and assessment. Without this knowledge the organization will find it difficult to effectively develop and implement the performance management system. In order for workers to be supportive of new ideas and concepts, they must first understand them. Knowledge must be sufficient to plan, design, implement, and support an effective performance management system.

The organization must also be careful to sustain its educational process. If education is not continuous, performance improvement support can suffer. Education and training provide an effective means of communicating to the organization that performance improvement is an essential part of organizational operation. The organization must be prepared to commit time and resources to this effort.

3.3.4 MANAGEMENT SUPPORT

Employees are highly aware of management actions. From management attitudes and behavior, employees learn what activities and behavior are important. If organizational members are consistently rewarded for meeting schedule objectives but are overlooked for other types of work successes, then the employee will learn that meeting production schedules are his highest priority. If, however, management demonstrates commitment by participating in and rewarding performance improvement activities, workers will respond with increased efforts in performance improvement. As such, management support must be a visible and integral part of the performance management system. The manager must get involved in performance activities and show by example that the performance improvement process is necessary and requires the same attention as other organizational activities.

In TQM the role of management is well defined. While the worker is responsible for implementing quality improvement in his day to day job, in TQM the manager is accountable for the overall quality improvement process. This approach should be taken for the organizational

performance improvement process as well. Employees are responsible for addressing performance improvement issues as part of daily activities. The manager, however, must be held accountable for the progress of the performance management system and the organizational improvement effort.

3.3.5 RESOURCE COMMITMENT

At this point, it becomes clear that resource commitment is a critical factor in the task of developing, implementing, and sustaining an effective performance management system. Cultural change, particularly during the design and initial performance management system implementation, requires resource commitment for the cultural support mechanisms essential to system success. In addition, participative approaches in organizational assessment and planning require commitment of worker time and effort. Education and training pulls workers away from regular organizational work activities. Supporting and sustaining measurement processes, and system maintenance also require resources.

Resource commitment is nonetheless critical to achieving effective performance management system output. Participative approaches achieve greater worker support and higher quality results. Cultural change mechanisms increase the chance of system success. Team efforts provide a greater sense of accomplishment and a quality output. It is critical for the organization to realize that the cost up front is necessary to achieve a long term return on investment. Investment up front ensures a quality development and implementation process and hence a potentially effective performance management system. Ignoring this commitment can result in the waste of resource dollars on an inefficient or ineffective development process.

Accepting this philosophy is difficult. It requires faith in the performance improvement process and faith in the organization's ability to implement and sustain an effective system. It also requires the organization to take a long term view of the performance improvement process. The

organization ultimately must decide if it can afford to change. An economic feasibility analysis early in the performance management system development is one approach. In answering this question, however, the organization should also consider whether it can afford not to change.

3.4 CONCEPTUAL DESIGN SUMMARY

A summary of the performance management system conceptual design is shown in figure 3.4-1. The conceptual design involves three phases, including system planning, system design, and system utilization and support. The system planning phase involves the establishment and implementation of a structured planning process, organizational assessment, development of organizational goals and objectives, and plan development. In addition, education and training in performance management system concepts, planning concepts, measurement, and related concepts begins in the planning phase. Education and training continues throughout the life of the performance management system.

The system design phase includes system synthesis and analysis, system detailed design, and performance criteria and measurement development activities. Performance management system functional components and cultural support functions are identified. Requirements and objectives for these components are established and components are modeled to identify process flow, guidelines, and interfaces. The overall performance management system configuration is also established. In addition, component and support mechanism detail design is completed. Designs are evaluated against organizational, system, and component objectives. Performance measure criteria and initial organizational performance measures are established. Data sources are identified and development of data collection procedures takes place.

The system utilization and support phase includes system implementation, utilization, and support activities. The performance management system, including the measurement and improvement intervention components, is implemented. Performance measure data is collected.

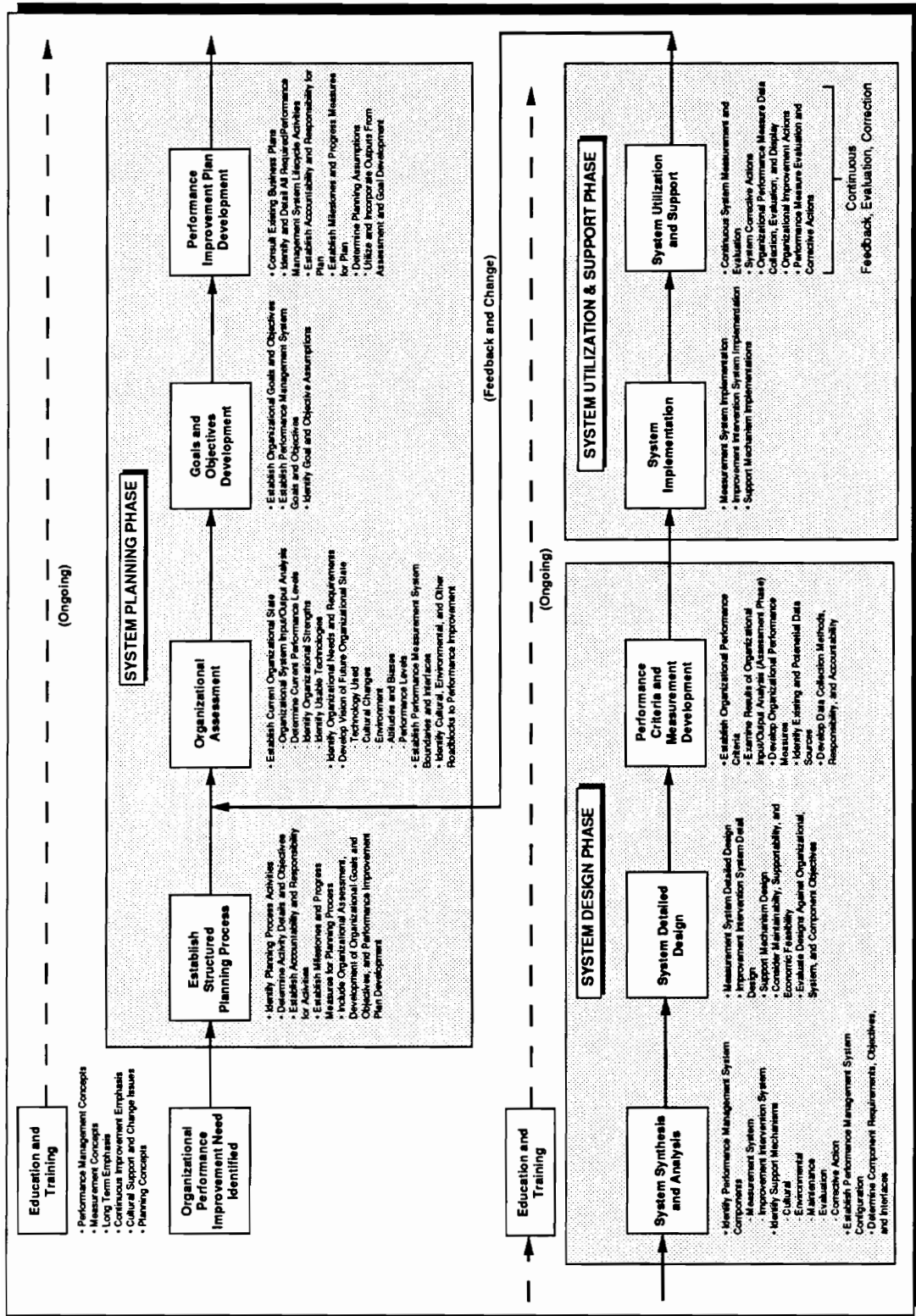


Figure 3.4-1 Performance Management System Conceptual Design

Organizational performance measures are evaluated, organizational improvement changes are implemented, and results are monitored. Performance measures, the performance management system, and the organization are periodically evaluated. Feedback potentially leads to organizational reassessment, changes in organizational goals, modifications to the performance improvement plan, and changes to the performance management system and performance measures. This process continues indefinitely.

4. DESIGN IMPLEMENTATION

The research period for this case study covers the department organization's initial attempt to design and implement a performance management system. The following sections describe this process. The description includes the department assessment and planning functions, organizational system analysis, performance management system component identification and design, measurement identification, and data collection. An evaluation of this process and a comparison to the conceptual design presented in chapter three will be made in chapter five.

4.1 BACKGROUND

At the time of this research, market pressures on the company were forcing the department to examine methods for lowering organizational costs. Recognizing a need for change was the department's first step towards developing a performance management system. The idea of change was not new to department members. In spite of environmental and cultural constraints, most department members believed that changes in department activities could help reduce workload, generate more efficient work output, reduce costs and create higher quality department and company outputs.

A permanent process for change, however, did not exist within the department. In addition, crisis work was common. Daily efforts focused on immediate priorities, leaving little time for improvement efforts. This situation presented a significant barrier to departmental change and improvement. Several events occurred, however, to partially alleviate this problem.

First, the department initiated the process enhancement project described in chapter two. This project provided a mechanism for change, elevating department enthusiasm for improvement activities. Second, company interest in TQM exposed some department members to improvement concepts and increased general interest in improvement activities. Third, a department employee

interested in TQM and performance management presented a proposal to the department supervisor for development of a performance management system. The department supervisor enthusiastically accepted the proposal and gave approval to commence work.

4.2 ASSESSMENT

The department began by forming a performance management system planning team. This team consisted of two department members, the originator of the performance management system proposal, and the coordinator of the process enhancement project. The planning team's first action was to identify basic department needs and requirements for the performance management system. No structured assessment process was used. Instead, informal discussion and a basic knowledge of TQM, systems engineering, performance management concepts, and department operation and activities helped the planning team identify several organizational needs and requirements.

First, the planning team identified a need for an improvement intervention mechanism. No formal improvement mechanism existed for changing department work activities and procedures. The planning team felt the addition of this component would provide the department with a mechanism for change.

Second, the planning team recognized that a data poor environment existed within the department. Measurement data, performance indicators, and performance feedback were not available to assist decision making and organizational assessment. To fill this gap, the planning team specified a requirement for a measurement system component in the performance management system design.

Third, the planning team identified a need to emphasize department member participation and responsibility. Significant department member involvement in the performance management system design and development would develop a sense of ownership for the system. Emphasis

on department member responsibility for improvement changes would force responsibility for change to the lowest level.

Fourth, the planning team identified the need for an organizational system input/output analysis. The team felt that knowledge gained from this activity would assist in the initial development of performance measures, in addition to providing department members with a better understanding of department activities.

Finally, the planning team identified the need for department education. The planning team believed that educating department members in measurement, performance criteria, and performance management concepts would provide some of the necessary skills for designing and implementing the performance management system. In addition, education would generate a better understanding of the performance management system, increasing department member interest, support, and sense of ownership.

At this time, details of these requirements were not addressed. Instead, the planning team developed a simple conceptual view of the performance management system. This vision consisted of an adaptive, continuously implemented performance management system incorporating measurement, improvement mechanisms, information and data feedback, and team emphasis.

The planning team categorized the requirements in a list of performance management system objectives:

- The department shall educate employees in performance management concepts to promote understanding and system ownership.
- The department shall perform an activity input/output analysis to provide department members with a better understanding of department operations and assist in performance measure development.
- The system shall provide a formal improvement intervention mechanism for change

and implementation of improvement ideas.

- The system shall contain a measurement system component to provide measurement data and performance feedback to the department.
- The system shall emphasize group participation and teamwork.
- The system shall emphasize employee responsibility for department improvement.
- The system shall promote continuous measurable improvement within the department.

The planning team discussed these objectives with the department supervisor and received input and support. These objectives were not, however, communicated to the rest of the department.

4.3 PLANNING

At this point, the planning team initiated a planning process. Again, the department did not use a structured approach. Instead, the team examined Sink & Tuttle's eight step performance improvement planning process for planning ideas and developed its own planning process. The planning steps identified are listed below:

- 1) Development of a schedule for the design and implementation process of the department performance management system.
- 2) Preliminary design of the performance management system and identification of major performance management system components.
- 3) Development of department goals and objectives, department guiding principles, and a list of assumptions.
- 4) Education of the department.
- 5) Organizational system analysis, including an analysis of department activities, inputs,

outputs, suppliers and customers.

- 6) Detailed design of the performance management system components.
- 7) Initial performance measure development.
- 8) Implementation of the performance management system components.

While the eight step planning process was attractive, department resources were limited. Thus, the planning team decided that only the most crucial planning steps of Sink & Tuttle's process could be implemented. The use of a group participative approach to developing the plan itself was also considered but ruled out because of budgetary constraints.

Two areas of the eight step planning approach were incorporated, the organizational system analysis and the development of goals and objectives. The planning team considered both these steps critical to a successful performance management system development. The organizational system analysis would aid significantly in measurement development. Development of department goals and objectives would provide both a reason and motivation for performance improvement.

The planning team initiated the planning process by developing a schedule that covered each planning step. It was assumed by both the planning team and the department supervisor that the established schedule could be met if the team and the department could continue to contribute time to performance improvement efforts. Tracking measures and milestones were not identified. The plan would be implemented as best as possible under current department conditions. The planning team took responsibility for the schedule, but in reality there was no strict accountability for achievement of each planning step.

During the assessment phase and the planning development, the planning team had already conceived a preliminary conceptual design for the performance management system. At this point, the planning team addressed the education issue. The planning team had identified early that department education was necessary to motivate people and provide understanding of new concepts, terminology, and ideas. In order to prepare department employees for performance

management system concepts, the planning team constructed an educational briefing package.

The briefing package contained information and discussion on a number of areas including:

- Measurement concepts
- Measurement system ideas and objectives
- Reasons why a performance management system implementation in the department was desirable
- How the performance management system would likely be implemented within the department
- Reasons why the performance management system could fail
- What major components the proposed management system would likely contain
- Some preliminary short term department goals and objectives

The planning team convened an education meeting for all department members and presented the briefing package topics. A copy of the briefing package was provided to everyone. To focus attention on the department's ability to change and improve, the planning team presented results of the process enhancement project. The merits of evolving from a single improvement project to a continuous improvement process were also presented. A brief questionnaire was included with the briefing package to gather inputs for the organizational system analysis, comments on the goals and objectives, and response about the presentation and package materials. Appendix B contains the materials presented in the briefing package.

Department response to the presentation was mixed. Some department members were intrigued and expressed interest in the concepts presented at the meeting. Questionnaire responses also reflected this interest. Other members, however, seemed uninterested in the topics presented. This was partly due to skepticism that improvement work would receive sufficient emphasis and support.

After the presentation, the planning team prepared to continue the performance management system development. Production crises, company market pressures, and layoff rumors, however, shifted priorities and focus away from the performance improvement effort. Over three months passed before the planning team returned to the performance management system development. At this time it was clear that both the design and implementation schedule and many department goals and objectives were invalid. The planning team began work again by reestablishing a schedule and addressing the development of department goals and objectives.

Examining the goals and objectives presented at the education meeting, the planning team determined that a better set of goals needed to be developed. The planning team also identified several current problems with department goals. Department goals were usually written by the department supervisor in response to company goals or passed down directly from upper management. These goals were rarely communicated to the department. The company philosophy maintained that workers at the lower levels did not need to be concerned with the company's objectives. The planning team, however, wanted to change this approach and effectively communicate department goals and objectives to the department. The planning team believed that this was essential to bringing about effective support for the performance management system and performance improvement.

The planning team identified a need for department participation in goal development but resource limitations prevented this. Instead, the planning team assigned the department supervisor the task of goal development. Department goals and objectives would then be communicated to the department at a performance improvement kickoff meeting. The planning team hoped this would be sufficient to increase support and interest in the performance management system development. The department goals and objectives developed are listed in figure 4.3-1 and 4.3-2.

In addition to department goals and objectives, the department supervisor generated a set of department guiding principles and a list of assumptions. The assumptions identified critical conditions and items necessary to reaching department goals. The guiding principles were

Design/Drafting Department Objectives

To enable the company to continue to prosper in the increasingly competitive market through the following:

- 1. Provide a technical advantage by innovative application of today's technology.**
 - Training (peer training, seminars, formal post graduate work)
 - Focus of investments (R&D and capital)
 - Rewards for exceptional contributors
 - Utilization of other division and corporate organizations
- 2. Provide a cost advantage by continually evaluating and improving the processes within the design/drafting department**
 - Process definition
 - Process enhancement
 - Measurement
 - Improvement suggestion system
 - Comprehensive guidelines
- 3. Provide a schedule advantage by shortening the overall product development cycle through the following:**
 - Improved work breakdown and task definition process (uniform across all contracts)
 - Improved planning and scheduling capability (uniform across all contracts)
 - Increased visibility within the design/drafting department and to other departments
 - Increased standardization
 - Increased attention to detail/minimized rework (do it right the first time)
 - Improved work quality

Figure 4.3-1 Design/Drafting Department Objectives

Design/Drafting Department Goals

1. Develop 1991 and 5-year IR&D plan
2. Increase training in 1991 by 50%
3. Implement internal reward system
4. Participate at group level in the following:
 - CAD CAE Council
 - Training System R&D Council
 - Corporate Rotation Program (Fellow)
5. Complete initial release of engineering and drafting manuals
6. Implement on-line component substitution
7. Implement first measurement system
8. Improvement suggestion policy and implementation
9. Complete Cost Estimating Guidelines
10. Develop "war room" for schedule and status display
11. Implement AutoCad software with accompanying procedures
12. Training for:
 - AutoCad
 - DADS
 - XILINX Logic Cell Array
 - dBASE
 - Dash Schematic Capture
13. Implement the following in Checking/Drafting:
 - Performance Feedback System
 - Living Checklist System
 - Task Tracking Database System
14. Reduce product design cycle to 18 months (2-3 yr goal)
15. Become more dominant players in new business development strategies (2-3 yr goal)

Figure 4.3-2 Design/Drafting Department Goals

developed to crystalize the department's desire to evolve into a continuously improving organization. The guiding principles and assumptions are listed in figure 4.3-3.

4.4 ORGANIZATIONAL SYSTEM INPUT/OUTPUT ANALYSIS

While the department supervisor developed the department goals, the planning team began work on the organizational system input/output analysis. The planning team had identified during the planning phase the need for better understanding of department activities. Identification of department activities, inputs, outputs, suppliers and customers would assist the department in measurement development, improvement changes and decisions, and identification of non-value adding activities.

An action team consisting of two engineers was formed to identify major department activities, inputs, outputs, upstream suppliers, and downstream customers. Management, drafting personnel, and other engineering personnel also supported this action team. Several days work resulted in a flowchart of company activities performed during the preliminary design, detailed design, drawing generation, manufacturing, test, and support phases of product development. Task responsibilities, primary inputs and outputs, and activity flow were listed.

In addition the action team stated several objectives on the flow chart. These objectives included periodic rework of the flowcharts to reflect changes in department activities, use of the flow charts for identifying performance improvement changes, and use of the flow charts for measurement development. The flowcharts developed are presented in Appendix C.

The action team took primary department activities and broke them down into smaller activities, again with inputs, outputs, suppliers and customers shown. After completing the flowcharts, the action team posted them for department examination and input. Figure 4.4-1 shows the flow chart developed for the department detail design activity.

Assumptions

1. 5-10%/year growth in department size
2. No major organizational changes
3. Stable budget for training equipment
4. No major changes in spec requirements and evaluation criteria
5. Continued autonomy for company

Guiding Principles

- o In order to maintain our competitive position with a shrinking defense budget, we must continually strive to provide a technically superior product at a competitive price within the schedule constraints defined by our customer.
- o As a normal practice, each employee must evaluate the processes and consider alternatives to ensure the processes are the most effective and efficient means for accomplishing the task.
- o Be receptive to change, evaluate all changes for their merit.

Figure 4.3-3 Design/Drafting Department Assumptions and Guiding Principles

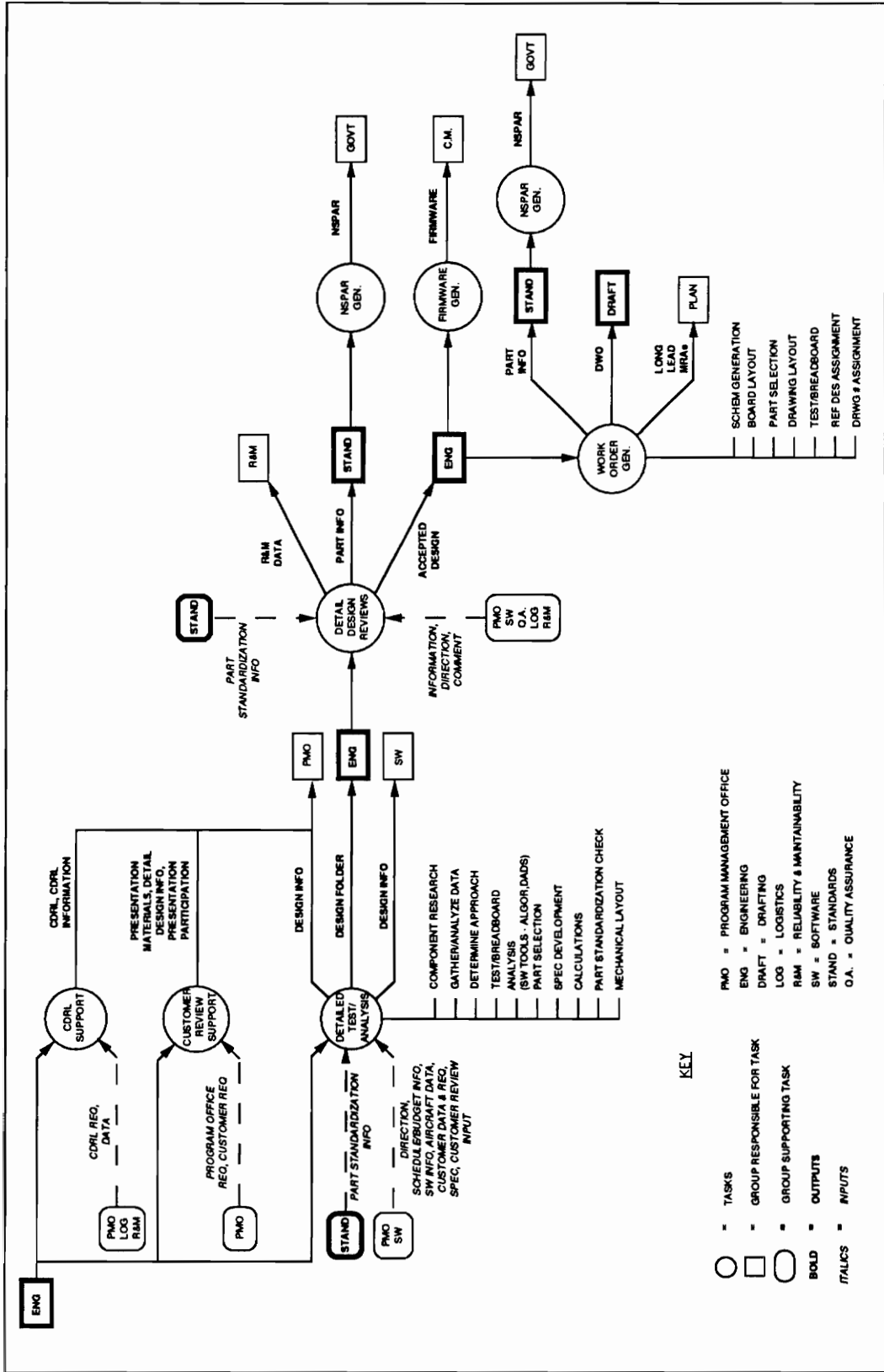


Figure 4.4-1 Detail Design Input/Output Analysis Flowchart

4.5 MEASUREMENT AND EVALUATION

After completion of the organizational system analysis, the planning team began work on department measurement concepts. During the planning phase the team had identified several department measurement related problems, including lack of measurement integration into daily activities and decision making based primarily on intuition or experience rather than data. An example of this occurred during the process enhancement project. Decisions to change company forms and add standardization practices were largely based on experience and problem history rather than actual measurement data. It was the planning team's objective to eliminate these problems.

4.5.1 PERFORMANCE MEASURE DEVELOPMENT

The planning team concentrated first on measurement development. Two levels of measures were identified. The first level was department performance measures. These measures would indicate department performance trends, aid decision making, and show impacts of improvement changes to department activities. Second level measures included detailed data or measures related to specific department activities or improvement projects. For example, pareto analysis data used to determine what types of drawing errors contributed most to drawing changes. The planning team established a requirement that performance measures would be continuously maintained. Data collection for specific improvement projects, however, would be allowed to stop once improvement changes had been made and impact verified.

The planning team selected a Nominal Group Technique (NGT) format meeting to develop initial department performance measures. The team selected the NGT format because it provided a highly structured, participative approach to idea generation. This format would allow department members from different sections and levels to communicate and work together in a structured,

organized manner. Results from the session would reflect a group consensus and provide a ranked listing of department performance measures. The NGT format also avoided a "free for all" environment typical of unstructured meetings, yielding quality output in an efficient manner.

The planning team selected ten department members to participate in the NGT session. Participants included electrical, mechanical, and drafting personnel. Participants of varying experience levels from recently hired, to greater than 10 years were also selected. In addition, the department supervisor participated. The planning team and department supervisor felt that this cross section of job type and experience would provide the best results from the NGT session.

None of the participants had ever experienced an NGT format meeting before. To prepare participants for the NGT session, the planning team distributed a briefing package to all participants one week before the session. A copy of the briefing package is contained in Appendix D. The package included the following:

- 1) A brief discussion of the departments objectives for integrating a measurement and improvement process into the department.
- 2) A list of the department short term and long term goals and objectives, assumptions, and guiding principles.
- 3) A discussion of measurement fundamentals and performance criteria, including an organizational input analysis chart of the department and a set of measurement criteria guidelines.
- 4) A list and description of the improvement projects worked on prior to the NGT session.
- 5) A description of the NGT meeting format.
- 6) A response sheet for questions concerning any of the packet information.

