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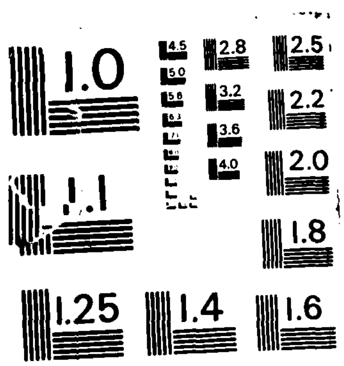

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Archester Houston
John P. Sheposh
Joyce Shettel-Neuber

Reviewed by
Richard C. Sorenson

Approved by
Robert E. Blanchard

Released by
Howard S. Eldredge
Captain, U.S. Navy
Commanding Officer

Approved for public release; distribution unlimited.

Navy Personnel Research and Development Center
San Diego, California 92152-6800

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Developing a Statistical Process Control for Supply Operations (S. Sorensen, S. L. Dockstader, & M. J. Molof) (NPRDC Tech. Rep. in preparation) should be read in conjunction with this report.

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The thrust of this research was to enhance the Naval Integrated Storage, Tracking, and Retrieval System (NISTARS) at two naval supply centers (San Diego and Oakland) through the application of sociotechnical systems analysis. Methods consisted of a system scan, a technical analysis, and a social system analysis. The system scan was used to identify environmental and organizational characteristics that influence overall performance at the supply centers. The technical analysis was used to identify major operations in NISTARS, variables that affect performance, and error control procedures. Information obtained from these analyses were used to develop measures of performance. The social system analysis identified factors that sustain and improve organizational performance.

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FOREWORD

This research was conducted by the Navy Personnel Research and Development Center (NAVPERSRANDCEN) as part of the Management of Technological Change Project under the sponsorship of the Naval Supply Systems Command. The thrust of this project was to enhance the quality of the Naval Integrated Storage, Tracking, and Retrieval System (NISTARS), a computer-directed warehousing system, through the application of sociotechnical systems analysis. The present work examines the naval supply center organization and the NISTARS operation to identify critical factors which influence the system's effectiveness. Another report (Sorensen, Dockstader, & Molof, in preparation) describes the technical analysis of the supply functions and the testing of the statistical process control (SPC) method in a work center at the Naval Supply Center, Oakland.

The authors express appreciation for the expert assistance of Mr. Brian Hood of Naval Supply Center, Oakland, and Mr. Ken Lindstrom of Naval Supply Center, San Diego, in the conduct of this research. Thanks are also given to Vel Hulton and Martin Molof of the NAVPERSRANDCEN research staff for data collection.

Questions regarding this work can be directed to Dr. Steven Dockstader, Navy Personnel Research and Development Center, Code 72, San Diego, California 92152-6800, AV 933-6935 or (619) 225-6935.

HOWARD S. ELDREDGE
Captain, U.S. Navy
Commanding Officer

JAMES W. TWEEDDALE
Technical Director

SUMMARY

Problem

The acquisition of the Naval Integrated Storage, Tracking, and Retrieval System (NISTARS) by all naval supply centers represented a major technological innovation for material handling operations. To obtain maximum benefits from this computer-operated system, however, human and technological factors critical to its effective implementation must be identified. To do this, information about both quantity and quality of the materials being handled was needed and appropriate measures developed to evaluate NISTARS performance over time.

Purpose

The first purpose of this research was to identify the critical organizational, managerial, and technological factors that could affect NISTARS performance. The second purpose was to develop measures that could be used to manage and improve NISTARS.

Approach

Sociotechnical systems analysis methods were used by researchers from the Navy Personnel Research and Development Center (NAVPERSRANDCEN) at two naval supply centers, located in Oakland and San Diego, which are in the process of implementing NISTARS. Methods consisted of a system scan, a technical analysis, and a social system analysis. The system scan was used to identify environmental and organizational characteristics that influence overall performance at the supply centers. The technical analysis was used to identify major operations in NISTARS, variables that affect performance, and error control procedures. The information obtained during the system scan and technical analysis was used to develop measures of performance. The social system analysis identified the factors which sustain and improve organizational performance.

Results and Discussion

The sociotechnical systems analysis helped to determine that the majority of factors that could affect NISTARS performance are related to organizational policies and management practices rather than technological requirements. NISTARS technology minimizes the potential for material handling errors and provides prompt and comprehensive data regarding the system's performance.

Conclusions

1. The sociotechnical systems analysis serves as an effective approach to describing a complex technological innovation and to identifying factors critical to its performance.

2. The system scan indicates that naval supply centers are confronted with a host of concerns that will not be alleviated by NISTARS. Many of the issues involve management practices and coordination among the departments and between the departments and external organizations.

3. Technical analysis of the NISTARS facilities and operations shows that if the system performs as designed it will maximize inventory accuracy and output while minimizing worker errors.

4. The identification of key variances in the operations provides useful information for the development of measures that can be used to monitor, improve, and evaluate NISTARS and naval supply center performance.

5. NISTARS provides the capability of measuring material handling activities to a degree previously unavailable to naval supply center managers. The way managers use this increased monitoring ability will have a significant effect on the overall performance of NISTARS. If the measurement system focuses on individual performance instead of system performance, however, the usefulness of NISTARS is likely to be subverted.

6. The social system analysis indicates that improved inter- and intra-organizational communications and cooperation could improve material handling at naval supply centers.

Recommendations

1. It is recommended that naval industrial activities adopting technologically complex systems to carry out their missions use sociotechnical systems analysis to identify factors critical to successful implementation.

2. The measurement capabilities of NISTARS should be used to monitor key variances identified through the technical analysis. Improvements should concentrate on the systemic factors represented by the key variances rather than on individual accountability.

3. Findings of the sociotechnical analysis should be used to improve interactions among line and support functions at the naval supply centers.

4. Naval supply centers should consider the use of statistical process control (SPC) techniques in the monitoring and improvement of NISTARS performance. SPC typically involves the use of simple descriptive statistics and group problem-solving methods to remove defects from a work process.

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INTRODUCTION

Problem

Naval supply centers have used automated material handling equipment for 17 years in an effort to increase productivity, enhance responsiveness to fleet needs, and promote cost-effectiveness (Defense Logistics Analysis Office, 1981). The Naval Integrated Storage, Tracking, and Retrieval System (NISTARS) represents the most recent and technologically advanced material handling system acquired by the Navy supply centers. NISTARS uses both robotic- and human-controlled material handling equipment that is monitored and directed by a central computer system. Managers and workers are required to use computer terminals and automated material handling equipment to perform their work.

In order to achieve the full benefits from NISTARS, however, the integration of people and machines will require careful attention. A methodology that addresses the effects such a change has on people, tasks, and technology must be identified and applied to the naval supply center work setting.

Background

Naval supply centers (NSCs) are tasked to meet the logistic needs of the U.S. Navy, both fleet and ashore. The maintaining of a high degree of inventory accuracy and the provision of supplies within prescribed time periods are critical to the fulfillment of their mission. In order to accomplish it, NSCs have relied heavily on the use of manual labor and semi-automated equipment such as forklift trucks and electrophoto-cell controlled conveyor systems. Storage, maintenance, and issuing of material have been handled by individuals using material documents provided by supervisors. There have been problems with document legibility, work performance monitoring, and worker accountability for completion of tasks. As a result, the maintenance of inventory accuracy and the monitoring of overall performance within the warehouses continue to be perceived as significant problems by the NSCs.

NISTARS was developed to enhance inventory accuracy and productivity of NSCs. The improvement of inventory accuracy was expected to result from the use of a computer system capable of monitoring over 4.5 million parts stored in 10.8 million storage locations throughout the Naval Supply Systems Command. The computer system was designed to check agreement between assigned storage locations and those already in use during material handling activities. These computer checks were intended to minimize worker errors in material storage and inventory record keeping. NSC productivity was expected to increase as a function of using computer-coordinated robotic and human-controlled storage and retrieval equipment. (See Appendix A for a general description of NISTARS.)