A task statement for the NGT session was selected by the planning team and department

supervisor. Because this was the department's first attempt at developing and integrating formal measures into its management process, the team decided to initially limit focus to two performance criteria, quality, and efficiency. These performance criterion were identified from Sink's seven measures of organizational performance. The task statement developed read:

**"Identify specific department performance measures indicating
Quality and Design/Drafting Process Cycle Time"**

This task statement was also supplied to the NGT participants in the briefing package.

The NGT session began with an introduction and overview of the briefing package materials. The purpose and expected results of the meeting were discussed to provide participants with an understanding of what was to take place during the meeting and what outcomes were expected. The new department guiding principles, goals, and objectives were presented to show cause and direction for the department's improvement efforts. The NGT format was presented to remind all participants the steps and rules of the NGT format meeting. The participants were also told that action teams would be formed at the end of the meeting to perform several activities, including development of measurement system guidelines, development of an improvement suggestion system, and analysis and implementation of the NGT session outputs.

After the introduction and discussion, the task statement was presented to the group and several members were asked what they thought the statement meant. Minor discussion ensued as to the meaning and ultimate wording of the task statement. After this discussion the participants felt they had a common understanding of the statement and elected to leave the statement unchanged.

Next the silent generation phase of the NGT session began. All participants were asked to respond to the task statement, writing their ideas on paper without discussion. Fifteen minutes was allocated for this phase of the session. Participants were advised that they could add to their list

at any time.

With the completion of the silent generation phase, the round robin phase was initiated. Participants were polled one at a time for a response from their list. The response was then written down and posted on the wall for all participants to see. Clarification by the person responding was the only discussion allowed. Responses were solicited around the group until all responses were recorded. The results of this phase were excellent. The group of 10 participants generated over 50 responses to the task statement. Enthusiasm was high throughout this phase and everyone was attentive to the ideas as they were written and posted.

With all responses recorded, the clarification phase began. Each response was examined and either clarified, incorporated into another response, or deleted. Changes, incorporations, and deletions were by group consensus only. Because of the large number of responses this phase took longer than anticipated. Many ideas overlapped making combination and deletion decisions difficult. At times the discussion wavered from identifying the disposition of a particular response to general discussion of department problems related to the measure. Discussion had to be turned back to examining the particular response. By the conclusion of the clarification phase, however, the group had reduced the number of original responses to approximately 30. Several participants felt that perhaps the task statement had been too broad. Everyone agreed, however, that the results were impressive.

Upon completion of the clarification phase, the voting and ranking phase began. Participants were asked first to identify the eight responses they viewed as most important. They were then asked to rank the responses by first selecting the most important of the eight, then the least important of the remaining seven, then the most important of the remaining six, and so on. After ranking was complete, the session broke while the session leader and facilitator tallied the results. The results were then posted. A short discussion ensued about the list and where various responses had fallen. Everyone was intrigued with the ranking results. Figure 4.5-1 shows the results of the top ranked responses.

Group: Design/Drafting Department Number of Participants = 10 n (number of ideas asked for) = 8	Task Statement: "Please Identify Specific Department Performance Measures Indicating Quality and Design/Drafting Process Cycle Time."	IDEA	VOTES (8 = most important, 1 = least important)	TOTAL (number of votes/ total votes score)
		1) Internal Drawing Quality 2) Time Spent in Each Stage of Drawing Generation 3) Labor Hours Spent on Common Assembly Designs From Contract to Contract 4) Number of Engineering Change Notices Categorized by Reason for Drawing Change 5) Reusability of Past Designs 6) External Drawing Producibility 7) Rework Costs Due to Design or Communication Problems 8) Design and Drawing Generation Costs - Bid vs. Actual 9) Labor Hours Supporting Hardware Integration, Test, and Assembly 10) Number of Engineering Change Notices from Drawing Release Through First Production	8-8-8-7-7-7-6-6-1 8-8-8-7-7-5-3-1 8-7-6-5-4-4-3 7-6-6-5-5-4-4-2 8-5-5-4-3-2 7-7-6-5 8-6-5 6-5-3 6-4-3 3-2-2-2-2	9/58 9/54 8/43 9/43 6/27 4/25 3/19 3/14 3/13 5/11

Figure 4.5-1 NGT Session Results

From the list it can be seen that efficiency of the drafting function was considered to be one of the key performance indicators. Measure of drawing changes by quantity and type were considered to be quality indicators. Design efficiency was also ranked high on the list of performance indicators. This was no surprise in that these measures reflected two primary activities of the department, areas that many department members often expressed concern about.

At the conclusion of the meeting, discussion took place about the next steps to be taken. The group formed three action teams, a measurement evaluation team to evaluate the top ranked measures and decide how best to implement these measures into department activities, a measurement system development team to develop measurement system activities and guidelines, and an improvement suggestion system development team to provide a formal input mechanism for improvement ideas.

The three action teams began work immediately. The measurement evaluation team included two volunteers from the NGT session and two additional department volunteers. Members of the team represented both the drafting and engineering sections. Objectives for the team established at the NGT session included evaluation of the top ranked measures, selection of several measures for implementation, modification or clarification of measures to ensure usefulness and accuracy, and development of data collection methods to support these measures.

To reduce workload and increase the chances for successful implementation, the team chose to initially implement just two measures. The two measures selected were the drawing generation process cycle time, an efficiency measure, and the quantity of Engineering Change Notices (ECNs) by type, a quality measure. The drawing generation cycle time measure was selected because of its high ranking in the NGT results, and also for the potential availability of data. At the time of the NGT session, a drawing tracking system was under development. The action team realized this system would provide valuable data for the drawing efficiency measure. The ECN measure was also selected for its high ranking in the NGT results. Company wide interest in reducing ECN quantities for cost reduction made this measure an attractive choice. Data collection for the

measure would also be relatively easy.

After selecting these two measures, the team examined the drawing generation process input/output flowchart developed during the organizational system analysis. Small modifications to the chart were made to correctly reflect the current state of the drawing generation process.

Next the team focused on the drawing efficiency measure. The team decided that it was not enough to simply measure the time from an engineer's work order submittal to drawing signoff. This measure would act well as a general performance indicator, but would not provide enough detail for improvement change decisions. For example, it would not reflect the time it took for the drawing to reach the checking cycle or how long the drawing remained in the checking cycle. This data was necessary to accurately evaluate and change the drawing generation process.

The action team next identified that, with some modification, the department drawing tracking system could be adapted to measure the key steps in the drawing generation process. These data points were added to the drawing generation process flowchart and posted. Figure 4.5-2 shows the modified flowchart.

Data collection for the drawing generation measure would occur through the computerized drawing tracking system. Time and location information on all drawings was entered into a PC on a weekly basis and reports could be generated easily. When a new work order was submitted, a blank report sheet would be generated, listing all drawings related to that work package. As the drawings were generated and circulated from drafting, to checking, to signoff and release, the dates were filled in at each step. The report also contained the hours spent to complete the drawing as well as estimates of both hours to complete and the drawing release date. An example of a typical data report is shown in Figure 4.5-3.

While the data sheets provided accurate data about specific stages of the drawing generation process, the team realized that the performance measure, average time from work order submittal to drawing completion, required incorporation of additional factors to ensure its usefulness. These factors included drawing size, the number of drafting personnel, and the number of open work

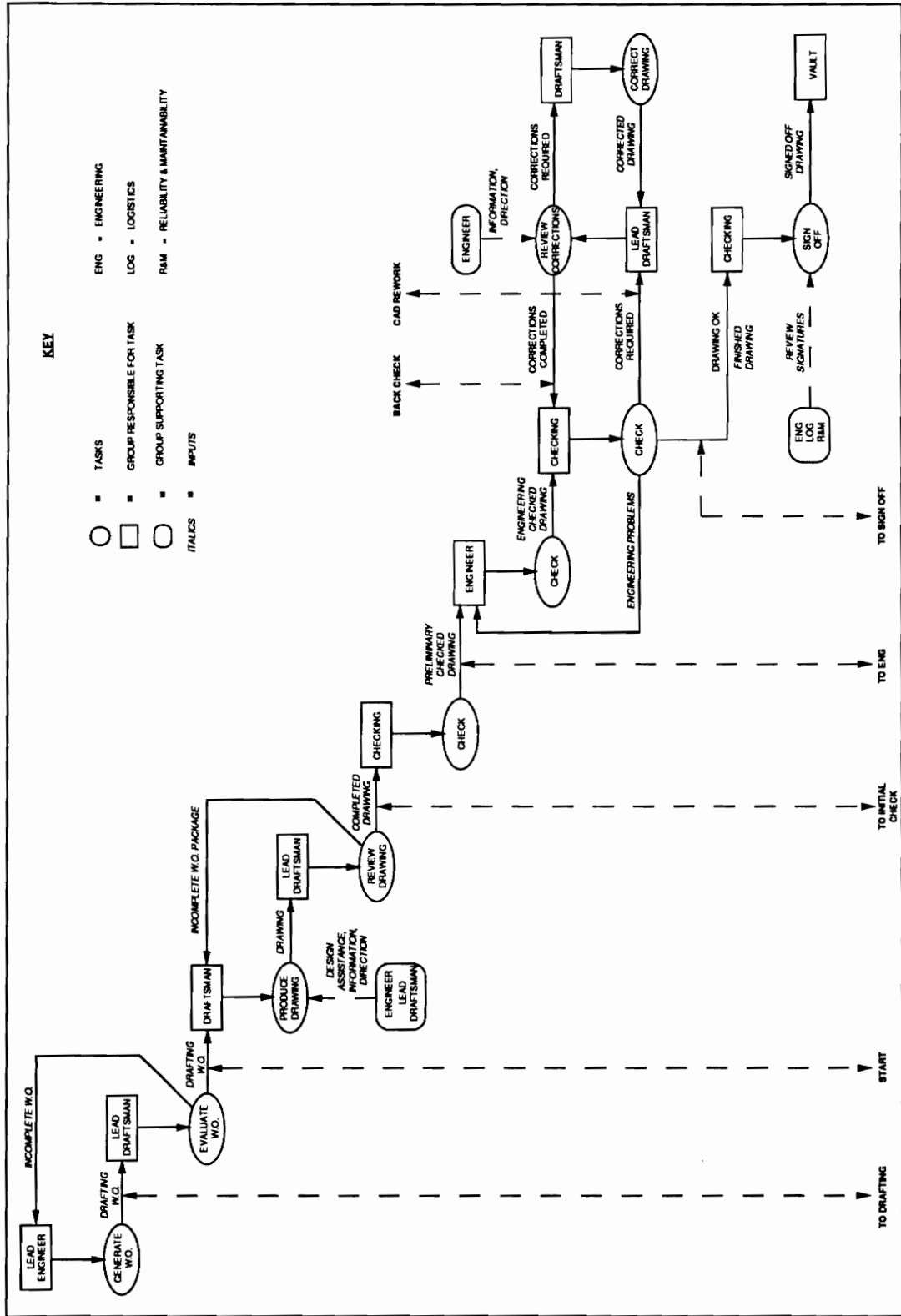


Figure 4.5-2 Drawing Work Order Tracking Flow Chart

WO NO.	DWG NO.	TITLE	DRAFTING	EST	EST	EST	ACT	INITIAL	TO	CHECK	CAD	BACK	TO
			YY.MM.DD	START	COMPLETE	HRS	HRS	CHECK	ENG	YY.MM.DD	REWORK	CHECK	SIGNOFF
			YY.MM.DD	YY.MM.DD	YY.MM.DD			YY.MM.DD	YY.MM.DD	YY.MM.DD	YY.MM.DD	YY.MM.DD	YY.MM.DD
L1M179	307950	SPACER, CLOCK	90.12.19			0.0	3.5	90.12.13	90.12.14	91.01.02		91.01.02	91.01.06
L1M179	307951	SPACER, CLOCK	90.12.19			0.0	1.5	90.12.14	90.12.17	91.01.02		91.01.02	91.01.06
L1M181	307953	MANIFOLD-ACTUATOR	90.12.19			0.0	0.0	91.01.07	91.01.21	91.01.21		91.01.30	91.02.01
ECP1181	307959	BRACKET, SIGNAL CONVERTE	91.01.16			0.0	0.0	91.01.16	91.01.28	91.01.28		91.01.29	91.02.01
L1M185	307964	COLLAR	91.01.29			0.0	0.0	91.01.29	91.01.29	91.01.29		91.01.30	91.02.01
L1M186	307967	CAP	91.01.30			0.0	0.0	91.01.31	91.02.01	91.02.01		91.02.01	91.02.01
L1M180	410552	CABLE ASSY-RS232C				0.0	2.0	90.12.20	90.12.21	91.01.02		91.01.02	91.01.03
L1M180	410553	MANIFOLD ASSY-G-SEAT	90.12.19			0.0	0.0	91.01.07	91.01.21	91.01.21		91.01.30	91.02.01
L1M181	410554	PLATE,BOTTOM-G SEAT	90.12.19			0.0	0.0	91.01.07	91.01.21	91.01.21		91.01.30	91.02.01
L1M181	410554	CABLE ASSY ECS CONTROL A	90.12.14	90.12.20	90.12.21	8.0	4.5	90.12.20	90.12.21	91.01.21		91.01.04	91.01.10
E071	410558	CABLE ASSY ECS CONTROL A	90.12.14	90.12.20	90.12.21	8.0	4.5	90.12.20	90.12.21	91.01.21		91.01.04	91.01.10
L1M181	410562	MANIFOLD,G-SEAT	90.12.19			0.0	0.0	91.01.07	91.01.21	91.01.21		91.01.22	91.02.01
L1M184	410563	DESICCANT DRIER ASSEMBLY	91.01.22			0.0	8.5	91.02.04	91.02.07	91.01.31		91.02.01	91.02.01
ECP1184	410564	CABLE ASSEMBLY- W289	91.01.28			0.0	0.0	91.01.31	91.01.31	91.01.31		91.02.01	91.02.01
ECP1183	410565	CABLE ASSEMBLY- W290	91.01.28			0.0	0.0	91.01.30	91.01.31	91.01.31		91.02.01	91.02.01
E101	410567	CABLE ASSY MEC POWER	91.01.16	91.01.16	91.01.16	8.0	5.0	91.01.30	91.01.17	91.01.17		91.01.28	91.01.28
M146	410569	LABEL, CIRCUIT BREAKER P	91.01.16	91.01.30	91.02.10	16.0	5.8	91.01.30	91.02.04	91.01.02		91.01.02	91.01.03
L1M180	410552	CABLE ASSY-RS232C	90.12.19			0.0	2.0	90.12.20	90.12.21	91.01.02		91.01.02	91.01.03
L1M181	410553	MANIFOLD ASSY,G-SEAT	90.12.19			0.0	0.0	91.01.07	91.01.21	91.01.21		91.01.30	91.02.01
L1M181	410553	MANIFOLD ASSY,G-SEAT	90.12.19			0.0	0.0	91.01.07	91.01.21	91.01.21		91.01.30	91.02.01
L1M181	410558	PLATE,BOTTOM-G SEAT	90.12.19			0.0	0.0	91.01.07	91.01.21	91.01.21		91.01.30	91.02.01
E071	410558	CABLE ASSY ECS CONTROL A	90.12.14	90.12.20	90.12.21	8.0	4.5	90.12.20	90.12.21	91.01.21		91.01.22	91.02.01
L1M184	410562	DESICCANT DRIER ASSEMBLY	91.01.22			0.0	0.0	91.01.07	91.01.21	91.01.21		91.01.22	91.02.01
ECP1184	410564	CABLE ASSEMBLY- W289	91.01.28			0.0	0.0	91.01.30	91.01.31	91.01.31		91.02.01	91.02.01
ECP1183	410565	CABLE ASSEMBLY- W290	91.01.28			0.0	0.0	91.01.30	91.01.31	91.01.31		91.02.01	91.02.01
E101	410567	CABLE ASSY MEC POWER	91.01.16	91.01.16	91.01.16	8.0	5.0	91.01.30	91.01.17	91.01.17		91.01.28	91.01.28
M146	410569	LABEL, CIRCUIT BREAKER P	91.01.16	91.01.30	91.02.10	16.0	5.8	91.01.30	91.02.04	91.01.02		91.01.02	91.01.03

Figure 4.5-3 Drawing Work Order Data Report

orders or drawings currently backlogged in the system. These qualifying factors were incorporated into the overall performance measure as shown in figure 4.5-4. The drawing backlog base number values was based on the acceptable backlog of work orders in the drafting section. The base number for drafting personnel was based on the acceptable number of CAD personnel working specifically on drawing generation. Data for the performance measure would be calculated on a monthly basis.

Next, the team addressed the ECN quantity measure. The team first analyzed the common reasons for generating a drawing change. From this analysis the team developed a list of ECN categories. Fourteen categories were identified relating to problem areas such as design quality, drawing generation, design performance, manufacturing, and vendor interface. By recording the number of ECNs generated in each category the team recognized that an effective pareto analysis could be accomplished. The department could then take action to reduce ECNs in the worst offending categories. ECNs were considered to be a large cost to the company. Reduction of ECN numbers would contribute not only to department performance but company performance as well.

The team developed a comprehensive set of guidelines for the ECN categories and distributed them to all engineers. The guidelines included a description of each category and several ECN examples. Engineers were responsible for assigning a category to each ECN when generated and recording the category on the ECN form. Data would be collected from ECNs returning to the department from ECN review board meetings. A copy of the ECN guidelines are shown in Appendix E.

In addition to tracking specific ECN types, the team specified a general performance indicator. This performance indicator tracked the number of ECNs generated per drawing for each contract. This indicator provided specific information about design and drafting quality. The team also specified tracking the number of ECNs generated per drawing type. For example, the number of ECNs generated on cable and electrical wiring drawings. Organizational improvements could then

$$\begin{aligned}
 \text{Average Drawing Generation Time} &= \frac{\text{Drawing Generation Time Drawing(1)}}{\text{Sheet Size Drawing(1)}} + \frac{\text{Drawing Generation Time Drawing(2)}}{\text{Sheet Size Drawing(2)}} + \dots + \frac{\text{Drawing Generation Time Drawing(n)}}{\text{Sheet Size Drawing(n)}} \\
 \text{Performance Indicator} &= \left(\frac{\text{Average Drawing Generation Time}}{\text{Number of Released Drawings (n)}} \right) \times \left(\frac{\text{Number of Draftspersons}}{\text{Base Number of Draftspersons}} \right) \times \left(\frac{\text{Base Number of Backlogged Work Orders}}{\text{Number of Backlogged Work Orders}} \right) \\
 \text{Performance Indicator} &= \frac{\text{Average Time Spent in Each Drawing Generation Stage}}{\text{Number of Released Drawings (n)}} \times \left(\frac{\text{Number of Draftspersons}}{\text{Base Number of Draftspersons}} \right) \times \left(\frac{\text{Base Number of Backlogged Work Orders}}{\text{Number of Backlogged Work Orders}} \right)
 \end{aligned}$$

Figure 4.5-4 Drawing Generation Cycle Time Measures

be made to reduce ECNs for the highest occurring drawing types. The ECN measures are shown in figure 4.5-5

4.5.2 MEASUREMENT SYSTEM DEVELOPMENT

At the conclusion of the NGT session, the measurement system development team also began work. The objective of the team was to identify primary activities in the measurement system process and develop a set of guidelines and procedures for using the measurement system. Critical issues the action team hoped to address included:

- How often data should be gathered and evaluated
- Who evaluates and validates data
- Who collects data
- Who prepares the data for presentation
- How often data is presented and to who
- Interface to an improvement intervention system
- When are performance trends reviewed and by who
- Providing a mechanism for introducing, evaluating, and modifying measures
- Who is accountable for specific steps in the measurement process
- What resources are required
- Teamwork emphasis
- Keeping the system simple

As part of measurement system guideline development, the action team also considered a set of measurement system objectives established earlier by the planning team. These objectives are listed in figure 4.5-6.

ECNs by Category Type

Total # ECNs Generated

ECNs by Drawing Type

Total # ECNs Generated

Total # ECNs Generated

(By Contract)

Total # Released Drawings

Figure 4.5-5 ECN Measures

Measurement System Objectives

- 1) Develop a system that is simple and cost effective.
- 2) Develop a system that is flexible and dynamic, allowing easy changes to both measurements and the system.
- 3) Develop a system that provides performance feedback to both department members and management.
- 4) Develop a system that promotes interest, innovation, participation, and a team philosophy with respect to improving department performance.
- 5) Develop a system that provides data that is clear, timely, and useful for decision making.
- 6) Develop a system that provides for periodic review of both measurements and the system.
- 7) Develop a system that provides well defined measurements which accurately portray trends in performance and that are arrived at through group consensus.
- 8) Devise data collection methods that are simple and fit easily into the day to day work environment.
- 9) Avoid trying to be too precise with measurements. Measurements should be simple and accurate enough to show trends.
- 10) Avoid focusing too much attention on a single measurement. A single indicator cannot portray performance within a complex departmental system.
- 11) Avoid measuring too many items at once. Keep the system simple while still meeting goals and objectives.
- 12) The system will receive continuous, enthusiastic management support.
- 13) Management will provide continuous feedback to department members as to how data is being used in management decisions.

Figure 4.5-6 Measurement System Objectives

The action team used Kurstedt's management systems model presented in Sink and Tuttle's Planning and Measurement in Your Organization of the Future as a guide for the measurement system development. The team felt the model identified three important phases in the measurement process. In the first phase, measurement techniques are used to produce organizational system data. In the second phase, data and measurements are displayed for feedback to the organization. In the final phase, organizational improvements are made based on the data. Measurement continues to determine the impact of these changes and the process repeats itself. The model is show in figure 4.5-7.

Building on this model, the action team developed a conceptual design for the measurement system. Key concepts from the model and the measurement system objectives list were incorporated into the design. These concepts included emphasis on data collection, data validation, measurement development, data and measurement display, measurement utilization for decision making, establishment of goals and objectives, measurement consistency with goals and objectives, and a measurement system evaluation and change mechanism.

Integration with the improvement suggestion system was at first a problem. The measurement system design did not provide a useable interface between the two systems. The measurement system development team worked with the improvement suggestion system development team to clear up this problem. It was first recognized that department measurement data would be utilized by department members to identify potential improvement projects whenever possible. Appropriate measurement data or performance indicators, however, might not always exist to support employee change suggestions and ideas. To ensure that changes were based on sound information, the measurement system and improvement suggestion system development teams established a requirement that all improvement action teams (called Responsible Action Teams or RATs) formed by the improvement suggestion system process would be required to follow measurement system activities and guidelines. This would ensure data collection and measurement development for all employee improvement suggestions to determine impact of the change on the department.

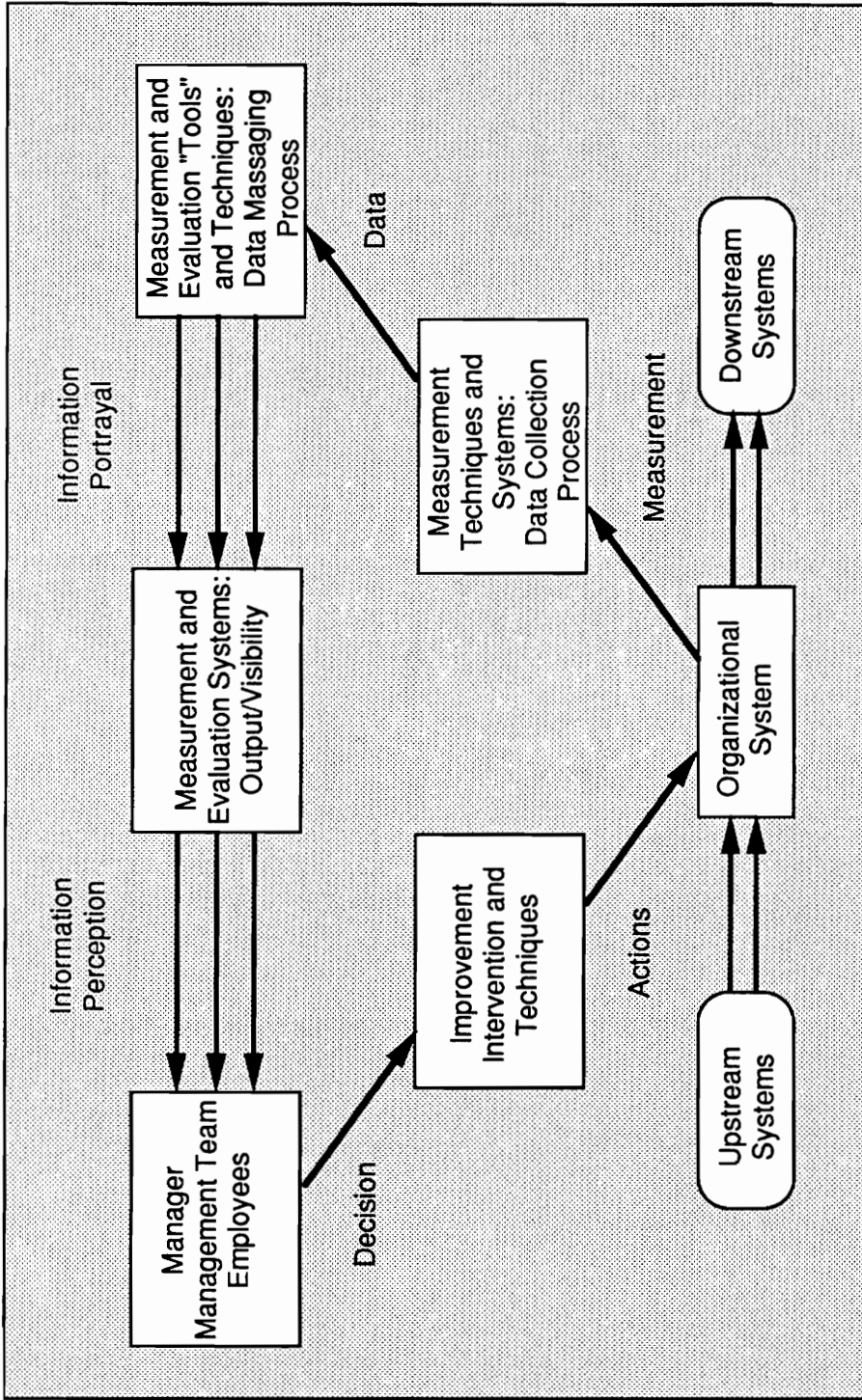


Figure 4.5-7 Management Systems Model

To ensure each RAT followed the measurement system guidelines, the measurement system development team identified the need for a department performance improvement support team. The purpose of the support team was to both assist responsible action teams with measurement activities and ensure that measurement system guidelines were followed. Additional responsibilities of the support team would include keeping communication between department members and management open, providing technical expertise and support, and coordinating with other departments when measurement or changes required inter-department team work. The support team would consist of four volunteers, with at least one electrical, mechanical, and drafting representative. Members would be rotated periodically to bring fresh views to the team.

The measurement system development team next developed a flow diagram of the measurement system conceptual design utilizing the same format as the organizational system analysis flow diagrams. The diagram outlined measurement system activities, inputs, and outputs, and responsibilities. The flow diagram developed is shown in figure 4.5-8.

The measurement system designed by the development team operates as follows. A responsible action team formed by the improvement suggestion system begins work on a proposed department improvement suggestion. The RAT establishes an objective for the improvement suggestion, identifies the area of the department affected or influenced by the improvement suggestion, and develops measures that will provide baseline and feedback data with respect to the proposed change.

Next, the RAT begins the data identification and collection process. The action team identifies data sources, data collection responsibilities, and how often data is collected and validated. Data collection begins. When the action team feels enough data has been collected a validity audit is performed. A decision is made whether the data is plentiful enough, timely, and meaningful. If there are problems, data collection is modified as required. If the data collected is valid then data analysis begins.

Data are compiled into a readable format and the appropriate measure is formulated. The

responsible action team then considers whether the measurement data is consistent with the improvement suggestions original objective. If not, measures and/or data collection is modified. Once the action team establishes that both data and measures are good, measurement displays and data reports are generated for the department and for management. Trend analysis is performed and if there is sufficient evidence to support the improvement suggestion it is implemented. If measurement data indicates an alternative is better, than the improvement suggestion is modified and then implemented. Data collection continues to determine impact of the organizational change. The improvement support team provides assistance as needed throughout this process.

The action team also considers the development or modification of department performance measures if required. The team develops new or modifies existing measures to ensure that performance impact of the organizational change is monitored. Data collection to support this performance measure becomes a permanent part of the department's normal activities. Detailed data collection in the area of change may be removed if it does not support the performance measure or is deemed no longer necessary.

Periodically the measurement system is evaluated. Areas that indicate problems are fixed. Areas that are too complex are simplified but not at the cost of losing valuable information.

After the flow diagram was completed, the measurement system development team constructed a set of guidelines to describe the measurement system activities in detail. These guidelines would then become a reference document for department members involved in department performance improvement efforts. A copy of these guidelines can be found in Appendix F.

4.6 IMPROVEMENT INTERVENTION SYSTEM

One of the realities of the department culture was its task oriented work ethic. Most department members felt comfortable identifying specific problems, solving them, and then moving

on to the next problem. This was exemplified by the process enhancement project where the team identified problems in the department activities and then developed solutions to alleviate those problems. Measurement data, however, was not used. This environment presented a potential barrier to the concept of developing performance measures and gathering measurement data before proposing improvement changes.

The performance management system planning team had identified this problem early in the planning phase. The planning team, however, felt that this cultural issue could be used as an advantage. An improvement suggestion system would provide department members with an organizational intervention mechanism, allowing department members to identify and implement department activities and procedure changes to improve department performance. Improvement projects, however would be integrally tied into the measurement system process. If data did not exist to support the proposed change, measurement development would be required. These ideas were conveyed at the conclusion of the NGT session.

After the NGT session, the improvement suggestion system development team began work developing a conceptual design for the improvement suggestion system. The team, consisting of both engineering and drafting personnel, identified several requirements for the system including development of a suggestion submittal form, emphasis on teamwork, a review process to ensure quality and consistency of suggestions with department goals and objectives, and emphasis on suggestion originator responsibility for improvement implementation. With these concepts in mind the team developed a flow diagram and a set of guidelines for the improvement suggestion system. Figure 4.6-1 shows the suggestion system process. Figure 4.6-2 lists the guidelines for the process.

The improvement suggestion system designed by the improvement suggestion system development team operates as follows. Improvement suggestions are submitted by department members to an appointed coordinator. After submittal, improvement suggestions are reviewed on a regular basis by a peer group, consisting of representatives from the mechanical, electrical, and

DESIGN/DRAFTING - IMPROVEMENT SUGGESTION SYSTEM

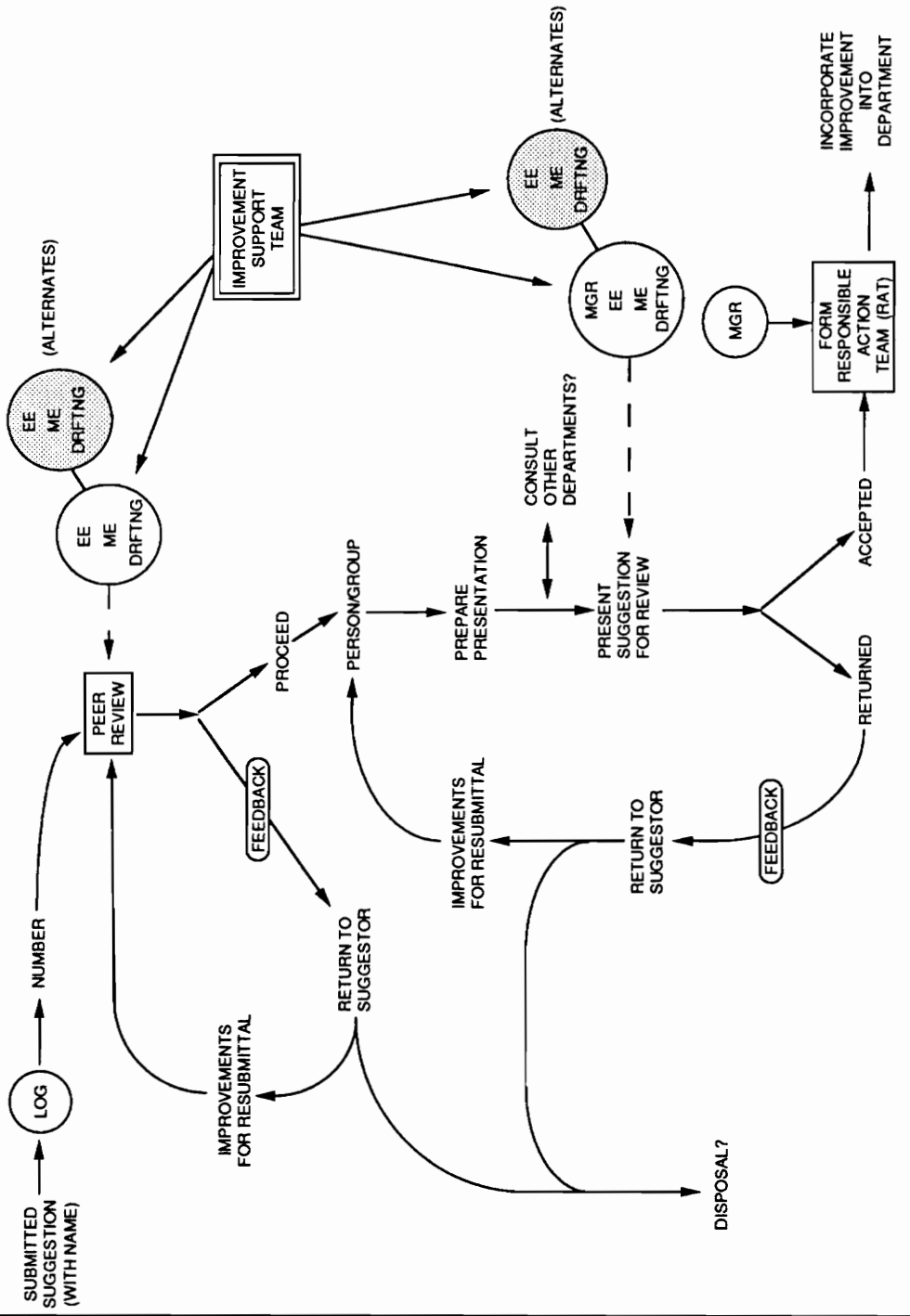


Figure 4.6-1 Design/Drafting Department Improvement Intervention System

Design/Drafting Department Improvement Suggestion System Flow Chart Description

- I Improvement suggestions shall be submitted by filling out the 'SUGGESTION LOG-IN' and 'SUGGESTION SUBMITTAL' forms. The log-in forms will be located in the same shelves as the other design/drafting department forms (i.e. ECN). Once the forms are completed, they are to be turned in to the log-keeper where they will be controlled.
- II All suggestions proceed to the peer review without name, so as to insure that the suggestion is reviewed upon its individual merits. No name will be associated with the suggestion (unless requested) until after the suggestion has passed the peer review.
- III The review team shall meet on a weekly basis, or as the amount of suggestions permits. The itinerary will be posted in a designated place. New suggestions will be reviewed, and presentations of suggestions will be heard during these meetings. All new suggestions must be submitted 48 hours before the next meeting. This will insure enough time for an itinerary to be posted.
- IV The peer review will consist of members of the Improvement Support Team.
- V The peer review team will review each suggestion upon its own individual merits. Due to the vague and vast nature of possible suggestions, strict guidelines will not be formalized. Each suggestion shall be reviewed and weighed against its own virtues.
- VI If the suggestion is deemed incomplete or unacceptable, the proposal will be returned to the log. From the log, the originator may find out the results of the review (or in person, if requested). In any case, the originator will be given feedback on the decision of the review. Under no circumstances will the review team dispose of the suggestion(s) themselves or return the suggestion without their comments or recommendations. If improvements/changes are needed, the suggester may make the necessary changes and resubmit the suggestion again for the peer review.
- VII Once the suggestion has been accepted by the peer review, the suggester will then be notified and asked to present his/her idea, in person, at the next meeting or at an agreed upon, scheduled date. If needed, any other affected departments shall be informed and asked to attend the presentation.
- VIII Presentations shall be limited to 15 minute time slots. During this time, the presenter(s) shall be responsible for explaining the idea, the impact to the company, savings or improvements of the suggestion, and possible implementations. Possible measures of the suggestion should be presented at the review.
- IX The presenter shall be responsible for implementation of the improvement.
- X As with the peer review, if the suggestion is deemed incomplete or unacceptable, the proposal will be returned. Under no circumstances will the review team dispose of the suggestion(s) themselves or return the suggestion without their comments or recommendations. If improvements/changes are needed, the suggester may make the necessary changes and resubmit the suggestion again.
- XI Once the suggestion has been accepted and all implementations have been agreed upon, the suggester(s) will meet with the department supervisor and proceed with the formation of a Responsible Action Team (RAT) The RAT will be responsible for the implementation of the suggestion, and instigation of possible measurements (with the aid of the Improvement Support Team).

Figure 4.6-2 Improvement Suggestion System Guidelines

drafting sections. The review board identifies suggestions that are incomplete or not well thought out and returns to them to the coordinator for distribution to the originators. The review board also passes suggestions focusing on larger, inter-department processes to management for action. The review board meets on a weekly basis to ensure quick response to suggestions.

The action team felt the review process was a necessary activity to ensure the quality and completeness of suggestions but also realized the cultural drawback of having a review board. The team realized department members might feel that suggestions were reviewed inconsistently or unfairly, resulting in suggestions not being submitted. To help combat this, the team proposed that a logbook would be kept by the coordinator. Suggestions would be logged by number. All suggestions would then be reviewed in anonymity, and no judgement based on the originator(s) could take place. Suggestions that were considered incomplete would be returned to the originators for changes.

After the review, originators of complete suggestions are notified and a 15 minute presentation to management and the improvement support team is scheduled. This presentation provides an opportunity for suggestion originators to talk through their ideas and scope out the size of the improvement project for management. Any problems identified are also worked out.

At this time, resource requirements are identified. If sufficient resources currently exist to begin the improvement project a Responsible Action Team (RAT) is formed and work begins. The team consists of the suggestion originator(s) and other members of the department if required. If sufficient resources do not exist, the improvement project is held until department members can be freed up. Under no circumstances is the suggestion thrown out.

One of the important aspects of the improvement suggestion system development team incorporated into the process is the emphasis on the originator(s) responsibility for the improvement project. This feature ensured that suggestions would be championed by the people who had originated the improvement idea. It would also prevent the problems associated with a typical "suggestion box" system where ideas are turned in and responsibility for action is placed on

management. The requirements of the system also promoted a team approach to solving problems. The system also provided a basis for a reward system by associating an improvement effort with a specific team of people.

After the flow diagram and guidelines for the improvement suggestion system were developed the team developed an improvement suggestion submittal form. On the form, the team required a problem statement identifying the improvement target, a description of the improvement idea, definition of measures to support the suggestion, and an estimate of the potential cost savings. A copy of the improvement suggestion submittal form is shown in Appendix G.

5. PERFORMANCE MANAGEMENT SYSTEM DESIGN IMPLEMENTATION EVALUATION

5.1 PLANNING

Strategic planning is a main component of the performance management system conceptual design presented in chapter three. Development of an organizational performance improvement plan takes place through a well defined, structured process. The planning process begins with the organization recognizing a need for performance improvement. An organizational assessment is performed, organizational and performance management system goals and objectives are established, and a formal performance improvement plan is constructed. Measures and milestones are identified to monitor plan progress. To ensure successful development and execution of the organizational performance improvement plan, accountability is established for both planning process activities and the organizational improvement plan itself. The scope of the plan covers lifecycle activities from system conceptual design through system operation and support. Teamwork, communication, and group participation are utilized to achieve greater cultural support and ownership for the performance management system. Above all, the development and implementation of the plan receives equal management support with other business plans.

Competition and other market pressures forced the company to consider cost reduction and performance improvement measures. The design/drafting department chose to implement a performance management system to meet this challenge. This decision was perhaps the most significant event in the performance improvement process. Without the identification of this need for change, the department would never have committed to the performance improvement work that followed.

The first step in the conceptual design planning phase is the establishment of a structured planning process. The department performance improvement planning team recognized the need for a structured planning process and attempted to identify critical steps within the process. The

planning team was successful in identifying the need for an organizational assessment, development of goals and objectives, education and training, and plan development. The planning team, however, was less than effective in defining the details and objectives of the planning process activities. For example, the team did not specifically outline a process for developing goals and objectives, nor did they address the existing cultural bias that goals and objectives were unimportant. As a result, this activity did not involve the necessary communication, participation, and emphasis required to establish support and interest for department performance goals.

Accountability and milestones for the planning process also were not firmly established. This was primarily due to the department's inability to fully commit dedicated resources to the plan development. Production problems, and daily work crisis contributed to interruptions and long periods of inactivity during the planning cycle. The result was a fragmented planning approach that reduced the quality of the planning process and prevented accountability for planning activities.

The department performance improvement plan also contained a number of problems. While the plan successfully identified critical activities such as organizational system analysis, education, performance measure development, and goal and objective development, the plan focused more on the performance management system development than on an overall department performance improvement plan.

In addition, activities were not sufficiently detailed to provide the department with a working plan. Instead, the plan simply listed the activities the department needed to perform and approximately what time frame the activities would occur. The result was development of a schedule rather than a descriptive planning document.

Other problems existed with the performance improvement plan. Measures were not established to monitor plan progress. Accountability for plan activities was not established. Activities and requirements after system implementation were not identified and plan assumptions were not developed.

In addition, the equality of performance improvement plan activities with other work activities

was not successfully established. Although, the education meeting held by the department indicated the importance of the performance management system development, this emphasis was not successfully sustained during the performance management system planning and development.

The department also should have made use of group participation in planning process activities. Increased department involvement would have generated a feeling of ownership for a department improvement plan, resulting in greater support and willingness to participate in performance improvement work.

Better communication of the department performance improvement plan and planning activity results to department members would also have resulted in increased support and awareness. Although the planning team attempted to increase communication to department members through office memos and informal dissemination of information, this method was not entirely effective. As a result, many employees did not take a strong interest in the ongoing activities.

In general, the planning process lacked much of the formal structure, detailed information, and quality activities necessary to achieve organizational support and significant planning effectiveness. Planning problems contributed to a less effective design and implementation process, reduction in long term commitment and department support, and the inability of the department to develop a quality, comprehensive performance improvement plan linked to organizational goals and objectives.

5.2 ORGANIZATIONAL ASSESSMENT

Organizational assessment is another primary component of the performance management system conceptual design presented in chapter three. Assessment activities include determination of the current organizational state, identification of organizational performance needs and requirements, conceptualization of a future organizational state, establishment of performance management system boundaries, and identification of cultural and environmental roadblocks to

performance improvement. Also tied to the assessment process is the development of organizational goals and objectives. These activities are undertaken as part of a structured process emphasizing communication, teamwork, and structured group techniques.

The performance improvement planning team was successful in identifying the need for an organizational assessment. Results of the organizational assessment contributed to decision making, measurement development, and performance management system design. The assessment, however, was not performed as part of a detailed, structured process. For example, the planning team formed a conceptual view of the current department state primarily through informal discussion and observation. Ideas about the organization were arrived at based on experience and understanding of department culture, environment, work ethic, operational difficulties, and activities.

The future characteristics of the department were arrived at in the same manner. Ideas generated included improvement of inter-department communications, greater participation in department performance improvement activities, increased use of teams, and increased understanding of department activities. In addition, department emphasis on continuous improvement, education in performance improvement concepts, and utilization of measures for decision making and monitoring performance were identified as desirable characteristics.

Although this process was informal, the planning team succeeded, at least conceptually, in identifying the current and future state of the department. Recognizing key concepts such as continuous improvement, measurement, understanding of department activities, education, and team emphasis as necessary building blocks for a successful performance management system contributed later to a better performance management system design.

The department also conducted a successful organizational system input/output analysis. A team approach was used, resulting in an effective quality output. Results from the activity were later utilized by management to gain better understanding of department activities and by NGT participants to develop performance measures.

Although the department's organizational assessment succeeded in several areas, lack of a structured assessment process reduced the quality and usefulness of assessment activity outputs. For example, ideas conceived by the planning team about the current and future states of the department were never recorded. Organizational needs and requirements were also not formally identified or recorded. Output from these activities should have been used as inputs to the department performance improvement plan, and goal and objective development activities.

Roadblocks to the performance management system were also not well defined. Although the planning team understood some of the potential cultural and environmental barriers, these ideas should have been recorded so that cultural support mechanisms could be designed and implemented. As a result, cultural support mechanisms were never formally addressed or incorporated into the performance management system design.

The development process for department goals and objectives could also have been more effective. An excellent set of department goals and objectives were developed by the department supervisor. They were not, however, linked to the vision of the department's future state. More importantly, goals and objectives were not developed through group participation or input. As a result department members felt no ownership for them. Had a participative goal development process been used, greater support and enthusiasm for department goals would have been generated.

Development of a detailed, structured assessment process would have helped eliminate some of these problems. Assessment activities would have been better defined, producing more useful, effective outputs. Teamwork, communication, and group participation could have been planned for and utilized to gain performance management system support and increase activity output quality.

5.3 MEASUREMENT AND EVALUATION SYSTEM

The performance management system conceptual design requires the development of a measurement and evaluation system. The objectives of the measurement and evaluation system include providing information for organizational improvement intervention decisions, revealing current organizational performance trends, and assisting in evaluating performance changes resulting from organizational improvement interventions. The development of the measurement and evaluation system includes the establishment of performance criteria for the organization as well as an organized system for collecting, evaluating, massaging, and displaying data.

Critical concepts in this process include evaluating data timeliness, usefulness, and accuracy, establishing accountability for data collection and evaluation, ensuring display data usefulness and clarity, incorporation of measurement and data collection into the day to day work environment, and development of performance criteria and measures. The measurement system should also contain self measurement and evaluation mechanisms.

The measurement and evaluation system developed by the department contained many of the characteristics identified in the conceptual design. This is greatly due to the quality of the department's measurement system development process. Objectives for the measurement and evaluation system were developed early in the performance management system planning phase, providing an effective design platform for the measurement system development action team during measurement system detail design. Knowledge of measurement concepts also contributed positively to the design.

In addition, the use of a structured group process, the Nominal Group Technique, for initial performance measure development was highly effective. This approach successfully brought together department members from different sections and levels and developed a list of over thirty design/drafting quality and efficiency performance measures.

The department also effectively used the enthusiasm generated at the NGT session. Action

teams were developed at the close of the session to address measurement and evaluation system design, improvement intervention system design, and the implementation of the performance measures. Action team motivation, productivity, and work quality were excellent.

The enthusiasm of the action team was evident in the quality of the measurement system detail design. Detailed flow charts and guidelines for the measurement system were developed. Important ideas such as data validation, measurement development, continuous measurement, measurement display, goal setting, and system self evaluation and change were incorporated into the design. The team was careful to interface with the improvement suggestion system and to include team building and department member responsibility in the measurement system activities.

The measurement system development team also identified a need for a department improvement support team to assist responsible action teams with improvement projects and to ensure that measurement system guidelines were being followed. The result was a detailed, robust measurement system design that addressed the original measurement system objectives.

Although the measurement system development process and measurement system design were successful, several problems still existed. For example, the department did not set forth a goal of establishing measures for other performance criteria. While the initial measures developed focused on quality and efficiency, no indication was made that the department would pursue the development of performance measures for other criteria. This objective should have been clearly stated in the department goals and objectives. As a result the department had still not addressed the issue of additional performance measures by the end of the research period.

In addition, the concept of department performance criteria was not effectively conveyed to the department. While performance criteria concepts were presented at the education meeting and in the NGT session briefing package, the department was largely unsuccessful in creating a general understanding of performance criteria and performance measurement. Thus, the measures developed in the NGT session were perceived more as methods of measuring specific department problems rather than measures based on a comprehensive set of department performance criteria.

The measurement system also failed to fully define a system evaluation and corrective action mechanism. Although this activity was specified in the measurement system guidelines, specific measures or evaluation criteria were not identified. Evaluation and corrective action is critical if the measurement system is to maintain effectiveness and should have been included as part of the design.

Although the measurement system process incorporated a large number of critical concepts, the system was initially perceived as too complex. For example, the measurement system process required a significant number of checking and evaluation activities during data collection, massaging and analysis. While these activities were included to assure usefulness and quality of output data, they added complexity to the measurement system process. Doubt existed within the department as to whether the system would be useful.

This perception represented a roadblock to the measurement system implementation. The measurement system development team addressed this issue by writing a brief explanation describing the necessity for these tasks. It is doubtful, however, whether this effectively addressed the perception problem.

At the conclusion of this research period the measurement system was not yet fully implemented. Evaluation of the operational effectiveness of the measurement system design will be a topic for further research.

5.4 IMPROVEMENT INTERVENTION SYSTEM

The conceptual design also requires an improvement intervention system. While the measurement system provides the necessary feedback to make improvement change decisions, the improvement intervention system provides a formal process for implementing these changes. Intervention system design is tailored to support the culture and environment of the organization. Characteristics of the improvement intervention system include utilization of measurement data,

ease of use, team emphasis, employee participation and employee responsibility.

The department addressed this design requirement through the development of a department improvement suggestion system. As with the measurement system, the department improvement suggestion system was also designed by an action team formed at the NGT session. The result was again a robust, quality design encompassing the concepts presented in the performance management system conceptual design.

The improvement suggestion system design team addressed a number of issues to ensure the effectiveness of the system. To make the system easy to use a suggestion submittal form was developed. The form was relatively simple but also required the originator to identify measures related to the suggestion, benefits of the suggestion to the company, and a problem statement. This helped ensure the input of well defined, quality suggestions.

For suggestion evaluation and implementation procedures the team carefully weighed department culture and system effectiveness. As a result, several requirements were identified. Incoming suggestions would be reviewed by a peer group to ensure their quality and filter out larger, inter-department suggestions for management action. Reviews were to be performed anonymously to avoid any perception of bias. Communication and quick feedback to department members were also emphasized by requiring the review group to meet regularly and post itineraries for review meetings.

In addition, personnel from each section, electrical, mechanical, and drafting were assigned to the review team to provide a broader knowledge base. Review team members were required to rotate regularly to avoid perception of bias and increase department member involvement. System requirements also specified that no suggestion could be rejected by the review team. The review teams sole purpose was to ensure quality of input suggestions.

Most important, the action team incorporated team emphasis and employee responsibility into the improvement intervention system. Suggestion originators were required to form teams to implement changes. All activities associated with the proposed change became the responsibility

of the this action team.

Although the improvement suggestion system design effectively addressed department cultural issues, system effectiveness, and system quality, some problems with the system existed. First, the suggestion system could be viewed by department employees as too complicated. This perception would effectively deter use of the system, resulting in few if any improvement suggestion inputs. An effective alternative to this system might be the use of an NGT session on a regular basis to determine what improvement interventions the department should implement.

Next, holding suggestion reviews and presentations, tracking suggestions, and providing logistical support for the system requires resource commitment. If the department is not prepared to support these resource requirements, the system will be useless. To determine economic feasibility the department could run the system for a trial period, measuring the cost of supporting the system versus the cost savings generated by improvement suggestions.

Finally, the system would have to follow its guidelines closely. Quick review and feedback of suggestions, communication to the department, and above all demonstration of management support for change proposals would be crucial to the success of the system.