If NISTARS operates as designed, it will not only change the technological aspects of the work but also will affect the social arrangements. Workers and supervisors are expected to need only minimal interaction to perform their work. Supervisory and material handling tasks will be accomplished through the use of terminals and intercoms located at individual work stations rather than through face-to-face interactions. It is expected, therefore, that NISTARS will affect the amount and type of communication among personnel.

In order to assess the potential impact of a major change such as NISTARS on an organization, it would be useful to have a methodology that addresses the effects such a change has on the work system as a whole. Research on organizational behavior (e.g., Schlesinger, 1982) concludes that an organization's ability to successfully incorporate changes in order to meet its mission is a function of a number of elements. They are: (1) employment of state-of-the-art technology; (2) development of a skilled workforce (including overlapping and redundancy among skills); (3) development of an organizational design that matches or fits the technology; (4) the establishment of a shared purpose among personnel at all levels; and (5) development of formal systems that monitor or measure for the purpose of diagnosis and improvement. One approach that takes into account the complex relationship between people, tasks, and technology and that might serve as a guide for implementation of the required changes is sociotechnical systems theory (e.g., Cotter, 1983).

There are a number of reports about increases in performance and satisfaction as a consequence of redesign efforts based on sociotechnical analysis (Taylor, 1975). Over half of them have dealt with assembly operations and semi-skilled machine-tending. A much smaller percentage has involved process operations, such as supply center operations.

Margulies and Colflesh (1982) have recommended that sociotechnical system concepts be used in the implementation of technological change. They maintain that the strength of the sociotechnical systems approach lies in its ability to proceed with organizational changes in both a planned and experimental fashion. They feel that in contrast to other theories of industrial technology, such as those employing technological determinism (i.e., technology controls performance) or those that emphasize the interpersonal aspect (e.g., reduction of group tension (Bennis, 1969)), the sociotechnical approach recognizes the complex relationship that exists between technology, people, work tasks, and management.

Another advantage of sociotechnical analysis is that it can aid in the development of ways to measure work system performance through the identification of key variances (Taylor, 1979). Taylor suggests that these measures may be particularly useful in assessing quality of performance. The sociotechnical approach provides a framework for creating a set of measures unique to the operations and goals of the organization under study.

The use of sociotechnical systems analysis to direct, implement, and monitor technological change was seen as a valid approach by researchers from the Navy Personnel Research and Development Center (NAVPERSRANDCEN) with respect to the introduction of NISTARS technology in NSCs. At the time of this study, the first installation of NISTARS equipment was being completed at the NSC in Oakland, CA. Subsequent installations were scheduled to occur in NSC, Norfolk, VA and NSC, San Diego, CA. For the present study, sociotechnical systems analyses were performed at NSC, Oakland and NSC, San Diego. The technical analysis portion reported here was conducted at NSC, Oakland because the NISTARS facility there was closer to becoming operational.

Purpose

The present research was designed to investigate the critical organizational, managerial, and technological factors (variances) which influenced supply operations prior to the introduction of NISTARS and which may continue to be of concern to management after NISTARS is operational. Measures were also to be developed for those variances that require close monitoring and control to ensure efficient handling of material. Sociotechnical systems analysis was selected as the approach to use to assess critical human and technological features of the supply system.

APPROACH

The approach used to study the NSC organizations that had adopted NISTARS was sociotechnical systems analysis (STSA). The concept of sociotechnical analysis is derived from the premise that any work setting requires both a technology, a process that transforms raw materials (input) into a product (output), and a social structure that links people with the technology and with each other. According to Taylor (1975), sociotechnical system design differs from other approaches with respect to effecting a people/machine match by "attending <u>simultaneously</u> to the technical and production requirements of the work, <u>and</u> to the psychological and social aspects of individual and group requirements" (p. 17).

Briefly, a sociotechnical analysis first looks at the overall organization to identify its mission, operations, and boundaries. Analyses of the technical and social systems then follow. The technical system analysis specifies the major operations or unit operations in the process in terms of inputs, transformations of the inputs, and outputs. Central to the technical analysis is the identification of key variances, factors that are critical to overall functioning of the technical system.

The social system analysis details work-related interactions among people in the organization and the relationship of organizational goals to the social system. Study of the social system can indicate where existing organizational structures are not conducive to communication and management control. The analyses of the social and technical systems are reviewed to determine any changes needed in the organization. These changes then are incorporated into a redesign of the organization that provides a better match between the technical and social systems. Following the social and technical analyses, work elements are recombined so that the key variances are controlled by the workforce. Control of key variances is placed at the lowest level at which there is both a technical subsystem and a social subsystem.

The STSA of the NSC supply system consisted of three steps: system scan, technical analysis, and social system analysis. The following defines each step and describes the data collection methods used.

System Scan

Step one of STSA at the NSCs was the system scan, performed to obtain a broad description of the organization and its concerns to see how they could influence the effectiveness of NISTARS.

The system scan was conducted at NSC, San Diego. Five NAVPERSRANDCEN researchers conducted a group interview of 12 managers at the NSC site. Seven of the managers represented the supply functions of receiving, bin storage, bulk storage, aviation material, NISTARS, inventory, and shipping. Five managers represented the support functions of civilian personnel development, data processing, employee relations, personnel, and planning.

This group of NSC managers participated in a 4-day series of interviews and discussions concerning 8 aspects of their NSC organization. The following list defines the aspects that were discussed.

1. Mission or purpose of the organization.

2. Inputs or raw material used by the organization.

3. Product or final output of the organization.

4. Boundaries of the organization, which refer to the physical input and output locations, the time requirements associated with work processes, and different organizational responsibilities.

5. Environmental elements, such as other organizations, resources, and requirements with which the NSC must work in order to accomplish its mission.

6. Economic objectives or the organization's goals to minimize operating costs.

7. Social objectives or the organization's goals in the areas of individual employee development and quality of work life.

8. System objectives or possible areas for improvement within the total system of the NSC.

Technical Analysis

Step two of STSA was the technical analysis, performed to obtain information on four technological aspects of the system:

1. Unit operations or the unique stages required to transform inputs into outputs.

2. Variances or changes in inputs, equipment, or work procedures that could affect system performance.

3. Key variances or those variances that have the greatest potential effect on the quantity, quality, or cost of system performance.

4. Control or procedures used to correct and minimize the harmful effects of key variances.

Information on the technological aspects of NISTARS was obtained through: (1) attendance of training sessions for NISTARS supervisors and operators at NSC, Oakland, (2) review of NISTARS documentation, and (3) site visit of facilities and interviews with the NISTARS managers at NSC, Oakland. NSC, Oakland was used as the site of the technical analysis because it was in the final stages of installation at the time the study was being conducted.

Social System Analysis

Step three of STSA was the social system analysis. The analysis of the management system of NSC, San Diego permitted a general description of the basic functions of the material department's social system along the lines recommended by Cherns, Wacker, and Cotter (1980). Their model defines four basic functions of an organization's social system:

1. Goal attainment or the short-term activities performed in order to generate products.

2. Adaptation or responses to short-term changes and emergencies in the organization.

3. Integration or the activities designed to minimize conflict and promote smooth interaction among people.

4. Long-term maintenance or preparations taken to meet future technological, personnel, and customer requirements.

Information on how these social system functions were performed was obtained through structured interviews. Twenty-eight NSC, San Diego employees from 5 functions were interviewed: receiving (8), storage (7), issuing (4), packing (6), and quality assurance (3). Individuals were asked 53 questions covering such topics as job duties, work impediments, communications, training, and conflict resolution. Appendix B presents the items used.

RESULTS AND DISCUSSION

System Scan of NSC, San Diego

The following organizational characteristics were examined during the system scan. The group of 12 managers from NSC, San Diego provided the following definitions.

Mission	Provide ashore and afloat units with the correct material in time to accomplish their mission. This responsibility should be fulfilled at the lowest possible cost.
Input	Material received and accepted for processing.
Products	Correct material released to correct mode of transportation.
Boundaries	The physical boundaries of NSC, San Diego consisted of four buildings where material was received and five buildings where material was released to transportation. Six time boundaries were identified--three deadlines each for storing and issuing of material based on the material's priority. Seventeen personnel boundaries were identified in NSC, San Diego, including receipt control clerks, customer service clerks, and contractor maintenance auditors.