At the conclusion of the research period the improvement intervention system was not yet fully implemented. Evaluation of the operational effectiveness of the improvement suggestion system design will be a topic for further research.

5.5 CULTURAL AND ENVIRONMENTAL SUPPORT

The conceptual design stresses the importance of developing cultural support mechanisms to ensure performance management system effectiveness. Cultural change is needed if the organization wishes to establish a bias towards performance improvement. In order to do so, the organization must identify cultural and environmental roadblocks early in the planning stage and formulate strategies and designs for support mechanisms.

Although cultural and environmental roadblocks were not formally identified, the department effectively addressed cultural issues in several ways. For example, the department used education as a cultural support mechanism. A department education meeting was held to present performance management concepts and discuss the need for the department to evolve into a continuously improving organization. This meeting was successful in increasing department member support and awareness of the performance management system.

In addition, the department utilized the positive cultural impact created by a previous department performance improvement project and the company's interest in TQM concepts to effectively launch the performance management system development. The cultural impact of this preliminary improvement project was particularly instrumental in initiating performance management system development activities.

The department also effectively addressed cultural issues in the design of the improvement suggestion system. Careful consideration of department culture led to specific system activities and requirements.

Both the department supervisor and the performance improvement planning team identified the need for a reward mechanism to support and emphasize performance improvement activities. Design of the system was scheduled after the measurement and improvement intervention system achieved stable operation. Although this had not yet taken place by the conclusion of the research period, the requirement for a reward system was not abandoned.

In general, however, the department was ineffective in addressing cultural and environmental issues affecting the performance management system. Cultural and environmental roadblocks were not specifically identified and addressed. Cultural change and support mechanisms were not included in the performance management system design. As a result, issues such as employee skepticism of management support, existing crisis work ethic and military environmental constraints were not addressed. By the conclusion of the research period, department member biases and constraints had not effectively changed.

5.6 EDUCATION

One of the support components of the conceptual design is education and training. The need to understand performance management, planning, cultural change, and measurement concepts is evident. Without this understanding, effective design, implementation, and support of an effective performance management system is difficult.

The department attempted to accomplish department member education on two occasions. Performance management and measurement concepts were first presented at the department education meeting. This meeting attempted to convey these concepts to department members to gain support for the performance management system and develop some of the knowledge required for later department improvement activities. The department also presented many of these same materials again to the NGT participants. Both times the department was successful in gaining some measure of understanding and support.

The department also effectively used members with performance management and TQM knowledge. A member of the original planning team possessed some training in these concepts. In addition, a member of the measurement system development team possessed some measurement and statistical training. Other company individuals with performance management experience and TQM knowledge were also consulted. The use of this knowledge contributed to some of the successes experienced by the department during the performance management system development.

In general, however, the educational process implemented by the department was insufficient. The primary reason for this was that the education process was not continuous. The initial education meeting should have been the first of several training sessions. Education should have been planned for throughout the performance management system development and implementation process.

5.7 MANAGEMENT SUPPORT

The performance management system received enthusiastic support from the department supervisor. When the supervisor was initially approached with the idea of a performance management system he was intrigued and supportive. This enthusiasm was instrumental in achieving the performance improvement work conducted by the department. Without this support, the performance improvement work would never have been initiated.

There were some problems, however. Management support was not always conveyed to the rest of the department. Management support both at the department level and at the company level needed to be more visible to department members, particularly since skepticism of management support was a cultural problem. Increased management involvement and periodic communication to the group would have been more effective. Also, establishing accountability for the performance improvement plan and demonstrating commitment to the plan would have raised enthusiasm and achieved better results.

5.8 COMMUNICATION, TEAMWORK, AND GROUP PARTICIPATION

One of the problems the department encountered was effective communication. While communication was attempted through such events as the department education meeting and memo generation, the department did not effectively communicate its own intentions with respect to performance improvement. For example, while the planning team was working on the performance management system conceptual design, information was not conveyed to the rest of the department. For the most part, the department was often in the dark about what was happening with respect to performance improvement activities. This reduced the level of commitment and support for the performance management system.

With respect to teamwork, the department was highly effective when teams were used. The

highest quality output was achieved through the use of action teams. For example, the I/O analysis, the measurement system development, and the improvement suggestion system development were all performed using teams. The quality of the output from these teams demonstrates the effectiveness of the team approach. The department, however could have better utilized the team approach by developing teams to address specific planning activities, for example.

Group participation could also have been better utilized. Goals and objectives were developed by the department supervisor and reviewed by the planning team. This process would have been better served by a group participative process for generating the goals and objectives. Group participation would have communicated the department's commitment and support for performance improvement and developed a sense of ownership for the performance management system. Group participation could also have been used early in the planning stages to address cultural issues and develop a vision of the organization's future state.

The department was very effective, however, in utilizing the NGT participative approach. As a whole, the NGT session was quite successful. The results of the meeting were informative and useful. It is doubtful that the large quantity or high quality of the results could have been achieved with an unstructured process, particularly with 10 people in attendance. Participants were enthusiastic throughout the session and seemed to fully appreciate the reasons for each NGT step as the session progressed. Many of the participants volunteered to lead action teams to continue performance management system work.

Some problems did exist with the session, however. Several participants felt that perhaps the task statement was too broad. This feeling was likely generated by a misunderstanding of the meeting intent. An attempt had been made in the briefing package and also during the introduction of the NGT session to emphasize that the department was searching for overall performance measures related to quality and efficiency to use for feedback and decision making. Many participants, however, focused on measures for specific problems with department activities rather than overall performance measures.

Two reasons can be cited for this. First, the participants were technically oriented and used to a problem solving environment. This led to a focus on specific problems within the department rather than developing a broader view of department performance. Second, the concept of measurement was difficult for most participants. Participants quickly identified areas that were easy to measure rather than deciding first what was important to measure.

Other problems with the NGT session included the size of the meeting. Ten participants for a first NGT session, particularly with this type of task statement, generated a large number of ideas, resulting in a long and difficult clarification phase. Another problem was preparation for the meeting. The briefing package was an excellent idea and was useful to a majority of the NGT participants. Many of the participants, however, did not utilize the entire week prior to the session to prepare. A meeting prior to the NGT session to discuss the briefing package materials may have yielded more precise task statement responses, reducing the clarification problems in the NGT session.

5.9 DATA COLLECTION AND ANALYSIS

Towards the end of the research period, the design/drafting department began collecting data to support some of the performance measures arrived at during the NGT session. While this preliminary data contained a number of problems, it still provided an opportunity to examine department performance and draw some conclusions about the data, the measures, and potential department changes. The following sections provide a brief description and analysis of the measurement development, NGT results and the performance measure support data.

5.9.1 NGT SESSION RESULTS

The task statement developed for the measurement development NGT session requested the identification of department quality and process cycle time performance measures. Figure 5.9-1 again shows the top ranked performance measure ideas generated at the NGT session.

From an examination of the NGT session results, it can be seen that the participants responded well to the task statement. In the top ten measurement ideas, six were related to quality issues, and four to efficiency issues. The quality and preciseness of the responses, however, varied. Some measures, such as internal drawing quality and external drawing reproducibility, were vague measurement concepts rather than usable performance measures. Other ideas, such as categorizing and measuring the number of Engineering Change Notices by type, and measuring different stages of the drawing generation cycle, represented a pareto analysis approach to pinpointing specific activity problems rather than identifying an overall department performance measure. The underlying concepts for each measure, however, reflected the department's firm interest in the performance of two primary department activities, assembly design and drawing generation.

5.9.2 MEASUREMENT DATA

The measurement evaluation team formed at the NGT session evaluated two of the top ranked measurement ideas. These included categorizing and measuring Engineering Change Notices by the reason for drawing change and measuring the drawing generation process cycle time. The team further refined these performance measure ideas to produce the measures identified in section 4.5.

Figures 5.9-2 and 5.9-3 show some of the preliminary data taken by the department supporting the ECN measures. Figure 5.9-2 shows the Engineering Change Notices generated each month

Group: Design/Drafting Department Number of Participants = 10 n (number of ideas asked for) = 8	Task Statement: "Please Identify Specific Department Performance Measures Indicating Quality and Design/Drafting Process Cycle Time."	IDEA	VOTES (8 = most important, 1 = least important)	TOTAL (number of votes/ total votes score)
1) Internal Drawing Quality			8-8-7-7-7-6-6-1	9/58
2) Time Spent in Each Stage of Drawing Generation			8-8-7-7-7-5-3-1	9/54
3) Labor Hours Spent on Common Assembly Designs From Contract to Contract			8-7-6-5-4-4-3	8/43
4) Number of Engineering Change Notices Categorized by Reason for Drawing Change			7-6-6-5-5-4-4-4-2	9/43
5) Reusability of Past Designs			8-5-5-4-3-2	6/27
6) External Drawing Producibility			7-7-6-5	4/25
7) Rework Costs Due to Design or Communication Problems			8-6-5	3/19
8) Design and Drawing Generation Costs - Bid vs. Actual			6-5-3	3/14
9) Labor Hours Supporting Hardware Integration, Test, and Assembly			6-4-3	3/13
10) Number of Engineering Change Notices from Drawing Release Through First Production			3-2-2-2-2	5/11

Figure 5.9-1 NGT Session Results

ECN		DA	DP	MP	MA	MI	PC	PE	PP	DWG	QC	QI	QM	V	X	
JAN		TOTAL:	11	22	2	5	11	8	-	1	13	1	-	5	3	4
		%:	13%	26%	2%	6%	13%	9%	0%	1%	15%	1%	0%	6%	3%	5%
FEB		TOTAL:	20	23	2	15	21	7	24	3	20	2	4	2	5	12
		%:	13%	14%	1%	9%	13%	4%	15%	2%	13%	1%	3%	1%	3%	8%
MAR		TOTAL:	15	29	1	5	7	8	2	8	17	-	1	5	-	3
		%:	15%	29%	1%	5%	7%	8%	2%	8%	17%	0%	1%	5%	0%	3%
CUMULATIVE		TOTAL:	46	74	5	25	39	23	26	12	50	3	5	12	8	19
		%:	13%	21%	1%	7%	11%	7%	8%	3%	14%	1%	1%	3%	2%	5%
RANK:		3	1	12	6	4	7	5	9	2	13	12	9	11	8	
			34%		19%		15%				14%					

Figure 5.9-2 Measurement Data - ECN By Category

MONTH	CONTRACT											DRAWING TYPE					TOTAL	
	A	B	C	D	E	A/I	CBL	WL	SCH	PL	SP	A/I	CBL	WL	SCH	PL		SP
OCT	COUNT: 41		25	50	41	21	113	25	8	2	16	14	178					
	%		23%	14%	28%	23%	12%	63%	14%	4%	1%	9%	8%					
NOV	COUNT: 34		36	22	7	8	63	13	11	9	11	-	107					
	%		32%	34%	21%	7%	59%	12%	10%	8%	10%	0%						
DEC	COUNT: 17		25	27	14	-	40	20	7	2	4	10	83					
	%		20%	30%	33%	17%	0%	48%	24%	8%	2%	4%	12%					
JAN	COUNT: 33		15	29	13	-	44	22	5	1	15	3	90					
	%		37%	17%	32%	14%	0%	49%	24%	6%	1%	17%	3%					
FEB	COUNT: 37		31	69	-	16	89	25	19	6	8	6	153					
	%		24%	20%	44%	0%	10%	58%	16%	12%	4%	5%	4%					
MAR	COUNT: 13		37	35	17	-	53	23	15	2	9	-	102					
	%		13%	35%	33%	17%	0%	52%	23%	15%	2%	9%	0%					
CUMULATIVE	COUNT: 175		169	232	92	45	402	128	65	22	63	33	713					
	%		25%	24%	33%	13%	6%	56%	18%	9%	3%	9%	5%					
	RANK:	2	3	1	4	5	1	2	3	6	4	5						

KEY

- A/I - Assembly/Installation Drawing
- SP - Specification/Procurement Drawing
- SCH - Schematic Diagram
- CBL - Cable Drawing
- WL - Wire List
- PL - Parts List

Figure 5.9-3 Measurement Data - ECN By Contract and Drawing Type

for each ECN category (category descriptions are given in Appendix E). The most reliable data occurred in March when the ECN categories were formally implemented as part of the ECN generation process. Data before March was taken by examining ECNs prior to the categorization process. Categorization of some ECNs was difficult since the original cause of the ECN was not always evident.

The trends indicated, however, can be considered relatively reliable. Taking into account the possibility of miscategorized ECNs the cumulative percentages should be accurate within five to seven percentage points for the combined design categories (DA, DP), combined manufacturing categories (MP, MA, MI), the drawing (DWG) category, and the program office directed change (PP) category.

Examining the cumulative totals and percentages in figure 5.9-2 provides some preliminary insight into the breakdown of ECN activity. For example, 15% of the ECNs generated during the three month period fell under the directed change categories (PC, PE). These categories indicated ECNs paid for by contract changes or utilization of previously generated drawings for new contracts. One in six ECNs could therefore be discarded as indicators of design and drawing quality problems and costs.

Another statistic showed that design related problems (DA, DP) contributed to 34% of ECNs generated over a three month period, followed by 19% for manufacturing related problems (MP, MA, MI). This statistic indicated the need to address design and manufacturing issues related to department activities and procedures.

To decrease design related ECNs, the department should consider requiring the consistent use of standard assembly designs, parts, design procedures and guidelines from contract to contract, greater transfer of expertise and knowledge from employee to employee, transfer of lessons learned on each contract, and better training, education, and use of current technology to alleviate design related errors. Some of these concepts were originally addressed by the department's Process Enhancement Improvement Project. As the standardized practices and databases

developed by this project become utilized, a decrease should be seen in the ECN design categories. The department is currently undergoing an upgrade in its level of technology which should also produce a positive performance trend.

The manufacturing related ECNs could also be reduced through standardization. For example, the development of common manufacturing and installation related notes might be successful. Implementation of the activities proposed for the reduction of design related ECNs would also help reduce many of the manufacturing related ECNs resulting from engineering and drafting error. Better understanding of manufacturing personnel needs and requirements when assemblies are built or installed also would help alleviate some of the manufacturing category ECNs. The implementation of a formal mechanism to provide better feedback and open communication to manufacturing personnel would be one solution.

The drawing error category (DWG) consisted of 14% of the total ECN count, the second highest individual category. Although this category represented only one in seven ECNs, this count is significant enough for the department to address some improvement considerations in this area. Again, standardization of practices, and access to standard databases would help alleviate some of these errors. Better use of technology could also help alleviate these types of drawing errors.

Figure 5.9-3 shows the number of ECNs generated by drawing type and per contract, the ECN total for each month, and the number of ECNs per active drawing for three existing contracts. This data was also arrived at by examining previously generated ECNs. Unlike the categorization of ECNs, however, there is little chance for error.

From this data, it can be seen that assembly and manufacturing installation drawings contained the highest incidence of ECN count, correlating with the higher incidence of design and manufacturing ECNs. This analysis, however, cannot be taken too far. Assembly and installation drawings make up the largest proportion of drawings generated, well over 50%. Thus, a higher incidence of ECN activity would be expected. Nonetheless this information does, to some extent, target assembly and installation drawings for possible improvement changes.

ECNs to cable drawings was the second largest count. This information is of particular interest to the electrical engineering section. It is a common perception that cable drawings are one of the most often changed drawing types. This data provides some support for this belief. Improving ECN count in this category would be relatively easy. Cable drawing format and requirements are fairly consistent from drawing to drawing, making them candidates for standard formats and guidelines.

Figure 5.9-3 also indicates the total number of ECNs generated on a monthly basis. Performance trends, however, cannot be inferred from this data. Fluctuations in ECN activity are tied to many variables. Products developed for company contracts are large, complex, multimillion dollar electronic devices. Often a contract only specifies the design and production of a single device. Product design, integration, test, and support usually occurs over a two year period or more. ECN count will vary during different product stages and also with the number of current contracts. These variations are unrelated to actual department performance. Thus, monthly ECN totals cannot be used to accurately indicate performance trends.

The measurement evaluation team attempted to address this problem by specifying the number of ECNs per drawing by each contract as a performance indicator. This measure is much more accurate because it indicates the relative impact of the ECN activity. This measure, however, does have problems. Changes in product stages from design, to manufacturing, to test, and support will cause fluctuations unrelated to actual drawing problems. In order to be accurate, the measure must be compiled at the end of a contract and then compared with performance on previous contracts. Thus, performance feedback may not occur for years, an unacceptable amount of time if the department wishes to link improvement actions to performance improvement progress.

To address this issue, the department should consider finding a shorter term performance indicator or a method that takes into account some of the fluctuations due to number of contracts and product development stages. The original measure, however, should not necessarily be abandoned since it does provide an excellent indication of design and drafting quality. The

department could also consider developing an aggregate measure of several different ECN related performance indicators. A technique such as the Multicriteria Performance/Productivity Measurement Technique (MCP/PMT) (Sink, 1985) could then be applied to integrate the separate measures into one performance indicator.

Figure 5.9-4 shows some of the preliminary data collected by the department supporting the drawing generation process cycle time measure. Data collected to generate the average drawing completion time came from the department's work order and drawing tracking system. Much of the data was suspect, however, since the system was immature and not yet stable. As a result, the average time spent in each stage of the drawing process for work orders was not yet available. The number of drawing releases was also suspect, although March data can be considered reasonably accurate.

Without accurate data and a past history of work order activity for a period of at least six months, it is difficult to draw any conclusions about performance trends. However, some problems with the performance measure itself can be identified. For example, the incorporation of the drawing complexity, number of draftsmen, and number of backlogged work orders qualifiers into the measure assumed a linear relationship between these factors and the average drawing development time. This is not likely the case. In addition, the complexity factor is based on the number of sheets in the drawing. While this effects the time to draw and inspect a drawing, it has no impact on the time the drawing sits at each stage of the drawing generation process. Thus, as the drawing generation cycle time increases, drawing complexity becomes less and less of a factor.

As a better approach, the department should consider the development of an aggregate measure addressing different performance characteristics and functions of the drawing generation process. For example, the department could track the size of the work order backlog, the number of drawings spending over two weeks at any one drawing generation stage, the number of times a draftsman must consult the engineer for work order completion, or the amount of actual drawing development and checking time versus the overall work order submittal to drawing release

JAN	<p># of CAD Personnel = 9 # of Drawings Released = 27 # of Backlogged Drawings = 273 # of Drawings With No Data Available = 8</p> <p>Average Drawing Generation Time = 6.6 weeks/drawing (without drawing size factored)</p> <p>Drawing Generation Indicator = 5.5 (with drawing size factored)</p> <p>Base # CAD Personnel = 8 Base # Backlogged Drawings = 100</p> <p>Performance Indicator = 2.3</p>
FEB	<p># of CAD Personnel = 9 # of Drawings Released = 9 # of Backlogged Drawings = 198 # of Drawings With No Data Available = 3</p> <p>Average Drawing Generation Time = 10.1 weeks/drawing (without drawing size factored)</p> <p>Drawing Generation Indicator = 7.7 (with drawing size factored)</p> <p>Base # CAD Personnel = 8 Base # Backlogged Drawings = 100</p> <p>Performance Indicator = 4.4</p>
MAR	<p># of CAD Personnel = 7 # of Drawings Released = 74 # of Backlogged Drawings = 221 # of Drawings With No Data Available = 10</p> <p>Average Drawing Generation Time = 17.9 weeks/drawing (without drawing size factored)</p> <p>Drawing Generation Indicator = 5.2 (with drawing size factored)</p> <p>Base # CAD Personnel = 8 Base # Backlogged Drawings = 100</p> <p>Performance Indicator = 2.1</p>

Figure 5.9-4 Measurement Data - Drawing Generation Cycle Time

time. Almost all of the data for these measures could be taken from the existing department work order and drawing tracking system. An approach such as MCP/PMT could then be utilized to integrate these measures into a single indicator to form a comprehensive performance measure.

6. CONCLUSIONS

6.1 DESIGN IMPLEMENTATION

The implementation period described in this report lasted for approximately one year. With respect to the original performance management system objectives, the department experienced several successes. A department measurement system and improvement intervention system had been designed and were ready for implementation. A department activity input/output analysis had successfully increased understanding of department activities and assisted directly in measurement development. Group participation had been utilized in an NGT format measurement development meeting with tremendous success. Action teams were used in several activities, resulting in high quality outputs. Furthermore the measurement system and improvement intervention system designs emphasized a team problem solving approach with responsibility placed at the employee level.

In addition, other successes occurred. Original design objectives set for both the measurement system and improvement intervention system were largely achieved, resulting in quality, robust processes and detailed guidelines. Initial performance measures were successfully identified, and the process of taking data initiated. A core group of department members began to understand and support the need for measurement data as a tool for department performance improvement. When the performance improvement effort began, the department was data poor. By the conclusion of the research period, however, data availability had increased and additional methods were being implemented to increase data levels.

The department also experienced a variety of failures. One of the original performance management system objectives required the education of department employees to promote understanding and ownership of the system. Although the educational presentation meeting raised the level of interest and understanding to a certain degree, and the NGT briefing package materials

contributed in part to the success of the NGT session, the educational process was not sustained. As a result, the department did not succeed in transferring knowledge to department members to increase understanding and support for the performance management system. In fact, by the end of the research period, many of the original concepts presented to the department had been forgotten.

The overall objective of creating a system to promote continuous measurable improvement in the department also was not achieved. While the department had taken steps in the correct direction, there are still many events that must take place before this objective is attained. For example, implementation of both the measurement and improvement suggestion system has yet to take place. While these systems have been designed with careful thought and effectiveness in mind, it is certain that the department will encounter problems during implementation. System effectiveness will need to be evaluated and corrective actions implemented. This process will take time, resources, and will likely be effected by outside factors such as company culture, and upper management support.

In addition, the culture of the department has yet to change. Department members were excellent at performing individual performance management design and development activities such as the input/output analysis, and the measurement system design. Department understanding of how these efforts fit in to a performance improvement plan, however, has not been achieved. The department must first instill this understanding, among a critical percentage of people, or else the system is likely to fail. Currently the department has fragmented pieces of the performance management system in place. These pieces must be pulled together into a working system through cultural change and education.

Additional problems occurred. The planning process initiated was not effective in developing a detailed, quality department performance improvement plan. This lack of a detailed plan contributed to problems in sustaining performance improvement work activity, and marshalling department support and understanding for the performance management system. Interruptions in

the improvement effort occurred frequently in response to company production crisis and personnel changes. As a result employees did not receive constant encouragement or emphasis on performance management system efforts.

The department also did not effectively develop and link department goals to the performance management system efforts. Department employees were not used to setting and achieving goals. Experience dictated that goals were typically not required nor was their accountability when goals did exist. This cultural barrier was not addressed. As a result, department members did not view the department goals and objectives developed as important. This also contributed to the lack of understanding and support of the performance management system.

6.2 ORGANIZATIONAL UNIT OF ANALYSIS

The organizational unit of analysis for this research was selected to determine possible impacts or problems in the performance management system implementation associated with a defense contracting, white collar, and department level organization. Each of these characteristics affected the department performance management system implementation to some degree.

Within the department, the cultural impact of the military contracting environment remained relatively low. While military contract restrictions and constraints continued to affect normal work activity, specific performance management system activities were largely unaffected by the environment. The perception that change was difficult due to military environmental constraints did not influence the level of effort during development and implementation activities.

A great deal of impact on the performance management system implementation occurred, however, from much larger market environment issues. The market conditions impacting the company level organization during the research period included increased competition, reduction in market size, and increased emphasis by DOD organizations on lowest bid awards for contracts.

Coupled with the generally low profit margin in the military market, these issues placed extreme pressures on the company as a whole to reduce costs.

A question was raised, however, about how to pay for performance improvement work. Performance improvement activity labor could not ethically be charged to a government contract. This left company profit dollars to fund efforts. Profits, however, were turned over to the corporate level organization. Capital budgeted back to the company typically went to bid and proposal and R&D efforts in order to win new contracts. Increased market competition, and decreased contract awards created a shrinking profit return. Overhead budgets were sharply curtailed, leaving little resource dollars for performance improvement efforts.

This market situation had serious effects on the department performance management system implementation. The high level of activity and effort required to initially design and implement the performance management system were not achievable because of resource constraints. Activities that would have benefitted from group participation such as goalsetting did not take place. As a result, the cultural support for the system was not obtained.

It is important to note, however, that by the conclusion of this research period, the issue of funding for performance improvement activities was being addressed both within the company and DOD contracting organizations. Trends indicated that performance improvement activities would soon be mandated within the company and hence become an allowable overhead cost. This long term results from this decision will benefit both the company and its customers.

The white collar, technically oriented environment existing in the department also impacted the performance management system implementation. The activities of the organization were fairly complex and not easily defined. This presented a significant problem to developing meaningful performance measures. The complexity of organizational activities meant that a large number of variables potentially affected the performance measure. Fluctuations in data could mean that the processes involved were not in control or simply that all the input factors were not considered in the measure development. This effect can be seen in the data gathered by the department.

From a cultural standpoint, department employees, particularly in the engineering section, were very problem oriented. People were usually quick to identify what was wrong with an activity or idea without giving time for the idea or activity to work. Everyone had their own idea of how problems should be handled or changes made. This cultural bias created perception problems with the measurement system and improvement intervention system designs. Questions were immediately raised about the need for specific activities, complexity issues, and procedures. This attitude represented a barrier to system implementation.

There also existed a problem with micro-engineering and overanalysis. For example, the measurement system design team had to continuously remind itself not to attempt to engineer every small aspect of the system. As it was, the guidelines for the system were fairly detailed. This problem also arose during the ECN category guideline development where long discussions ensued about the nuances of each category. Department members involved in performance measure development had to constantly remind themselves that only data trends were necessary, not 100% accuracy.