Environmental Elements — Seventeen external elements were identified and included the Naval Supply Systems Command, customers, Public Works Center, and vendors.

Economic Objectives — Nine economic objectives were identified, including "minimizing lost time due to accidents and reducing material handling damage."

Social Objectives — Nine social objectives were identified. Examples included "achieving affirmative action objectives and improving communication in all directions."

System Problems — Forty-nine problems were identified and organized into seven categories. The categories and number of associated problems were: operational (11), management (10), personnel (6), internal coordination (7), working conditions (5), material and documentations (4), and computer process control (6).

Appendix C presents the responses in detail.

NISTARS Technical Analysis

The findings of the NISTARS technical analysis have been organized into three sections: unit operations, NISTARS variance matrix, and NISTARS material handling errors.

Unit Operations

As noted earlier, unit operations refer to the unique stages and associated tasks in a process. NISTARS has five unit operations: induction, stow, issue, consolidation/packing, and shipping. Figure 1 shows the relationship among the unit operations. The activities performed within each unit operation are described below.

Figure 1. Unit operations of NISTARS at two naval supply centers.

Induction. The function of the induction operation is to transfer material from central receiving warehouses to NISTARS storage areas. Material arriving at the induction work station is compared to its stow document for possible discrepancies, counted, and measured for cube/weight data. The material is then assigned a bar code label that serves as the material's stow identification number (SIN). The material is sent by conveyor to a NISTARS central controller (NCC)-assigned storage area.

Stow. When material arrives at its assigned storage area, its SIN label is entered in the work station terminal. The work station video monitor then displays the information needed to store the material. The material is reinspected for discrepancies and placed in the assigned location by the operator.

Issue. Following directions given by the NCC, the material to be issued is obtained by either the automated "ministacker" crane or worker-driven storage-and-retrieval machine. Once the material is obtained, a worker checks the stow document against information presented on the video monitor. The worker then picks out the amount of material indicated on the monitor. The material is then assigned a pick identification number (PIN) label and sent by conveyor to the consolidation/packing area.

Consolidation/Packing. The function of the consolidation/packing operation is to prepare materials and documents needed to release material to transportation services. On its arrival, the PIN of the material is entered in the work station terminal. Material is weighed, consolidated with other ordered materials, and packed. Labels are printed by the work station printer and affixed to the packing carton. The completed packages are then placed on a conveyor that takes them to the shipping area.

Shipping. The function of the shipping operation is to sort material into parcel post and local delivery shipping units for transportation. Parcel post material is placed in bins for pickup by the parcel post carriers. Local delivery material is consolidated by customer, placed on a pallet, and routed by conveyor to a cargo truck for delivery. For local delivery, the shipping operator performs a computer transaction to verify that the customer order has been shipped.

NISTARS Variance Matrix

Variances refer to factors or events in a process that are capable of deviating from a desired value or level. Variances could exist in the inputs, equipment, or procedures associated with a process. It should be noted that variances are not necessarily problems to be solved, but reflect technical requirements to be met or "controlled." Fifty-three variances were identified in the NISTARS unit operations. Variances that have the greatest potential to affect quantity of output, quality, or cost of a process are known as "key variances." Twenty-one of the variances were identified as key variances. Figure 2 presents a matrix of the NISTARS variances.

The variance matrix depicts the potential interactions of variances both within and between unit operations. On the matrix, dots indicate that there is a relationship between the two variances. The matrix shows that there is a minimum of variance interaction between adjacent unit operations and no interaction between non-adjacent unit operations such as induction and issue. This finding indicates that NISTARS is a tightly controlled system, which minimizes the possibility that errors within one unit operation will affect the performance of subsequent unit operations. An exception is the amount of material transferred from one unit operation to the next. Although the NISTARS system concentrates on minimizing individual material errors and their subsequent impact on unit operations, it does not address the impact of volume fluctuations from one unit operation to the next.

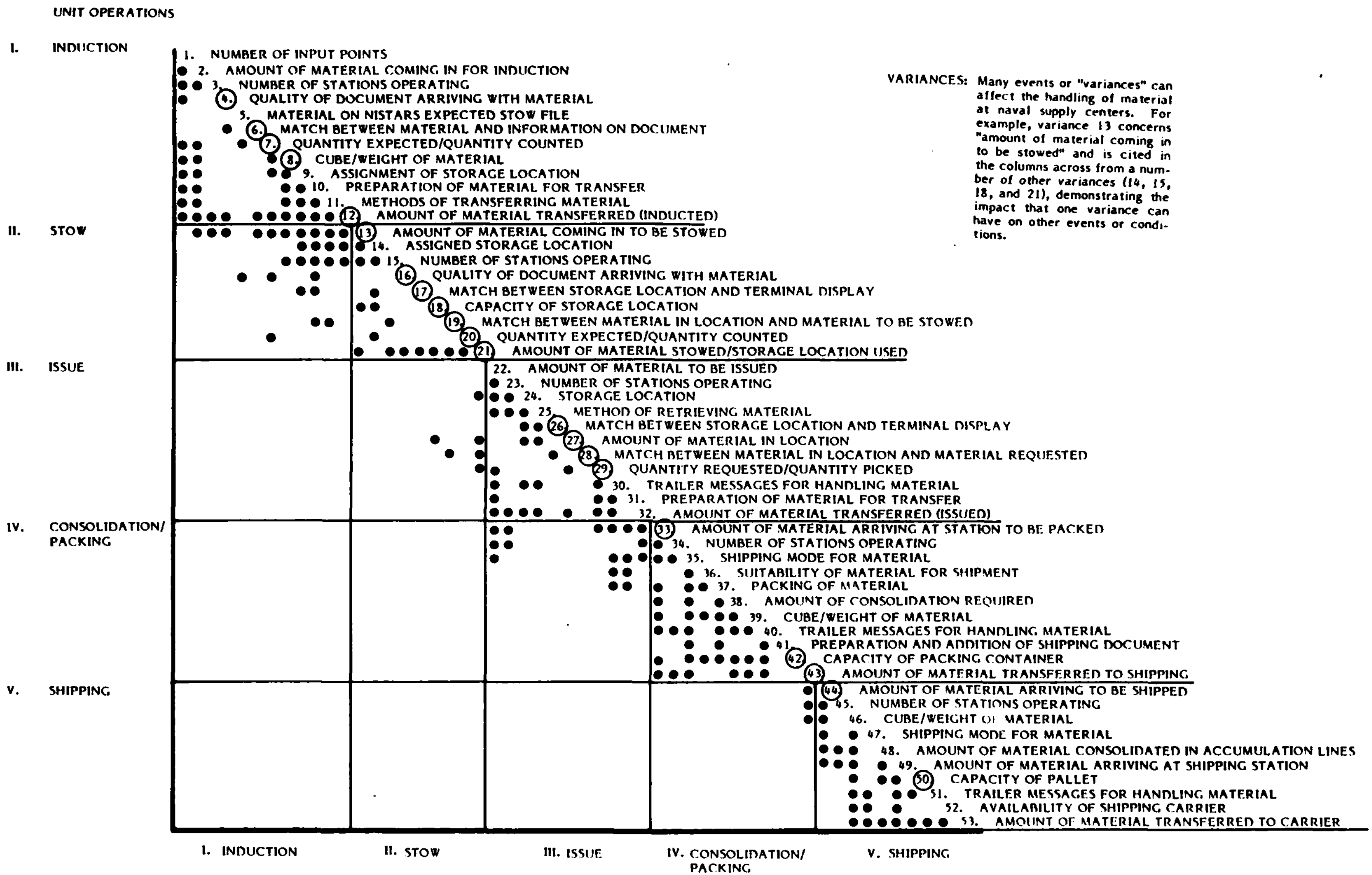

Figure 2. NISTARS variance matrix. A circle around a number indicates a key variance.

NISTARS Material Handling Errors

The key variances, if uncontrolled, result in material handling errors. In most cases, these errors are the result of one key variance being uncontrolled. In the others, several uncontrolled key variances result in the error. Appendix D presents the major material handling errors, the unit operations in which they can occur, and the key variance(s) associated with them.

Table 1 depicts the material handling problems and actions taken to resolve each problem. The purpose of analyzing the error correction procedures was to identify potentially ineffective problem-solving activities. The analysis identified where the key variances occurred, where they were observed and controlled, the individual(s) involved in controlling them, the activities required to control them, and sources of information used in the control process. The technical analysis revealed that while uncontrolled key variances represent system disruptions within NISTARS, the factors that lead to those disruptions for the most part were found outside NISTARS. For example, a condition code error occurs when incorrect data are provided on the document accompanying material generated outside NISTARS. In order to correct this problem, NISTARS personnel must interact with personnel outside the NISTARS system (in this case, NSC material inspectors). Material handling problems frequently lead to "frustrated" material, that is, material removed from the work station and placed in a special holding area until the error can be corrected.

The correction of errors within NISTARS required specially designed computer software. This software enables individual workers to resolve these problems without the intervention of supervisors. While NISTARS software allows individual workers to deal with problems as they occur, the software was not designed to identify and resolve problems in a systematic fashion nor to identify the sources of those problems. Problems can be dealt with only on an individual basis. Quality improvement efforts in NISTARS could be prone to cycles of error identification and correction rather than error prevention and system improvement.

Social System Analysis

The results of the social scan are grouped by social system, as defined by Cherns et al. (1980).

Goal Attainment

With regard to goal attainment, warehouse workers are clear as to their duties and performance levels. Information about performance standards is available to them and the standards appear to be attainable by the workers. Overall, the material handling operations are seen by personnel as effective.

Adaptation

Fluctuations in volume of material and special material handling are dealt with in a routine fashion. These potential problems are controlled within reasonable limits by such means as shifting manpower resources, reordering priorities, and maintaining an accurate backlog. In summary, NSC, San Diego has developed procedures that adequately deal with many of the material handling perturbations that arise.

Table 1

NISTARS Error Correction Procedures

Key Variance	Where Occurs	Where Observed	Where Controlled	Controlled By Whom?	Activities Required To Control	Information and Sources of Information Related to Control Activities
Identification error	Induction and stow/issue stations	When material first arrives at work station.	In frustrated material area	Induction operator Material inspector	Material is placed in frustrated material area and inspector is contacted to classify material so that a document can be generated.	Data provided on material packaging.
Condition code error	Induction station	When material's physical condition is compared to code on document.	At induction station	Induction operator Material inspector	Material is placed in frustrated material area and inspector is contacted to classify material so that a document can be generated.	Physical condition of material and training provided earlier to operator on identification of condition code status.
Receiving error	Induction station	When material does not match document.	In frustrated material area	Induction operator Material inspector	Material is placed in frustrated material area and inspector is contacted to identify material so that a proper document can be generated.	Data provided on material packaging, inspection of material, and information on Material Movement Document (MMD).
Cube/weight error	Induction station	When material is placed on cube/weight sensor.	At induction station	Induction operator	Material is divided into acceptable cube/weight movement units, if possible, or frustrated for later resolution.	Cube/weight data provided by sensor. Inspection of material.
Quantity error (receiving)	Induction and stow/issue station	When amount counted at station is entered into the terminal.	At induction station	Induction operator	Material is recounted and the number is entered into the terminal.	Quantity counted by operator. Information of material quantity expected by NCC.

Table 1 (Continued)

Key Variance	Where Occurs	Where Observed	Where Controlled	Controlled By Whom?	Activities Required To Control	Information and Sources of Information Related to Control Activities
Misdirected material	Stow/issue, packing, and shipping stations	Inspection of frustrated conveyor spurs or when bar code of material is entered.	At nearest work station	Stow/issue station operator or supervisor	Bar code label of material is entered and material is taken by operator to the location given by the terminal screen.	Bar code label, tote pan setting assigned destination in NCC stow files, messages presented on terminal screen.
Configuration error	Ministacker and binnable manned storage/ retrieval machine (MS/RM) stow/issue stations	When storage location is compared to display on terminal screen.	At ministacker and binnable MS/RM stations	Stow/issue station operator	Operator verifies mismatch between display and location. Checks to see if material is presented in storage location for issue.	Inspection of storage location on terminal display and NSNs in storage location.
National Stock Number (NSN)/location area	Stow/issue stations	When last two digits of NSN found in storage location are entered in terminal.	At the stow/ issue stations	Stow/issue station operator	Operator checks to see if NSN is present in storage location.	NSN in storage location, NCC inventory files, and messages on terminal screen.
Location-empty error	Stow/issue stations	When terminal requests NSN check and location is empty.	At the stow/ issue stations	Stow/issue station operator	Operator checks to see if material is present somewhere else in the storage location. Stores material in assigned location.	Inspection of NSNs in location, NCC inventory files, messages on terminal screen.

Table 1 (Continued)

Key Variance	Where Occurs	Where Observed	Where Controlled	Controlled By Whom?	Activities Required To Control	Information and Sources of Information Related to Control Activities
Location-full error	Stow/issue stations	When capacity of location is insufficient for stowing incoming material.	At the stow/issue stations	Stow/issue station operator	NCC assigns different location; material is then stowed by operator.	Inspection of NCC storage location inventory files, messages on terminal screen.
Quantity error (issue)	Stow/issue stations	When amount of material in storage location is less than amount requested on terminal.	At the stow/issue stations	Stow/issue station operator	NCC requests the total amount be issued and the remainder be issued from another station or assigns total issue to another station.	Quantity counted by operator, NCC inventory files, messages on terminal screen.
Carton-full error	Consolidation/packing stations	When carton is full and additional material arrives.	At the packing station	Consolidation/packing station operator	Operator indicates carton is full. NCC initials new carton consolidation for remainder of issue.	Inspection of carton capacity, NCC cube/weight files, customer requisition data.
Pallet-full error	Shipping stations	When pallet is full and additional material for the pallet arrives.	At the shipping station	Shipping station operator	Operator indicates that pallet is full. NCC initiates new pallet for remainder of issues.	Inspection of pallet capacity and NCC "pallet full" subroutine program.

Integration

The most problematic of the four social system functions is integration of activities designed to minimize conflict between people. Several areas threaten the integration function. Foremost are the problems associated with vendors and carriers, who represent external input and output functions respectively. Vendors provide material to the NSC for warehousing and eventual distribution to the fleet. There are instances in which vendors make late or unscheduled deliveries, deliver the wrong material to the NSC, or deliver an amount of material less than that indicated on the document. When these errors occur, the NSCs hold discussions with the offending vendors to explain the type of service desired. In extreme cases vendors are dropped by the supply center.

Difficulties with carriers involve the coordination of the shipping operation with the arrival of the required carrier service. Because carriers sometimes have to stop off at several different warehouse locations, the actual delivery of a customer's order can be delayed. While potentially serious, carrier problems are considered to occur infrequently and perceived more as irritants than crises.

Another potential threat to integration is a tense, if not adversarial, relationship between quality assurance and the various NSC operations. Responses from quality assurance inspectors indicate a distrust of the workers in the supply operations. They feel that without frequent inspections of workers, the quality of NSC service would be considerably poorer. Respondents from the warehousing operations state that, for the most part, the activities of the quality assurance inspectors are not contributing significantly to the quality of NSC service. Greater effort to enhance integration between the quality assurance inspectors and the warehouse workers appears to be warranted. No other major inter-departmental conflicts were evident.

Another source of turbulence, common to organizations that have a mix of military and civilian workers, is the periodic rotation of military personnel in command positions. The work phases that military managers pass through--learning the system, operating it, and preparing for transfer--are perceived as leading to inconsistent management of NSC operations. There was some concern voiced about the sufficiency of information conveyed; comments were made about the inadequacy of communication, both vertical and horizontal. It was suggested during the social system analysis interviews that more frequent, informal "rap" sessions be held between supervisors and their work groups.