The low level and small size of the department created some problems as well. The initial perception was that a performance management system would be much easier to implement in a small, low level organization. It is evident from this case study, however, that implementation of the performance management system, even in a small department level organization is just as difficult. Although the performance management system development and implementation activities occurred without outside intervention or input, the department was still hampered by the market, culture, and environmental constraints of the company. In addition, the department experienced the same problems that a larger organization would have experienced such as resistance to cultural change, resource commitment difficulties and the ability to use group participation and teamwork.

6.3 ADDITIONAL DESIGN & IMPLEMENTATION GUIDELINES

The performance management system conceptual design presented in chapter three represents one approach to performance management system design and implementation. The process identifies key performance management system components such as a planning process, organizational assessment, measurement system and improvement intervention system. Factors affecting the system implementation are also identified and addressed, including culture, market environment, management support, and resource allocation. Although the design/drafting department used in this research did not fully perform all the activities identified in the conceptual design process, actions taken by the department and resulting successes and failures provide some additional guidelines for the performance management system design and implementation process.

To begin with, the organization should first attempt a performance improvement project using action teams and the NGT format meetings prior to the performance management system planning process. This activity will introduce group participation strengths, show the organization that change is possible, generate enthusiasm for change, and act as a spring board to the performance management system development.

The addition of an economic analysis activity prior to the planning process implementation would also be helpful. A quality planning process is critical to generating a successful performance improvement plan and galvanizing the organizations improvement efforts. Information generated in the economic analysis would assist the in the proper allocation of organizational resources to the planning process.

In addition, the development of clear guidelines and methods for funding performance management system design, implementation and support activities is desirable. Establishment of funding methods and guidelines would assure that all levels of management could fully support performance improvement activities within budget constraints.

Planning for group participation and team work should be considered at every step. The highest quality output during the department's performance management system development and implementation occurred from action teams or structured group techniques. In spite of the resource commitments required, the organization should consider the quantity and quality of output that can be achieved utilizing these techniques.

Specifically the organization should consider utilizing the NGT format meeting for organizational goal and objective development, roadblock identification, measurement development, and improvement intervention decisions. The enthusiasm and quality work resulting from the department implementation of the NGT indicates the worth of this technique for generating consensus ideas from a large, diverse group. The NGT sessions should also be used as spring boards for action teams.

As an organization gains experience and exposure to measurement concepts and techniques, more accurate and sophisticated performance measures can be developed. For the initial implementation of a performance management system, however, an organization should start with simple measures and obtain some small, measurable successes before attempting more sophisticated performance measurement techniques. The difficulty of develop meaningful performance measures for the first time is well documented by the design/drafting department. Starting with simple measures will allow the organization to gain confidence and ability in performance measure development.

Communication from management and from employees involved in improvement work to the rest of the organization should be a high priority throughout the performance management system development and implementation. Mechanisms should be in place to ensure that this occurs. The organization needs to be consistently informed about progress and activities to sustain enthusiasm and a sense of ownership for the performance management system.

Finally, the plan should be laid out such that there is at least one achievable milestone, no matter how small, per month. The continuity of the performance improvement process needs to

be maintained throughout system design, implementation, and utilization to ensure a sense of progress and commitment among employees. If the organization anticipates resource problems during a period, then activities should be broken down so that at least one activity can be completed during this period.

6.4 OPPORTUNITIES FOR FURTHER RESEARCH

This research presents a great deal of opportunities for further research. First, the case study organization has not yet fully implemented a working performance management system. Data gathering is in its initial stages, system components are not fully implemented, cultural change has not taken place, and the organization has not utilized measurement data to identify and evaluate changes. It would be valuable to continue observation of the organization until the system reaches a stable configuration. Additional implementation successes and failures would provide insight into the department's system component design and implementation.

Next, further analysis, testing, evaluation, and tuning of the proposed conceptual design is desirable. This research presents an initial baseline performance management system design. Further analysis and additional implementations in other organizations is required to refine and simplify the design.

The development of organizational assessment tools is also an opportunity for research. An established set of assessment tools would enable an organization to better perform the organizational assessment activity, increasing the potential for performance management system success.

Another opportunity for research is the development of guidelines and tools for organizational culture identification and cultural support mechanism development. Identifying cultural roadblocks and designing support mechanisms to alleviate roadblocks is difficult but necessary for performance management system success. A set of tools to assist the organization in this process would be

useful, particularly for white collar organizations.

Finally, further study in the application of the system engineering process to management system design is another opportunity for research. This research used system engineering design concepts in the performance management system design. Further analysis and application of the system engineering process in management system design could well lead to better, and more successful performance management system designs and implementations.

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APPENDIX A - ECN FORM



CMI: **ENGINEERING CHANGE NOTICE** DOC. CONTROL RCVD. INIT: _____ DATE: _____

REV. : _____ SHEET _____ OF _____
DRAWING NO. : _____

DRAWING TITLE :

JOB NO. _____

REASON FOR CHANGE:

ECN CLASS: I II

DASH NO. _____

NEXT ASSY. _____

DEVICE NO(S) _____

AFFECTS SER. NO(S) _____

TYPE OF CHANGE:

NORMAL

PRIORITY

PROG. CH

CM _____

AFFECTS:

PUBLICATIONS

SPARES

LOGISTICS

PROG CNTRL _____

NONE

MATERIAL DISPOSITION:

IS _____

QA _____

STANDARDS _____

DESCRIPTION/CHANGE :

GOVT REP _____

APPROVALS

DATE

<p>DESCRIPTION/CHANGE :</p>	
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APPENDIX B - EDUCATION MEETING PRESENTATION MATERIALS

**PROCESS ENHANCEMENT
MEASUREMENT CONCEPTS**

WHY MEASURE PERFORMANCE?

- **Support and Enhance Improvement**
- Measurement helps to determine:
 - group performance capabilities
 - how we are doing with respect to performance
 - effects of group procedure and process changes
 - areas to focus on for future improvement
 - where to place resources
- Measurement provides valuable feedback for decision making

WHAT WILL MEASURING PERFORMANCE DO FOR US?

- Assist in *identifying* and *evaluating* procedures and processes needing *change*
- Provide *positive* evidence of group *performance improvement*
- Provide accurate bidding information
- Provide information to help determine resource allocation
- Identify capital equipment or other budget needs
- If data is gathered, analyzed, and used properly possible outcomes could be:
 - Higher quality product
 - Labor waste reduction
 - Technical improvement
 - More competitive bidding
 - Increase in pride, team spirit, morale
 - Reduced cycle time

HOW WILL WE MEASURE?

- 1) Define the system to be measured
- 2) Identify initial areas of interest for study
- 3) Develop and evaluate measures
- 4) Establish data source locations
- 5) Devise data collection methods
- 6) Gather data
- 7) Validate data and evaluate measurements and measurement system
- 8) Publish data for group members and management
- 9) Modify measurements and measurement system if required
- 10) Review performance trends
- 11) Make changes to group processes, procedures, etc.; identify new areas of study
- 12) Repeat steps 3 - 10 continuously

WHY DO PERFORMANCE MEASUREMENT SYSTEMS FAIL?

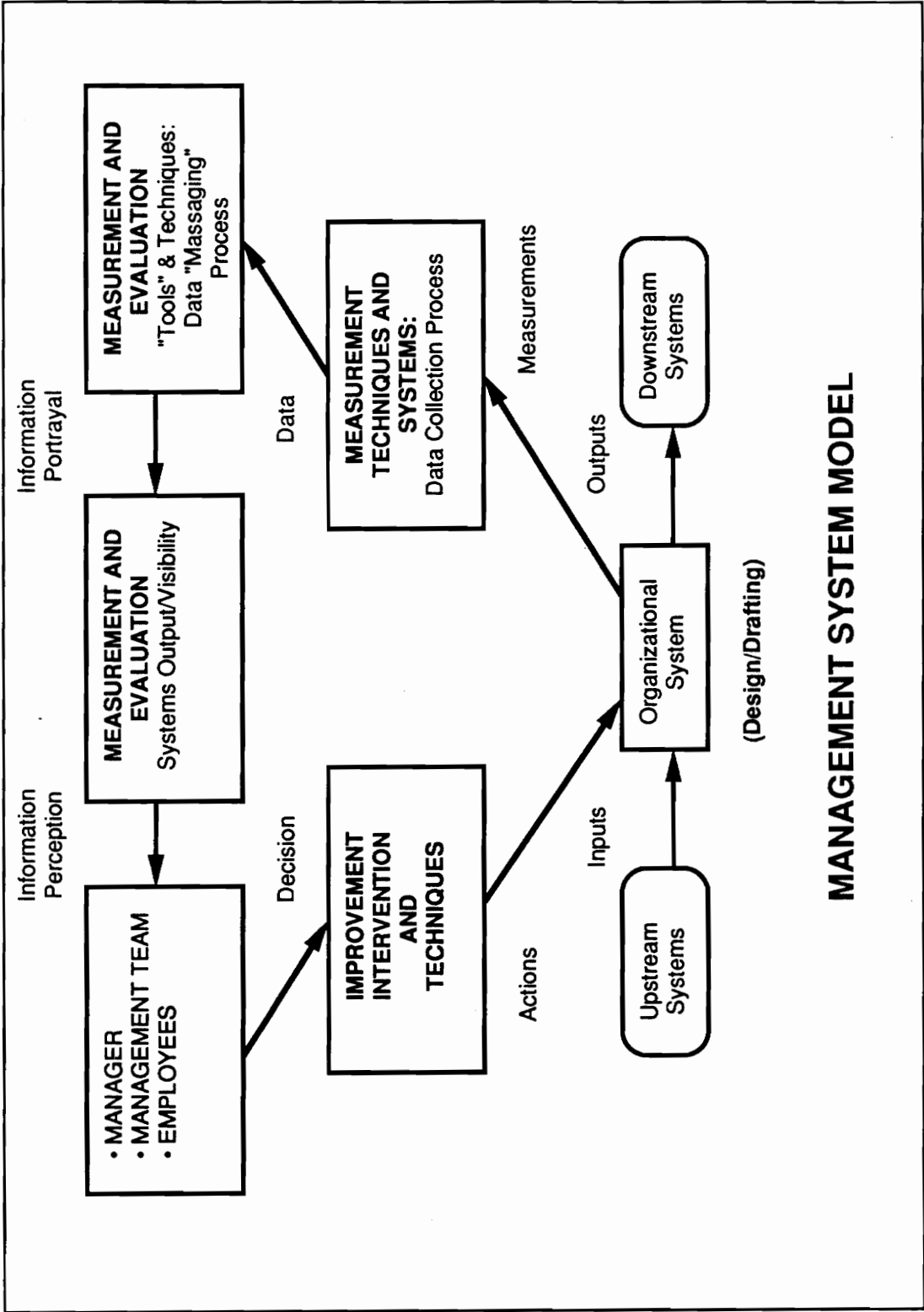
- Important performance criteria not clearly defined
- Attempting to measure too precisely
- Focusing too much on a single measure
- Lack of visible management support
- Lack of employee involvement
- Lack of feedback to employees
- Lack of group member education
- Believing that measuring alone will change performance
- Using measurement data to pressure or punish

PERFORMANCE IMPROVEMENT PROCESS HIGHLIGHTS

- **CONTINUOUSLY IMPLEMENTED MEASUREMENT SYSTEM**
- **CONTINUOUS EVALUATION AND MODIFICATION**
- **IMPROVEMENT SUGGESTION SYSTEM**
- **REWARD SYSTEM**
- **TEAM PHILOSOPHY**
- **NEW WAY OF THINKING AND WORKING**

The process enhancement system model on the next page provides a graphical representation of the continuous measurement, evaluation, and improvement cycle. The organizational system can be any group or department. For our purposes it is the design/drafting department. In more detail, the continuous cycle represents the following process:

- 1) *Develop performance measurements for areas of key interest*
- 2) *Determine data sources and data collection methods*
- 3) *Gather measurement data*
- 4) *Validate data to determine if it is useful, timely, in proper format; if a problem exists, modify measurements and/or system*
- 5) *Publish data for employees and for management*
- 6) *Evaluate performance trends; audit against established goals and objectives*
- 7) *Implement changes to organizational system (design/drafting) processes, procedures, etc.*
- 8) *Go to step 1*



MANAGEMENT SYSTEM MODEL

**ROLE OF GROUP MEMBERS AND MANAGEMENT IN THE
IMPROVEMENT CYCLE:**

- 1) ENSURE OUR JOBS GET DONE, ON TIME, IN SPECIFICATION, WITHIN BUDGET
- 2) CONSTANTLY IMPROVE PERFORMANCE

The organizational system model is shown below. Definitions and examples of each box follow. The model is important when thinking about measurement and ways to improve our processes, procedures, etc. The upstream systems are our suppliers (production control, purchasing, program office, ...) providing us with inputs (data, information, requests, ...). We use the inputs as part of our daily work and in turn generate outputs (data, information, drawings, ECNs, ...). The outputs are then supplied to our downstream systems (production control, purchasing, program office, ...) which can be thought of as our customers. It is important when considering changes to our processes that we understand what is needed from our suppliers, and what our customers need. Communication and teamwork within the group and with other groups is essential. It is important to understand our inputs, our processes, and our outputs when defining our performance measurements.



ORGANIZATIONAL SYSTEM

(PRODUCT DESIGN)

Upstream Systems - any organizational system product design receives inputs from

- Examples:
- In-process Inspection
 - Manufacturing
 - Configuration Control Board
 - Program Office

Downstream Systems - any system or person that receives outputs from product design

- Examples:
- Purchasing
 - Production Control
 - Program Office
 - Manufacturing

Inputs - any resource acquired by product design

- Examples:
- Labor to perform tasks
 - Requests for ECNs
 - Requests for data/information
 - Request for design

Outputs - any resource delivered by product design to another organizational system

- Examples:
- Drawings
 - Completed Designs
 - Data/Information
 - Completed service tasks

Transformation processes - major activities or transformations that are made to convert inputs into outputs

- Examples:
- Design process
 - ECN generation process
 - Drafting process

PERFORMANCE CRITERIA

Developing meaningful measurements is a difficult task. It requires detailed knowledge of the inputs, processes, and outputs of the system under study. It also requires defining a set of comprehensive criteria by which to judge performance.

Researchers in the fields of total quality management, performance measurement, and other related fields have developed a set of comprehensive criteria to measure performance. This set of criteria includes effectiveness, efficiency, productivity, quality, innovation, quality of work life, and profitability/budgetability. If measurements are taken in at least a majority of these areas it will provide a better overall view of the group performance. This does not necessarily mean we should measure in all these areas all the time. If our current objective is to improve quality related items, or to study the ECN process, or study the work order process, then measurements might be concentrated in only a few of the seven areas.

We do not want to take too many measurements at once as this could become cumbersome. We also do not want to focus on a single measurement as an indicator since the design/drafting processes are much to complex. The key is to make the measurement process comprehensive but simple. Definitions and examples of each of the performance criteria follow.

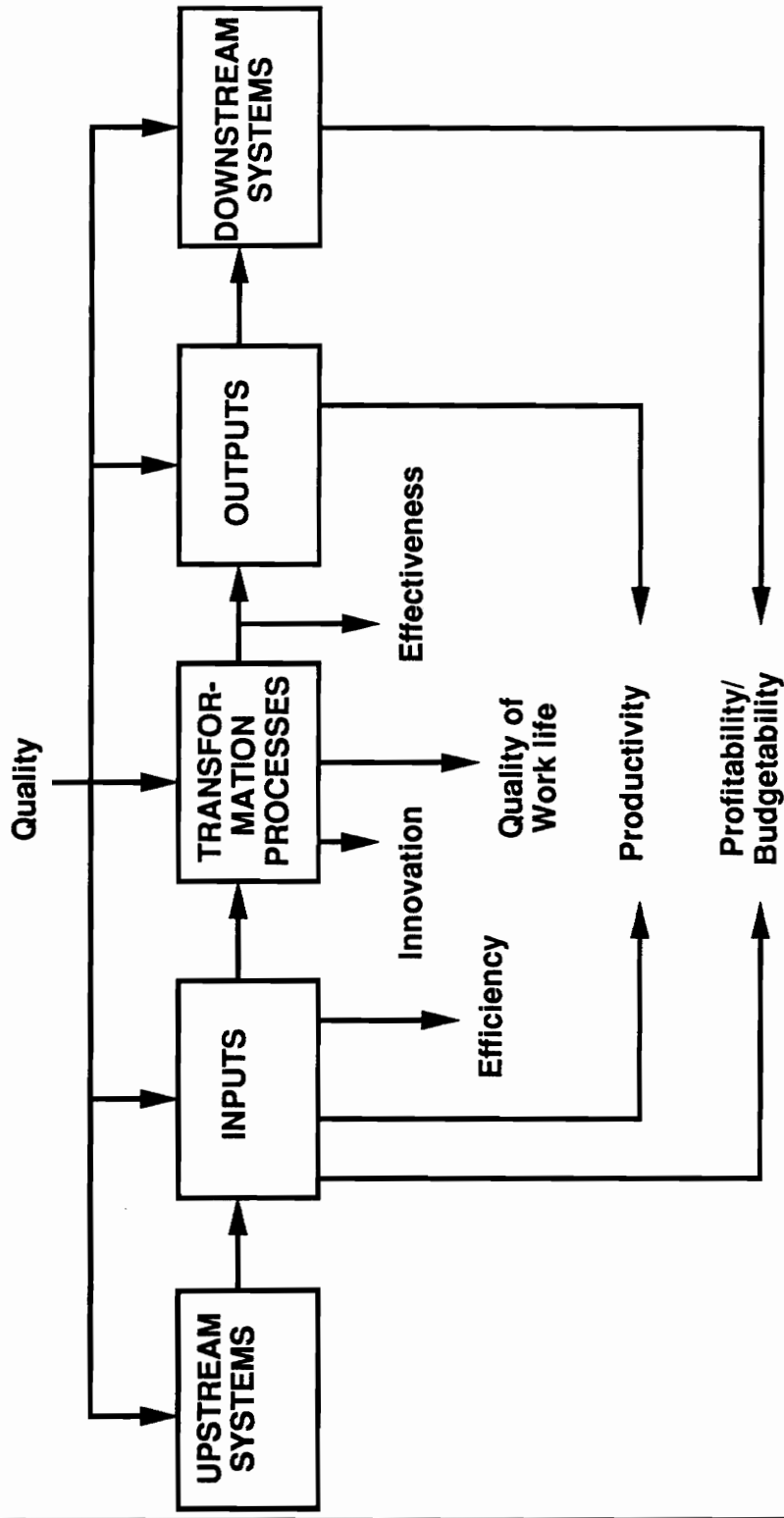
PERFORMANCE CRITERIA

<p>Effectiveness - degree that the system accomplishes the "right" things, on time, within the quality requirements specified</p>	<p>- measure: <u>actual output</u> expected output</p> <p>example: <u>actual number of released drawings / time</u> expected number of released drawings/time</p>
<p>Efficiency - degree to which the system uses the "right" things at the "right" time</p>	<p>- measure: <u>resources expected to be consumed</u> resources actually consumed</p> <p>example: <u>drafting labor hours estimated</u> drafting labor hours used</p>
<p>Quality - degree to which system conforms to requirements, specifications, or expectations - critical in all stages of department resource and process flow</p>	<p>- measure: various formats</p> <p>example: number of ECN's generated because of QC rejections</p>
<p>Productivity - relationship between group outputs and group inputs</p>	<p>- measure: <u>quantity of outputs</u> quantity of inputs</p> <p>example: <u># of panel assembly designs complete</u> labor hours expended</p>
<p>Quality of Work Life - way group members "feel" about social and technical aspects of their system and environment</p>	<p>- measure: various formats</p> <p>example: # of valid requests for needed tools and equipment</p>
<p>Innovation - creative process of changing to successfully respond to pressures, challenges, and opportunities</p>	<p>- measure: various formats</p> <p>example: # of new design ideas implemented to improve training systems/ year</p>

Profitability/Budgetability - relationship between budgeted costs and actual expenses

budgeted costs budgeted cost to incorporate ECNs
- measure: actual expenses - example: actual cost to incorporate ECNs

The diagram below shows where each of the seven areas fit into the organization model.



ORGANIZATIONAL SYSTEM AND SEVEN PERFORMANCE CRITERIA

Measurement System Purpose and Objectives

PURPOSE:

The purpose of developing a performance measurement system is to provide the Design/Drafting department with a tool that can continuously measure key areas of department performance such as quality, effectiveness, efficiency, productivity, innovation, and quality of work-life. Data collected by the system in these areas will:

- 1) Provide feedback to department members and management about changes in department performance.
- 2) Provide a decision making tool when considering procedure and policy changes, performing manloading tasks, and determining bid and proposal information.
- 3) Highlight areas of improved performance as well as areas requiring future focus.
- 4) Promote interest and contribution from all members of the department and management in improving quality, effectiveness, efficiency, productivity, innovation, and quality of work-life within the Design/Drafting department.

OBJECTIVES:

- 1) Develop a system that is simple and cost effective.
- 2) Develop a system that is flexible and dynamic, allowing easy changes to both measurements and the system.
- 3) Develop a system that provides performance feedback to both department members and management.
- 4) Develop a system that promotes interest, innovation, participation, and a team philosophy with respect to improving department performance.
- 5) Develop a system that provides data that is clear, timely, and useful for decision making.
- 6) Develop a system that provides for periodic review of both measurements and the system.
- 7) Develop a system that provides well defined measurements which accurately portray trends in performance and that are arrived at through group consensus.
- 8) Devise data collection methods that are simple and fit easily into the day to day work environment.
- 9) Avoid trying to be too precise with measurements. Measurements should be simple and accurate enough to show trends.

- 10) Avoid focusing too much attention on a single measurement. A single indicator cannot portray performance within a complex departmental system.
- 11) Avoid measuring too many items at once. Keep the system simple while still meeting goals and objectives.
- 12) The system will receive continuous, enthusiastic management support.
- 13) Management will provide continuous feedback to department members as to how data is being used in management decisions.

Department Goals:

One to Three Months:

- 1) Implement a useful performance measurement system.
- 2) Design an improvement suggestion system and incorporate into process.
- 3) Acquire data that will show before effects of Process Enhancement Team efforts
- 4) Increase interest, participation, contribution, pride in achievements, and a team philosophy in the department with respect to performance.
- 5) Complete process enhancement project efforts.

Three to Six Months:

- 1) Develop reward system.
 - Department activities
 - Individual
 - Equipment
- 2) Acquire data that will show after effects of Process Enhancement Team efforts.
- 3) Update new manuals from project as required.

Six Months to One Year:

- 1) Make performance improvement part of out everyday business.
- 2) Make measurement system output an integral part of department decision making.
- 3) Increase interest, participation, contribution, pride in achievements, and a team philosophy.
- 4) Propose 1991 plan, budget, schedule.
- 5) Improve performance

ASSIGNMENT:

**PLEASE ANSWER QUESTIONNAIRE AT BACK OF
HANDOUT**

QUESTIONNAIRE

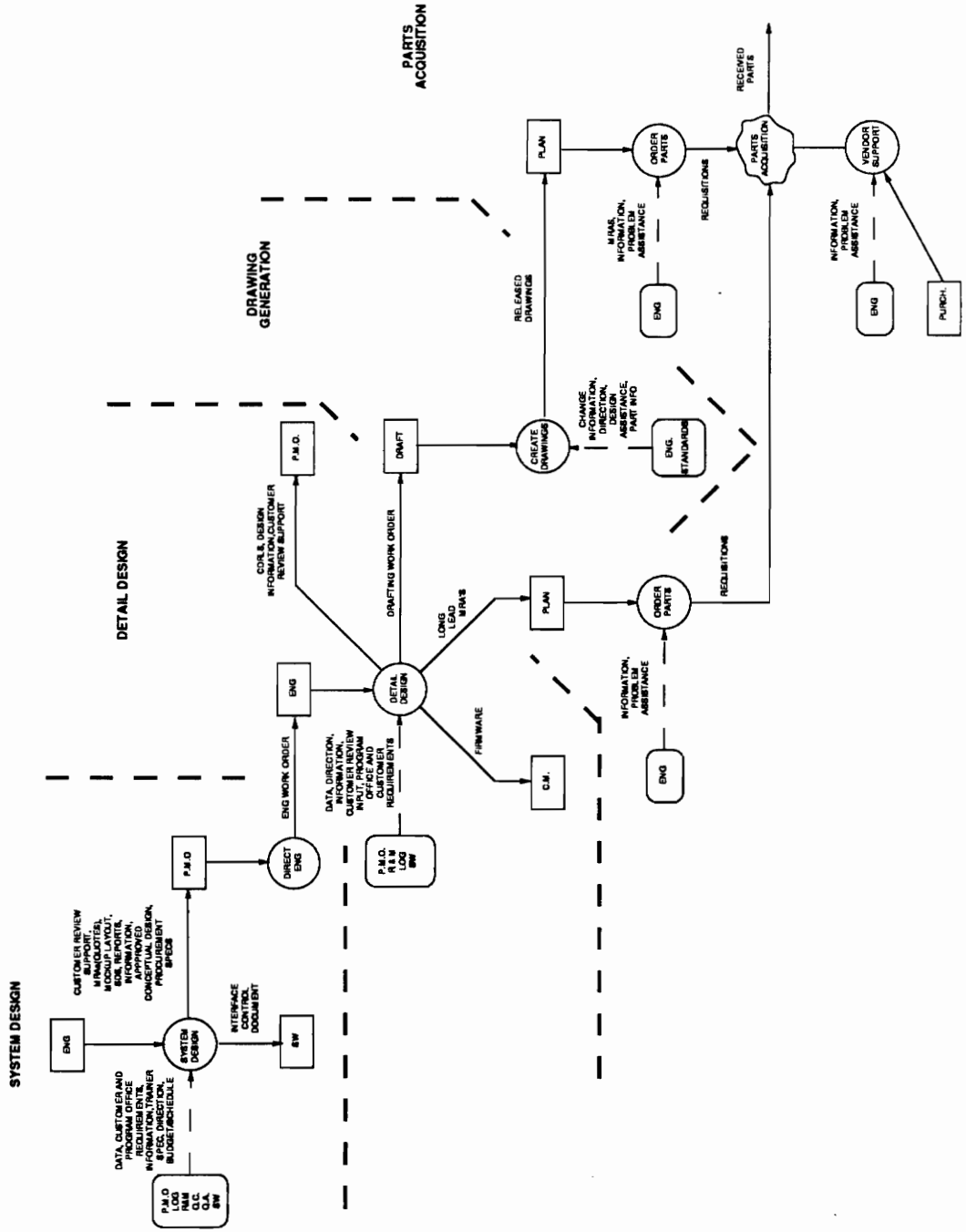
- 1) In order to develop valuable, accurate measures it is important to understand what tasks the group performs, what inputs the group receives from other parts of the company, and what outputs the group generates. Please list some tasks that are part of your everyday job. Also list what kinds of inputs you receive and outputs you generate. These responses will be incorporated into a published list for everyone to use.

- 2) Look over the purpose, objectives and goals section of the handout. If you have suggestions, comments, or questions, concerning this section please write them down. Performance improvement is a group effort so please respond. Suggestions will be incorporated.

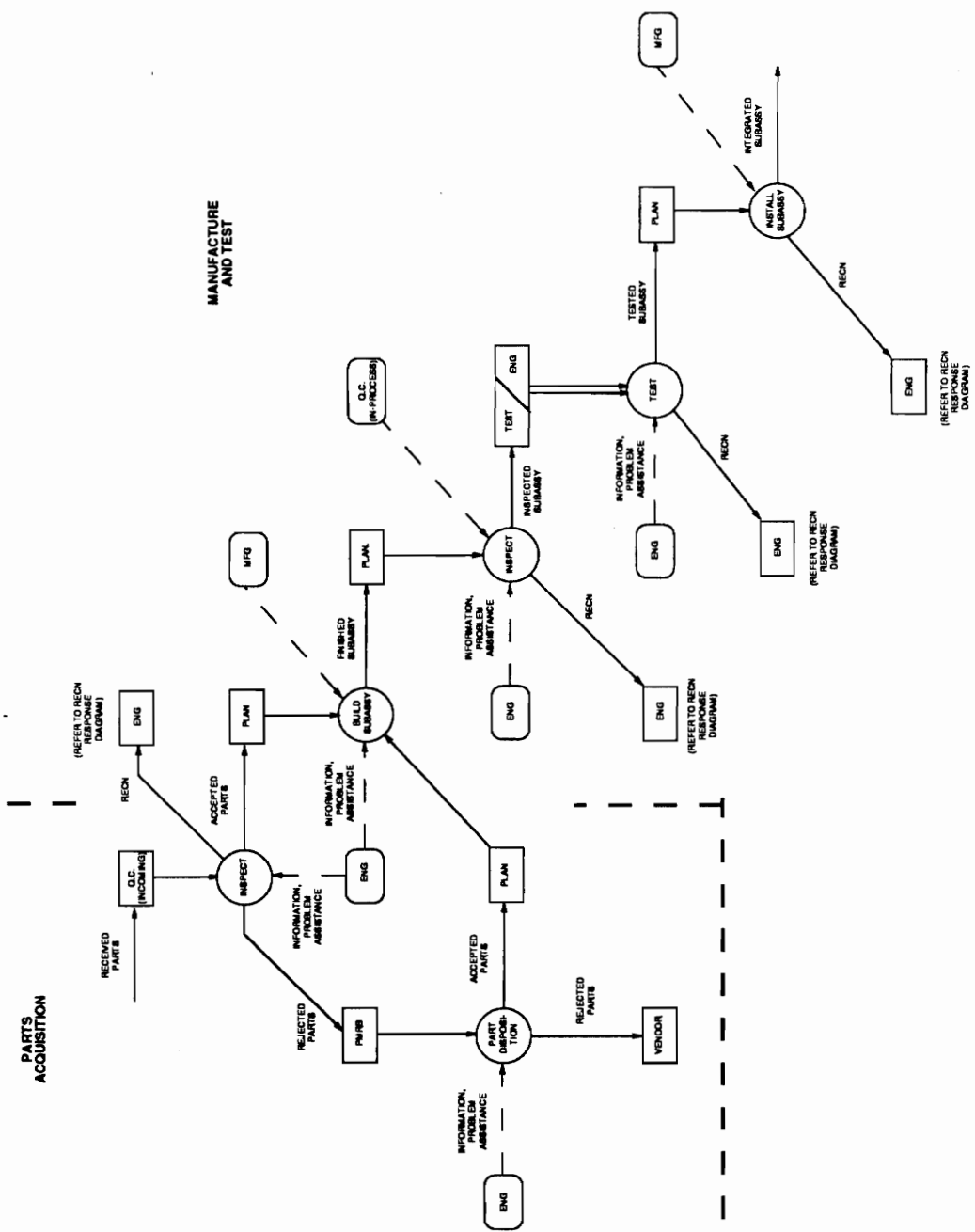
- 3) If you have any general comments, questions, suggestions about the presentation, the handout, what we intend to do, etc. please respond. Additional literature will be made available for those that are interested.

APPENDIX C - ORGANIZATIONAL I/O ANALYSIS FLOWCHARTS

DESIGN/DRAFTING WORK FLOW INTERFACE DIAGRAM



DESIGN/DRAFTING WORK FLOW INTERFACE DIAGRAM



DESIGN/DRAFTING WORK FLOW INTERFACE DIAGRAM

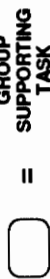
PURPOSE

THIS DIAGRAM IS TO BE USED TO HELP IDENTIFY AREAS OF FOCUS FOR DEPARTMENT IMPROVEMENT PROJECTS, IDENTIFY PERFORMANCE MEASURES FOR THE DESIGN/DRAFTING DEPARTMENT IN THE PRODUCT DEVELOPMENT PROCESS, AND TO PROVIDE AN UNDERSTANDING OF WHAT GROUPS/DEPARTMENTS ARE RESPONSIBLE FOR INPUTS, OUTPUTS, AND TASKS IN THE DEVELOPMENT PROCESS.

OBJECTIVES

- 1) THIS DIAGRAM IS TO SHOW PRIMARY TASKS IN A PRODUCT DESIGN/MANUFACTURE/TEST PROCESS, FOR WHICH THE DESIGN/DRAFTING DEPARTMENT IS RESPONSIBLE. INPUTS, OUTPUTS, PRIMARY TASKS & SUPPORTING TASKS OF THESE TASKS SHOULD ALSO BE SHOWN.
- 2) WHERE NECESSARY, PHASES, TASKS, AND PROCESSES SHOULD BE EXPANDED ON A SEPARATE DIAGRAM TO PROVIDE MORE DETAIL AND CLARIFICATION OF INPUTS, OUTPUTS, RESPONSIBILITIES, AND SUBTASKS.
- 3) THIS DIAGRAM IS TO BE A LIVING DOCUMENT, OPEN TO COMMENT, EVALUATION, AND IMPROVEMENT.

KEY



BLACK = INPUTS

GREEN = OUTPUTS

RED = ENGINEERING, STANDARDS

BLUE = DRAFTING

PMO = PROGRAM MANAGEMENT OFFICE

ENG = ENGINEERING

DRAFT = DRAFTING

Q.A. = QUALITY ASSURANCE

Q.C. = QUALITY CONTROL

R&M = RELIABILITY & MAINTAINABILITY

LOG = LOGISTICS

SW = SOFTWARE

C.M. = CONFIGURATION MANAGEMENT

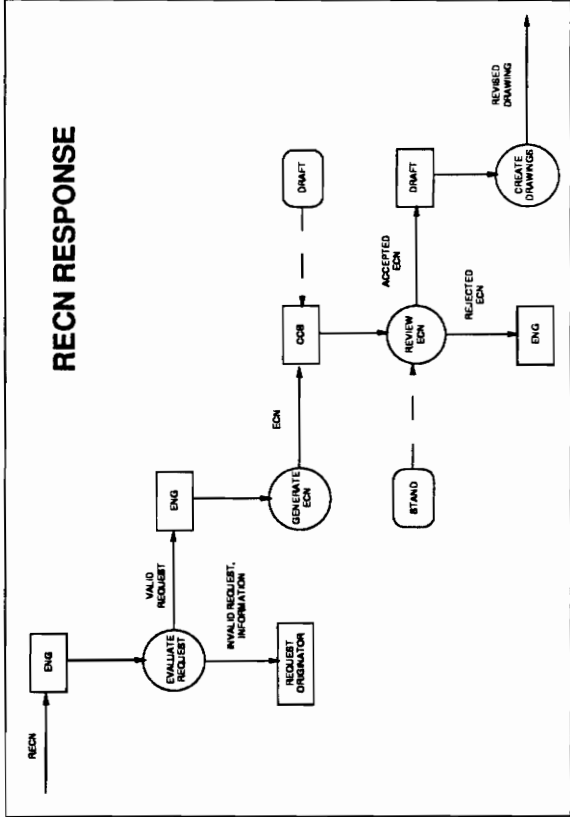
PURCH = PURCHASING

PLAN = PLANNING (PRODUCTION CONTROL)

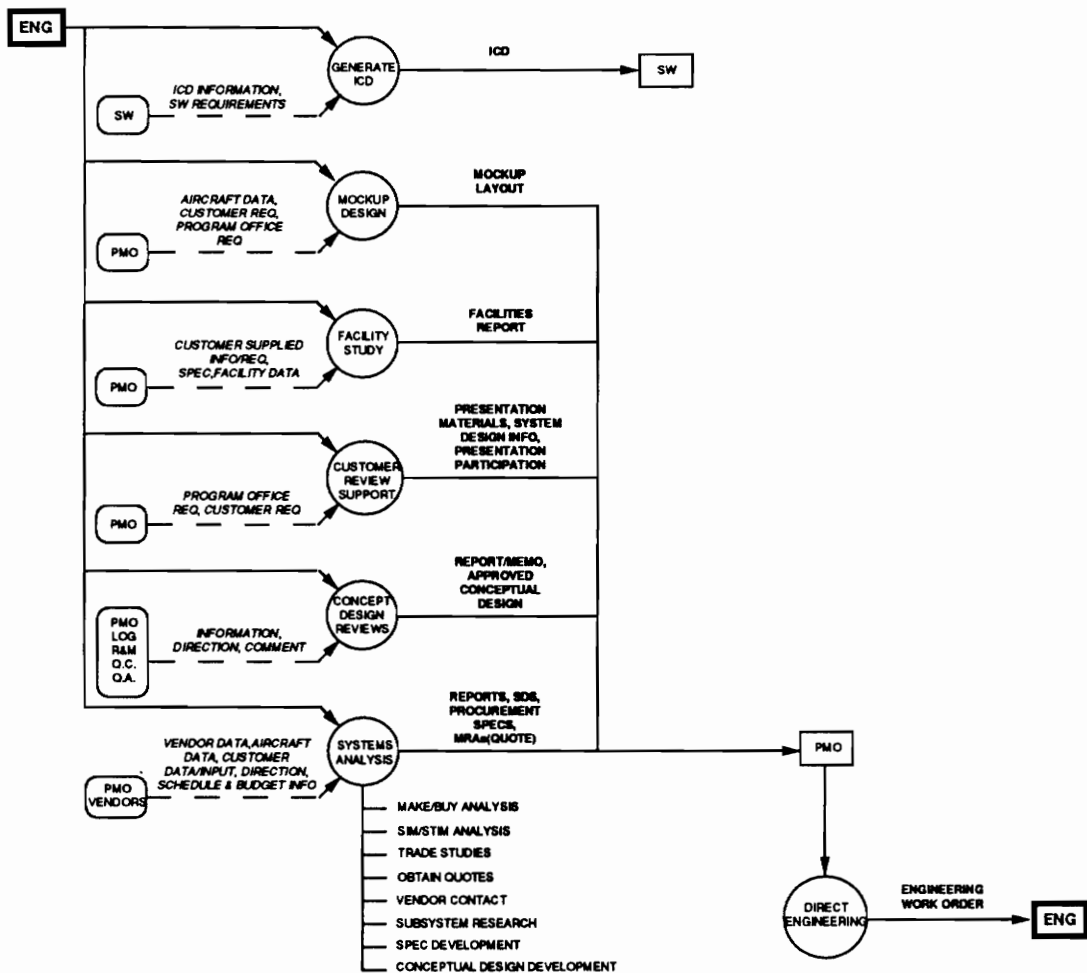
STAND = STANDARDS

PMRB = PRELIMINARY MATERIAL REVIEW BOARD

CCB = CONFIGURATION CONTROL BOARD



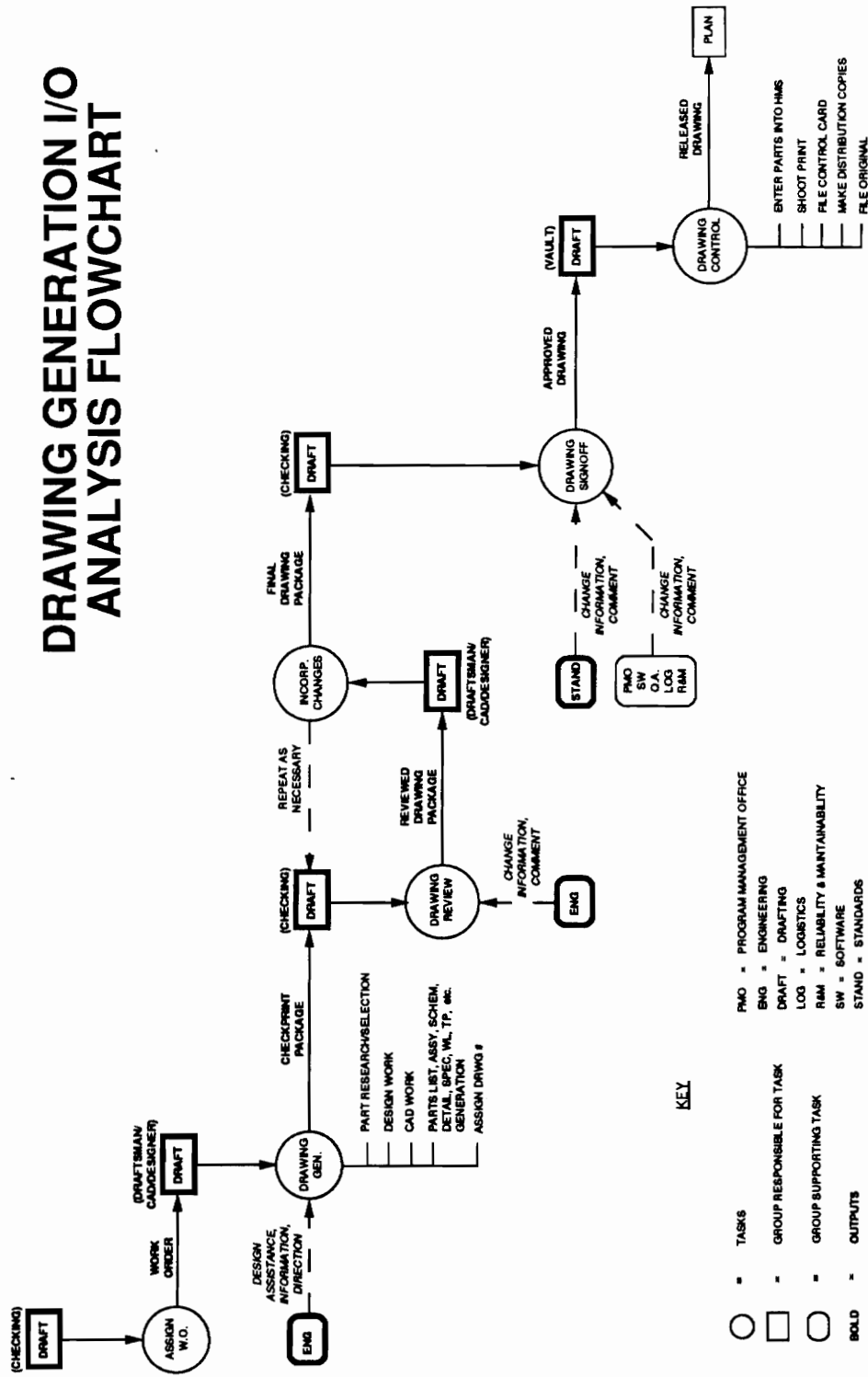
SYSTEM DESIGN I/O ANALYSIS FLOWCHART



KEY

- | | | | |
|----------------|------------------------------|-------|---------------------------------|
| ○ | = TASKS | PMO | = PROGRAM MANAGEMENT OFFICE |
| □ | = GROUP RESPONSIBLE FOR TASK | ENG | = ENGINEERING |
| ○ | = GROUP SUPPORTING TASK | DRAFT | = DRAFTING |
| BOLD | = OUTPUTS | LOG | = LOGISTICS |
| <i>ITALICS</i> | = <i>INPUTS</i> | R&M | = RELIABILITY & MAINTAINABILITY |
| | | SW | = SOFTWARE |
| | | STAND | = STANDARDS |
| | | Q.A. | = QUALITY ASSURANCE |
| | | Q.C. | = QUALITY CONTROL |

DRAWING GENERATION I/O ANALYSIS FLOWCHART



APPENDIX D - NGT BRIEFING PACKAGE MATERIALS

PERFORMANCE MEASUREMENT DEVELOPMENT BRIEFING PACKAGE

The purpose of this briefing package is to provide information to those people attending the Design/Drafting department performance measurement development meeting. The objective of this meeting is to develop a list of measures that will indicate Design/Drafting department performance in the areas of quality and process cycle time. At the conclusion of the meeting an action team will be assigned to review the measures for accuracy and feasibility, and to devise data collection methods for the most significant measures determined at the meeting. The data collection methods will then be implemented. This briefing package contains some general information that may assist you in developing our first set of performance measures. Each participant in the meeting is responsible for reviewing the attached material and preparing ideas for specific measures prior to the meeting. The success of the meeting depends on this preparation. A question sheet is provided at the back of the briefing package. If anything is unclear, please write your questions on the sheet provided and return by close of business Wednesday. If you have any suggestions or comments, please include these as well. This briefing package includes the following:

- I. A brief discussion about the Design/Drafting Department's objectives for integration of performance measurement techniques.
- II. A list of the Design/Drafting Department's short and long term goals and objectives, assumptions and guiding principles.
- III. A discussion of measurement fundamentals including:
 - A. A top level task and input/output analysis of the Design/Drafting department.
 - B. A measurement criteria guideline
- IV. A list of the Process Enhancement Improvement Project changes.
- V. A description of the meeting format.
- VI. A question sheet.

I. PERFORMANCE MEASUREMENT & CONTINUOUS IMPROVEMENT

Budget cuts and increasing competition for training dollars have produced a need for improving company quality, efficiency, productivity, and other aspects of performance in order to place the company in a better competitive position. The Design/Drafting department plays a large role in the life cycle of a training system. If the department can improve its own performance, then it will also have a major impact on placing the company at a competitive advantage in the bidding process. Improvements will also help us produce a higher quality product in a more efficient manner.

The Process Enhancement Improvement Project was a project oriented activity. The next effort for improving department processes and procedures will concentrate on developing a system to promote continuous improvement, with contributions from all department members as part of their day-to-day efforts. This is the idea behind the performance management system effort.

Many hours of hard work have been put in by those participating in the Process Enhancement Improvement effort. Many ideas were generated about ways of improving how the Design/Drafting department performs its tasks. These ideas are currently in the process of being implemented. As these process improvements are implemented it is important that the department develops a means for measuring the improvement generated by these changes. Measuring will show the group where improvements are being or not being made. Measuring will also provide a means for determining new areas for process enhancement actions.

Building a working performance management system is a long term approach to improving department performance. Results will not happen immediately. Strong support and commitment are required. In the long run, however, implementation of the system will increase department quality and efficiency, decrease waste labor, and reduce costs.

The measurement development meeting is the next step in the process of developing a performance management system for the Design/Drafting department. The meeting is intended as a brain-storming session to compile a list of specific measures indicating group performance. The first measurement development meeting will focus on measures related to Quality and Design/Drafting cycle time. At the completion of the meeting an action team will be assigned to review and develop implementation procedures for the most significant measures determined in the meeting.

II. DESIGN/DRAFTING DEPARTMENT GOALS AND OBJECTIVES

The following is a list of department objectives, goals, assumptions, and guiding principles. It is important to have an understanding of where the group is headed over the next 5 years and develop a sense of purpose in what we are trying to accomplish by implementing our performance management system. The list will also be influential in determining specific performance measures for the department. The goals and objectives list will be a published document so that all group members have an understanding of what we are trying to accomplish.

Design/Drafting Department Objectives

To enable the company to continue to prosper in the increasingly competitive market through the following:

- 1. Provide a technical advantage by innovative application of today's technology.**
 - Training (peer training, seminars, formal post graduate work)
 - Focus of investments (R&D and capital)
 - Rewards for exceptional contributors
 - Utilization of other division and corporate organizations

- 2. Provide a cost advantage by continually evaluating and improving the processes within the design/drafting department**
 - Process definition
 - Process enhancement
 - Measurement
 - Value suggestion system
 - Comprehensive guidelines

- 3. Provide a schedule advantage by shortening the overall product development cycle through the following:**
 - Improved work breakdown and task definition process (uniform across all contracts)
 - Improved planning and scheduling capability (uniform across all contracts)
 - Increased visibility within the design/drafting department and to other departments
 - Increased standardization
 - Increased attention to detail/minimized rework (do it right the first time)
 - Improved work quality

Design/Drafting Department Goals

1. Develop 1991 and 5-year IR&D plan
2. Increase training in 1991 by 50%
3. Implement internal reward system
4. Participate at group level in the following:
 - CAD CAE Council
 - Training System R&D Council
 - Corporate Rotation Program (Fellow)
5. Complete initial release of engineering and drafting manuals

6. Implement on-line component substitution
7. Implement first measurement system
8. Improvement suggestion policy and implementation
9. Complete Cost Estimating Guidelines
10. Develop "war room" for schedule and status display
11. Implement AutoCad software with accompanying procedures
12. Training for:
 - AutoCad
 - DADS
 - XILINX Logic Cell Array
 - dBASE
 - Dash Schematic Capture
13. Implement the following in Checking/Drafting:
 - Performance Feedback System
 - Living Checklist System
 - Task Tracking Database System
14. Reduce product design cycle to 18 months (2-3 yr goal)
15. Become more dominant players in new business development strategies (2-3 yr goal)

Assumptions

1. 5-10%/year growth in department size
2. No major organizational changes
3. Stable budget for training equipment
4. No major changes in spec requirements and evaluation criteria
5. Continued autonomy for company

Guiding Principles

- o In order to maintain our competitive position with a shrinking defense budget, we must continually strive to provide a technically superior product at a competitive price within the schedule constraints defined by our customer.
- o As a normal practice, each employee must evaluate the processes and consider alternatives to ensure the processes are the most effective and efficient means for accomplishing the task.
- o Be receptive to change, evaluate all changes for their merit.

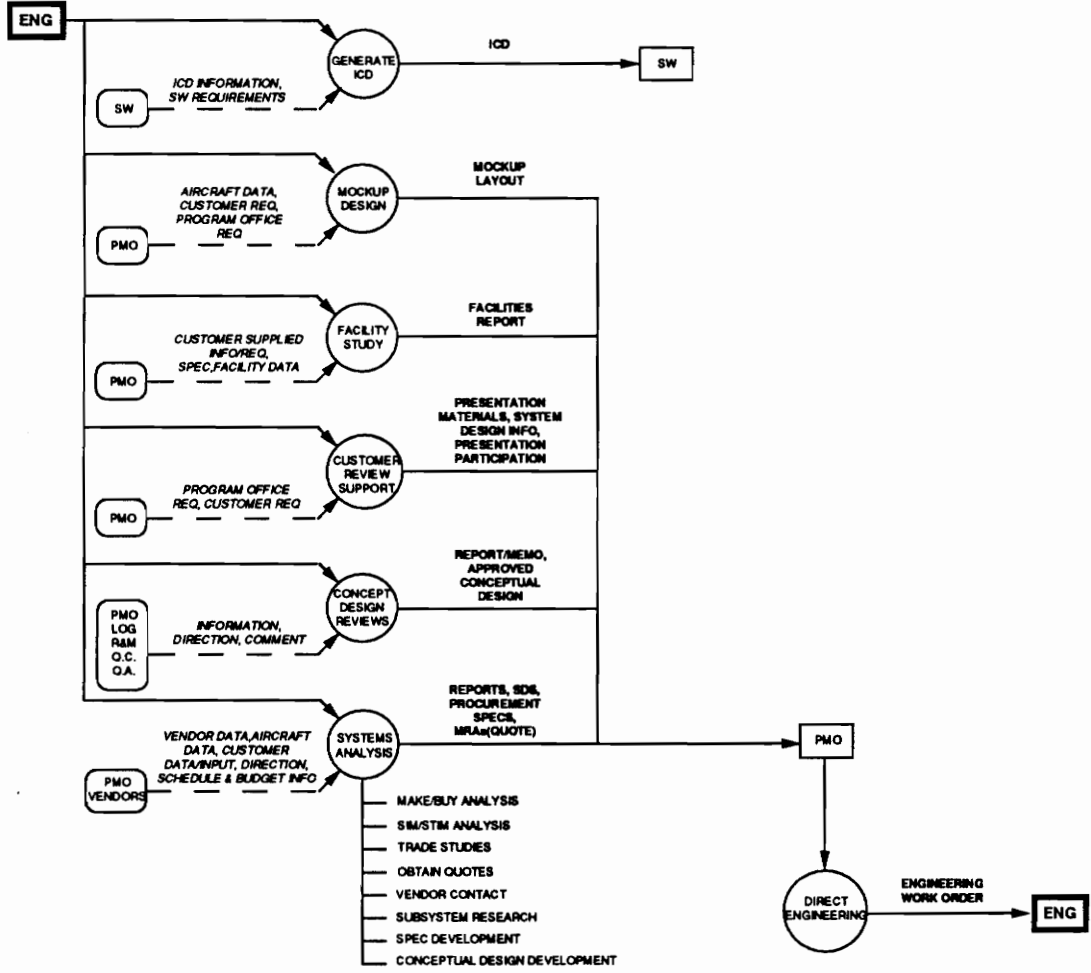
III. MEASUREMENT FUNDAMENTALS

A. Design/Drafting Department Task and I/O Chart

Since measurements are based on relationships between inputs, outputs, or combinations of both, an analysis of Product Design inputs, tasks, and outputs will be helpful in developing our first set of measurements. A workflow diagram has been developed showing the primary tasks involved in our product development process. The diagram also shows department responsibility and support for each task, and some of the primary inputs and outputs associated with each task. The focus of the diagram is on the responsibilities and support provided by engineering and drafting. The workflow diagram will be posted for viewing and comment. The following pages provide a detailed picture of the first three phases on the workflow diagram where the department is heavily involved. These include system design, detailed design, and drawing generation. The diagram will help provide a picture of what functions our department performs and will assist in the generation of measurement ideas.