Long-term Maintenance

Attempts to maintain the system over the long-term are accomplished primarily through training, a large proportion of which is carried out on the job. One training program being developed is the Competency-based Certification Program that is being established to deal with long-term training concerns. Many personnel have also received specialized training, for example, a course on the recognition and handling of hazardous or flammable material. (This course was perceived as valuable because it improved the timely handling of such material and served to enhance the job skills of NSC workers.) Issues identified as important in maintaining the system included improved methods for dispensing awards, for classifying personnel changes, and for handling contractor relationships.

Measurement Issues in NISTARS

The use of sociotechnical analysis helps to identify appropriate measures for evaluating work systems performance. The determination of boundaries, unit operations, and key variances provides the framework for identification of measures of variances, throughputs (resulting from each unit operation), outputs (the culmination of all unit operations), and outcomes (the external evaluation of performance). Figure 3 illustrates the relationships of these different levels of measurement.

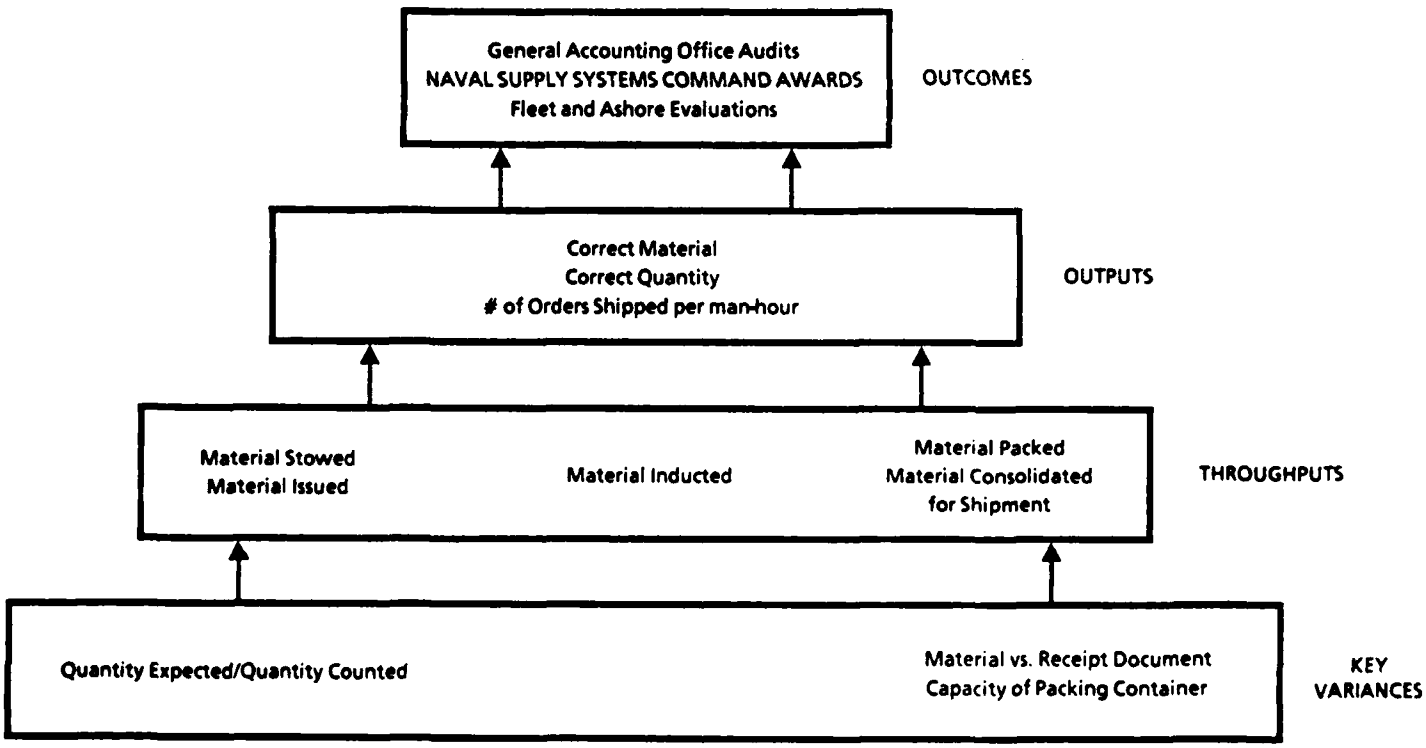

Figure 3. Levels of measurement to support NISTARS within a naval supply center setting.

The most elemental level of measurement deals with the key variances, which affect the unit operation and operations down the line in the transformation process (throughputs). The performance at the unit operation level should, in turn, have an effect on output measures. Appendix E provides sample measures for evaluating these three levels.

The NISTARS computer system is capable of providing information on the material handling operations to a degree previously unavailable. NISTARS can produce on demand data on work-in-progress, system throughput, and individual worker productivity through the use of its computer terminals. While the wealth of information provided by NISTARS can contribute to the efficient operation of the system, simple collection of data will not ensure the most efficient operation of NISTARS. The value of data collection in NISTARS will be determined by how the information is used by management. It is possible that the NISTARS information system could be used to over-control the activities of individual workers, while ignoring systemic sources of variance that may be more serious.

Sociotechnical theory hypothesizes that a system would be most efficiently run by monitoring and controlling key variances close to their sources. That hypothesis suggests that the development of a measurement system that would aid in identifying those sources would be of greater value than the simple recording of system problems and productivity levels. For example, the cube/weight error could be presented as the number of inductions too large or too heavy to transfer to storage over the total number of inductions performed for a specified time period. Although that ratio provides information on a NISTARS problem, it is not particularly useful to a manager attempting to prevent cube/weight problems. Of greater use to a NISTARS manager would be the ability to identify cube/weight problems by source, such as vendor or other supply center, and the degree of the discrepancy. With that type of information, the NISTARS manager could make a recommendation to a specific vendor to pack material so that it meets the cube/weight requirements of NISTARS material handling equipment.

CONCLUSIONS

1. Sociotechnical systems analysis serves as an effective approach to describing a complex technological innovation and to identifying factors critical to its performance.

2. The system scan indicates that naval supply centers are confronted with a host of concerns that will not be alleviated by NISTARS. Many of the issues involve management practices and coordination among the departments and between departments and external organizations.

3. Technical analysis of the NISTARS facilities and operations shows that if the system performs as designed it will maximize inventory accuracy and output while minimizing worker errors.

4. The identification of key variances in the operations provides useful information for the development of measures that can be used to monitor, improve, and evaluate NISTARS and naval supply center performance.

5. NISTARS provides the capability of measuring material handling activities to a degree previously unavailable to naval supply center managers. The way managers use this increased monitoring ability will have a significant effect on the overall performance of NISTARS. If the measurement system focuses on individual performance instead of system performance, however, the usefulness of NISTARS is likely to be subverted.

6. The social system scan indicates that improved inter- and intra-organizational communications and cooperation could improve material handling at the naval supply centers.

RECOMMENDATIONS

1. It is recommended that naval industrial activities adopting technologically complex systems to carry out their missions perform sociotechnical systems analysis to identify factors critical to successful implementation.

2. The measurement capabilities of NISTARS should be used to monitor key variances identified through the technical analysis. Improvements should concentrate on the systemic factors represented by the key variances rather than on individual accountability.

3. Findings of the sociotechnical analysis should be used to improve interactions among line and support functions at the naval supply center in San Diego.

4. Naval supply centers should consider the use of statistical process control (SPC) techniques in the monitoring and improvement of NISTARS performance. SPC typically involves the use of simple descriptive statistics and group problem-solving methods to remove defects from a work process. One such SPC approach, espoused by Deming (1982), includes a set of management principles intended to maximize inter- and intra-organizational communication and cooperation. The research effort of Sorensen, Dockstader, and Molof (in preparation) represents an attempt to use SPC techniques in a naval supply center setting.

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APPENDIX A

GENERAL DESCRIPTION OF NISTARS

GENERAL DESCRIPTION OF NISTARS

The Naval Integrated Storage, Tracking, and Retrieval System (NISTARS) was developed in 1980 by Sperry Corporation for the Naval Supply Systems Command. NISTARS features a computer complex called the NISTARS central controller (NCC). Functions of the NCC include: selecting the most efficient storage location based on an item's volume, weight, and demand; routing it to the proper location; selecting the most efficient retrieval location; preplanning mechanized storage/retrieval trips; and coordinating the consolidation of items coming from different areas of the warehouse.

At each stage of the material handling process, workers are linked to the NCC by work station terminals. All work stations are similar in design and have the equipment necessary to allow the worker to receive and provide information under the direction of the NCC.

Most work stations consist of a computer terminal keyboard, video display monitor, and a photo-optical wand for reading bar code labels. NISTARS tracks and diverts material through the warehouse conveyor system using bar code labels for identification. When items are first received, the NCC directs the receiving worker to attach a bar code label to the item and "read" it into the computer using the optical wand. Laser scanners along the conveyor system read the bar code and direct the item to the proper location for storage, retrieval, consolidation, packing, or shipping.

For the storage and retrieval of items, robotic and semiautomatic equipment is used. For small items, a robotic device called a "ministacker" retrieves storage trays at the direction of the NCC and delivers them to work stations for storage or retrieval operations. When the worker has finished with a tray, the ministacker automatically returns it to its original location.

For larger items, manned storage-and-retrieval machines move along storage racks under the control of a worker. The worker drives the machine to a location displayed by the NCC on the work station video monitor. Upon arriving at the location, the worker performs the storage or retrieval operation indicated on the monitor at the time. The NCC preplans the route, combining storage and retrieval operations through a software "workload planner" in order to maximize the efficiency of each trip.

After an item has been picked up, it will be carried to consolidation and shipping operations by conveyor. At this point, required papers and labels will be printed automatically and matched to the material. The items are loaded into the appropriate ground transportation for delivery to their destination.

The NCC provides a management information system to assist supervisors and managers control warehouse operations. The system provides information such as inventory stock and order levels. Warehousing operations can be monitored on a moment-to-moment basis. The NCC also provides a simulation program of the warehouse operations, intended to be used by the NISTARS general manager in evaluating the effect of shifting workers to different operations when the warehouse cannot be fully manned and to assist the manager in devising an optimal manning strategy.

APPENDIX B

SOCIAL SCAN SURVEY QUESTIONNAIRE

PRESENT JOB

1. What is your job title? and location? (Code, Bldg., Number)

2. How long have you had this job?

MISSION

3. What is the purpose of the NSC? (in your words)

4. Is the NSC meeting its mission (purpose)?

DESCRIPTION OF JOB DUTIES

5. Tell me what you do? Describe your job duties (procedures).

MAJOR PROBLEMS

6. What are the major difficulties/obstacles you encounter while doing your job?

7. What do you do about it? Give me a step-by-step description. What sources of information are used? (Manuals, computer files, people, etc.)

8. If the problem is passed on to someone else, who handles the

problem? (Position, Code)

9. What is the final outcome?

10. Do you know of anything being done to keep it from happening again?

11. Do you have any suggestions or recommendations for handling this problem?

COMMUNICATIONS

12. How do people in your work area get their work assignments?

13. Are they usually complete and clear?

14. How are people notified of changes in routine or assignments?

15. How do people find out how well they are doing?

16. Are there any problems in job-related communications between you and your supervisor?

17. Are there any problems in job-related communications between you and co-workers?

18. Are there any problems in job-related communications between you and people outside your code?

CONFLICT RESOLUTION

19. Have there been any conflicts between workers and supervisor?

20. Have there been any conflicts between workers and co-workers?

21. Have there been any conflicts between workers and people outside your code?

22. How were the conflicts resolved?

QUALITY ASSURANCE

23. Is your work inspected by the Quality Assurance Department?

24. By whom? (Quality Assurance branch inspectors/examiners? Quality Assurance realtime team? Internal department team? Supervisor/leader?)

25. Anyone else?

26. Do you think Quality Assurance inspection improves the

service of NSC? That is, does it help your work unit to perform better?

27. Have you had, or do you have any problems with the Quality Assurance effort?

28. Do you have any suggestions for improving Quality Assurance?

TRAINING

29. What kind of training did you receive for this job?

30. Describe the training you had.

31. How long did it last?

32. Who conducted your training? (NSC, outside contractor, school or other government agency).

33. How much did it help you in performing this job?

34. Have you had any additional training pertaining to this job?

35. Describe the training you had. (Lectures, on-the-job-training, hands-on exercises, etc.)

36. How long did it last?

37. Who conducted your recent training?

38. How much did it help you in performing your job?

39. Are you scheduled to receive any job-related training in the future?

40. What is the purpose of the training (type, content)?

41. How long will the training be?

42. Who will conduct it?

43. How do you think it will help you?

44. Do you think the training you have received is adequate to do the job?

45. Would you like to have training specific to this job? What other training would you like?

46. How do people get center or job-related information? (Training courses, job openings, personnel changes, etc.)

GENERAL RECOMMENDATIONS AND SUGGESTIONS

47. Do you have any suggestions for how to improve your job to make it more efficient, easier, less costly, more accurate?

48. Do you have suggestions for your department?

49. Do you have suggestions for your work group?

50. Have you ever submitted a suggestion?

51. To whom?

52. Did anyone acknowledge your suggestion?

53. Was anything done with regard to your suggestion?

APPENDIX C

SYSTEM SCAN OF THE PHYSICAL DISTRIBUTION DEPARTMENT, NAVAL SUPPLY CENTER, SAN DIEGO

SYSTEM SCAN OF THE PHYSICAL DISTRIBUTION DEPARTMENT
NAVAL SUPPLY CENTER (NSC), SAN DIEGO

1. THE SYSTEM OBJECTIVE. The overall system objective statement developed at NSC San Diego was to "provide ashore and afloat units with the correct material in time to accomplish their mission. This responsibility should be fulfilled at the lowest possible cost consistent with good service."

2. SYSTEM OUTPUT. The product was identified as "correct material released to the correct mode of transportation."

3. SYSTEM INPUT. The input is the raw material which the system transforms or converts into the output. It should be noted that the input is not the expendable tools or materials which are used up or consumed by the transformation process. Nor is input the labor or methods of conversions. The input was identified by the task group as "material received and accepted for processing."

4. THE BOUNDARIES OF THE NAVAL INTEGRATED STORAGE, TRACKING, AND RETRIEVAL SYSTEM (NISTARS). This organizational analysis deals with multiple boundaries, that is, technical boundaries, territorial or physical boundaries, time boundaries, and people boundaries. Although all of the boundaries are important for the scan, the technical boundaries are the most important because they identify where the product enters and leaves the system. In other words, these points indicate when material first "belongs" to NSC and when it ceases to be under NSC control.

The input boundaries were defined as:

National City Annex (NCA), Bldg. P014
NCA Bldg. 279
NISTARS, Bldg. 3302
NCA Cold Storage, Bldg. 7

The output boundaries were defined as:

NCA Bldg. 65 (Parcel Post, United Parcel Service)
NCA Local Delivery, Bldg. P034
NISTARS Bldg. (Parcel Post, United Parcel Service)
Dry Provisions, Bldg. P014
Frozen Provisions, Bldg. 7

The time boundaries for issues were defined by issue priority groups (IPGs) as outlined by NSC Notice 5250, 25 March 1983. These were:

IPGI--within 24 hrs. + 1 day for determining availability
IPGII--within 2 days + 1 day for determining availability
IPGIII--within 8 days + 1 day for determining availability

The time boundary from tailgate to stow was defined by the NSC goal of 100 percent within 4 days.

The time boundaries for the material to be stored were 90 percent processed within 5 days for priority 03 and 06 items, and 85 percent processed within 10 days for priority 13 items.

People boundaries were defined to include activities both inside and outside of the NISTARS warehouse. Those outside were quality assurance, receipt control, shipping, documentation, nonmechanized warehouses, customer service, inventory, stock requirements (inventory manager), Servmart central receiving, and contractor maintenance (software and hardware). Those activities within the NISTARS warehouse were induction, storage, retrieval, packing, shipping, process control, and system management.

5. ENVIRONMENTAL ELEMENTS. There are many diverse aspects in any system's environment. It is important to consider these environmental elements during the analysis and later during the design process. The following elements were listed by the task force:

   a. Union
   b. Naval Supply Systems Command
   c. Customers
   d. Vendors/contractors
   e. Carriers
   f. Equal Employment Opportunity office
   g. Auditors
   h. Available labor pool
   i. Other NSC organizations
   j. Inventory managers
   k. Regulations
   l. Physical environment (light, temperature, etc.)
   m. Military operations/mobilization
   n. Fire department
   o. Office of Safety and Health Administration
   p. Public Works Center

6. ECONOMIC OBJECTIVES. The task group generated the following list of economic objectives:

   a. Stay within authorized costs.
   b. Be competitive with the private sector.
   c. Provide quality service (i.e., error-free).
   d. Operate with optimal use of available human resources.
   e. Stay within time standards.
   f. Minimize lost time due to accidents.
   g. Reduce material handling damage.
   h. Minimize lost time due to sick leave and unauthorized leave.
   i. Minimize physical inventory adjustments.

7. SOCIAL OBJECTIVES. The social objectives can describe aspects of an organization's values. In some cases those values are stated in terms of current levels of achievement and sometimes in terms of what the system would like to provide for people. The task group arrived at the following list:

   a. Provide a safe working environment.
   b. Provide training.
   c. Provide appropriate recognition that will include 90 percent of the workforce.
   d. Maintain a motivated workforce.
   e. Improve communication in all directions.
   f. Encourage innovation.

g. Develop a management philosophy.
h. Eliminate fear.
i. Provide methods for improving productivity other than numerical goals, posters, and slogans.
j. Remove barriers that stand between workers and their right to pride in workmanship.
k. Achieve affirmative action objectives.
l. Provide a career progression for the employees in the Physical Distribution Department.
m. Provide experience in areas outside Physical Distribution that offer alternative career opportunities and help workers to better understand NSC operations.

8. PRESENTING PROBLEMS. The term "presenting problems" refers to the issues raised in response to the question, "What problems would you like to resolve?" The problems listed below were generated by the task group. They were organized into seven categories.

a. Operational (methods and procedures)

- Nonuniform workload
- Accountability difficult to track
- Inventory inaccurate
- Transportation of material between locations incorrect
- Location accuracy not maintained
- Physical security not maintained
- Quality assurance process not effective
- Nonproductive backlog
- Returned material (How will NISTARS handle temporary storage of excess material?)
- Lack of clear NISTARS procedures for handling repairables
- Lack of clear NISTARS inventory procedures

b. Management and Supervision

- Inefficient first-level supervisors
- No center-wide management philosophy
- Goals not communicated to workers
- Introduction of technological change
- Management's excessive paper workload
- Management reports not used
- Washington central control over daily operations (micromanagement)
- Supervisors not effectively handling worker problems
- Poor response to employee suggestions
- Higher grade positions in nonline departments

c. Personnel
- Lack of skills
- Inadequate assessment of employee skills
- Lack of opportunity for upward mobility
- Poor performance measurement and related procedures
- Excessive turnover rate
- Abuse of sick leave

d. Internal Coordination

- Organizational layering
- Shifting personnel according to workload
- Inconsistent data processing priorities
- Poor communication among NSC departments
- Minimal cooperation among NSC departments
- Too many nonproductive, ineffective meetings
- Lack of accountability

e. Working Conditions

- Poor quality of work life
- Lack of adequate eating facilities
- Lack of parking
- Personal needs (e.g., toilets and lockers for clothing)
- Lack of credit union access

f. Material and Documentation

- Unavailability of pallets and tote pans
- Loose material not palletized
- Frustrated material
- Mismatch of documentation and materials

g. Computer Process Control

- Unreliable issue document output
- Lack of sufficient data processing capability
- Slow computer terminal response time
- Three major computer systems introduced at the same time
- Two computer systems (NISTARS and Uniform Automated Data Processing System) used to record induction of material
- Inadequate software maintenance capability (skill and knowledge of NSC data process equipment operators)

APPENDIX D

GLOSSARY OF NISTARS MATERIAL PROCESSING ERRORS

GLOSSARY OF NAVAL INTEGRATED STORAGE, TRACKING, AND RETRIEVAL SYSTEM (NISTARS) MATERIAL PROCESSING ERRORS

This glossary presents the possible problems which could result when the system's key variances are not "controlled," that is, not maintained within appropriate levels. Each error will be defined, the unit operations in which it occurs identified, and the key variances which produce it listed. The types of errors are presented in alphabetical order.

1. Carton full: There is insufficient room in carton to hold all of the items assigned to it. The "carton full" error could occur at the consolidation and packing operations. The key variance leading to this error is number 42--capacity of packing container.

2. Condition code: The state of the item does not match the condition code given on its accompanying document. For example, an item that is unassembled or in need of repair has a condition code of "A," meaning ready for issue. The "condition code" error could occur at the induction operation. The key variance refers to the legibility or presence of the item's documentation. The key variance that could lead to this error is number 6--match between the material and information on document.

3. Configuration: The layout storage tray or bin obtained by the worker does not match the design presented on the work station video monitor. For example, the video monitor displays a storage tray with eight compartments while the actual storage tray at the work station has six compartments. The "configuration" error could occur during the storage or picking operations. The key variance that could lead to this error is number 17--match between the storage location and terminal display.

4. Cube/weight: The material is placed on a cube and weight measuring device and is found to be too heavy or too large to be transported by the conveyor system. The "cube/weight" error could occur at the induction operation. The key variances that could lead to this error are number 7--quantity expected/quantity counted, and number 8--cube/weight of material.

5. Identification: The item arrives at a work station without any documentation. The "identification" error could occur during induction or storage operations. The key variances that could lead to this error are numbers 4 and 16--quality of document arriving with material, at the induction or storage operation respectively.

6. Location empty: A compartment in a storage tray is found to be empty although information provided on the video monitor indicates that material is present. The "location empty" error could occur during the storage operation when the worker was directed to verify that material being stored matched that already present in the storage location. The key variances that could lead to this error are number 17--match between storage location and terminal display, and number 19--match between material in location and material to be stored.

7. Location full: There is insufficient capacity in a storage location to hold all of the material assigned to it. The "location full" error could occur during the storage operation. The key variance that could lead to this error is number 18--capacity of storage location.

8. Misdirected material: As the result of incorrect information being transmitted by tote pan optical settings or bar code scanners, material is transported to the wrong

work stations or to an unidentified (frustrated) material-holding chute. The "misdirected material" error could occur at the storage, consolidation and packing, or shipping operation.

Unlike the others errors, misdirected material is more likely to result from mechanical or software errors. Such errors are reflected in the following variances: number 17--match between storage location and terminal display; number 19--match between material in location and material to be stored; number 26--match between storage location and terminal display; and number 28--match between material in location and material requested.

9. National stock number (NSN) and storage location: The national number of material found in a particular storage location does not match the national stock number assigned to that location. The "national stock number (NSN) and storage location" error could occur during the storage and picking operations. The key variances that could lead to this error are: number 19--match between material in location and material to be stored; number 21--amount of material stowed/storage location used; and number 28--match between material in location and material requested.

10. Pallet full: The capacity of a pallet to hold all of the material assigned to it is found to be insufficient. The "pallet full" error could occur at the shipping operation. The key variance that could lead to this error is number 50--capacity of pallet.

11. Quantity: The amount of material counted at the work station does not match the amount of material presented on the video monitor. The "quantity" error could occur during the induction, storage, or picking operations. The key variances that could lead to this error are: numbers 7 and 20--quantity expected/quantity counted; number 21--amount of material stowed/storage location used; and number 29--quantity requested/quantity picked.

12. Receiving: Information on document accompanying material does not match the material. For example, the document gives the wrong name, color, or national stock number. The key variances that could lead to this error are: number 4--quality of document arriving with material (induction); number 6--match between material and information on document; and number 16--quality of document arriving with material (at storage).

APPENDIX E

SAMPLE MEASURES FOR NISTARS

SAMPLE MEASURES FOR NAVAL INTEGRATED STORAGE, TRACKING, AND RETRIEVAL SYSTEM (NISTARS)

Frequently Used Terms

The use of the word "material" here as part of a measure is a convenience; the items will actually be categorized by package size and type of material.

Measures obtained by calculating the correct number over the total number of items are derived by stratified random sampling. These measures do not denote 100 percent measurement.

When the term "correct" is used in a measure, it is in reference to the instructions presented on the work station terminal. The integrity of the information provided on the NISTARS work station terminal is dependent upon the quality of information provided by the customers and the Uniform Automated Data Processing System (UADPS).

INPUT MEASURES

Inputs are defined as labor hours and the other resources used to process material.

1. Labor hours relate to processing material from receiving through shipping (including physical distribution, inventory, receipt control, quality assurance).

2. Other costs associated with labor hours relate to processing material, for example, equipment, energy, maintenance, and packaging.

Data for labor hours are available from cost account records corresponding to Navy Supply Center (NSC) unit operations in Physical Distribution and Staff Departments.

Unit Operation I--Induction

This unit operation begins with the material being received from outside the NSC and ends when the material has a Material Movement Document (MMD) and is sent by conveyor to the storage area.

Key Variance Measure: Receiving

This includes all cases where there is discrepant, inadequate, or illegible information on the receipt document and/or the material container. Examples include: illegible annotations, no National Stock Number (NSN), discrepancy between document and NSN on material and discrepancy between quantity on document and quantity on package (or quality counted).

Measurement. The number of material documents with discrepant, inadequate, or illegible information over the total number of material documents processed. The ratio indicates how often this variance occurs.

Data Collection Points. Observation at induction work station by operator.

Induction Throughput Measure. Correct material and documentation are forwarded to the storage operation.

The percent of material correctly prepared (correct documentation, MMD, quantity, etc.) and forwarded to the stow operation =

$$\frac{\text{Amount of material correctly prepared}}{\text{Total amount of material received}} .$$

Unit Operation II - Stow

This unit operation begins when the material arrives at a stow work station and ends when the material is stowed, that is, the material is in a storage location and ready for issue.

Key Variance Measure: Quantity

This variance refers to a discrepancy between the quantity counted at time of stow and the quantity on the MMD.

Measurement. The amount of material with quantity discrepancies found during stow over the total number of items stowed. The ratio indicates how often this variance occurs.

Data Collection Points. NISTARS center controller (NCC) file. Number of MMDs with quantity annotations made during stow.

Key Variance Measure: Location Full

This variance involves locations indicated for stow on the MMD that are already full.

Measurement. The amount of material to be stowed for which locations are full over the total amount of material to be stowed. The ratio indicates how often this occurs.

Data Collection Points. NCC files.

Stow Throughput Measure. Material correctly stowed, that is, placed in its assigned location.

The percent of material correctly stowed =

$$\frac{\text{Amount of material correctly stowed}}{\text{Total amount of material received for stow}} .$$

Unit Operation III - Issue

This unit operation begins with the picking of materials for issue and ends when the material arrives at the packing and consolidation area.

Key Variance Measure: National Stock Number (NSN) and Storage Location

Measurement. Amount of material not in indicated location over the total number of issue documents.

Data Collection Points. NCC files and UADPS.

Issue Throughput Measures. Material correctly picked according to NCC directions.

The percent of material correctly picked (NSN, quantity) and forwarded to the packing operation =

$$\frac{\text{Amount of material correctly picked and forwarded to next operation.}}{\text{Total amount of material to be issued}}$$

Unit Operation IV - Packing/Consolidation

This unit operation begins with the arrival of material from the storage area and ends when the material arrives at shipping operation.

Key Variance Measure: The Carton Full

This variance occurs when the capacity of a carton used to consolidate material is found to be too small.

Measurement. The total number of times a carton is too small to hold the material over the total number of consolidations completed for a specified time period.

Data Collection Points. The NCC files that resolve "carton full" errors and calculate the number of consolidations completed in the packing/consolidation unit operations.

Packing/Consolidation Throughput Measures. Material correctly packed, consolidated, and forwarded to shipping.

The percent of material correctly packed, consolidated, and forwarded to shipping =

$$\frac{\text{Amount of material correctly packed, consolidated, and forwarded.}}{\text{Total amount of material from issuing operations}}$$

Unit Operation V - Shipping

This unit operation begins with the receipt of material from the packing and consolidation unit operation. It ends when the material is accepted by the delivery service and the shipment has been posted.

Key Variance Measure: Pallet Full

This variance occurs when the pallet being used to consolidate the material is too small.

Measurement. The total number of times the "pallet full" key is pressed over the total number of consolidations completed for a specified time period.

Data Collection Points. The NCC file that resolves "pallet full" errors and the file which measures the number of consolidations completed in the shipping unit operation.

Also, a manual count by the operator of the amount of material repacked due to pallet size.

Shipping Throughput Measure. Material and documentation correctly prepared for delivery.

The percent of material correctly prepared (address, carrier, documentation, and material) for shipment =

$$\frac{\text{Amount of material correctly prepared for shipment}}{\text{Total amount of material prepared for shipment}} .$$

OUTPUT MEASURES

Correct Material

Correct material is defined as the material specified by the customer requisition.

The percent of correct material received by customers =

$$\frac{\text{Amount of correct material received}}{\text{Total amount of material received by customers}} .$$

Correct Quantity

Correct quantity is the quantity of material (per order) requisitioned by customers.

The percent of material with the correct quantity for each item =

$$\frac{\text{Amount of material with correct quantity}}{\text{Total amount of material received by customers}} .$$

Correct Number of Items

This heading refers to the number of orders submitted by customers.

The percent of material issued that is received =

$$\frac{\text{Amount of material ordered by customer}}{\text{Total amount of material issued to the customer}} .$$

Correct Mode of Transportation

This heading refers to material sent by the mode of transportation specified by the regulations.

The percent of material shipped correctly =

$$\frac{\text{Amount of material shipped by the correct mode of transportation}}{\text{Total amount of material shipped}} .$$

Correct Time Frame

The material has been shipped within time standards.

The percent of material shipped within time standards =

$$\frac{\text{Amount of material shipped within time standards.}}{\text{Total amount of material shipped}}$$

Correct Customer

Material has been addressed to the customer who requisitioned it.

The percent of material addressed to the customer who requisitioned it =

$$\frac{\text{Amount of material addressed to correct customer.}}{\text{Total amount of material shipped}}$$

Overall Measure of Output

This refers to material requisitioned by customer that is processed correctly (NSN, condition, quantity, mode of transportation, address, and time requirements).

The percent of "perfect" material =

$$\frac{\text{Amount of material correct in all aspects}}{\text{Total amount of material requisitioned by customers x 100}} .$$

OUTCOME MEASURES

External Evaluation

Assessment of NSC's performance by:

1. Fleet and shore activities, e.g., customer satisfaction.
2. General Accounting Office, e.g., independent evaluation.
3. Naval Supply Systems Command.
4. Naval Material Command.
5. Office of the Chief of Naval Operations.
6. Other federal agencies, e.g., Defense Logistics Agency.

Internal Evaluation

1. a. Productivity =

$$\frac{\text{Amount of material processed correctly.}}{\text{labor hours}}$$

b. Productivity =

$$\frac{\text{Amount of material processed correctly.}}{\text{labor costs}}$$

2. Inventory Accuracy. Material is in the correct location in the correct quantity.

The percent of material in correct location with correct quantity =

$$\frac{\text{Amount of material in correct location with correct quantity}}{\text{Total amount of material in inventory}}$$

3. Receipt Processing Time. Receipts are processed for storage within specified time standards.

The percent of material processed on time =

$$\frac{\text{Amount of material processed on time.}}{\text{Total amount of material processed}}$$

4. Quality of work life surveys.

5. Absenteeism through employee records.

6. Disciplinary actions through management records.

7. Turnover through personnel records.

8. Management/union relationships through legal files.

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