The analysis by no means shows all tasks performed, nor all the inputs and outputs of these tasks. This analysis is, however, intended to grow into a living, supported document that will show a complete, detailed task list with corresponding inputs and outputs of all Product Design Group functions. The diagram will assist in determining new areas of improvement focus, provide an understanding of the effects of any changes to our processes and procedures, and provide an understanding of the Design/Drafting department needs from other departments as well as other department needs from Design/Drafting. For the purposes of defining our first set of measurements, the workflow diagram is intended to stimulate thought about different areas of department processes and functions.

SYSTEM DESIGN I/O ANALYSIS FLOWCHART



KEY

- | | |
|--|--|
| <ul style="list-style-type: none"> ○ = TASKS □ = GROUP RESPONSIBLE FOR TASK ○ = GROUP SUPPORTING TASK BOLD = OUTPUTS <i>ITALICS</i> = INPUTS | <ul style="list-style-type: none"> PMO = PROGRAM MANAGEMENT OFFICE ENG = ENGINEERING DRAFT = DRAFTING LOG = LOGISTICS RAM = RELIABILITY & MAINTAINABILITY SW = SOFTWARE STAND = STANDARDS Q.A. = QUALITY ASSURANCE Q.C. = QUALITY CONTROL |
|--|--|

B. Measurement Criteria Guideline

The first measures developed are to focus on quality of work and design/drafting process cycle time within the department. In order to develop meaningful measures it is important NOT to ask "What can we measure?". Instead, the correct question should be "What can the department do to improve quality and design/drafting cycle time?" and then "What measures are needed to support and motivate continuous improvement?". The goal is to translate performance into real terms.

As the department increases its use of measuring as a technique to improve performance, a set of guidelines or criteria will help define what each measurement means with respect to performance. The following pages present a performance criteria guideline that may be useful in understanding and developing the first set of measures.

PERFORMANCE CRITERIA

Developing meaningful measurements is a difficult task. It requires detailed knowledge of the inputs, processes, and outputs of the system under study. It also requires defining a set of comprehensive criteria by which to judge performance.

Researchers in the fields of total quality management, performance measurement, and other related fields have developed a set of comprehensive criteria to measure performance. This set of criteria includes effectiveness, efficiency, productivity, quality, innovation, quality of work life, and profitability/budgetability. If measurements are taken in at least a majority of these areas it will provide a better overall view of the group performance. This does not necessarily mean we should measure in all these areas all the time. If our current objective is to improve quality related items, or to study the ECN process, or study the work order process, then measurements might be concentrated in only a few of the seven areas.

We do not want to take too many measurements at once as this could become cumbersome. We also do not want to focus on a single measurement as an indicator since the design/drafting processes are much to complex. The key is to make the measurement process comprehensive but simple. Definitions and examples of each of the performance criteria follow.

PERFORMANCE CRITERIA

<p>Effectiveness - degree that the system accomplishes the "right" things, on time, within the quality requirements specified</p>	<p>- measure: <u>actual output</u> expected output</p> <p>example: <u>actual number of released drawings / time</u> expected number of released drawings/time</p>
<p>Efficiency</p>	<p>- degree to which the system uses the "right" things at the "right" time</p> <p>- measure: <u>resources expected to be consumed</u> resources actually consumed</p> <p>example: <u>drafting labor hours estimated</u> drafting labor hours used</p>
<p>Quality</p>	<p>- degree to which system conforms to requirements, specifications, or expectations</p> <p>- critical in all stages of department resource and process flow</p> <p>- measure: various formats</p> <p>example: number of ECN's generated because of QC rejections</p>
<p>Productivity - relationship between group outputs and group inputs</p>	<p>- measure <u>quantity of outputs</u> quantity of inputs</p> <p>example: <u># of panel assembly designs complete</u> labor hours expended</p>
<p>Quality of Work Life - way group members "feel" about social and technical aspects of their system and environment</p>	<p>- measure: various formats</p> <p>example: # of valid requests for needed tools and equipment</p>
<p>Innovation - creative process of changing to successfully respond to pressures, challenges, and opportunities</p>	<p>- measure: various formats</p> <p>example: # of new design ideas implemented to improve training systems/ year</p>

Profitability/Budgetability - relationship between budgeted costs and actual expenses

budgeted costs
- measure: actual expenses

budgeted cost to incorporate ECNs
- example: actual cost to incorporate ECNs

IV. PROCESS ENHANCEMENT IMPROVEMENT PROJECT CHANGES

Because many changes are being made in our processes and procedures as a result of the Process Enhancement Improvement Team efforts, it is a good idea to keep these changes in mind when developing a list of measures. As a reminder, the process enhancement team efforts are listed below.

Three Volumes of Ready Reference Material

A. Design Guidelines - procedures needed to be documented and forms changed

1. Temporary Modification Log - to allow reversible engineering troubleshooting
2. First Article Release - intended for high level assemblies that are being built for the first time, should reduce the number of ECNs and eliminate early sign-off of designs prior to them being functionally proven designs
3. Specification/Drawing Generation - to define the types, format and content of specifications and drawings which we use here. These are in accordance with MIL-STD-490 and DOD-STD-100.
4. Design Work Order - modifications made to the form, it is now a folder with specific information required, reflects requirements of (c.)
5. Materiel Release Authorization - redesign of the ERA form and definition of the form release
6. ECN - complete redesign of the form, signature block will match that on drawings, obsolete information deleted, required information added
7. Design Folders - intended to be a historical information file for a particular system, assembly, etc.

B. Drafting Guidelines - reviewed corporate and current company practices

1. Drawing Types and Formats - reflects requirements of the Specification/Drawing Generation section
2. Drafting Practices and Checking
3. Layout, Symbols, Tolerances and Notes - standardization of all of these will eliminate many errors and ECNs
4. Reference Designation Guidelines - standardization of ref des markings
5. Printed Wiring Board Design Guidelines

C. Standardization - database for selection of parts, materials and processes

1. **Components - electrical and mechanical parts for standardization within the company, eventual acceptance/approval of these for use on programs as "standard" rather than GFB (Government Furnished Baseline)**
2. **Materials - use of common materials, ex. adhesive, paint, metals**
3. **Processes - selection of common practices for fabrication (in-house and out), will be coordinated into standard notes section (drafting 2.c)**
4. **Parts Substitution List - allow substitution of parts without an ECN, will also see eventual acceptance/approval by the customer, will benefit Incoming Inspection, Production Control, CM, Design/Drafting, Logistics, and final inspection**
 - obsolete parts
 - equivalent parts
 - preferred parts with substitutes
 - parts substitution due to buildup of tolerance

V. NOMINAL GROUP TECHNIQUE FORMAT

The purpose of the measurement development meeting is to identify specific measures that will indicate department performance in the areas of Quality and Design/Drafting Cycle Time. Results of the meeting will include:

1. Generation of a ranked list of performance measurements.
2. Development of an action team to review accuracy and feasibility of top-ranked measures, select the initial measurements to be taken, and devise methods for gathering measurement data.
3. Development of an action team to set up the overall measurement system process and guidelines.

The format of the meeting is called the Nominal Group Technique (NGT). This technique is designed to maximize idea generation from a group of individuals in a useful, structured manner. The following is a brief description of the process involved in an NGT format meeting. Please familiarize yourself with the process.

The NGT has four phases in addition to an introduction and conclusion. The session is controlled by a facilitator and an assistant.

Introduction

The introduction will include the following:

1. A brief review of some of the concepts in this briefing package.
2. A review of the steps in the NGT process.
3. A brief discussion of how the meeting results will be used and the next steps to be taken.

The task statement for the session will be read. For our session the task statement will read: Identify specific department performance measures indicating Quality and Design/Drafting Cycle Time.

Silent Generation

After the task statement is read and any clarification is made, the session members will take 10-15 minutes to write their responses to the task statement. No discussion occurs during this period.

Round Robin

After 10 - 15 minutes the facilitator will interrupt the silent generation process and call upon each of the participants one at a time to state one of their responses. Only one response is allowed at a time. The response is recorded and displayed. The only discussion allowed is between the facilitator and the participant responding. Discussion, if any, is

limited to seeking a concise statement of the idea for easy recording. This process continues until all items generated by the group have been recorded and displayed.

Clarification

After all ideas have been recorded and displayed, the facilitator goes over each recorded item to determine that all participants understand the item. Any participant may offer clarification, or suggest modification, deletion, etc. Evaluation is avoided. Through group consensus some items may be deleted or combined with others due to duplication. Emphasis is on clarification rather than evaluation.

Voting and Ranking

After all the items have been looked at and the group is satisfied each participant will be supplied with eight index cards. The facilitator will ask the participants to select the eight most important items from the item list and write down one item in the center of each card. The facilitator will then ask the participants to select the most important item out of the eight they have written down and place an 8 in the upper right hand corner of that index card. The facilitator will then ask the participants out of the seven items remaining which is the least important and write a 1 on that index card. This process continues until the ranking is complete. Tabulation of the results is made and displayed for the participants to see.

Conclusion

The conclusion includes the following:

1. A brief discussion of the voting results.
2. A discussion and determination of the next steps.
3. Assignment of action teams.

VI. QUESTIONS, SUGGESTIONS, COMMENTS

NAME: _____

List your questions, comments, and suggestions and return by close of business Wednesday. Responses will be returned to you as quickly as possible. If there is an abundance of questions, a preliminary meeting may be held to cover all items.

APPENDIX E - ECN GUIDELINES

ECN TRACKING CATEGORIES

PROGRAM CHANGE - This category covers ECNs written to accommodate use of an existing drawing on a different contract, ECNs written because of approved ECP/SCPs that affect existing drawings, and ECNs written for program office directed changes.

POSSIBLE ECN DESIGNATIONS - PC, PE, PP

<u>PROGRAM CHANGE</u>	<u>C</u>ONTRACT	ECNs written to utilize existing drawings on a new contract.
	examples:	ECN written to create a new dash number card tray assembly configuration. New configuration is to be used on a different contract. ECN to add views of new dash number assembly configurations required by new contract to installation drawing.
	<u>E</u>C/P/SCP	ECNs written for changes required by customer approved ECPs or SCPs on an existing contract.
	examples:	ECNs to change console configuration in accordance with customer ECP. ECNs to add fire detection equipment in electronics rack as specified in customer ECP. ECNs to add interface capability to assembly in accordance with SCP.
	<u>P</u>ROGRAM OFFICE	ECNs written for changes or improvements directed by the program office but not specifically required by the contract.
	examples:	ECN to add audio capabilities to monitoring station in response to customer request. Program office directs the change.

DRAWING CHANGE -

This category covers ECNs written to correct basic drawing errors such as simple mistakes made in the creation of the drawing or in the transfer from layout to a finished drawing. Examples include:

- * Missing Dimensions
- * Insufficient/Incorrect/Missing View
- * Missing Text
- * Missing Standard Notes
- * Part Marking
- * Title Block/Application Block Incorrect
- * Text Spelling Errors
- * Incorrect Matching of Part and Description

POSSIBLE ECN DESIGNATIONS - DWG

DRAWING CHANGE

ECNs written to correct basic drawing errors missed at time of drawing creation.

examples:

ECN to add missing "solder per mil ..." note on electrical assembly.

ECN to change incorrect part number in parts list when "s" was used instead of "5".

ECN to add missing hole location dimension in plate assembly.

VENDOR -

This category covers ECNs generated due to changes in vendor equipment or parts (expected or unexpected), vendor misinformation, changes recommended by vendor, or changes required because of vendor quality or error.

POSSIBLE ECN DESIGNATIONS - V

VENDOR

This category covers ECNs generated due to changes in vendor equipment or parts (expected or unexpected), vendor misinformation, or changes recommended by vendor.

examples:

ECN to change wiring to air conditioning condenser due to new equipment used by vendor.

ECN to change power cord wire colors. Vendor now using different colors.

ECN to change DC motor part number. Part sent by vendor was wrong but accepted due to schedule.

DESIGN CHANGE -

This category covers ECNs written to correct design problems such as fit, form, performance and functional operation.

The basic criteria for this category is that the assembly was built but did not fit when installed, did not meet specific contract performance requirements, did not meet the engineer's design criteria, or did not functionally operate.

In the case of form and fit problems, the assembly was built but could not be installed or piece parts of the assembly could not be put together because of form and fit problems.

Whereas the quality category pertains to areas such as maintainability, accessibility, safety, and appearance, this category pertains to functional and performance requirements.

POSSIBLE ECN DESIGNATIONS - DA, DP

DESIGN CHANGE ASSSEMBLE/INSSTALL

ECNs written to correct form and fit problems. Assembly was built but could not be installed or assembly piece parts could not be put together because of form and fit problems.

examples:

ECN to cut notch in baseframe support to accommodate linkage installation.

ECN to relocate incorrectly located mounting holes for air conditioner duct support.

ECN to lengthen standoffs for assembly connector deck. Connector interfered with switches.

ECNs to relocate card tray assemblies in rack because tray assemblies and power supplies interfered.

PERFORMANCE

ECNs written to correct performance and operational problems. Assembly was built but did not meet contract requirements, engineering design requirements, or did not perform its desired function.

examples:

ECNs for new higher performance hydraulic actuator to meet specification.

ECNs to add taper pins to reduce slop in mechanical linkage so system will perform in accordance with the trainer specification.

ECN to change spring in mechanical loader to meet force requirements.

ECNs to fix circuit card assembly so that it will function.

FACILITATE MANUFACTURING -

This category covers ECNs written to correct drawing information problems preventing the building or installation of an assembly. These are not design problems.

Problems include missing, unclear, or inconsistent information. This category also covers ECNs written to address part purchasing problems such as long lead or obsolete parts.

POSSIBLE ECN DESIGNATIONS - MP, MA, MI

MANUFACTURING

PARTS

ECNs generated to assist purchasing of parts, address long lead or discontinued parts, change to standard parts, or change to government approved part.

examples:

ECN to change integrated circuit part number from long lead part to shorter lead time part.

ECN to call out a new vendor's spring part number. Old vendor has discontinued previously specified part.

ECN to change marker band part number to new standard marker band.

ECN to change part to government approved part in response to NSPAR submittal.

ECN to add voltage amount to circuit breaker part number. Vendor needs information to send correct part.

ASSEMBLY

ECNs generated when drawing errors prevented manufacturing of assembly in-house or by vendor. Errors include misinformation, unclear or missing notes, incorrect information, or inconsistencies.

examples:

ECN to correct wire termination location. Location called out does not exist.

ECN to change note on altered item drawing. Note indicates removal of wire from panel. Wire does not exist.

ECN to add view of potentiometer terminal designation. Electrical assembly could not wire pot because terminal designation was not marked.

INSTALLATION

ECNs generated when drawing errors prevented installation of assembly in-house or by vendor. Errors include misinformation, unclear or missing notes, incorrect information, or inconsistencies.

examples:

ECN to mechanical assembly installation. Installation notes do not indicate method and hardware for mounting asseby to floor plates.

QUALITY CHANGE -

This category covers ECNs written to correct assemblies that do not meet either contract or company specified quality requirements and standards.

This category also includes ECNs written to improve maintainability, appearance, accessibility, safety, reliability, and adjustability, reduce cost, or to ease building and installation of an assembly.

Whereas the design category pertains to functional and performance requirements this category pertains to areas listed above.

POSSIBLE ECN DESIGNATIONS - QC, QI, QM

QUALITY

CONTRACT

ECNs generated because assembly does not meet contract quality standards or requirements.

examples:

ECN to change wire type. Old type has PVC material not allowed by contract.

ECN to add corrosion preventative conformal coating to circuit card as specified in quality provisions of contract.

ECN to change nameplate. Current name plate does not meet standards.

ECN to paint cover panel black as required by specification.

INTERNAL

ECNs generated because assembly does not meet company quality standards or requirements. These are company established standards that are different than those specified by the trainer specification.

examples:

ECN to change wire color from black to white where white and black signal wires meet on same contact.

IMPROVEMENT

ECNs written to improve maintainability, appearance, accessibility, safety, reliability, and adjustability, reduce cost, or to ease building and installation. These are changes made that are not specifically called for by the contract.

examples:

ECN to add card tray stuffing charts in electronics racks.

ECN to reposition hydraulic valve for easier adjustment and maintenance.

ECN to change LVDT part number. New vendor offers comparable LVDT at greatly reduced cost.

ECN to add power disconnect switch at location not required by specification.

examples:

ECN to add cable supports to facilitate maintenance and improve general appearance.

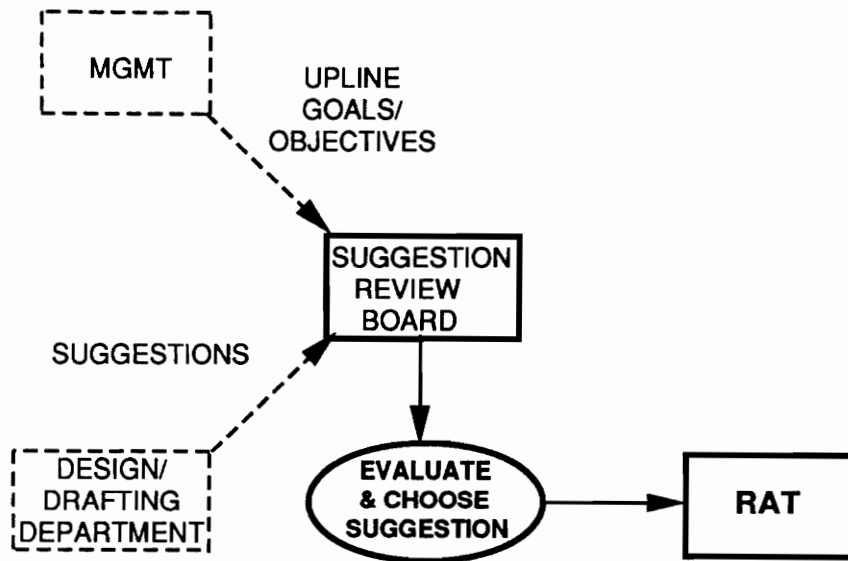
ECN to add cable cover interior to improve product appearance.

OTHER -

This category will be used for those ECNs that do not fit well into any of the designated categories.

POSSIBLE ECN DESIGNATIONS - X

APPENDIX F - MEASUREMENT SYSTEM GUIDELINES



TASK: *Evaluate and Choose Suggestions*

- Collect and log all suggestions
- Review each suggestion and determine if the suggestion should be returned for resubmittal, accepted, or rejected.
- State all reasons why a suggestion was either accepted, rejected, or returned for resubmittal.
- Organize Responsible Action Team (RAT).

INPUTS: Suggestions from the Design/Drafting Department and upper management.

OUTPUTS: Acceptable suggestion to the **Establish Objective and Preliminary Goal Task, Refine/Define Key Areas of Focus Task, and Refine/Define Measures Task.**

RESPONSIBILITY: Design/Drafting Manager and one person from each department (Mechanical, Electrical, and Drafting).



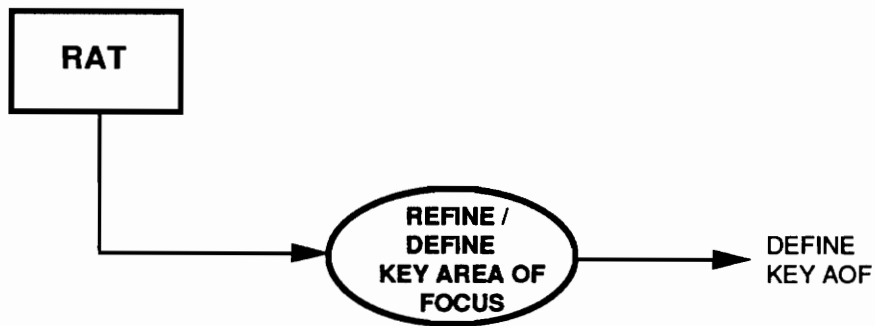
TASK: *Estimate Objective and Preliminary Goal*

- Review the accepted suggestion.
- Create an objective statement that best describes what each project will obtain.
- The objective statement should not be of such magnitude that it cannot be obtained.
- If possible, establish a preliminary goal that is to be obtained.

INPUTS: Accepted suggestion from the **Evaluate and Choose Suggestion Task**.

OUTPUTS: A good quality objective statement and established goals to the **Identify Data Sources Task**.

RESPONSIBILITY: Responsible Action Team



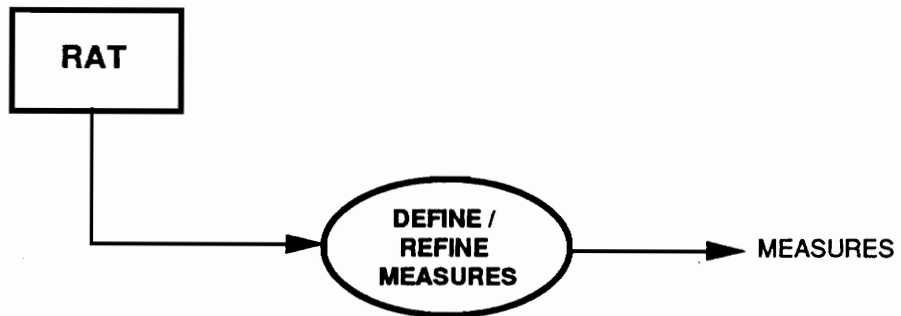
TASK: *Refine/Define Key Area of Focus*

- Review the accepted suggestion.
- Determine what specific areas of Design/Drafting, the company, and the process(s) that need to be monitored to establish baseline and supporting data for the suggestion.
- This task can be simplified if the chosen area of focus has readily available data.
- Not all areas of focus will have data (make your own data).

INPUTS: Accepted suggestion from the **Evaluate and Choose Suggestion Task**.

OUTPUTS: A well defined area of focus to the **Identify Data Sources Task**

RESPONSIBILITY: Responsible Action Team



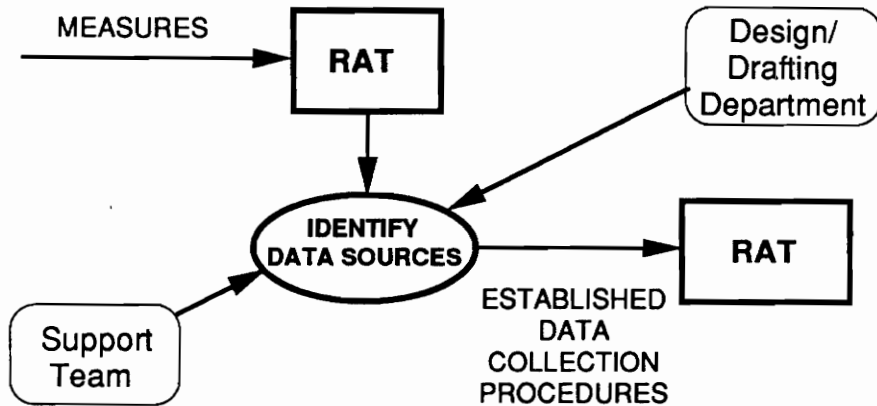
TASK: *Define/Refine Measures*

- Review the accepted suggestion.
- Determine which kind of measures will best indicate the status of an area in the company or process.
- Refine measures if required.
- Do not create a measure that will require unobtainable data.
- More than one measure is good, but too many can be confusing.
- The measure should directly reflect the objective.

INPUTS: Accepted suggestion from the **Evaluate and Choose Suggestion Task**.

OUTPUTS: Refined or modified quantitative measures to the **Identify Data Source Task**

RESPONSIBILITY: Responsible Action Team



TASK: *Identify Data Sources*

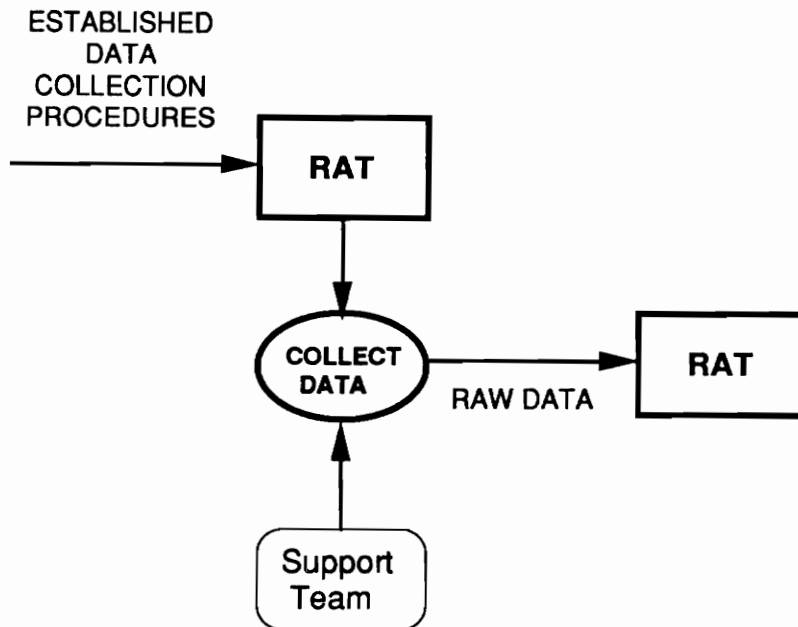
- Review the objective, the area of focus and all measures.
- Determine what type of data is needed to obtain the proper measures.
- Create a data collection procedure.
- The data source should be plentiful, easy to obtain and cheap to collect.
- Determine how the data should be obtained and for how long (create data logs if needed).
- Determine how often the data is to be collected.
- Determine when data is to be checked for validity.

INPUTS: Measures from the **Define/Refine Measures Task**

OUTPUTS: Data collection procedures to the **Collect Data Task** Includes Information:

- From where data comes
- How often data is collected
- When data is input to the **Test Validity Task**

RESPONSIBILITY: Responsible Action Team, 1-2 Support Team members (depending on the size of the project), and Design/Drafting Management.



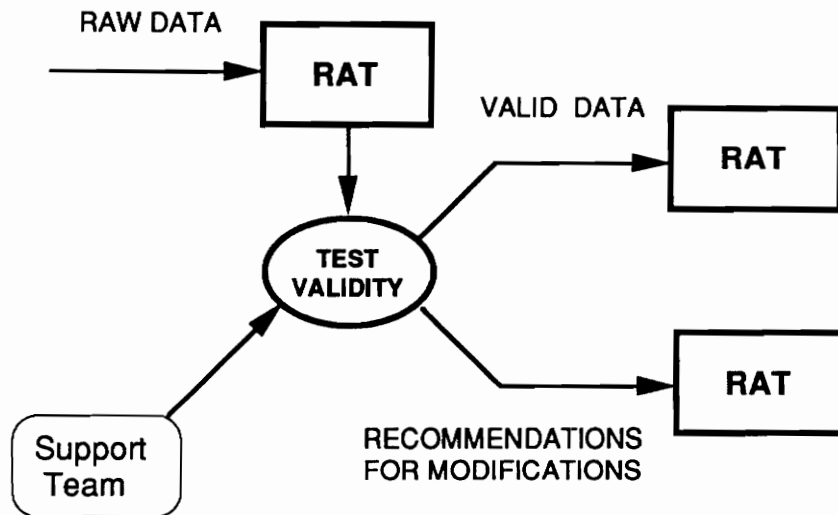
TASK: *Collect Data*

- Collect all data according to the data collection procedure.
- Log all dates of collection.
- All data are good data -- do not discard any data for any reason.
- If the collector feels that the data are bad, record his or her comments to that fact.

INPUTS: Data collection parameters from the **Identify Data Source Task**

OUTPUTS: All raw data to the **Test Validity Task**

RESPONSIBILITY: Responsible Action Team and 1-2 Support Team members (depending on the size of the project).



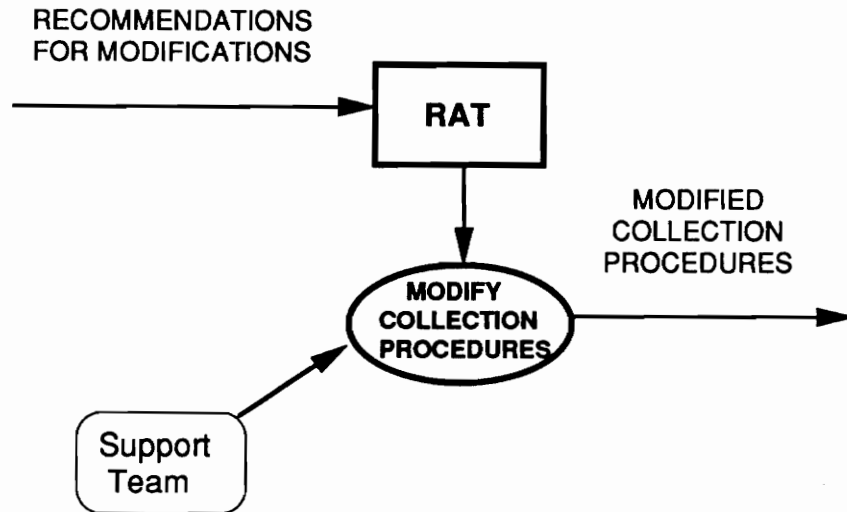
TASK: *Test Validity*

- Perform a quick check, if necessary, of the data to test for statistical significance.
 - Does the data mean something?
 - Is the data timely?
 - Is the data being gathered at the optimum rate?
 - Is the quantity of the data sufficient for analysis?
- Identify modification to data collection as needed.
- This task is not concerned with the exact meaning or applicability of the data

INPUTS: Raw Data from the **Data Collection Task**

OUTPUTS: Validated data to the **Detailed Analysis Task**, or recommendations to the **Modify Collection Parameters Task**

RESPONSIBILITY: Responsible Action Team with support from the Support Team as required.



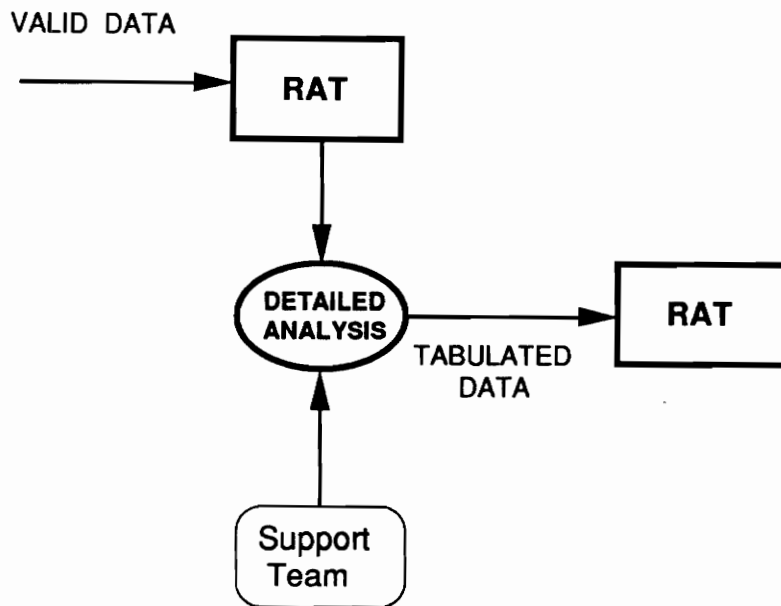
TASK: *Modify Collection Procedures/Parameters*

- Based on recommendations, modify data collection techniques, procedures or parameters to ensure statistical significance in future raw data.

INPUTS: Recommendations from the **Test Validity Task**

OUTPUTS: Modified data collection parameters to the **Identify Data Sources Task**

RESPONSIBILITY: Responsible Action Team with support from the Support Team as required.



TASK: *Detailed Analysis*

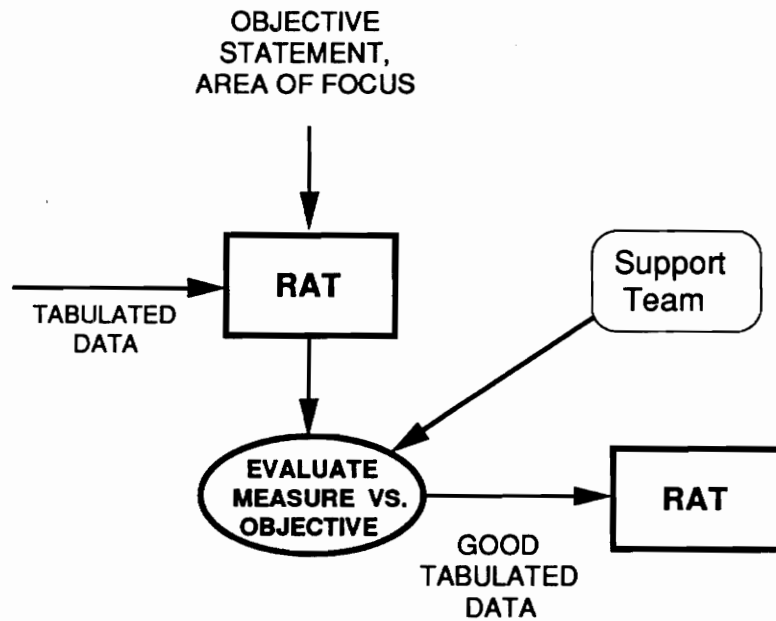
- Tabulate raw data into readable format.
- Perform statistical and/or non-statistical analysis as required to extract significant information for use in later evaluation steps

INPUTS: Valid data from **Test Validity Task**

OUTPUTS: Tabulated data to **Evaluate Measure vs. Objective Task** and extracted data such as:

- means
- medians
- standard deviations, and
- other, more sophisticated, statistical outputs, if required.

RESPONSIBILITY: Responsible Action Team with statistical support from the Support Team, as required.



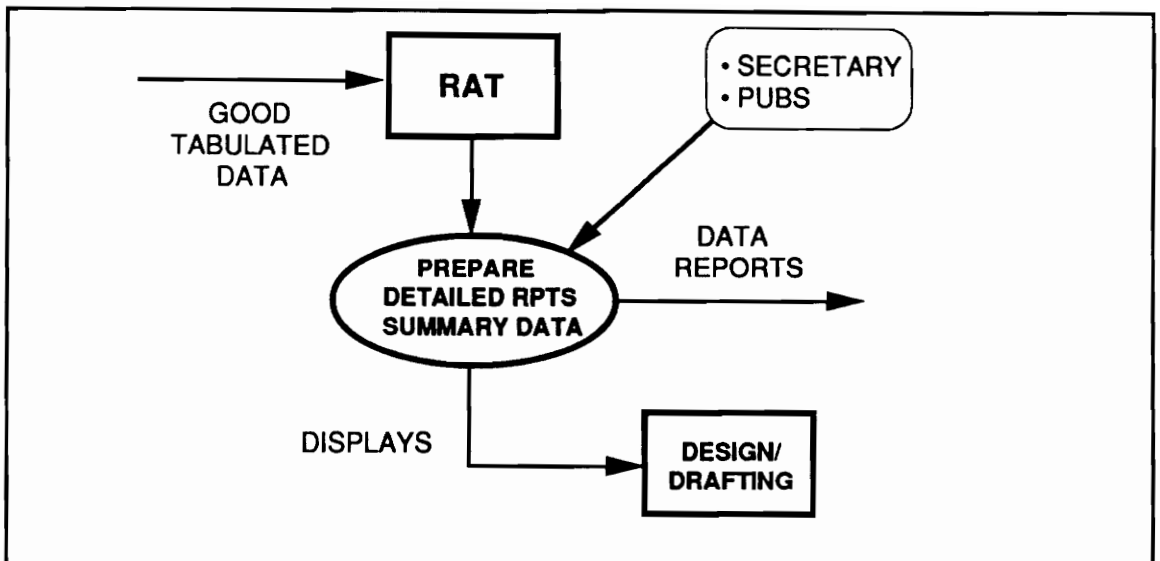
TASK: *Evaluate Measure vs. Objective*

- Evaluate data with respect to its applicability to the established measure, objectives, and area of focus.
- Modify measure, if required, to better match objective or area of focus.

INPUTS: Objectives statement, area of focus from **Establish Objectives and Preliminary Goal Task**, tabulated and extracted data from **Detailed Analysis Task**.

OUTPUTS: Good tabulated data to the **Prepare Detailed Reports and Summary Data Task** and good extracted data to the **Prepare Detailed Reports and Summary Data Task**, or modified measures to the **Identify Data Sources Task**.

RESPONSIBILITY: Responsible Action Team with support from the Support Team, as required.



TASK: Prepare Detailed Reports and Summary Data

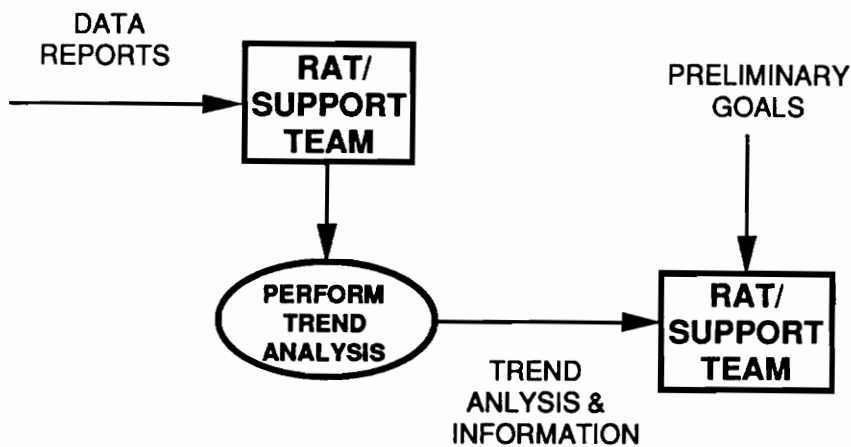
- Prepare simplified and readable displays for department feedback.
- Prepare detailed reports of data suitable for Process Enhancement tasks, improvement suggestion support and decision making.

INPUTS: Tabulated data from the **Evaluate Measure vs. Objective Task** and extracted data from the **Evaluate Measure vs. Objective Task**.

OUTPUTS: Simple displays of measures to the **Design/Drafting Department** and detailed reports of data to the **Trend Analysis Task**, including:

- raw data in tabulated format,
- methods of analysis
- significant extracted data
- peripheral data points, and
- anomaly explanations.

RESPONSIBILITY: Responsible Action Team with support from secretarial staff and Tech Pubs, as required.



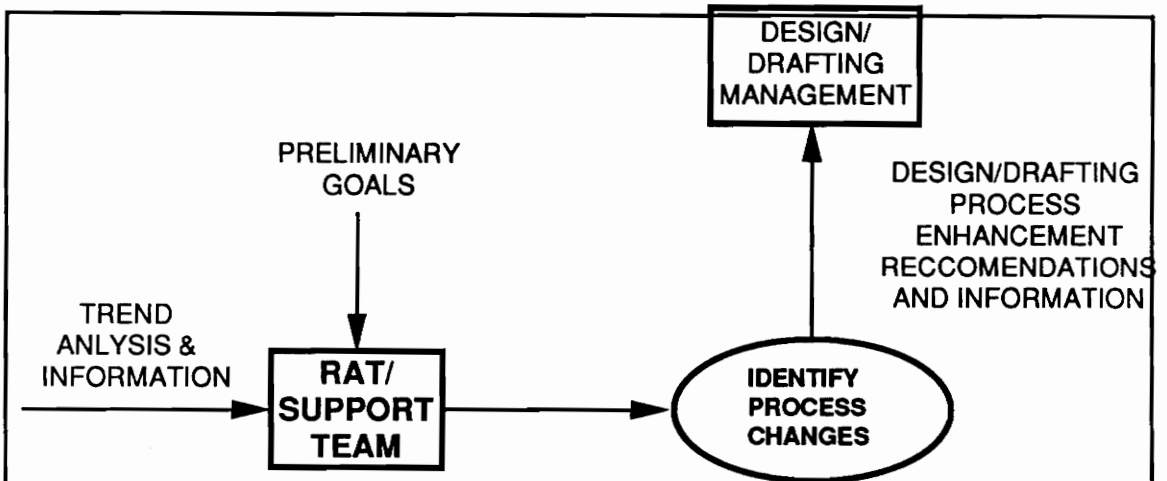
TASK: *Perform Trend Analysis*

- Examine incoming data reports from ResponsibleAction Teams.
- Identify data trends that indicate possible candidates for process change. Look for improvements and decline in the area of focus.
- For trends identified, can a valid reason be seen for these changes? Ask, are the trends merely because of normal changes in the processes or do they point to a need for change? Write down conclusions.
- Consider if trends should continue to be monitored or if they should be acted on. Ask, has enough data been gathered to clearly indicate a trend.

INPUTS: Data Reports and information from **Prepare Detailed Reports and Summary Data Task**.

OUTPUTS: Trend analysis information to **Identify Process Changes and Define/Refine Goals Tasks**.

RESPONSIBILITY: Responsible Action Team with 1-2 Support Team members (depending on size of project).



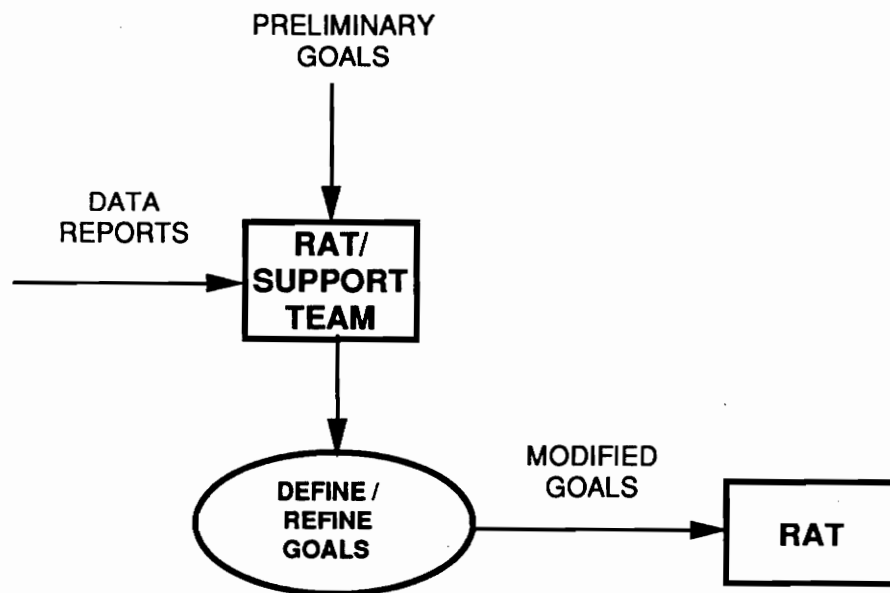
TASK: *Identify/Evaluate Process Changes*

- For areas that have been judged to be candidates for change, make recommendations for changing process and procedures.
- Discuss proposed changes with affected personnel both inside and outside the group.
- Revisit suggestion and determine if data supports change..
- Modify original suggestions as required.

INPUTS: Trend analysis information from **Perform Trend Analysis Task**.

OUTPUTS: Process change recommendations and information to **Process Change Implementation Task**.

RESPONSIBILITY: Responsible Action Team with 1-2 Support Team members (depending on size of project).



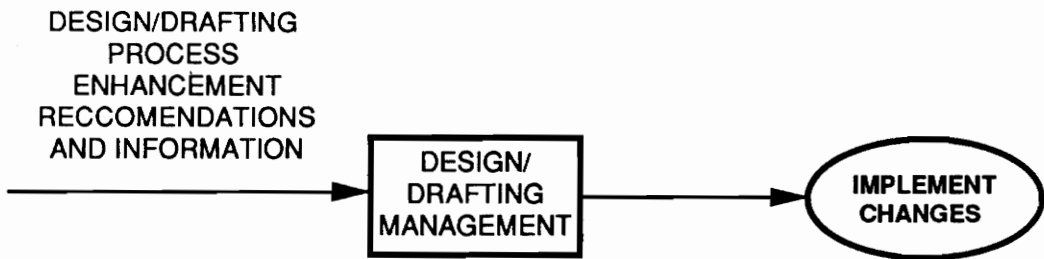
TASK: *Define and/or Refine Goals*

- If any preliminary goals were established by Responsible Action Team at the start of the analysis, these should be revisited and revised.
- If no goals existed, new goals should be established if sufficient information and data is available.
- Write the goals down, distribute them, post them. They are a focus for the improvement process.

INPUTS: Preliminary goals from **Establish Objective and Preliminary Goal Task**, trend analysis information from **Perform Trend Analysis Task**.

OUTPUTS: New or modified goals.

RESPONSIBILITY: Responsible Action Team with 1-2 Support Team members (depending on size of project).



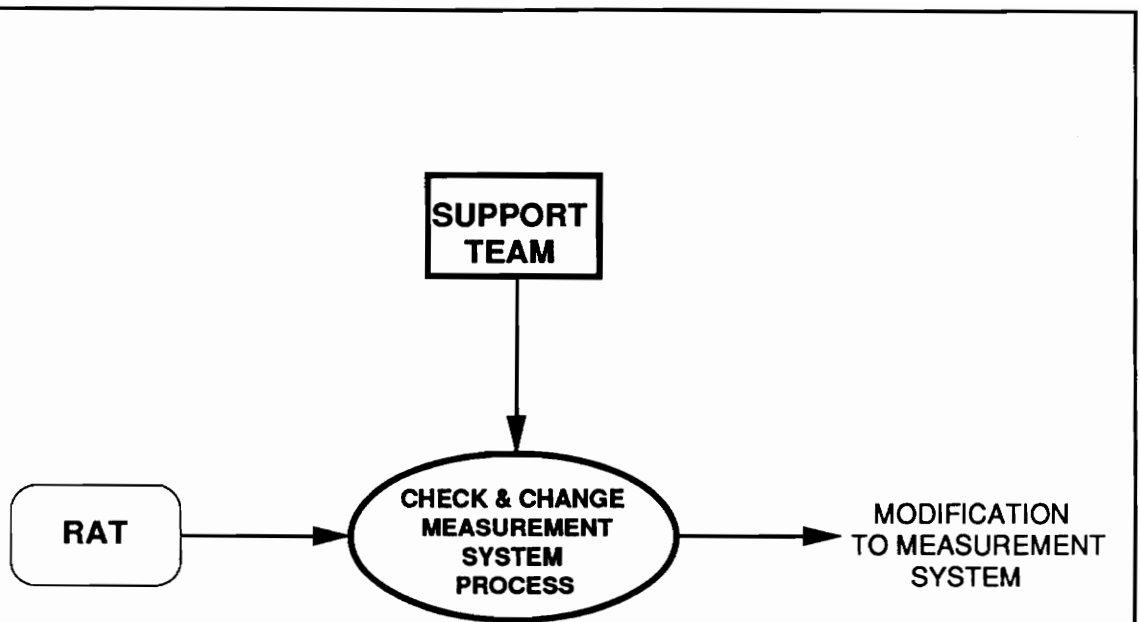
TASK: *Implement Changes to Design/Drafting Department Processes & Procedures*

- Process change justifications and recommendations are reviewed.
- If sufficient justification exists, changes to processes and procedures are developed and implemented.

INPUTS: Process change recommendations and information from **Identify Process Change Task**.

OUTPUTS: Process and procedures changes to Design/Drafting Department.

RESPONSIBILITY: Design/Drafting Department management is responsible for implementation process.



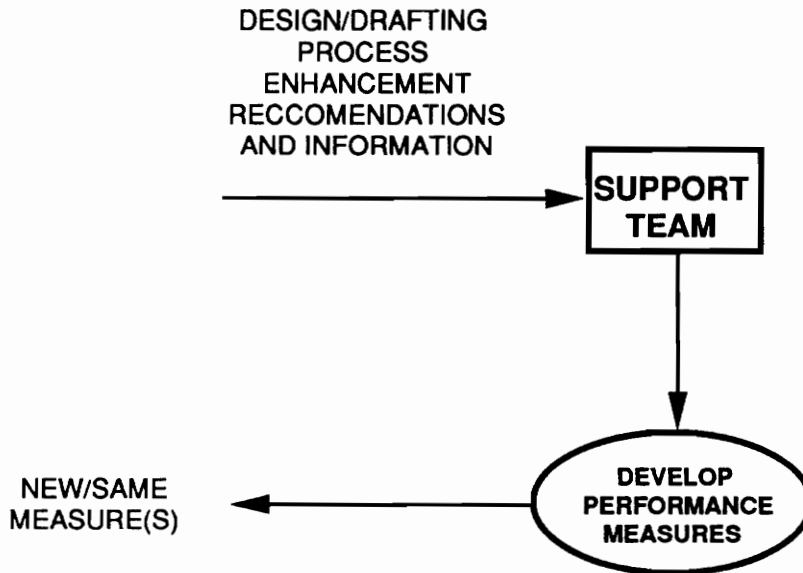
TASK: *Examine and Change Measurement System*

- Critical Step!
- Should be performed on a periodic basis (once a month?)
- Take input from Support Team and Action Teams and discuss problems and recommended changes to the measurement system.
- This Process should also include the suggestion system.
- Implement required changes.

INPUTS: Information and recommendations from Responsible Action Teams and Support Team.

OUTPUTS: Measurement system changes.

RESPONSIBILITY: Support Team - a group of 2-3 members.



TASK: *Develop Performance Measures*

- Critical Step!
- When the area of focus has been looked at and optimized satisfactorily, a monitoring measure (or measures) should be put in place to keep track of the effects of changes elsewhere in the system.
- These performance measures will be the foundation for monitoring the overall performance of the Design/Drafting Department.

INPUTS: Process change recommendations and information from **Identify Process Change Task**.

OUTPUTS: Performance measures.

RESPONSIBILITY: Support Team - a group of 2-3 members with input from management.

APPENDIX G - IMPROVEMENT SUGGESTION IDEA FORM

NO. _____

IMPROVEMENT SUGGESTION SYSTEM
SUGGESTION LOG-IN SHEET

Date of Submission:

Name of Submitter(s):

Name of Suggestion:

NO. _____

IMPROVEMENT SUGGESTION SYSTEM
SUGGESTION SUBMITTAL SHEET

Name of Suggestion:

STATEMENT OF PROBLEM:

SUGGESTED SOLUTION:

SUGGESTED IMPLEMENTATION/MEASURE:

BENEFIT TO COMPANY:

DO YOU WISH TO BE PRESENT AT THE PEER REVIEW?

Action Taken: