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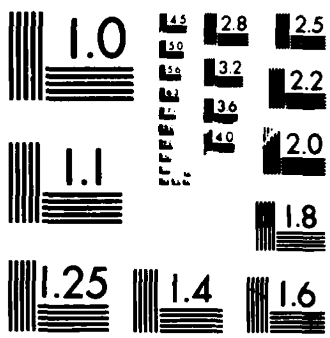

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Monterey, California

THESIS

IMPROVING INFORMATION MANAGEMENT AT
MARE ISLAND NAVAL SHIPYARD

by

Kenneth R. Brattin
and
Eric M. Dahinden

March 1987

Thesis Advisor: Barry Frew

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Improving Information Management
at
Mare Island Naval Shipyard

by

Kenneth R. Brattin
Lieutenant Commander, United States Navy
B.S., California State University at Long Beach, 1974

and

Eric M. Dahinden
Lieutenant Commander, United States Navy
B.A., California State University at Long Beach, 1973

Submitted in partial fulfillment of the
requirements for the degree of

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March 1987

Authors: Kenneth R. Brattin

Eric M. Dahinden

Approved by: Barry A. Frew, Thesis Advisor

Roger D. Evered, Second Reader

Willis R. Greer, Jr., Chairman,
Department of Administrative Sciences

Kneale T. Marshall,
Dean of Information and Policy Sciences

ABSTRACT

This thesis discusses the problems of information management within a Naval Shipyard. The research was conducted at Mare Island Naval Shipyard in Vallejo, California; however, the findings may apply on a much larger scale to all NAVSEA industrial facilities. Discussion is focused on the Shipyard MIS installed by the Bureau of Ships (BUSHIPS) in the early sixties to aid shipyard managers in accomplishing a complex overhaul of a modern vessel. Present system problems resulting in inefficiencies and information degradation are described and possible actions to improve information flow without cognitive overload are explored.

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Grateful appreciation is expressed to the entire IRM staff at Mare Island Naval Shipyard for their unwavering support despite a very high workload and significant demands placed on their time. All the yard employees we met and dealt with were most gracious; however, the following personnel gave much towards this project and deserve special recognition:

Mr. Paul Berglund
Mr. Jerry Britton
Mr. Henry Dye
Mr. Ron Munden
Ms. Rosie Weber

I. INTRODUCTION

A. DIRECTION OF THIS STUDY

1. The Sponsor

Mare Island Naval Shipyard (MINSY) is located in Vallejo, California on the mouth of the Napa River with access to the Pacific Ocean through San Francisco Bay. The Vallejo facility is one of eight Naval shipyards in operation to provide logistic support for ships and service craft and has been an active yard since the mid-nineteenth century. Mare Island is primarily a submarine overhaul facility with a nuclear engineering repair and conversion capability.

The Information Resources Manager (IRM) at Mare Island Naval Shipyard, Mr. Ron Munden (code 140), has sponsored this thesis to aid in the definition of problems related to information transactions that occur within the shipyard. Potential options for alleviating the overload on information processing facilities while addressing the needs of system users were examined within the scope of this thesis

2. What is Information Management?

An organization's success depends on the decisions of its management. The level of productivity, or the success of a project, depends upon the proper execution of several managerial functions such as planning, organizing, directing, and controlling [Ref. 1: p. 296].

To carry out these functions, managers are engaged in a continuous decision-making process which is based on all available data. With imprecise or untimely information a manager's actions will be based on less than optimal input. The likely result will be flawed decisions.

In large and complex organizations, such as the Mare Island Naval Shipyard, managers must work together to provide one another with the accurate and timely information needed to achieve optimum performance within their organization. Thus, managers act as channels of communication to ensure correct functioning of their unit. The larger and more complex the manager's area of responsibility, the more dependent he is on correct and current data being presented in a concise and easily-obtainable format. The complexity of today's management problem has naturally led to the increased use of the computer to collate data. The computer is now able to present the statistics for the hundreds of individual jobs being processed simultaneously.

In the late sixties and early seventies, computers began producing large amounts of data, more than managers had ever dealt with in the past. More data was demanded in a shorter period than ever before and most businesses found that computer information systems were a necessity. The Navy industrial organization shared the need for better information management and in the early sixties the Bureau of Ships (BUSHIPS) adopted a system known as Shipyard Management Information System (MIS).

3. **Project Scope**

This study project began with a set of specific questions designed to probe the information management problems, real or implied, that shipyard users are experiencing. The research questions fit into two general categories as follows:

1. What improvements can be made to the information dissemination process within Mare Island Naval Shipyard?
   - What information is available to users on-line and what programs make on-line services available?
   - What flexibility is built into individual modules of the NAVSEA MIS system?
   - How can 'special handled' reports be eliminated while including user required data in standard reports?
2. Can a micro-computer create an effective user interface with the existing MIS system?
   - What type of link would maximize data transfer between the existing Honeywell S 70 and S 44 computers and the PRIME token ring?
   - Within the constraints of the PRIME system, which micro user interface, icons or text commands, provides the more simple data retrieval process?
   - What is the best way to get only the required data to the users?

The research for this project was conducted primarily in the production department and involved upper and middle managers. In defining the problems two clear objectives were generated for this project:

- **Improve the efficiency of gathering information for managing ship overhauls**
- **Reduce the number of written reports produced at Mare Island Naval Shipyard**

The scope of these objectives addresses a large problem that is integral to the operation of not just Mare Island Naval Shipyard, but many of the NAVSEA industrial activities. This thesis uses the principles of structured analysis to clearly present the problem of information management from three different points of view: the user, the data processing group, and the MIS system. Since Shipyard MIS was created for the users, project research began with managerial interviews from shops directly associated with the overhaul process. The production department is the center of activity in a shipyard and produces the yard's major product, a modified or newly-constructed ship. Accordingly, the interviews focused primarily on the production department and the resultant perspective was used to formulate the objectives stated above.

The structured analysis of an information management problem begins with a problem definition that includes the scope of the problem and the objectives for solving the problem within the confines of a probable solution. Typically a feasibility study follows if the problem is worth pursuing. Finally, if a solution is considered economically, technically, and practically feasible, a project is begun that will ultimately solve the original problem [Ref. 2: p. 9]. This thesis is the beginning of that cycle and serves to draw attention to today's problem of information management at the Mare Island Naval Shipyard.

B. SHIPYARD MIS HISTORY

Digital computers first began appearing in Naval shipyards in the early fifties and were used primarily for accounting and payroll functions. During the fifties each shipyard had evolved a separate ADP system with existing technologies and had tailored its system to specific needs within its yard. Consequently, there was no standardized approach to information processing from one yard to the next. The problem of diversification was exacerbated by regional differences in the work force and by different types of work performed at each yard. In 1959, SECNAV outlined goals and objectives for Navy-wide use of ADP equipment which included using computers in the development of plans, programs, budgets, schedules, and other management decision-making tools. Following SECNAV guidance, BUSHIPS (now NAVSEA) established a task force to develop a shipyard management system. By 1962, several elements of BUSHIPS MIS were being evaluated at Mare Island and Philadelphia Naval Shipyards. In the beginning, BUSHIPS selected the best existing ADP elements in each of the shipyards and formed a standard system for Navy-wide use. The Boston Navy Yard became the first to receive all elements of MIS as a complete package. Shortly thereafter, Shipyard MIS was installed in six Naval Shipyards. Not long after MIS was running, BUSHIPS realized that if each shipyard were allowed to generate its own program fixes or to develop its own reports gradual disintegration of the standardized MIS might result. Therefore, in 1965, NAVSHIPS created the computer applications support and development office (CASDO, now SEAADSA for Naval Sea Systems Command Automated Data Systems Activity) which was given total responsibility for centralized system design, development, implementation, and maintenance of shipyard MIS [Ref. 3: p. II-16]. In the early sixties, the heart of the Shipyard MIS was the UNIVAC III mainframe. In 1973 NAVSEA directed implementation of an upgrade for MIS hardware [Ref. 4] because the system had become overloaded. The replacement was a third generation Honeywell 6000 series mainframe. The processor in that machine has been periodically upgraded through the seventies and early eighties. The mainframe has evolved from the 6000 series to a 6060 machine, to a 66 80, then to the DPS 8/70 (dual processor) and DPS 8/44 processors found today.

Control over changes to Shipyard MIS are the responsibility of the Management Information Executive Group (MISEG). This group consists of three senior shipyard commanders who establish policies concerning Shipyard MIS and review all proposed system changes. SEAADSA is responsible for centralized design and implementation standards. Each local shipyard data processing office can add locally-generated code to create additional report formats to meet its individual need; however, modifications to the fundamental report format produced by MIS are to be accomplished by SEAADSA.

II. ADP SYSTEMS AT MARE ISLAND NAVAL SHIPYARD

We will discuss, in four sections, the major information management systems used by the Mare Island Naval Shipyard. The first section describes Shipyard MIS, which functionally is the primary software package used by the yard for information management. The second section of this chapter centers on the primary computing hardware used to support Shipyard MIS. In the third section, an existing ring of PRIME computers used for numerous support functions is discussed. Finally, in the fourth section, several independent computer systems with specific applications to information management are described. Although a large number of micro computers are used by the shipyard, they are not addressed here as they are primarily used by individuals for word processing and specialized applications.

A. SHIPYARD MIS

In its early days, Shipyard MIS was designed to support three basic shipyard operations: industrial, financial, and material. As the system developed, two more sub-systems or modules were added: personnel management and radiation control. The departmental organization of a typical shipyard is mirrored in the sub-system structure of MIS as shown in Figure 2.1 . Each MIS sub-system contains one or several applications to support all the functions required of that particular module. The logical diagrams in Appendix A, known as data flow diagrams, graphically depict information processes and data interrelations currently in place at Mare Island.

The three most complex and detailed sub-systems are the financial, industrial, and material modules. The Personnel and Radiation Control (RADCON) modules are essentially stand-alone systems run by MIS.

1. Industrial

The industrial sub-system models the flow of productive work in a shipyard. It addresses the planning and scheduling of work, forecasts of manpower and material needs, identification and correction of out-of-control (jeopardy) situations, and evaluation of the results of the productive effort [Ref. 3: p. II-5].

a. Design (DP)

This application maintains an inventory of NAVSHIP drawings, SHIPALTs, ORDALTs, work items, special projects, and test memos. Inputs are man-

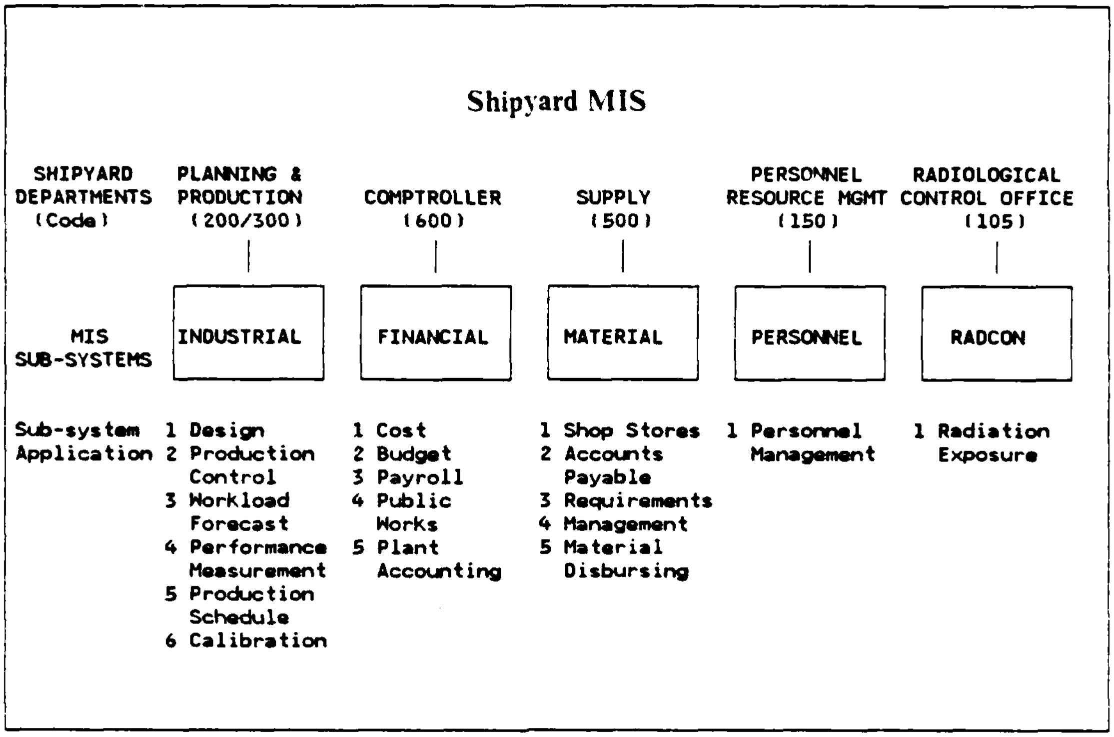

Figure 2.1 Functional Diagram of Shipyard MIS

hour estimates and expenditures to locate and or develop the necessary drawings, test memos, and special projects. Outputs include control, schedule, and work-package reports [Ref. 3: p. II-10].

b. *Production Control (PC)*

This application maintains scheduled shop manpower loading information, daily direct labor and overtime, labor estimates, authorized work, scheduled and actual dates for job orders and KEYOPS. Outputs are specific key operations (KEYOP) status reports that permit management to monitor scheduled start and completion dates, manpower allocations, and actual expenditures versus allocations [Ref. 3: p. II-8].

c. *Workload Forecasting (PF)*

This application generates man-hour forecasts and the distribution of these forecasts over time. Input data includes information on work force, forecast, load, and expenditures plotted against manning curves from the production department. In addition, man-hours scheduled versus actual hours expended are analyzed. Outputs are work load forecasts and force distributions. Reports indicate actual man-days for each ship, shop, and shift as compared to the forecast figures [Ref. 3: p. II-8].

d. Performance Measurement (PM)

This application is not presently used at Mare Island, however, it accumulates actual man-hour performance compared with existing standards. Inputs include scheduled and actual work load estimates, as well as scheduled and actual completion dates for job orders and KEYOPS. Outputs display planned versus actual man-hours and compare those figures to the standards [Ref. 3: p. II-9].

e. Production Scheduling (PS)

This application develops the PERT (performance evaluation and review technique) and CPM (critical path method) data to aid the planning and production departments in execution of a complex overhaul. Inputs are descriptions and the scope of all KEYOPS to be performed as well as the anticipated and actual start dates, estimated completion dates, charges to customer and job orders, and event and activity data. Outputs include reports which provide schedule dates, critical jobs, and potential areas of logic improvement. In addition, manually-developed schedules can be accommodated and a Gantt-type schedule, that essentially provides the scheduler with a record of events for a specific overhaul, can be generated based on key events [Ref. 3: p. II-9].

f. Calibration (PQ)

This application has been added during the evolution of MIS. It stores the results of tests and inspections for components repaired or replaced during an overhaul and it keeps track of all calibration equipment used in the yard. Output includes a daily status on non-destructive testing items, certification status, calibration schedule, and reliability analysis.

2. Financial

The financial management sub-system began with three basic applications: cost, budget, and payroll. Over the years it has been expanded to include all the areas listed below. The basic purpose of this MIS module is to monitor the flow of money through the Shipyard. It validates charges to job orders, provides accounting controls over direct labor and overhead-type work, and it generates shipyard-wide budgeting data [Ref. 3: p. II-10].

a. Cost (FA/FV)

This application processes all shipyard transactions that account for cash flow, as well as a file of historical data that can serve as an audit trail or as a basis for predictive cost. Outputs are reports for the comptroller such as general ledger accounts, financial and operating data, and summary information that serves as the basis for special management reports. For production, reports include work in progress, unallocated costs, overhead pro-rata, and budget compared to actual cost [Ref. 3: p. II-11].

b. Budget (FB)

This application processes quarterly and annual budgets, determines the overhead rate to be applied to each shop per direct labor hour expended, and maintains the availability and adequacy of operating funds. Outputs are departmental labor summaries, inter-shop transactions, employee leave figures, group and cost center acceleration data, department and cost center overhead budget estimates, and estimates of labor and materials [Ref. 3: p. II-12].

c. Payroll (FP)

This application maintains timekeeping and job charge functions, making it the most input-oriented application in MIS. It establishes a payroll record for each employee and takes as input personnel identification data, rate of pay, payroll deductions, and labor charge per job. Outputs are labor charges that are fed into the cost and budget applications, daily and weekly summaries of pay activity, the bi-weekly payroll, monthly reports of wage rates and leave usage by shop, monthly and on-demand reports of statistical data and employee population, and reports of personnel by salary groups and positions [Ref. 3: p. II-12].

d. Public Works (FW)

This application processes public works department reporting requirements. The objective of this application is to support facilities requirements in addition to reporting public works performance and financial accountability in support of the shipyard industrial effort. Input is primarily from daily timecards. Output includes maintenance cost analysis, real property maintenance cost, family housing status, utility reports, and man-hours expended [Ref. 5: p. 84]. This application is currently being run on a Honeywell mini-computer as a stand-alone application.

e. Plant Accounting (FC)

This is also an added application that provides the controls over Federal Government property owned by the shipyard. The inputs are initial acquisition, identification number changes, depreciation and cost, equipment disposition, and custody transfer. The outputs include summaries of acquisitions and maintenance activity, equipment dispositions and rejects by class, and master lists with nomenclature [Ref. 5: p. 83].

3. Material

The material sub-system was designed to provide continuous quantitative, financial and status information on industrial materials. It processes transactions for DMI (direct material inventory), end use (services), and shop stores. DMI items are specific items ordered against a job order and stored for a specific availability. Some common-use DMI items, such as steel sheeting and line, are ordered in bulk then reallocated for a specific job or KEYOP. The services function provides information on transportation costs, rent, communication, utilities, printing and reproduction, and other contractual services. Shop stores items are those used regularly by the shops, such as welding rods or connectors, and generally fall into the category of consumable material [Ref. 3: p. II-13].

a. Shop Stores (MS)

This application processes data to aid the supply department and the comptroller in controlling consumable material used by the shops. Inputs are material receipts for shop stores items, material issue data, item descriptions, prices, quantities and suppliers. The outputs are shop stores catalogs, projected stock status and replenishment requirements, statistics on inventory transactions, and punch cards to locate stock and transfer materials [Ref. 3: p. II-16].

b. Accounts Payable (MP)

This application processes billing information to reconcile the accounts payable ledger. The material-in-transit ledger is established when material is paid for prior to its receipt. Reconciliation occurs when material or services are received. Inputs are vendor bills and outputs are reports of bills processed, reconciliation data, liquidation actions, and a management evaluation report [Ref. 3: p. II-16].

c. Material Requirements (MR)

This application maintains material information to monitor stock issues required for each job in the yard. Inputs are job order numbers, work order numbers, drawing numbers, the allowance parts list, and material inventory. Outputs are material lists by job, material history, and usage reports.

d. Material Management (MM)

This application maintains transaction data for all raw material and components used in the yard. It has grown to such an extent that it is now run as a separate program on the mainframe. (See mainframe section B.2.a.)

e. Material Disbursing (MD)

This application processes all financial transactions associated with raw material used in overhaul. Outputs are a disbursing summary, interest payments, payables, and a check audit.

4. **Personnel**

The personnel sub-system was added to the original Shipyard MIS and is designed to provide a data store of personnel skills, education, and training received.

a. Personnel Management (SE)

This application generates more than fifty reports which include distribution of civilian personnel, grade computations by department, equal opportunity summaries, age profile reports, OSHA exposure, payroll reconciliation, injury reports and personal claims, training planned and accomplished, occupation summary, and expenses (planned versus actual).

5. **Radiation Control (RADCON)**

The radiation control portion of MIS is the second sub-system addition to the original program. It is used for monitoring and managing all aspects of nuclear-related operations.

a. Radiation Exposure (RC)

This application maintains radiation information to assist the nuclear engineering department in managing exposure limits, training, and material tracking. Outputs provide radiation dosages, dates of accomplished training, and medical examination information for each person enrolled in the RADCON program.

B. THE SHIPYARD MAINFRAME

The mainframe chosen was a Honeywell 6000 series and has been in operation for fifteen years. In the last five years NAVSEA has installed upgrades to their two mainframe units changing the designation of the machines to a Honeywell DPS 8/70 and DPS 8/44. Both machines are limited in capability by the standards of the early eighties and further limited by their non-standard operating systems. When the Honeywell machines were purchased the Navy specified that the operating system had to be compatible with the UNIVAC operating system on which the shipyard MIS was developed. That specification ensured that MIS would run without major rewrites but it also guaranteed that NAVSEA would never be able to acquire off-the-shelf software to support or modify any MIS functions. Recently the operating system has been upgraded to GCOS-8 which reduces I/O processing time by more efficient use of virtual memory operations; however, this is still a non-standard operating system [Ref. 6].

1. Functional Diagram

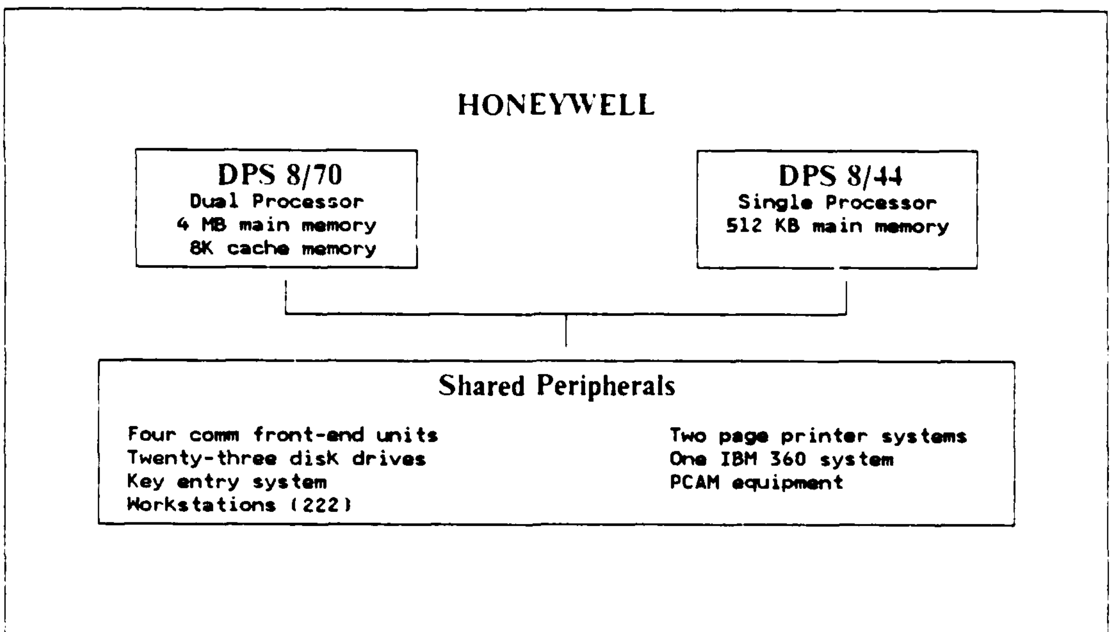

Figure 2.2 MINSY Mainframe Computers

2. Mainframe Programs

Although several dozen applications exist for the mainframe computers there are four primary applications used for information management within the shipyard: Shipyard MIS (discussed above), Material Management (MM), on-line query programs such as LOUIS (logical on-line user information system), and SWCS (ship work control system).

a. Shipyard MIS

Shipyard MIS is run in batch mode with magnetic tape as the primary medium. During the day shift, disk packs are loaded with the applications that require user input, such as financial job order input, and KEYOP closures (PC). At the completion of the first shift, all the on-line applications are saved to tape. Then the second and third shift computer operators begin the job of updating the MIS data base and outputting printed reports. This update process is a batch operation and performed by merging several tapes onto an output tape, then taking the output tape and merging it with another input tape. This continues until all components of an application have been updated. The scheduling of tapes is performed manually and is critical to ensure that each program module has been provided with the correct input. A mistake in the sequence would produce inaccurate output data and be very difficult to detect.

In addition to providing for data input, the on-line feature makes several MIS applications available to the user during the day. A few major applications such as Material Management and Workload Forecast are loaded onto disk packs to allow programs such as LOUIS to access data for users in a real-time environment from Honeywell terminals located in several work areas.

b. Material Management (MM)

This application was originally part of the Shipyard MIS and known as the Industrial Material application. It encompassed the present day MR, MD, and MM modules, but was split due to the size and complexity of the MM module. Inputs to MM include material transactions, material inventory, job material lists, transactions, and job status. Output includes jeopardy reports, shop stores issue cards, inventory reports, and work measurement reports.

c. On-line query

The need for on-line access to data has been recognized as critical for managers who have been forced to deal with time-sensitive data produced by the

Shipyard MIS. The data is made late by batch processing and manual distribution of hard-copy output. In the early days of MIS, disk packs were just being thought of and magnetic tape batch processing made sense from a technical viewpoint. Further, the requirements for early computer systems were primarily payroll and accounting applications that lent themselves to batch processing. It was later that management began to demand production-oriented data that is more useful in a real-time environment. However, by this time, MIS had been established as a batch system.

With the advent of high-capacity disk packs the possibility of loading data to a disk then accessing it as needed was explored. Not a true real-time system because data updates are periodic, this option still offered a reduction in report distribution delays. Several programs have been developed to allow users to interface with data directly. One such system known as LOUIS is described below.

In order to use LOUIS, data processing personnel must establish an account for each user. This account identifies the data that a user is allowed to access and provides security for sensitive information. Of note is that the data processing personnel must get approval for each new user from the "owner" of the data base being accessed. For example, the nuclear repair officer would have to approve an individual gaining access to the RADCON data. Once a user has data base access he may call for information from that file using any search criteria desired. LOUIS also helps with report formatting. In other words, instead of waiting for a written report that must be batch-processed, printed, and distributed the user can call up the data he needs. This also alleviates the problem of a standard report containing fields of information not needed by the user [Ref. 7].

Several other applications are run on-line and include: financial billing, design plan tracking, occupational safety & health support, automatic timekeeping and management, material purchase control, material special allowance, badge and pass support, training records, and executive transaction processing.

d. SWCS

The Ship Work Control System (SWCS) is a production-oriented system that provides on-demand reports to assess the status of remaining work on non-nuclear shipboard systems. The system maintains a list of all outstanding and completed deficiencies, test documents, work authorized by the work permit system, and other documents for component certification for vessels in overhaul at MINSY. SWCS does not interface with the MIS data base, therefore all data in SWCS is entered separately and accessed apart from the MIS. This system has been developed in-house for MINSY use; however, its value has been recognized by several other Naval Shipyards and many have adopted SWCS. There are approximately thirty terminals throughout the waterfront area for SWCS use. Each terminal is interfaced to the Honeywell mainframe through a front-end processor. In addition, several high-speed (300 lines per minute) printers are co-located in terminal centers to provide hard-copy reports [Ref. 8: pp. 1-4].

C. PRIME TOKEN RING

The prime ring is a token-type computer network linking five PRIME computers electronically. Each computer in the ring has a frontend processor to support several terminals. Each machine also has several common programs and then many applications unique to that machine. A user must have access granted to each machine by a password system. Once logged into a host computer the user can only access another host on the ring if he logs onto the new machine. The computer link as it is now used is primarily for E-mail services. The most common uses of the PRIME net are for news (a bulletin board), electronic mail, word processing, and data filing.

1. Functional Diagram

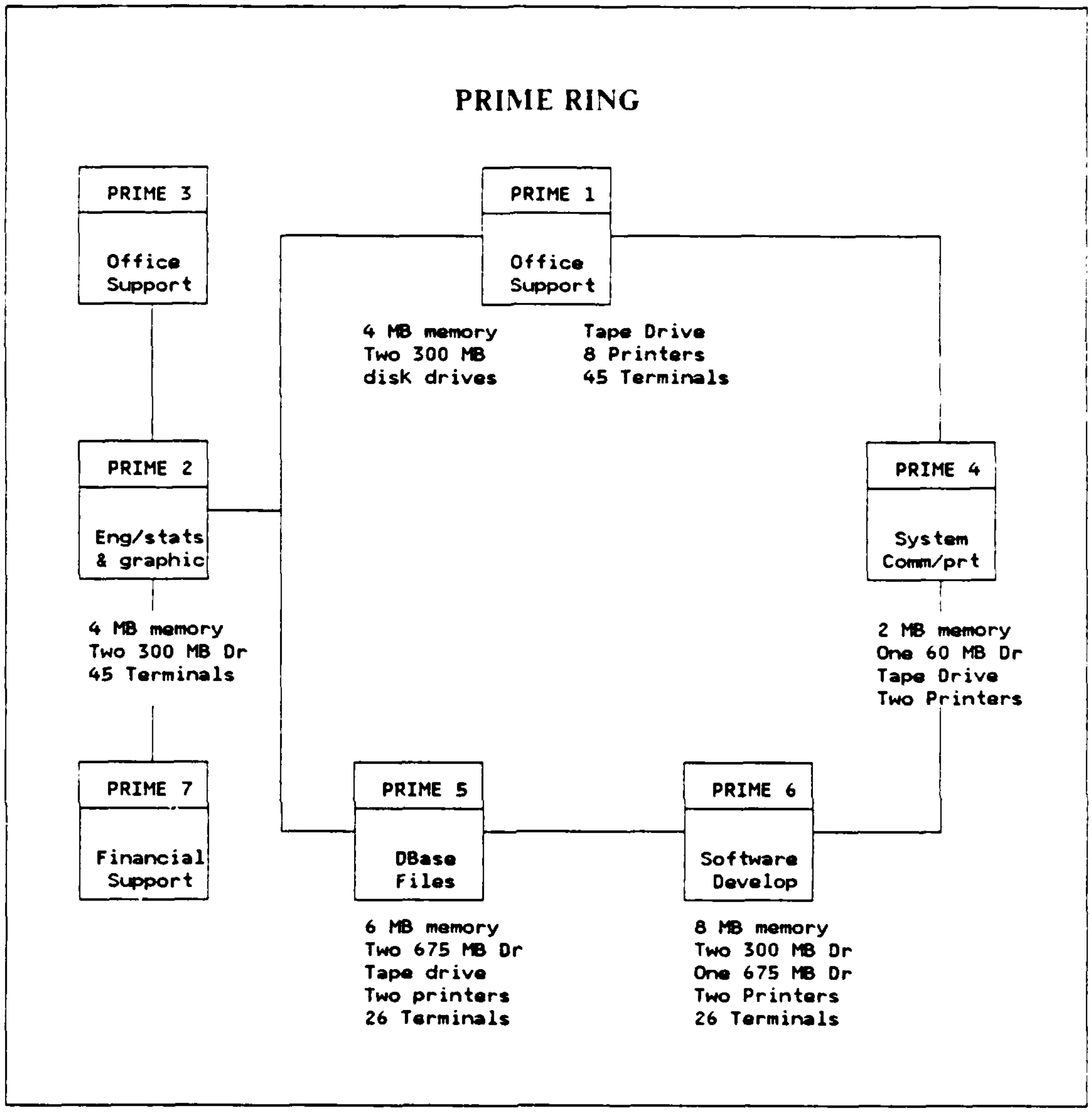

Figure 2.3 MINSY Prime Token Ring

2. Prime Programs

Several specific applications available on one or more machines in the net are high-level language compilers (Pascal, C, basic), in addition to the following information management applications [Ref. 9: p. II-4].

a. CA (communications application)

This is a group of general-purpose programs that includes word processing, electronic mail, and spreadsheet applications. Access is gained through any one of 125 terminals throughout the yard.

b. CAD/CAM Support

The shipyard computer-aided design computer-aided manufacturing systems currently support the following areas:

- Structural, mechanical, electrical, and naval architectural design
- Industrial and facilities engineering
- Sheetmetal fabrication, design, and manufacture
- Mechanical components fixture fabrication, design, and manufacture
- Organization charts
- Equipment layouts
- Building floor plans

c. Customer Order Documentation Standards & Electronic Fund Transfer

This system is used to support the comptroller with electronic fund transfers (EFT) between fund grantors (Type Commanders) and the shipyard. The customer order documentation system (CODS) is used to establish and maintain customer orders as well as provide the records needed to review and audit the orders. The system is also used for word processing, electronic mail, spreadsheet, and data base support for the Comptroller.

d. Design Tracking System (DOTS)

Formally called Design Plans Tracking System (DPTS), this system is used as an integrated data base containing documents that affect the engineering effort. It contains an index of over 600,000 drawings as well as records for modified drawings and documents specifically for Mare Island.

e. Engineering Analysis

This system is used for support of Naval architecture, mechanical engineering analysis, and structural analysis. This application also incorporates two commercial software packages known as PATRAN and NASTRAN.

f. Graphics

This system is used to prepare graphics, plots, and job order trends. On a weekly basis over 2,000 plots, charts, and graphs are produced that depict job order trends by ship or shop. Several third-party programs are used in this application such as TELEGRAPH by ISSCO and Versagraph by Henco Inc.

g. Industrial Engineering Management Applications

The engineering division uses a number of programs supported by the PRIME 3 to aide them in document tracking, word processing, specification retrieval, and limited CAD CAM work.

h. Medical Scheduling

This system is used to assist the MINSY medical clinic with records of appointments and physicals. It provides a list of personnel that require a medical examination or are in need of a dental check-up. It also is used for scheduling of appointments for patients.

i. Production Department Office Information System

This system is presently used for office automation functions performed by the Production Department Codes. Applications include word processing, file management, and document-tracking aides.

j. Project Management (PERT/CPM)

This system is used to provide graphic schedules in the PERT or CPM formats. Inputs are provided by the user and are not directly linked to the scheduling functions performed by FASS.

k. Shipyard Automated Budget Reporting System (SABARS)

This system is used to generate weekly budget information for code 600 (Comptroller). Actual expenditure figures are obtained from MIS batch updates run on the Honeywell mainframe and merged into the PRIME 7 to produce a locally-prepared budget. Hard-copy reports are produced weekly and on-line queries can be made at the user's convenience.

D. OTHER MINSY DATA PROCESSING SYSTEMS

The shipyard contains numerous stand-alone computers with dedicated applications to fill a variety of data processing needs. These systems have been purchased to more efficiently perform functions not adequately supported by Shipyard MIS. The proliferation of these systems has led to the distribution of information management which dilutes the original NAVSEA concept of a centralized MIS.

Figure 2.4 is an overview of each major stand-alone computer presently installed at MINSY and it lists the major application running on each system [Ref. 9: pp. III-1:III-200].

1. **Functional Diagram**

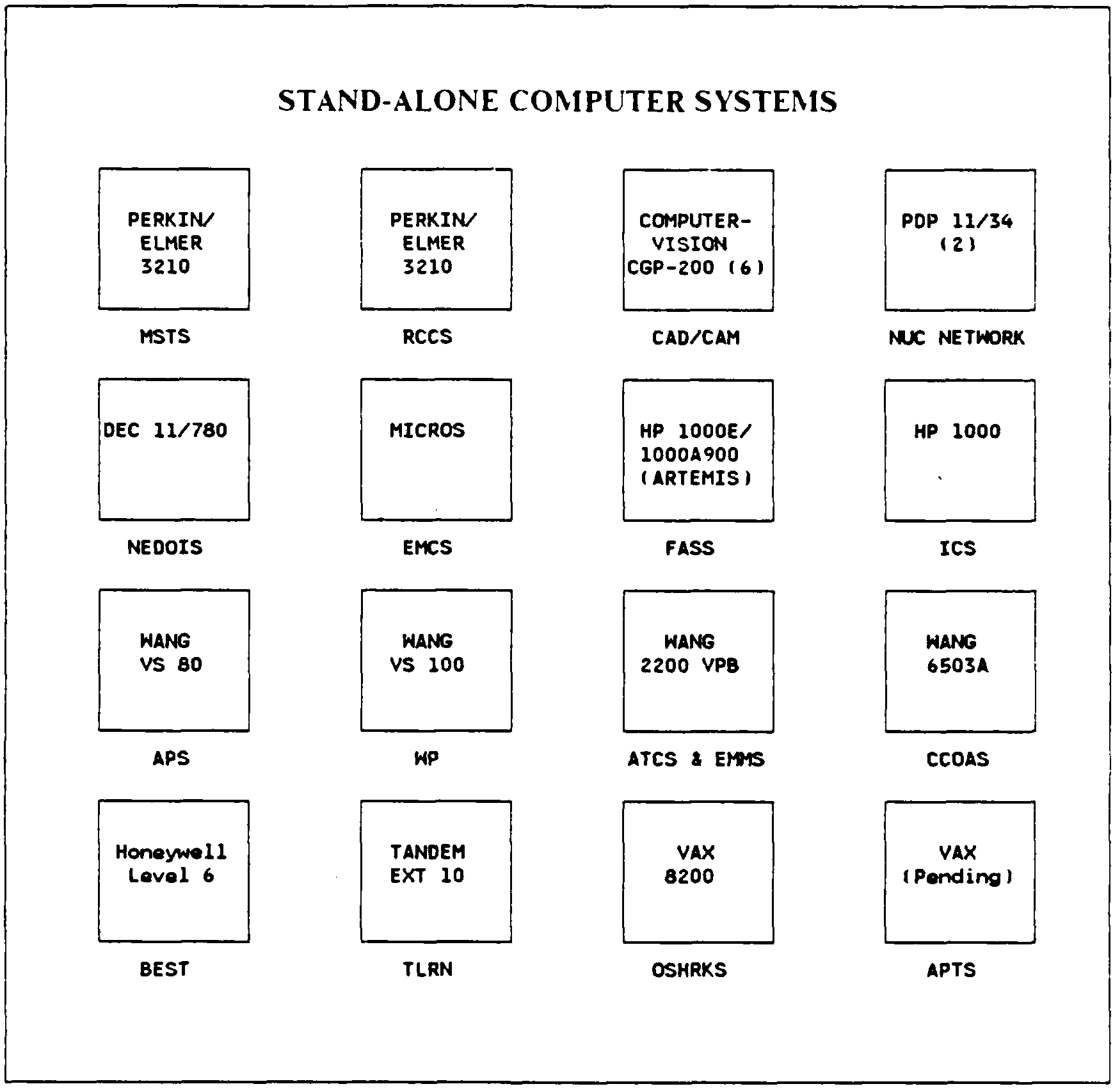

Figure 2.4 Ancillary Data Processing Systems at MINSY

2. **Stand-Alone Programs**

The following programs comprise the major applications running on the computers listed in Figure 2.4 .

a. APS - Auto Planning System

The APS system automates a corporate planning system which performs the electronic transfer of job orders, operating funds, and material orders. The Wang VS 100 is used for word processing support for the Planning and Supply departments co-located in building 483.

b. APTS - Automated Procurement Tracking System

APTS provides support for code 500 (Supply) material procurement tracking functions. It updates material jeopardy lists that can be sorted by the expediters to provide a manageable output.

c. ATCS - Auto Tool Control Systems

ATCS controls the portable tool inventory maintained by the yard tool crib. Inputs include tool serial numbers, unit price, issue point, issue date, and custodial responsibility. Outputs generated are tool listings by shop and cost.

d. BEST - Base Engineering Support, Technical

This system provides the Public Works Department with a standardized automated management system whose primary uses include transportation management, maintenance management, and utilities management. Secondary uses will support office automation and CAD CAM CAE within the Public Works Department.

e. CAD - Computer-Aided Design and Manufacturing

The CAD system is used for the preparation of drawings and models, data for finite element analysis, numerical control tapes, flat pattern templates, status diagrams, and scheduling networks.

f. CCOAS - Calibration Center Office Automation System

This system was acquired by the Navy Calibration Center to support a project for another Navy activity. Upon project completion this system was acquired by the Shipyard Calibration Shop. The system provides automation support for the functions of the calibration center such as: technical repair standards management, material and job control documents management, and word processing.

g. FASS - Fundamental Automated Scheduling System

FASS prepares PERT and CPM network schedules for the repair of Naval ships. It includes on-line access to scheduling data, hard-copy schedule generation, process conflict identification, test sequence scheduling, work load forecasting, and schedule adherence tracking. Its secondary use includes chart generation in the CSCS (cost schedule control system) format.

h. EMCS - Energy Monitoring and Control System

This system is used by the Public Works Department for energy monitoring and environmental control of buildings. Intelligent controllers interface with micro computers to read sensor input and activate environmental systems.

i. EMMS - Equipment Maintenance Management System

The equipment maintenance management system provides an automated method of maintaining records for accomplishing industrial plant equipment maintenance.

j. ICS - Instrument Calibration System

ICS is used primarily in support of the local instrument calibration and recall program. It will support the MEASURE recall data base and print-out of MEASURE meter cards. It is also used for information management office automation for code 134 (non-nuclear inspection department), Procurement Quality Control System, and work load forecasting.

k. MSTS - Machine Shop Tracking System

MSTS is used for planning, scheduling, and maintaining status information on all work assigned to the Inside Machine Shop (shop 31). It provides the basis for developing work load information, monitoring schedules and capacity, developing standards, and provides control status of all components and related parts.

l. NEDOIS - Nuclear Engineering Department Office Automation System

NEDOIS provides document status and indexing for testing, WIN (work instruction: nuclear), reactor plant technical specifications, training schedules, work load schedules, and nuclear qualifications. This system is isolated from all other shipyard computers for security of formally restricted data (FRD). Additional applications include word processing, access to nuclear power manuals, nuclear engineering calculations and analysis (hydrostatic, vibration and noise, flow rates, etc.), nuclear work scheduling, budget planning, and work load analysis.

m. NUC NETWORK - Nuclear Engineering Department Network

This system allows the Nuclear Engineering department to interface with other computer systems in the yard without compromising the security required for the information kept on the NEDOIS.

n. OSHRKS - Occupational Safety & Health Record-Keeping System

The OSHRKS system supports an integrated, comprehensive occupational safety and health computerized record-keeping management information system. Its primary purpose is the storage and retrieval of safety and injury claims and compensation, deficiency abatement data, medical surveillance and examination scheduling information, personnel and environmental exposure records, and hazardous materials and hazardous substance training records. The secondary use is for automation of general office management functions in Code 106 (Nuclear repair).

o. RCCS - RADCON Control System

RCCS maintains an on-line data base of records containing the status of radiation workers and Thermoluminescent Dosimeters (TLD's), data base management of individual worker radiation exposure accounts, reports on TLD user data, and radioactive material accountability. The secondary uses are for special report generation and office automation.

p. TLRN - Technical Logistics Reference Network

The technical logistics reference network provides on-line item identification of material stock items through the Federal Library Committee of the Library of Congress. A variety of information services on 114 categories of hull, mechanical and electrical equipment used aboard Navy ships is accessible. Inquires can be made by stock number, manufacturer, manufacturer part number, MIL-SPEC or MIL-STD, and by specific technical characteristics. For each part accessed the system provides a description of technical characteristics in tabular form, unit price, standardization information, and up to six alternate vendors.

III. USER PROBLEMS WITH CURRENT INFORMATION SYSTEMS

After decades of manual data processing in shipyards computers have arrived! It was expected that they would save thousands of man-hours used for keeping track of data, improve the accuracy of information provided to managers, and simplify reports. This chapter explores the frustrations of the users and focuses attention on the fact that information management in Naval Shipyards today is approaching a serious overload. This overload of the information systems could result in disaster. Disaster can be defined as:

- A significant loss of data
- Late information which causes critical decisions to be made with data that is no longer applicable
- A loss of credibility because of inaccurate information being entered into the system

Computers began life in shipyards as tools to organize and manipulate the large volumes of data being generated. As overhaul complexity increased and technology placed more stringent demands on the accuracy of information, the early computer systems responded by producing volumes of data every day. Soon most supervisors reached a saturation point where the data was managing them instead of the supervisors managing the problem by using the data.

The information management problem is expressed in this chapter in four categories: user difficulties, data processing support group problems, MIS limitations, and related issues. The final section summarizes the research and highlights the problems identified in the first four sections.

A. USER DIFFICULTIES

Numerous shipyard production personnel from top management to waterfront supervisors were questioned during the research phase of this thesis regarding the value of Shipyard MIS. Early in each interview the managers expressed a clear dislike for Shipyard MIS because it was considered cumbersome, slow to respond, and the output was not considered credible. The response was clear that Shipyard MIS was not effectively meeting their needs. This was simply another confirmation of a well-documented fact. In 1981 SEAADSA sent questionnaires to all Naval Shipyards requesting information about the utilization of MIS production scheduling output. The yards responded by saying that they seldom used MIS and they were actively seeking alternatives [Ref. 10: p. 9]. In 1984, Project Systems Consultants, Inc. (PSC) studied the Mare Island Information Management problem with an eye towards production scheduling and observed that there is a lack of reliance on management information now produced [Ref. 11: para. 2.3.1]. A recent study by Coopers & Lybrand summed up the MIS problem by stating, "We found that the shipyards do not have effective and efficient information systems because of obsolete systems, lack of Automated Information Systems (AIS) planning, inconsistent leadership, ineffective organizational structures and impediments in the present system approval and acquisition process" [Ref. 12: p. MIS-1]. Plainly our research was yet another foray into a morass that has been well-defined over the years; however, the problems outlined in this chapter were rediscovered by the authors and it is that research that is reported herein.

Most managers told stories of how difficult it was for their organizations to receive a modified report output.[1] Further, it was apparent that managers are time-constrained, mostly by numerous coordination meetings, making it impractical for them to search through the volumes of data provided by the typical MIS report. The problem is further complicated by the fact that users typically find that they must request more information than they need to ensure that they get the few pages required or to receive the specific column of data they use. The preferred report format for applications that the various managers needed was the Cost Schedule Control System (CSCS) [Ref. 13]. This output is graphic in nature and therefore eliminates most numeric fields provided by a typical MIS report [Ref. 14]

Another major concern for each manager was the delayed receipt of MIS data. An example given was that of the overtime report which contains man-hour charge summaries by shop for a particular overhaul in progress [Ref. 15]. Weekly data, as of each Sunday, is included in each report but typically these reports are not available for up to a week.[2] At the same time the manager must determine if overtime is to be scheduled and notify workers at least seventy-two hours in advance (to comply with union regulations). The result could be too few workers assigned to a particular job

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[1] The capabilities offered through LOCIS are not well known and even knowledgeable users find it difficult to access and manipulate.

[2] Overtime data is closed out on Sunday evenings. Timecards are sent to a keypunch vendor (on contract) for magnetic tape generation. The timecard data cannot be processed before Monday evening when batch updating begins. The outputs are printed early Tuesday, then separated for distribution. Overtime results are routed along with the approximately 1,300 different daily reports produced by MIS. Shipyard routing and subsequent distribution often delays receipt of reports by several days.

which causes scheduling difficulties at the shop, or too many overtime hours worked forcing the shop to go over budget.

Most managers expressed skepticism about the validity of the information they received through MIS reports. In fact, it seemed typical that the data received was used to only establish trends and was not perceived as being numerically accurate [Ref. 12: p. MIS-7]. For example, a report might indicate that shop 51 worked 200 hours overtime during a certain week. If past reports indicated that 100 hours of overtime was normal for shop 51 during an average week, the group manager would investigate the increase. He would not necessarily accept the 100 200 hour figures as accurate, but he would be concerned by an indication of an abnormal increase in overtime hours. Several probable causes for this situation seem plausible: timecard information is being adjusted to charge jobs that are under budget vice actual work on KEYOPS that are over their man-hour allocation to avoid a negative shop variance [Ref. 12]

'p. MIS-7' critical data relating to cost and schedule is tracked manually as well as automatically by MIS and most often the two do not agree. With the advent of additional systems that duplicate MIS functions some double entry of data is occurring that has given MIS a lower priority for raw input.

The supervisors interviewed expressed concern with the lack of terminals with which to gain access to automated systems, as well as the difficulty of using the automated systems and lack of training on available systems. Waterfront users have a Honeywell terminal to access the SWCS system, which is considered by the front line supervisors to be the most valuable ADP system for assisting in overhaul. A different terminal is used to access the PRIME ring for electronic mail and a limited amount of word processing.

Several of the everyday terminal users made clear the problem of computer systems that are not user-friendly. For most of these users MS-DOS commands are not easy to work with, but even more frustrating is the fact that each system is unique unto itself and must be learned and practiced [Ref. 16]. From the user's perspective one terminal, with one type of command format, should allow him to access any ADP system that he requires for his work.

Finally, virtually all of the ADP users feel a great need for training and support. Typically a department is hesitant to release an employee for a period of time to achieve the skills needed to better utilize the computers within that department.

Consequently employees are left to struggle with the system and learn what they can on-the-job. Additionally, most workers do not know whom to contact in the code 141 (IRM-Information Resources Management) group with their questions.

B. DATA PROCESSING SUPPORT GROUP PROBLEMS

There are five general areas of problems that affect the data processing (DP) group: manager concerns, purchasing restrictions, programming and operation of the DP center, training, and distribution problems.

1. Manager Concerns

The IRM manager is faced with a paper overload. Presently, in just the MIS system, over 1,790 different reports are being generated [Ref. 17]. Approximately 75% of these reports are generated daily, and multiple copies are produced so that each report represents about 200 pages. Each month the yard prints over 2.5 million pages of MIS reports [Ref. 12: p. MIS-7].

A significant factor that leads to poor support is old equipment and old software. One of the oldest items used daily to support MIS is a card reader. MIS generates cards for material draws and has to maintain the capability to process timecards even though this function is performed by an outside vendor. The card reader is no longer supported by its manufacturer and each breakdown requires creative maintenance to produce the parts needed. The Honeywell disk packs being used are no longer near state of the art. Today disk packs are available that have twice the storage capacity with no increase in physical size and a decrease in data access time. The software running on the Honeywell mainframe is COBOL 68 which is nearly twenty years old.[3] It is very expensive to use a commercial firm that supports software that old, so most programming and consulting for software-related problems is done in-house.

The IRM manager is tasked with monitoring the purchase, installation, and control of all shipyard CPU's. This task became unmanageable with the proliferation of micros in the late seventies along with the exponential increase of mini's in the eighties. It is difficult to interface all these machines. Most often, stand-alone micros are duplicating data that is in (or should be in) the MIS. Therefore, users are having to

[3]The MIS program code was written for the UNIVAC operating system (OS) used in the sixties. Subsequent hardware used was contracted to emulate the UNIVAC OS to avoid a rewrite of all the MIS applications. This made the Shipyard Honeywell operating system a one-of-a-kind program that has been difficult to support throughout its life.

double-enter data or perhaps are not keeping the MIS data current.

The shipyard organization places data processing at a relatively low position in the hierarchy (see Figure 3.1), which tends to de-emphasize the importance of DP services. The effectiveness of the DP organization is further undermined by the distributed nature of CPU ownership in the shipyard. Most departments own one or several computer systems and are responsible for the operation of those systems. Since IRM is responsible for the interfacing of computers it falls on the IRM group to insure the new system is on-line properly. However, since the new system is operated by another organization no additional manpower is authorized within the IRM group to provide the needed support.

2. Purchasing Restrictions

The issue of micro standardization is a much contested point that has yet to be fully resolved in ADP circles in general, much less within the shipyard. The best vendor support is perceived to be from IBM so the MS-DOS operating system supported by IBM has become the de facto standard in the government. Micro evolution has led to graphic based machines in the eighties that use icons to simplify the user interface with the computer. These machines have been shown to significantly reduce training time allowing even novice computer users to produce usable documents and manipulate data in a matter of minutes vice hours or days on a non-graphic based machine.

The issue of centralization versus decentralization is an ongoing problem that is slowly being influenced by the purchasing practices of NAVSEA. Although the original concept of data processing for the shipyards was one of centralization regulated by SEAADSA, NAVSEA has admitted that the centralized concept is not working in its present form by the purchase of numerous ancillary computer systems that duplicate MIS functions. Consequently the IRM group is caught in the middle of distributing ADP functions while maintaining a centralized ADP function that requires much local manpower to support and is little used within the yard.

Additionally, the add-on computers are planned, purchased, and installed with little thought of data interfaces to MIS. Since MIS receives nearly all the information inputs for the entire yard, a viable two-way interface is not only reasonable but necessary to avoid duplicate entries or data inconsistencies in output from one system to the next. Typically, the interface is an after-the-fact concern that falls on the data processing group to work out with MIS which was not designed to interface with several ancillary systems.

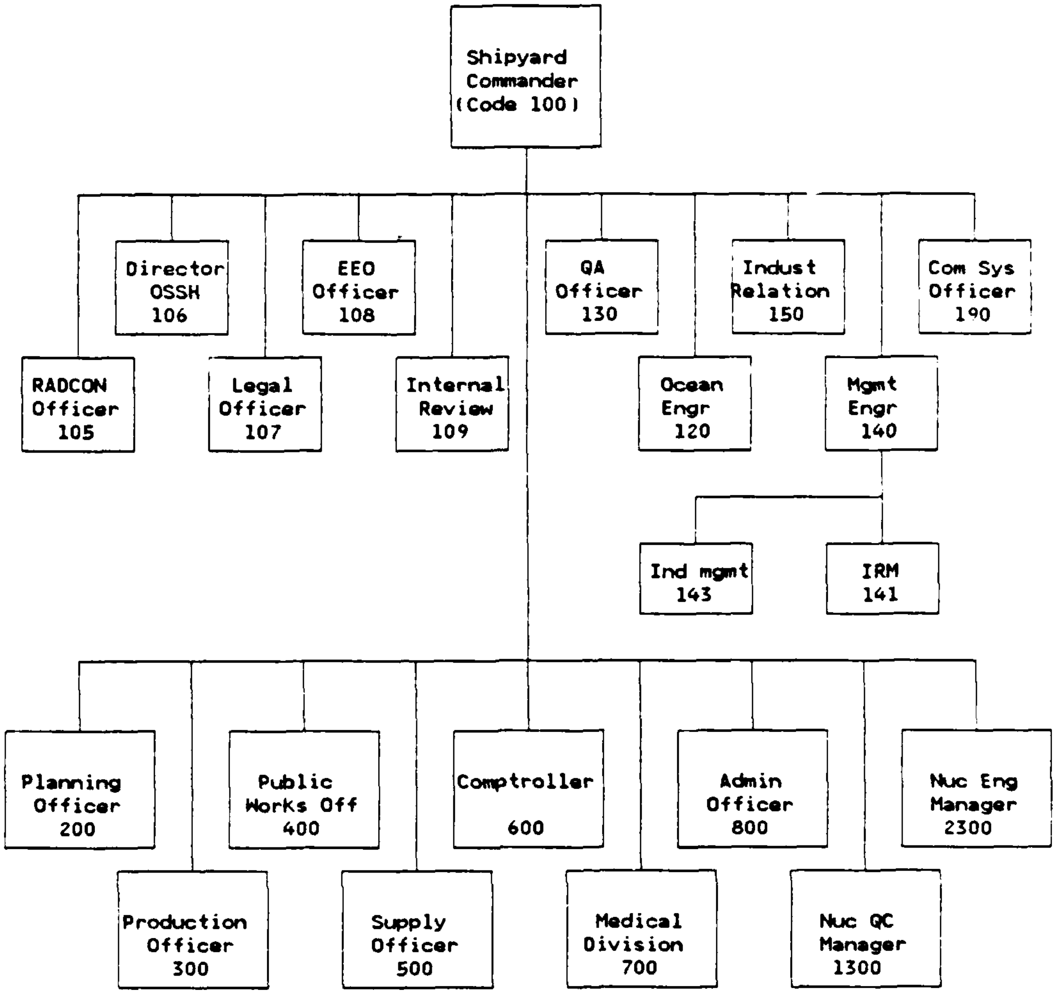

Figure 3.1 MINSY Organization

3. Programming and Operation of the DP Center

The programmers have numerous local modifications to MIS that are maintained and updated as needed. Each time a master MIS module is updated by SEAADSA any locally-generated code that interfaces with that module must be amended to ensure that the proper data is produced. When the MIS program was written, the dominant programming philosophy was to minimize CPU time and use of memory. Additionally, modular program construction was not yet used. Consequently, the MIS code is very cryptic, even to an experienced programmer. Several hours are needed to trace a code sequence, make the modification, and ensure that only the desired variables were affected by the change.

Since the MIS was installed over twenty years ago the original programmers that were most familiar with the operation of MIS and the interfaces have retired or left the MIS environment. Those that now work with this system are several generations removed from the "plankowners" and accordingly there has been a steady loss of in-depth system understanding which is manifested by the need for more time to make system adjustments and a greater training effort to make a new programmer productive.

Programmer incentive and morale is a problem generated by relatively low pay in the "GS" wage environment. In a high-cost area, such as the San Francisco Bay Area, it is difficult to hire the best and brightest in the ADP world and keep them for any useful length of time because the government wage is a nationwide average and does not match the cost of living in the Vallejo region [Ref. 18]. Further, the heart of the computer industry is located in the Bay Area which means all the state-of-the-art companies offer high salaries to hire the ADP talent. What young programmer would take a job with an organization that offered the least salary, promised a working environment in a building older than his grandfather, and allowed him to exercise his craft by working in code that is twenty years old (COBOL 68)? It is no wonder turnover of ADP personnel is high and morale is low.

The computer operation personnel spend two shifts everyday hanging one tape after another on the mainframe drives for the daily batch updates. Unfortunately the tape sequence schedule is manually produced which can lead to errors. The tape merge sequence is modified when local program changes have been generated that require new data or updated program calls. The data requirements for the revised program look for information in a different sequence than did the old program. If the manual sequence schedule is incorrect the batch updates will not have the proper data, or if the operator accidently places an incorrect tape into the sequence that data will be suspect. However, this error is nearly impossible to detect by analyzing the output. Another problem with the manual system is in the case of a system failure that requires restart. It is critical to correctly determine how far back in the batch sequence to go to ensure that the batch update is accurate. A complete restart is impractical because the batch update takes all of second shift and most of third shift to accomplish everyday.

4. Training

The data processing group is as anxious to provide training for shipyard ADP users as the users are to receive the training. The biggest limitation is lack of manpower to dedicate to ongoing training programs. Several welcome-aboard-style training workshops are held on an as needed basis, but this is mostly an introduction to ADP services in the yard with little or no hands-on training. Courses for special access programs, such as LOUIS, have been offered but most shops were unable to take time from their operations to send their employees to these classes. Training often is relegated to a low priority because of day-to-day operational problems.

5. **Distribution**

The distribution of MIS reports has become a large-scale operation because of the sheer volume of paper (2.5 million pages monthly). The fact that the information being produced is not on-line means that the value of most reports declines in proportion to the time expired from data input. Essentially, the information provided by MIS is out-of-date before it is even printed.

Special handled reports are those reports which are normally generated by the standard MIS applications as received from SEAADSA and manually separated, hand stuffed into envelopes for users, and routed for distribution. This labor-intensive procedure has slowly expanded over the years to include 118 different reports and now requires a person on each of the three shifts to ensure proper distribution of these reports. Special handling evolved from user requests for output data that related only to the activity or shop at hand. For example, shop 31 might have received a report of overtime activity for all shops in the production department. Meanwhile, every other production shop was receiving a duplicate of that report with all the overtime data. A simple fix was to print one overtime report, separate it into parts according to the shops and distribute the parts to each shop. This avoided the entanglements of modifying the program with local patches and at the same time reduced the number of copies produced which lowered the volume of paper generated. This method of report distribution, known as the special handled report system, has grown to a 24 hour operation which requires three clerks to manually tear apart reports and insert them into routing envelopes.

C. MIS LIMITATIONS

Shipyard MIS limitations are addressed in this section as either hardware-related or software-induced problems. It is important to remember that the problems discussed are those experienced in the eighties while the system was designed to the needs of the sixties. MIS was conceived as a vertical implementation (system driven) that hinges on the concept of centralized data processing. Consequently, the concept of SEAADSA was developed to control MIS. The dominant philosophy of the eighties is one of distribution of ADP resources which leads to a horizontal implementation (user driven) of data systems. This accounts for the large number of stand-alone computers as well as the systems that duplicate existing MIS functions such as FASS (Fundamental Automated Scheduling System).

1. Software

At the time MIS was developed structured design and programming techniques were unknown. Further, CPU time was expensive and code was written to be memory-efficient and increase throughput which makes error detection and correction, as well as maintenance of the code, more difficult. Consequently, shipyard programmers tasked to modify output for local report formats find custom software patches difficult to write and time-consuming to implement. The situation is aggravated when SEAADSA makes fundamental changes to MIS applications and the local programmer is forced to rewrite many of the local software patches previously generated.

Several software limitations of the MIS system were discussed above which include: batch vice on-line processing, difficult restarts non-modular code, non-standard operating system, and manual scheduling of magnetic tapes used for data base updates. Additionally, it is difficult for shipyard users to affect changes to basic MIS applications through SEAADSA, data is duplicated among several MIS applications, and the print routine is embedded in the program code limiting printer functions.

Although MIS was conceived with a feedback program to allow individual yards to influence a program change, in practice this is a rare occurrence. The MISEG (Management Information Executive Group) is a little-known and, we suspect, a rarely-used vehicle of change.[4] The way the system is established, users in the yard have to make their recommendations for change to the IRM group who in turn make recommendations to the MISEG. The MISEG then must approve the changes and recommend implementation to NAVSEA who directs SEAADSA to modify the MIS application. With this many filters, even if the system were running properly, changes would be slow in coming and user frustration would be high. A high level of user frustration can easily lead to neglect of the system or, at best, disdain when inputting

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[4]The authors asked several MIS personnel about MISEG and no one was aware of a group by that name. To our knowledge NAVSEA has not called MISEG into session in recent years.

data.

Data duplication occurs among the MIS applications by design. Each MIS sub-system (see Figure 2.3) repeats several data fields after the initial batch update. Although this was done to reduce tape handling in the early days it means that the same data is loaded at least four times and then manipulated by the various applications.

Because the printer driver is in the code, there is little flexibility in output adjustment. The print routine used is called PRINT6 and it is difficult to modify in order to support such things as high speed laser printers.

2. **Hardware**

Several limitations inherent in the hardware that supports the MIS applications include: limited communications interface with the PRIME ring, inadequate virtual memory due to disk pack limits, environmental constraints, terminal mix, and printer capacity.

Interface from the Honeywell mainframe is limited to two modem lines. This connection does not incorporate time sharing, therefore a maximum of two users can interface from the PRIME ring to the Honeywell at any one time. Further, the data transfer rate is 1200 bps[5], which is significantly slower than the 9600 bps terminal capability.

The present disk packs provide a limited amount of virtual memory which allows loading of a restricted number of MIS applications for on-line access. The amount of virtual memory could be increased with a purchase of the current higher-density disk packs. The new units would not require any additional floor space or necessitate any additional front-end processors for the I/O[6] connection to the mainframe.

The physical environment where the mainframe is located does not provide adequate support for the hardware. The space cooling system is barely adequate, the building is low in relation to the water table and the basement which houses the Honeywell computer is subject to dampness, the size of the space housing the computer and its ancillary equipment is small making it difficult to work on the equipment, and the building is old (pre-World War II) and does not have adequate wiring to support today's power requirements.

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[5]Bits per second - Telecommunication term that is often referred to as baud rate.

[6]Input/Output - Channels used for CPU communication with peripheral devices.

The mainframe supports asynchronous and synchronous terminals. This mix increases the maintenance overhead for the IRM group and also means that all Honeywell terminals cannot be used to access all the programs running on the mainframe. For example, SWCS uses an asynchronous terminal while LOUIS users must find a synchronous terminal.

The system printers are running at full capacity to support the present MIS output. Equipment downtime immediately causes a queue to develop which generates a significant paper backlog. Should an extra printer capacity become necessary with any future application changes either a significant hardware purchase would need to be made or some hard-copy output would be deferred for a long time.

D. RELATED ISSUES

This section discusses problems that are indirect to the MIS functions but impact information management throughout the organization.

It only takes a small amount of investigation before one realizes that many problems within the shipyard have their roots in information management. This is almost expected as poor decisions many times reflect poor up-front information. Although the shipyard MIS system was envisioned as a long-term management aid and was state-of-the-art technology, (circa 1960), it currently is not meeting the shipyard requirements in the 1980's. Two decades ago computers were very expensive, costing about two million dollars for a typical mainframe, such as a UNIVAC I. Consequently CPU time was expensive and throughput was considered a top priority. This led naturally to batch processing for first-generation computers.

As time passed the volume of information processed increased and the output, mostly reports, grew exponentially. Currently recipients of MIS reports are buried in a sea of paper and because of the batch processing operation none of the reports are real-time. Consequently managers receive late information that is often cluttered with unnecessary data. Managers also indicated that the present MIS outputs are difficult to interpret and understand [Ref. 19].

At the same time, waterfront supervisors are spending many hours each day ensuring that KEYOPS (key operations for overhaul) are correctly charged for man-hours expended. This, as well as other administrative overhead, is keeping the average supervisor off the job site for the majority of the day. This has led to inefficiency on jobs which results in increased rework and greater cost, as well as coordination problems with other shops working on a particular KEYOP.

The indirect problems have become more acute with the emphasis on cost vice schedule as the prime motivater for yard operations. The original concept of MIS was not geared to a profit organization but a schedule-driven system [Ref. 20].

E. PROBLEM SUMMARY

The problems identified above during yard interviews have been summarized and sub-divided into two main categories below. The first category will be referred to as direct in that it addresses problems directly related to information flow and processing within the shipyard. The direct problems are further sub-divided into three areas: the user, the data processing support group, and MIS limitations. The second category is indirect and describes the second-generation problems that are occurring because of the information transfer anomalies identified in the direct category.

1. Direct

a. The User

(1) *Manager Supervisor.*

- Reports are cumbersome to use
- Late receipt of time-sensitive data
- Lack of credibility
- Lack of terminals
- Not user-friendly
- Lack of training

b. The Data Processing Support Group

(1) *Manager.*

- Paper overload
- Old equipment & old software
- Too many isolated CPU's (micro & mini computers)
- Shipyard organization does not support central DP responsibility

(2) *Purchasing.*

- Standardization of micros
- ADP systems purchased by NAVSEA cause distributed DP functions yet SEAADSA is tasked to centralize IS functions with MIS
- Limited system interface

(3) *Programming Operation.*

- Non-modular code is difficult to change
- Experience of original programmers no longer available
- High turnover in programmers (low pay, working conditions)
- Batch processing tape mergers are manually scheduled & loaded

(4) *Training.*

- Inconsistent - on request of users
- Low priority

(5) *Distribution.*

- Time delay for routing
- Special handled reports are labor-intensive

c. MIS Limitations

(1) *Software.*

- Batch vice on-line processing
- Difficult to restart
- Non-modular code
- Non-standard Operating Systems
- Manually scheduled update for magnetic tapes
- Software updates are system-driven vice user-driven
- Data duplication in MIS applications
- Printer driver limitations

(2) *Hardware.*

- Limited communication interface
- Inadequate virtual memory
- Environmental problems
- Terminal mix
- Printer capacity

2. Indirect

A summarized list of indirect problems from the previous discussion follows:

- Data is difficult to interpret
- Reduced on-site supervision
- Inaccurate job histories
- Double entry for users with micros (re-enter MIS output in micro program)
- Strategic shift in shipyard objectives.

IV. ADP DESIGN CONSIDERATIONS

This chapter presents a summary look at the shipyard users' need for automated information. The thoughts expressed were derived from discussions with a variety of users and observations of employees attempting to access data in order to accomplish their jobs, as well as from the authors' experience. The term "user" covers a large spectrum of people. In MIS terms a user can be an individual who is assigned to a specific task, such as overhauling the main steam stop for the USS NEVERSAIL, or the user could be a supervisor who monitors the activities of several employees. The term "user" in the MIS environment could also identify a manager whose responsibilities include maximizing the productivity of an entire group or the user could be a leader in the yard who is concerned with providing strategic guidance for the entire organization.

Consequently, users' needs for information are many and varied. A system which satisfies these demands must be responsive and flexible. This chapter addresses the needs of all shipyard automatic data processing (ADP) users in five categories: input, output, access, data, and training.

A. INPUT REQUIREMENTS

The inputs to any ADP system should be consistent and easy for any user to manipulate. This means that the man-machine interface needs to be understandable and it should require little or no training to operate in order to achieve maximum efficiency.

The man-machine interface is the communication that occurs between a human operator and a computer. The interface must be understandable, easy to use, consistent, and remove any ambiguity. Natural language communication has the same requirements in order to allow humans to effectively pass ideas, instructions or information from one to another. Just as someone who speaks only Japanese cannot understand someone who speaks Spanish, neither can a non-computer-trained individual understand the machine language of binary. Over the years machine interfaces have developed from a series of blinking lights representing 0's and 1's to systems that generate cryptic screen messages and allow keyboard commands to be entered to expert systems that permit a user to speak commands in plain English and hear the outputs in like manner. The point is that the interface is so critical to effective communication that a poor or difficult-to-use system negates the benefit of the computer.

1. Interface Variety

Discussions with several users made it clear that a single computer interface for an individual was not only nice but necessary [Ref. 16]. Users are not allocated time enough to learn and become proficient with numerous man-machine interfaces, therefore being forced to use several different systems will reduce proficiency with any one system. The net effect is that a reduction in productivity and an increase in data entry time results in a lower level of output. The practicality of "the real world" means that there is no time to learn several systems with the crush of day-to-day problems. This leads to the straightforward conclusion that only one system should be used by any user. One terminal should allow a user access to multiple systems via networking.

a. Consistency

Users can be taught to use almost any type of input device and over time become proficient. The point of consistency is that the chosen interface must remain constant for a significant period of time and be supported by the data processing group. Certainly modifications can be made to an interface as long as functions are not changed. For example, if the ESC key always returns to the previous menu then a subsequent upgrade to the program should not change the function of the ESC key to aborting the operation in progress. Users will offer much less resistance to modifications or future system changes if these seemingly small areas of functionality are maintained. Accordingly, NAVSEA should specify programming standards which will allow programmers to develop consistent interfaces.

It is noteworthy that an organization does not have to be limited to one type of terminal or processor, but can use several different types of machines with appropriately different interface methods if those units are networked. The key is that a certain department or division should have the same type of machine interface so that employees within that group can use any available machine. Variety in terminals processors does significantly complicate the support group responsibilities and therefore should be carefully considered before purchasing new equipment.

b. Ease of Use

The ability for users to communicate with a computer with little or no effort greatly enhances the machine's utility for that user. It also promises to increase productivity because one experiences less frustration in producing the needed output. Computer systems have been improved over the last forty years and are now much more "user-friendly". In the beginning, computers were programmed by connecting relays and vacuum tubes in a specific sequence. Program modifications required a change to soldered connections. Later, card readers were used for input and then evolved to magnetic tape. During this time the Von Neuman stored program concept[7] became popular and changed the way operating systems performed. Users then began keyboard communication by inputting symbols to initiate a function and usually the output was in equally strange notation. Operating systems continued to evolve and improve the quality of the man-machine interface, especially with the advent of the micro-computer. All of a sudden computers have come to the common man, and with a few hours of studying the manufacturer's manual, the interface is now understandable. Several operating systems were developed to support micros, but MS-DOS has become the most common. The most recent stage in the evolution of interfaces, at the operating system level, has been the advent of GEM[8] which uses icons or pictures to represent certain functions. For example, an icon of a filing cabinet can be touched by an arrow (controlled by a mouse) and opened to see the files that are inside. This simple mouse action achieves the same result that typing DIR achieves, only it is easier to understand the actions taking place because of the graphic representation. The graphic presentation is easy to learn because the pictures represent logical functions and, for the most part, a user simply points and clicks with the mouse.

2. Data Manipulation

The interface most likely to be seen by the user is determined in large part by the computer's operating system which performs, among other operations, I/O functions. The remaining discussion in this section will be concerned with aspects of the user interface that are performed by programs or applications running "on-top" of the operating system.

Data manipulation requires three basic actions from the user's perspective: input, error correction, and update. The true manipulation of data is done by the machine, but the user must communicate the data to be processed.

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[7]The Von Neuman stored program concept permits the loading of a program into the computer's memory.

[8]Graphic Environmental Manager (GEM) was originated by Xerox Corporation and developed by Digital Corporation in the early eighties.

a. Initial Entry

Data entry needs to be logical and easy, in order to avoid mistakes. The program that is accepting the data should allow the user to enter the appropriate fields of information by prompting him for the information in a sequence that makes sense for the operation. For example, if a person's name and address are being entered into a data base to produce mailing labels, it would be awkward for the program to prompt the user by asking for a zip code, then a first name, then a street number, then a state, then a last name, etc. Even though each one of those items is a separate field, a logical sequence makes data entry much easier. Ease of data entry reduces mistakes and increases productivity.

b. File Update

The second function with which a user is concerned, dealing with data, is that of editing the information. This could be changing a single data field or eliminating an entire record. As with data entry, the prompts for change should be logically sequenced. Modification or elimination of certain key fields should perform some associated changes. In the mailing list example, if a user desires to remove a name from the list one command should remove the name and address.

Additionally, data entry is duplicated by multiple stand-alone processors, such as isolated micros, each of which must have its data base updated individually. A centralized data base is a repository of information which serves multiple users. This allows current corporate data to be available for all authorized users. Lack of duplication saves many man-hours by eliminating inconsistencies among the isolated data bases.

c. Error Correction

The ability to correct a mistake is fundamental to any input function. There are two classes of error, those that are not detected by the operator and those that are observed by the operator. The first type is difficult to avoid but a friendly interface might allow the operator to enter data, then review the information on the screen before that data is sent to the data base or saved. This procedure offers the user a second chance for proofreading the input. This is particularly useful with word processors, but can be adapted, to a certain degree, to most input applications. The second error is one that is already in the data base and must be recalled, corrected, and saved. Any program that does not allow this type of correction is not very efficient and is destined to be under-utilized by the users.

B. OUTPUT REQUIREMENTS

The outputs must also be user-friendly to complete the communication cycle between the user and the machine. If the user has everything he needs but doesn't understand the output then the information is of no use to him and in essence the computer is useless. Although several types of output exist, such as voice-generated, punch tape, etc., the two most common methods of output are to the screen (CRT) and to a printer.

1. Screen

The most important aspect of user interface in receiving data at the screen is that the layout is easy to comprehend and use. The mailing list example is appropriate here, too. If a user wishes to call up an individual to check an address, two possible data displays are:

Presentation #1

John Smith
125 Lance Lane
Monterey, CA 93940

Presentation #2

JohnSmith125LanceLaneMontereyCA93940

It is fairly obvious which output is more useful. Pictorial output further enhances this interface and can include simple boxes that separate text on the screen or highlight a system message for a user's attention. Screen output should also be in full screen display vice a line by line display. A full screen print displays an entire screen then waits for the user to continue when he is ready. A line by line output is similar to a teletype output and can be tedious to read. The screen output is interactive with the user and allows him to adjust as necessary. The user should be able to page up or down to recall the previous screen display or bring up the next sequential display, pause, then restart. Further enhancements to the interface include the use of color, large high resolution screens, and faster response times.

2. Printed

Output to a printer is different from output to a screen only in that it is not interactive. Once a print option has been selected the data is sent to the printer continuously until all the information has been printed. The format of the data is important and it must be as readable as the screen output. Again, the program being used is the vehicle for a good interface at this level.

In many cases a graph or pictorial output is needed to convey a lot of information that can be quickly assimilated. This format is especially useful in monitoring trends without the requirement for interpreting several pages of numbers. In essence, a graph amounts to a pictorial report summary. Since managers face the greatest time constraints, need overview information, and monitor trends more than bottom-line figures, the graphic output is well suited to their needs.

C. ACCESS TO DATA

As discussed here, access refers to the authority to receive certain data. This area is of concern first to the owner of the various shipyard data bases and secondly to the data base administrator (DBA) who must manage the access problem. The issue then is security. Allowing authorized access and preventing illegal system entry while maintaining a user-friendly interface presents an extraordinary challenge for the system designer.

1. Interactive

Interactive access to data is also referred to as on-line manipulation. This type of man-machine communication can be referred to as conversational. The user enters a command and waits for a reply. The machine interprets the command, executes an operation, generates output, and waits for the next input.

Interactive updates to the data base offer an advantage in that rapidly changing information is immediately available to all system users. This rapid update ensures that timely information is available for decision making. For example, a data base that is updated nightly, such as the one at MINSY, could have an inventory control system that operates as follows: at 10:00 o'clock user 1 queries the system for bolts and is shown five in stock. User 1 then draws four bolts. At 11:00 o'clock user 2 queries the system for the same bolts and finds five listed in stock and attempts to draw three only to find one bolt remaining.

In the preceding example an interactive or real-time update to the data base is needed. Other types of data, such as man-hour charges against a KEYOP, are not nearly as time-sensitive and could easily be updated daily without any degradation of information.

2. Printed Material

Printed output is a "snapshot" of data at the point-in-time when the last update was accomplished. Two methods exist to achieve a hard-copy output: a centralized system with established print routines and a distribution network, or a distributed output to individual printers that allows a "screen dump"[9] at the user's discretion. The centralized system is well-suited for routine reports that use an established and static format. Typically this system will be used to generate everything from daily to annual reports. Once a report is established within the system it will continue forever, unless a user makes a special request to terminate it. This works well for monthly, bi-weekly, and in some cases weekly reports that act as a summary of transactions for that period of time. It becomes impractical to use the centralized system for daily reports primarily because this information is time-sensitive. By the time distribution is complete the data has been superseded; consequently, it is more practical to receive daily output from an interactive system with local printers for users needing this type of data.

It is noteworthy that most managers don't need daily data [Ref. 19] and, in fact, they would be taking a high risk to base operational decisions on one days report. An analogous situation is that of a Wall Street broker who sells ABC stock because it fell two points in one day. The next day that stock had a ten-point rise and the broker was looking for a new line of work. Obviously the broker had lost the "big picture" just as any manager would lose sight of his overall objective if he deals in minutia.

3. Security

The security of data in this information age has become a major consideration for any manager. Almost every organization has sensitive data that merits safeguards because of proprietary information, or national security, or any one of several other valid reasons. The two aspects of safeguarding data are access control and proximity control.

a. Access Control

Controlling access to data is the primary responsibility of the owner of the data and the manager of the data. The owner is typically the department manager of the group that generates input to a particular data base. He must develop a list of individuals authorized to access his data with a read only or a read write capability. The manager of the data, typically a DBA or at MINSY the IRM, must provide a

[9] A screen dump is the duplication of an existing screen output in printed form.

means of safeguarding the data so only the correct individuals have access. This is usually achieved through passwords. For example, a user ID and password might be required to gain entry into the system. Once on-line, a request for data might require a second password to determine a user's type of authorization (read only or read write). To this can be added levels of access such that a level rating implies a user's need to know and his clearance. In a ten-level system a clerk may have a need for only unclassified non-privacy-act information which requires a level-ten rating. On the other hand, the Shipyard Commander may have a level-one access for unrestricted entry into any data base.

Additionally, it is easier from a control standpoint to have a centralized system running various programs rather than having numerous copies of the same program running on distributed micros. For example, software duplication is an ever-present problem with such programs as LOTUS 1-2-3. If this problem is allowed to go unchecked it is likely that software companies will begin copyright litigation. The ADP manager must then maintain control of each micro program copy in existence. With a centralized mainframe or mini-computer system only one program exists and is not capable of being copied to and used by micros.

b. Proximity Control

Access can further be supervised by physical constraints such as system terminals locked in rooms with entry monitored by key or combination lock or placing a key-operated on-off switch directly on the terminals. These physical limitations can be used in conjunction with some access control procedures to achieve even greater data security. It should be noted, however, that every additional security measure decreases the user's accessibility to the data which will have a negative impact on that user's productivity with the system. If the system is too hard to use then it won't be used and it becomes an enormous waste of money.

An additional security concern is to prevent unauthorized tampering with the support hardware or software. Consequently, it is logical to provide a room with limited access to house the CPU, programs, and storage devices. To avoid a potential loss of data from a catastrophic event (fire, flood, etc.) most DBA's back-up their data (and programs) and archive the back-up material in a secure storage at a remote location.

D. TYPE OF DATA

There are two kinds of data generated by a computer: a detailed look, that displays every number or data field generated while processing a specific program, and summary data, where only requested data is provided to the user.

1. Detailed

Just as a math teacher asks to see all the work a student performs in a problem in order to derive an answer, detailed data produces every number or character generated by a program. For example, an audit clerk might need to see every employee name, gross pay, deductions, and net pay listed in the payroll data base, but a secretary may only be interested in a specific employee's paygrade. Generally, a high level of detail is needed by workers assigned to monitor or report on a very specific activity, but is not needed by, nor should be accessible to, most shipyard employees. An example of detailed information printed within the shipyard includes the following reports:

- DLSC Cards
- NSF Status of Funds
- Plant Account Inventory
- Employee Sick Leave List
- Accounts Payable Reconciliation
- Individual Annuity Calculations
- Monthly Expense Statement
- KEYOP Scheduled Starts
- Transfer of Labor Charges by Job Order
- Personnel with Expiring Nuclear Qualifications

2. Summary Statistics

Summarized data is, by far, the most useful information for some managers because it is easier to read, provides only relevant material, and it can be customized to individual requirements. The very feature of customizing output also brings the penalty of increased effort from the user in identifying, in detail, his required output, and a need for programmers in the data processing group to modify the program code to produce that report. Nevertheless, most managers and supervisors interviewed don't want to be bothered with much more than bottom-line figures and computers are the best tool that exist today for screening unwanted output.

E. TRAINING

Training is fundamental to the proper use of any system. Training is usually accomplished by on-the-job exposure to the activity, by formal class sessions where a system understanding is gained, or by self-study of prepared materials. When management provides proper training, they are preparing an individual to productively perform a specific task (in our context the task is accessing and manipulating data with a computer) in the shortest possible time. One of the biggest costs of a training program is time. An employee is on the payroll and not producing while in training and this up-front cost of sparing a person for "school call" is difficult for many supervisors to accept. Since in many cases a person can muddle through a job with no formal training, the supervisor receives some productive work while that person is on the job, but he can never be too sure how much of an increase he will see if that person is sent to a formal course of instruction. For a valid training program to exist it is necessary for every manager and supervisor in the chain of command to fully support and emphasize local training with more than mere lip service. Training falls into two categories: initial and periodic.

1. Initial

MIS orientation is the initial computer "training" received by most employees. In the shipyard this means learning what computer services exist, where they are located, what types of programs are available, and what services are provided by the data processing group. Follow-on training dealing with specific programs and interfaces is offered on request. Unfortunately, not many are sent for specific training opportunities. This leaves the new employee with only a brief orientation to all of the ADP systems and on-the-job training with which to become proficient. An investment in training is needed to bring each new employee to a functional level of competence in his work area.

2. Periodic

Once a user is proficient, a system refresher or ongoing training can be beneficial to keep productivity high. With ADP systems, changes are constantly being implemented and a method of keeping employees up-to-date will avoid the possibility of long-term problems. Periodic training is used throughout our society to keep proficiency high. A good example of that concept is the re-licensing of drivers every few years. This allows drivers to review the current regulations and take an examination to prove their proficiency. The effect is efficient utilization of vehicles for transportation where, in the absence of effective training, drivers would proceed with their best guesses as to the current safe motoring procedures hoping the other car will do something predictable. The net effect would be chaos. Efficient use of our ADP systems requires the same type of ongoing training to ensure that the information system is used efficiently.

F. FEEDBACK

User feedback is critical to maintaining and improving an efficient system. The user is the individual "stuck" with using the system to accomplish his tasks. If there is an anomaly in the program or a feature that is awkward or difficult to execute, the user will often communicate that shortcoming to system maintenance personnel in an effort to ease his burden. There are several elements to consider in developing and maintaining an efficient feedback program. First, the user must know that a method for corrective action exists. Second, the user must be willing to communicate suggestions for improvement. Third, the system manager must provide a timely response acknowledging the suggestion with an explanation of the action to be taken (study the proposal, implementation plan, etc.). After final disposition of the suggestion, the manager should explain the actions taken to the user. Fourth, all suggestions used need to be advertised, giving proper credit to the originator, thus encouraging other users to participate in the feedback program.

G. SUMMARY OF ADP REQUIREMENTS

The needs discussed in this chapter that must be met for an information system to be effective can be summarized as follows:

- A clear and understandable user interface which includes a consistent command structure
- Ease of data base manipulation and update
- Convenient access to data entry and data output devices
- Flexible report generation to produce either detailed, summary, or graphic output on demand
- Interactive systems to achieve real-time updates to data base
- A corporate data base to allow access to a central repository of information without duplication of data
- An effective physical security and access control program to ensure data integrity and avoid compromise of sensitive information
- An effective training program for familiarization and continuing education
- An efficient feedback method for user improvement of the system

V. CONCLUSIONS AND RECOMMENDATIONS

This final chapter addresses ways to improve the information management in the shipyard. Within each category are several individual options that can be implemented in part or in whole. Chapter III of this thesis describes several significant MIS system problems. Chapter IV attempts to quantify some of the real information needs of users in the shipyard environment which pave the way for several suggestions that follow in the options section. The suggestions are divided into categories by approximate cost. The recommendation section below is an attempt to address the frustrations identified in Chapter III and meet the users' needs as outlined in Chapter IV.

A. CONCLUSIONS

The present MIS is not perceived as functioning well. It was clear from the research that MIS is not viewed as a workable tool. Management gives little credibility to the output and supervisors are frustrated by the time they expend to make system entries. The data processing group is discouraged when trying to keep the system current.

There is not enough flexibility in the system. Changes to MIS report formats are slow because of a limited number of programmers, most of whom are inexperienced in COBOL 68 and are trying to absorb application changes produced by SEAADSA. The original MIS implementation was designed as a batch system, however, over time, user demands have forced changes toward the present quasi on-line system. Disk packs were added to create readily accessible data storage. Virtual memory, combined with disk storage, allowed multiple programs to be accessed directly by the user. MIS developed into an on-line system by use of disk storage, however, the original batch design impedes further evolution towards a real-time system. The demands continue to call for on-line data access with a real-time response but MIS is unable to perform this feat. Consequently, numerous special computers have been added to the system information management scheme to decrease response time and add flexibility.

The Trend in shipyard computing is towards distributed systems. As the efficiency of MIS decreased, numerous individual computers have been acquired to run single-purpose applications. Consequently, data duplication has increased, report volume has increased dramatically, and new equipment operators and maintenance functions have severely taxed the IRM manpower resources.

Lack of real-time data base complicates the information distribution problem. The limited on-line data access of MIS, combined with the batch design, forces users to rely on hard-copy reports for information. Thousands of reports are produced daily and subsequently create a distribution backlog throughout the shipyard. Further, data entry irregularities have taken a toll on the system's credibility which reduces the value of the reports. Finally, time-sensitive information is not being received when needed to facilitate management decisions.

B. IMPROVEMENT OPTIONS

Three general options are presented here in abbreviated form and categorized by estimated implementation expense. Both the low cost and the moderate cost options assume that there will be no replacement of existing major equipment at MINSY. Therefore, the Honeywell and PRIME computers remain as mainstay systems for these two solutions. The high cost option is a "money is no object" look at a solution. In each category the ideas presented are divided into functional areas.

1. Low Cost

a. *Terminal Access*

1) *Network the PRIME Ring and Honeywell mainframe systems with a high-speed gateway.* Terminals for the PRIME ring and the Honeywell mainframe are located throughout the yard. More terminals are available for the PRIME system, and indeed, most users find interfacing with the PRIME computers more pleasant than working with the mainframe. These systems are linked by two 1200 bps phone lines to allow PRIME users to interface with the mainframe. These lines limit mainframe access to two PRIME users at any one time. Installation of a high-speed gateway and a protocol converter, such as a Hyperchannel, would, in essence, put both Honeywell mainframes on the PRIME ring. This would increase user access through the 222 terminals now in the PRIME ring without creating the data flow "bottleneck" now caused by the 1200 bps lines linking the two systems.

2) *Add a multiplexer to the PRIME ring to handle multiple phone lines at 2400/1200/300 baud.* Use of a multiplexer allows time sharing to occur with several users calling in over standard phone lines. This procedure eliminates the need for new terminal lines to remote sites in the yard. It also facilitates data links to shipyard tiger teams operating off-site.

3) *Use graphics-based micro-computers or work stations as smart terminals with hard disk and file servers.* Tie each micro into the PRIME ring by use of modems over the common phone lines. A hard disk and printer with each unit would allow users to download data base information for manipulation and in-shop printing of custom reports. Use of a graphics-based machine will significantly reduce operator training time and make data manipulation easier [Refs. 21,22: p. 22, 58].

b. ***Information Distribution***

1) *Use LOUIS or ASPEN for on-line queries, then download files to micro hard disks for manipulation and printing on local dot-matrix printers.* To make this option viable users must receive on-going training in data base interfaces. A LOUIS hot-line for phone inquiries would also be of great value to the users.

2) *Use in-shop dot-matrix printers for reports vice the central line printers and for replacement of special handled reports.* Since most reports are printed daily or weekly, the downloading of this data by supervisors and managers would reduce centrally produced and distributed materials by about 70%.

3) *Sort material issue cards by nuclear and non-nuclear applications to the shop level.* This will reduce manual card submission that generates duplicate material orders. A large volume of material draw cards are produced by the system but they are not used because it is easier for the users to write a new card than sort through thousands of cards for the right part.

c. ***User Interface***

1) *Install a software shell.* User frustration could be lowered with the creation of a software shell for both the Honeywell system and the

PRIME ring. The shell should generate a full screen display that is a combination of text and graphics,[10] such as is found in the 1DIR shell used with MS-DOS micro computers.

2) *Form a MIS interface team that deals directly with users to adjust report content provided by the MIS system.* This team should check, as a minimum, on a monthly basis with every department at the shop level to validate user report quantities, routing, periodicity, and content.

3) *Create a full-time information center.* This center would provide orientation to MINSY computer system users. In addition it could instruct users on basic terminal computer access procedures, provide formal courses on LOUIS or ASPEN, SWCS, Prime, CAD CAM, and MIS. It should offer instruction on use of micro-computers and act as a software library for micro programs maintained by the yard.

4) *Customize MIS reports by fields for each user with a dedicated DP technician as a liaison.* The flexibility built into MIS software is the ability to generate patches to modify the local report formats. Therefore, careful customization of report formats by the user has the potential to reduce the volume of paper distributed and will lead to optimized use of the reports. In order to make any gains in this regard, the user must know exactly what data he needs and identify those needs to the data processing group. In reality, this requires a dedicated DP technician who will survey each shop and group receiving MIS reports to document the precise fields required by the users. Critical to success here is that the smallest unit reviewed is a data field in a report and not the whole report. In the past, paper reduction and efficiency improvement programs have concentrated on reducing unnecessary reports as opposed to unnecessary data within each report. Not surprisingly, most users have not cut a large number of reports because some portion of most reports is required.

[10] Graphics in this application would be limited to boxes that outline and separate a directory listing, general information or notes, and user commands.

2. **Moderate Cost**

a. ***Terminal Access***

1) *Complete installation of the Shipyard Local Area Network.* Use the Prime mini-computers presently on the PRIME ring as host computers for each department. Each department could then branch several terminals from front-end processors to connect to the hosts. Essentially, this would expand the PRIME ring, yet still allow users access to each of the PRIME machines. Efficiency on the net could be increased if appropriate Prime applications for departmental use were loaded on each computer.

b. ***Information Distribution***

1) *Purchase an inventory control system with real-time access and update capability.* This would allow better management of jeopardy items and maintain an accurate and instantaneous inventory of materials on-hand. Further, on-line ordering of parts could be achieved thus eliminating the use of draw cards and reducing the possibility of dual material orders.

2) *Install a Compact Disk (CD) archive system.* An optical laser disk could be used to archive all data generated for each ship upon the completion of overhaul. This would free disk pack storage in preparation for the next ship arriving for overhaul. Information from previous platforms could be available through an automated retrieval system. Conceivably, several CD players could be networked to the shipyard LAN or the PRIME ring to allow planners to gain access to hull specific historical data. CD technology permits quick retrieval of information because of its extensive indexing system. It is expected that all the data for a single ship overhaul could be stored on one or more compact optical disks since these disks are currently able to store more than 500 megabytes each.

c. ***User Interface***

1) *Purchase new disk packs to increase data storage.* Additional data storage would greatly enhance the interactive capability of the present system by allowing users to have greater virtual memory allocations. Consequently, data storage and manipulation would be enhanced

allowing greater use of LOUIS or ASPEN. This would also assist the mainframe operators with the nightly batch updates by reducing magnetic tape handling.

3. High Cost

a. *Terminal Access*

1) *Replace the present system with a large, fault-tolerant, dual-processor mainframe and several distributed computers using a central data base management system.* It should include a high-speed backup capability and exist primarily as a server for the corporate[11] data base. Use of a corporate data base would eliminate duplicate data entries now required for multiple stand-alone systems. At the same time it would enhance the physical security of the data. This machine should have the ability to time share 200 to 300 users and it would require a full time DBA and staff to administer such functions as access control, data update protocol, and storage issues. This machine would then act as a repository for all the data needed by the yard.

2) *Use PRIME computers as departmental mini's in data hierarchy.* The existing PRIME computers can be removed from the present ring and used as front-end processors to departmental host computers that connect the department to the shipyard LAN. In the case of smaller departments these computers could serve as the LAN host for that department. Departmental host computers would reduce mainframe usage through daily downloading and local manipulation of data.

3) *Install a fiber optic LAN.* The installation should include sub-LAN's that run throughout departments divisions and connect to a primary fiber optic LAN by way of departmental host computers. Fiber optics are light weight, improve data transmission rates, reduce error rates, and are immune to the electrical or magnetic interference associated with twisted pair and coaxial cable.

4) *Install radio modems.* Radio modems exist at 2400 bps and could be used for remote site terminals (such as onboard a ship with work in progress) with unclassified data needs. This option could also allow

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[11] A corporate data base is a central repository of data that is applicable to a specific organization such as a shipyard.

installation of terminals at sites where placing a cable is impractical or financially infeasible. To be effective this should be done in conjunction with multiplexing as discussed in item 1.a.2. above.

5) *Connect all distributed processors to the LAN.* A universal LAN protocol, such as X.25 with the DDN,[12] would allow virtually any type of processor to connect to the network. If all yard computers were connected a user could gain access to any application he is cleared to receive from any terminal in the shipyard.

6) *Use the existing Honeywell mainframe processors as production department and supply department host computers.* The largest departmental information needs exist in the production and supply departments, consequently, the capabilities of a mainframe are needed to adequately serve as host machines so these two groups can interface with a LAN. This option should include a conversion of the present operating system to a standard, currently supported, operating system.

b. ***Information Distribution***

1) *Replace the present page printers with one high-speed laser printer.* The present page printers could be located in those departments whose printing needs are greatest. Those departments which do not have their own printers should be given dot matrix, line, or page printers depending on their needs. Today's high-speed laser printers are capable of producing typeset quality outputs at approximately 10 pages per second. This option requires operating system modifications to control queuing and priority assessment of print requests. This would best be implemented in conjunction with a new mainframe supporting the corporate data base concept.

2) *Install a satellite receive transmit facility.* The purchase of a satellite capability would permit connection to the shipyard LAN from any other site, notably a ship on sea trials. A yard repair team called to any location could take a portable satellite set with a terminal and access the shipyard LAN to receive vital data necessary to correct a

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[12] DDN stands for Defense Data Network which is a worldwide packet switched network that supports hundreds of host computers that in turn support hundreds more terminals processors.

problem. Additionally it would allow MINSY to easily link with any other Naval shipyard computer system for data comparison and information transfer.

c. ***Other***

1) *Build a new central site data processing facility.* Existing facilities are inadequate to house data processing equipment. A new structure could provide adequate floor space for ADP central site equipment, proper electrical power with backup emergency systems to allow the equipment to remain on-line and avoid any data loss, tempest control, and proper physical security. Spending millions for a new ADP system and then placing it in an inadequate structure is analogous to putting used retreads on a brand new Cadillac.

C. RECOMMENDATIONS

Some of the options listed above are easy to implement and some will require a major commitment of manpower and funds. Our research has indicated that the core of information processing at MINSY is in need of replacement. We are aware that the Secretary of the Navy is investigating the feasibility of procuring a new system that will solve the problems addressed within this thesis. We believe that the study will identify the major components and software needed to bring shipyard data processing into the 21st century. Our recommendations to improve information dissemination within Mare Island Naval Shipyard and to create an effective MIS interface using micro-computers are divided into two areas: the elements essential for a full system conversion and the interim actions to bridge the gap from the present situation to the new system, which is several years away.

1. Elements for Full System Conversion

- Create a full-time micro-computer center
- Install a Compact Disk (CD) archive system
- Install a fiber optic LAN
- Connect all distributed processors to the LAN
- Replace the present page printers with a high speed laser printer
- Install a satellite receive transmit facility
- Build a new central site data processing facility
- Use corporate data base concept
- Install micro-computers as smart terminals

- Establish a user feedback program for information system improvement

2. **Interim Actions**

- Network the PRIME Ring and Honeywell mainframe systems with a high-speed gateway.
- Add a multiplexer to the PRIME ring to handle multiple phone lines at 2400/1200/300 baud.
- Use graphics based micro-computers or work stations as smart terminals with hard disk and file servers.
- Use LOUIS or ASPEN for on-line queries, then download files to micro hard disks for manipulation and printing on local dot-matrix printers.
- Use in-shop dot-matrix printers for reports vice the central line printers and for replacement of special handled reports.
- Sort material issue cards by nuclear and non-nuclear applications to the shop level.
- Install a software shell.
- Form a MIS interface team that deals directly with users to adjust report content provided by the MIS system.
- Customize MIS reports by fields for each user with a dedicated DP technician as a liaison.
- Complete installation of the Shipyard Local Area Network.
- Purchase new disk packs to increase virtual memory.
- Install radio modems.
- Improve credibility - Remove punitive connotation for negative variance on KEYOPS. Allow shop supervisors to report actual time expended without fear of career consequences.

D. COMMENTS

MIS began as a classic batch run system and has migrated, over the years, to a quasi on-line system[13]. The demands placed on the system by the users have been forcing a migration to a distributed network of computers to perform the MIS functions. Unfortunately MIS, as it was originally designed, is not elastic enough to make the transition from a centralized batch system to a distributed system. It seems clear to the authors that changes to the MIS, as it now stands, must be made soon in order to maintain data integrity and information flow within the shipyard. The decentralization die has been cast by the installation of numerous stand-alone systems (FASS, RCCS, BEST, etc.) and the momentum away from MIS is increasing daily.

[13]On-line approximation is achieved by the use of virtual memory.

The Secretary of the Navy has recognized the need for action and has authorized a full scale analysis [Ref. 12] which is now in progress. It will be vital to act decisively on the results of this study and not lose momentum towards MIS replacement when dollars are mentioned. Much of the real cost benefit will not be quantifiable. For example, a new information system that reduces the administrative load for first line supervisors, especially by simplifying input requirements, would allow those supervisors to spend more time on the job site which will increase the workers' awareness of their interest in the them. The workers will respond to this attention with greater productivity[14] thereby contributing to maintaining the schedule, and simultaneously raising the quality of work performed which ultimately reduces rework.

Another example of a hidden cost benefit is the one that addresses the user who constantly manipulates MIS data. An improved information system, that permits the user to receive and manipulate data while on-line, would ease the frustration now experienced by users. This will improve job satisfaction and could very well prevent an employee from seeking employment elsewhere. This will prevent unplanned personnel losses thus reducing hiring costs, training costs, and the loss of expertise that could lead to operating inefficiencies.

It is impossible to quantify these benefits in dollars and cents with any kind of accuracy, yet the benefits are real and will be realized by the shipyard as well as the ships undergoing overhaul. The bottom line is that the shipyard needs a new information system now.

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[14]The experiments of Elton Mayo in 1927 at Western Electric's Hawthorne plant showed that employees respond positively to special attention even if the actions are negative. This is known as the Hawthorne effect [Ref. 1: pp. 45].

APPENDIX A
INFORMATION PROCESSING AT MINSY

This appendix contains a sampling of data flow diagrams (DFD) depicting the flow of information at Mare Island Naval Shipyard as it now exists. These diagrams were produced using reports currently generated by shipyard MIS. The diagrams included herein are not all encompassing but describe major functional areas and essential data. The level zero diagram (Figure A.1) is an overview of the major components that make up the Shipyard's Information Management flow. The level one diagram is the overall picture with more functional displays of information. In order to achieve a useful level one DFD it was necessary to generate a level two breakdown. An example of a level two breakdown is shown in Figures A.2b to A.2i. The data elements and files are further amplified by the preliminary data dictionary in Appendix B.

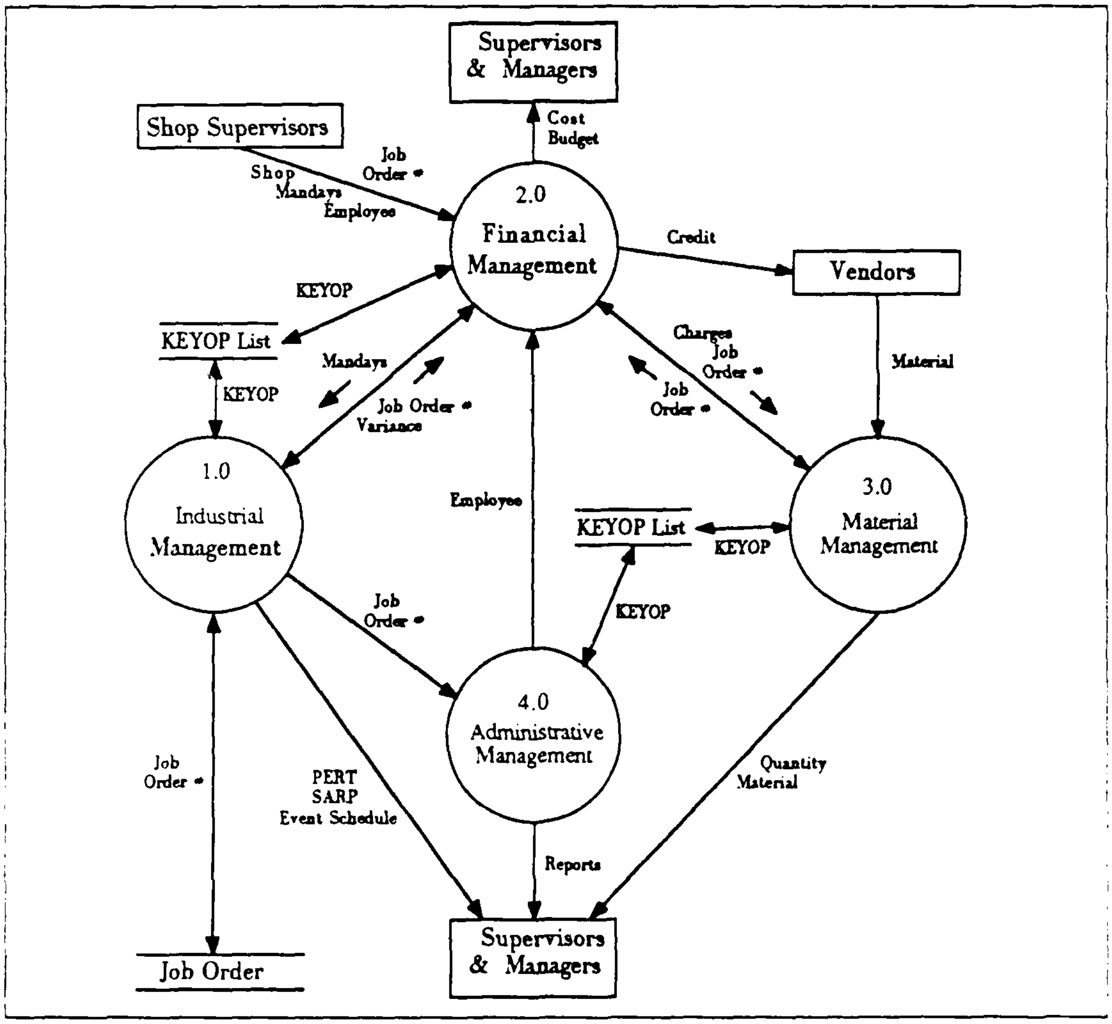

Figure A.1 Level 0 - Shipyard Information

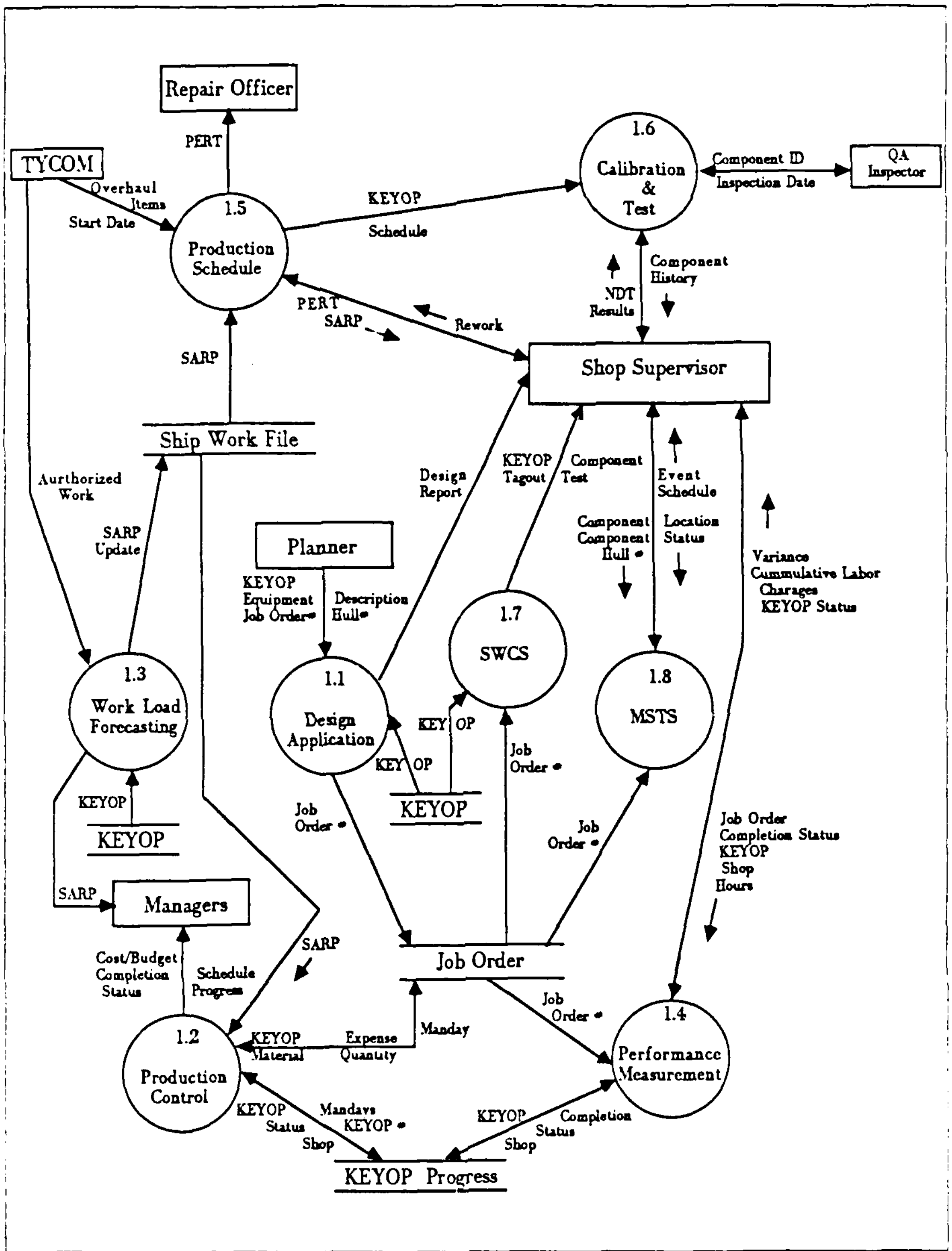

Figure A.2a Level 1 - Industrial Applications

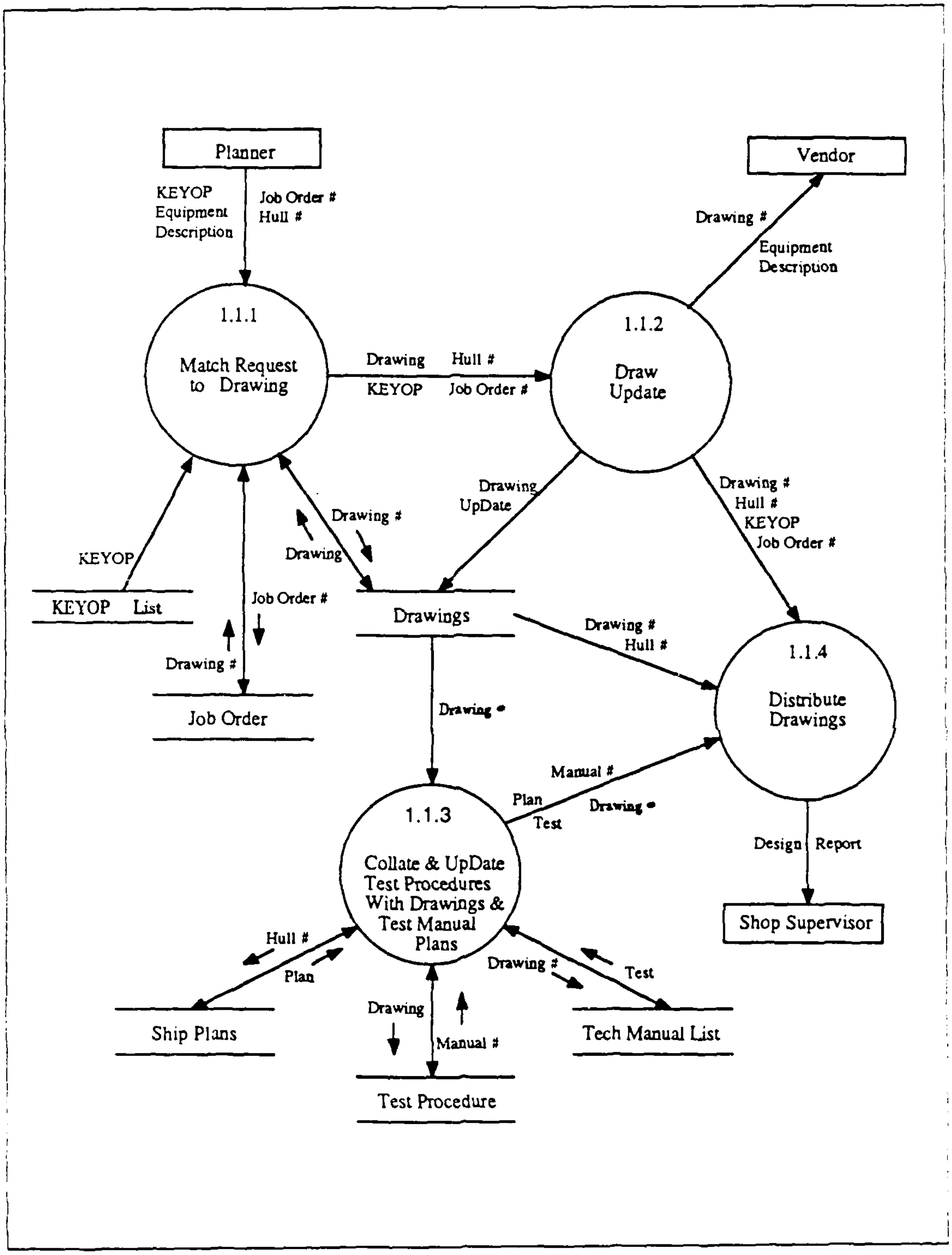

Figure A.2b Level 2 - Design Application

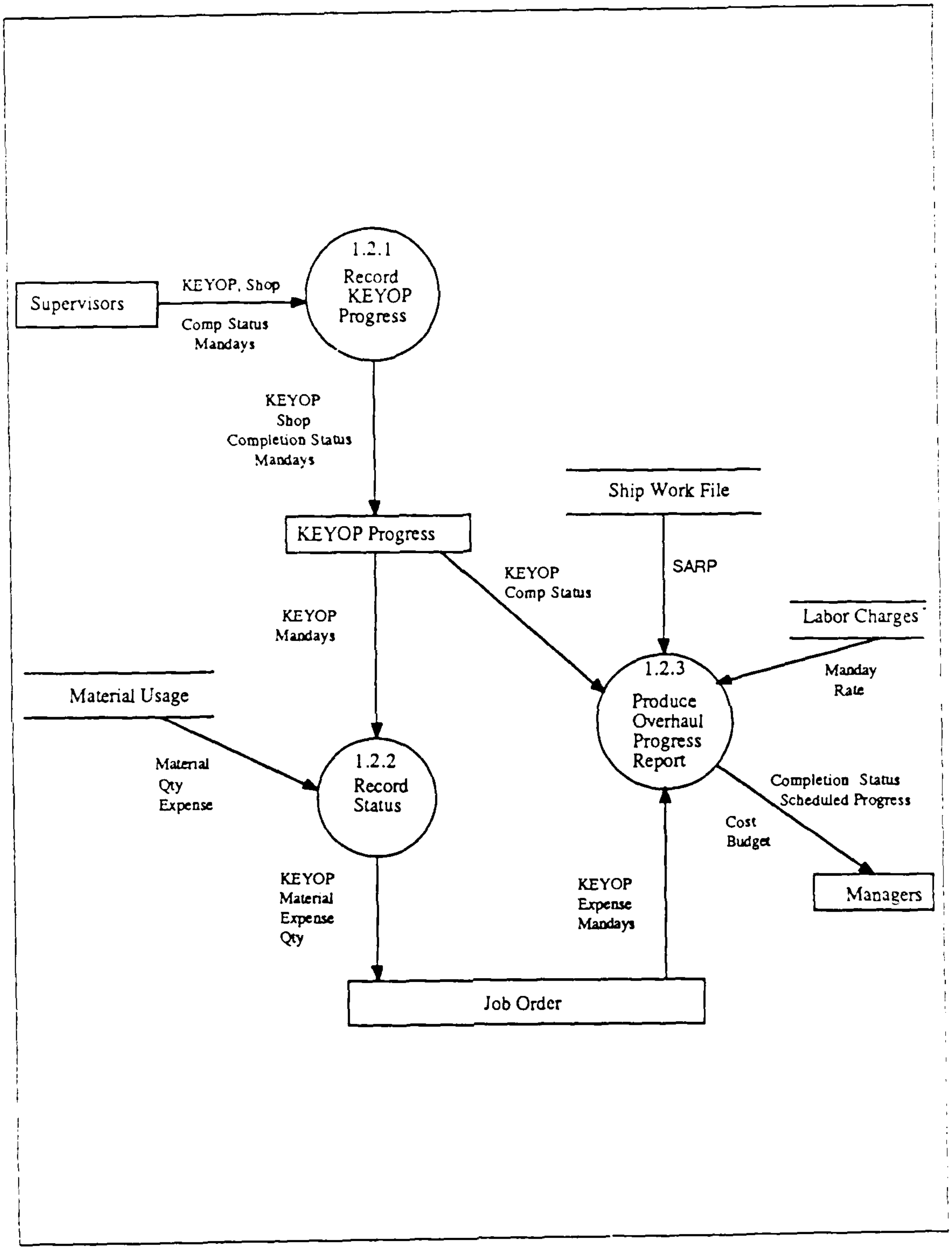

Figure A.2c Level 2 - Production Control

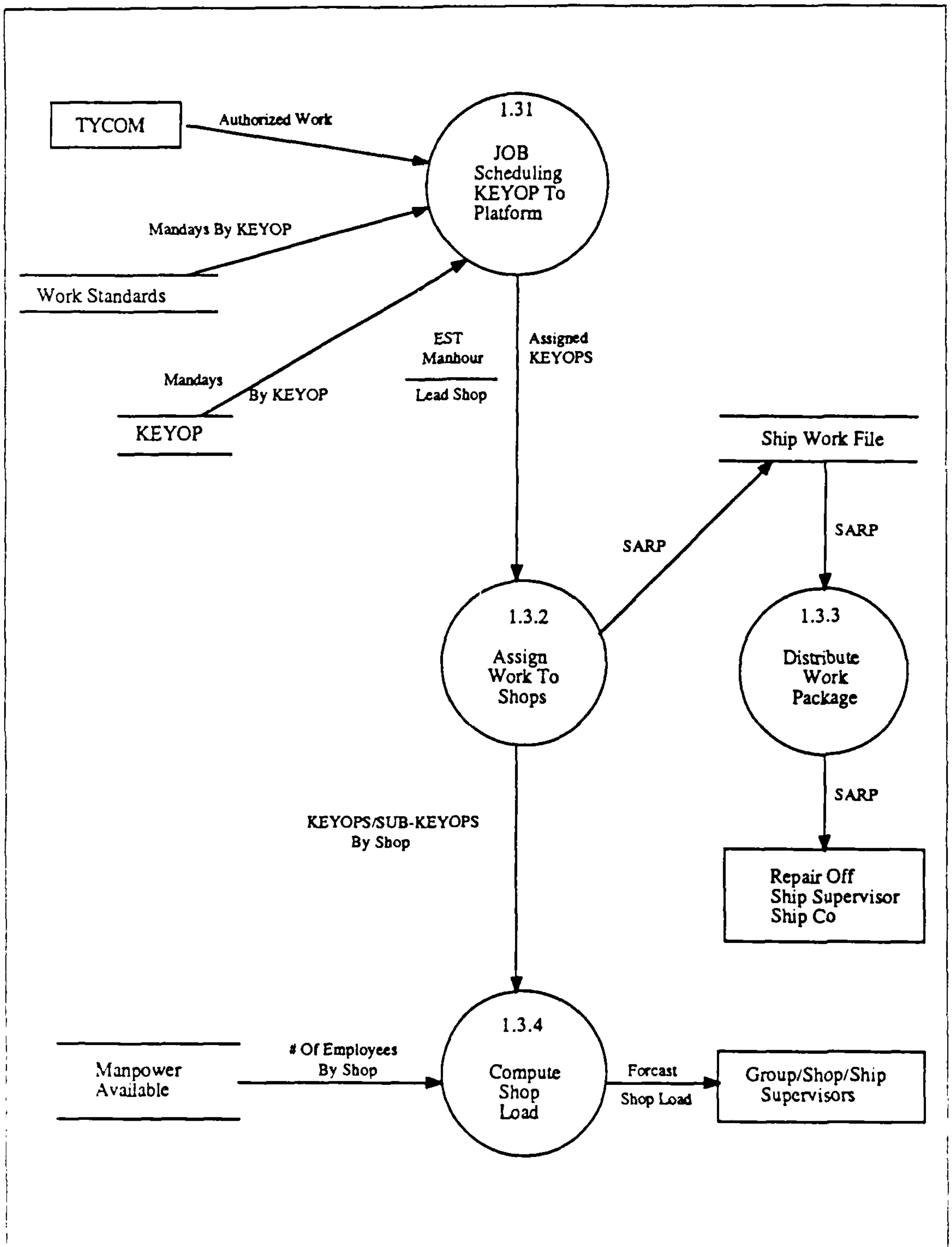

Figure A.2d Level 2 - Work load Forecasting

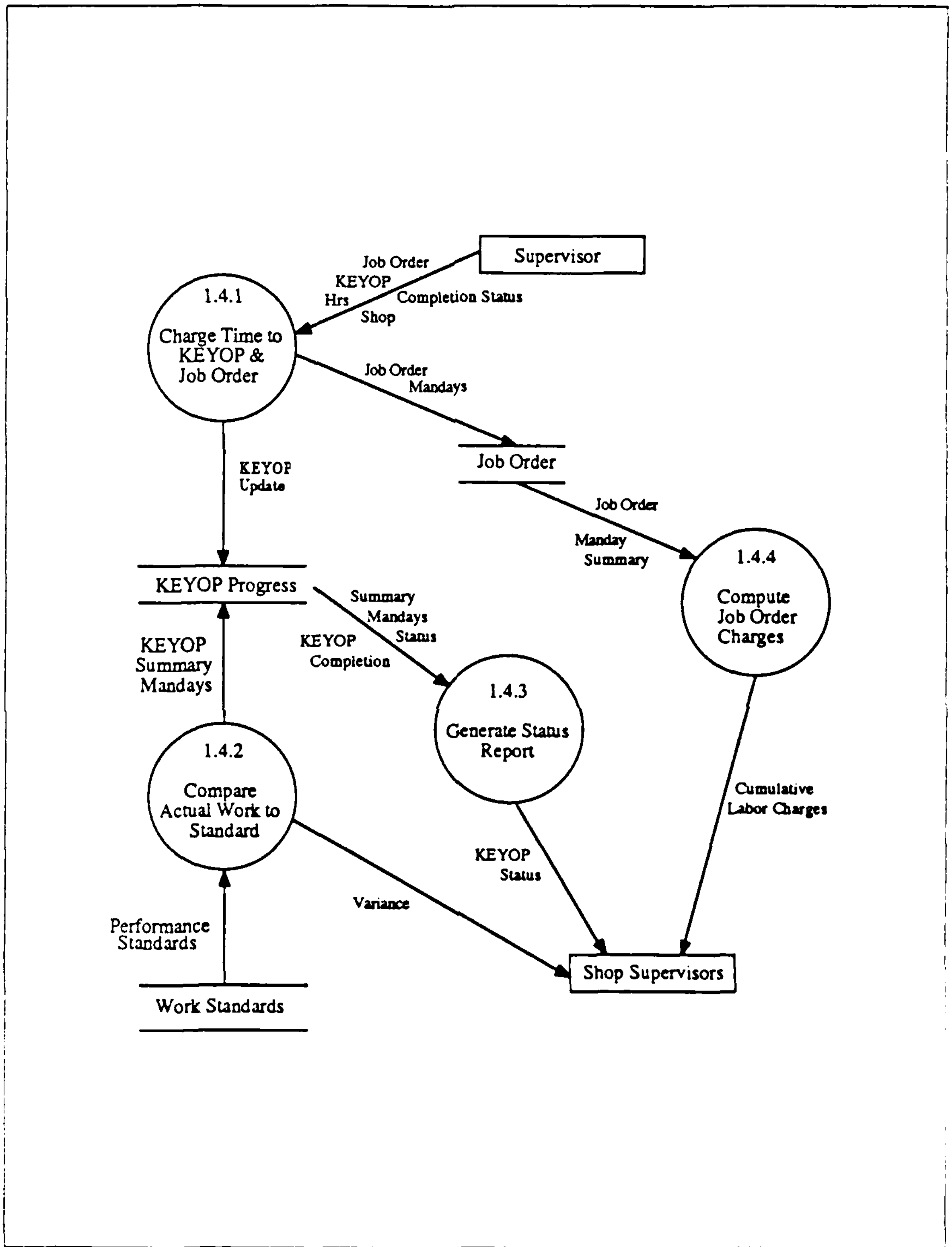

Figure A.2e Level 2 - Performance Measurement

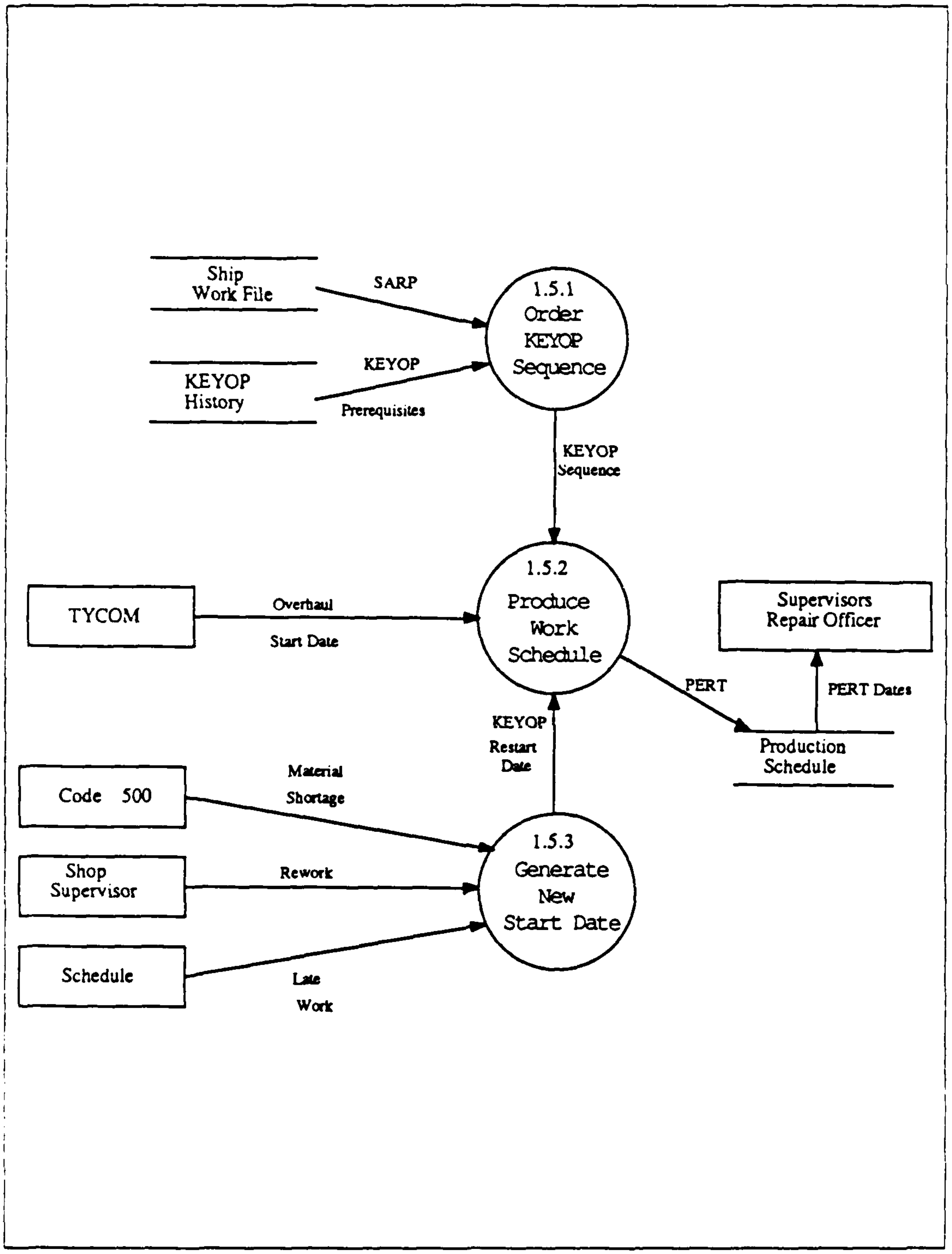

Figure A.2f Level 2 - Production Scheduling

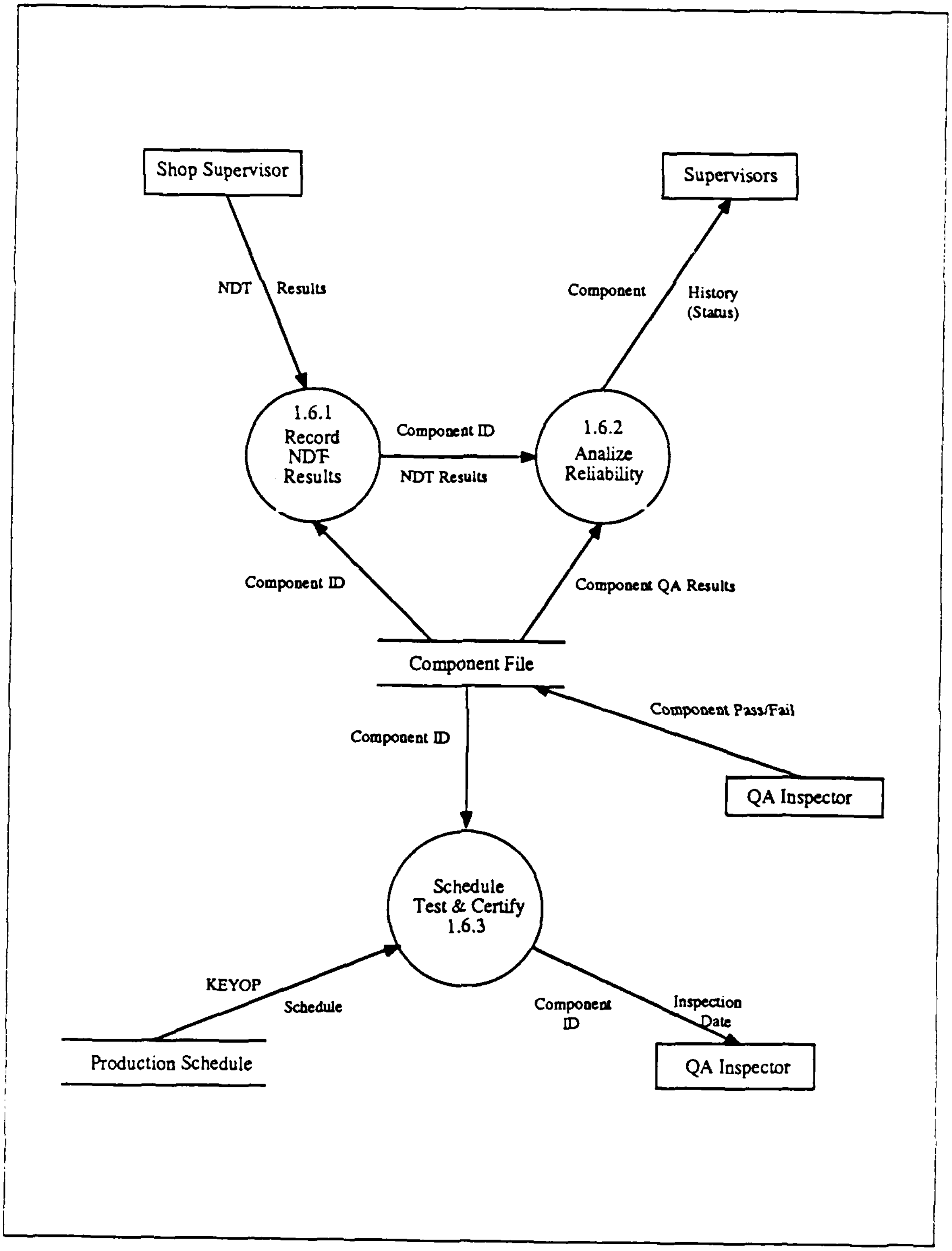

Figure A.2g Level 2 - Calibration Recall

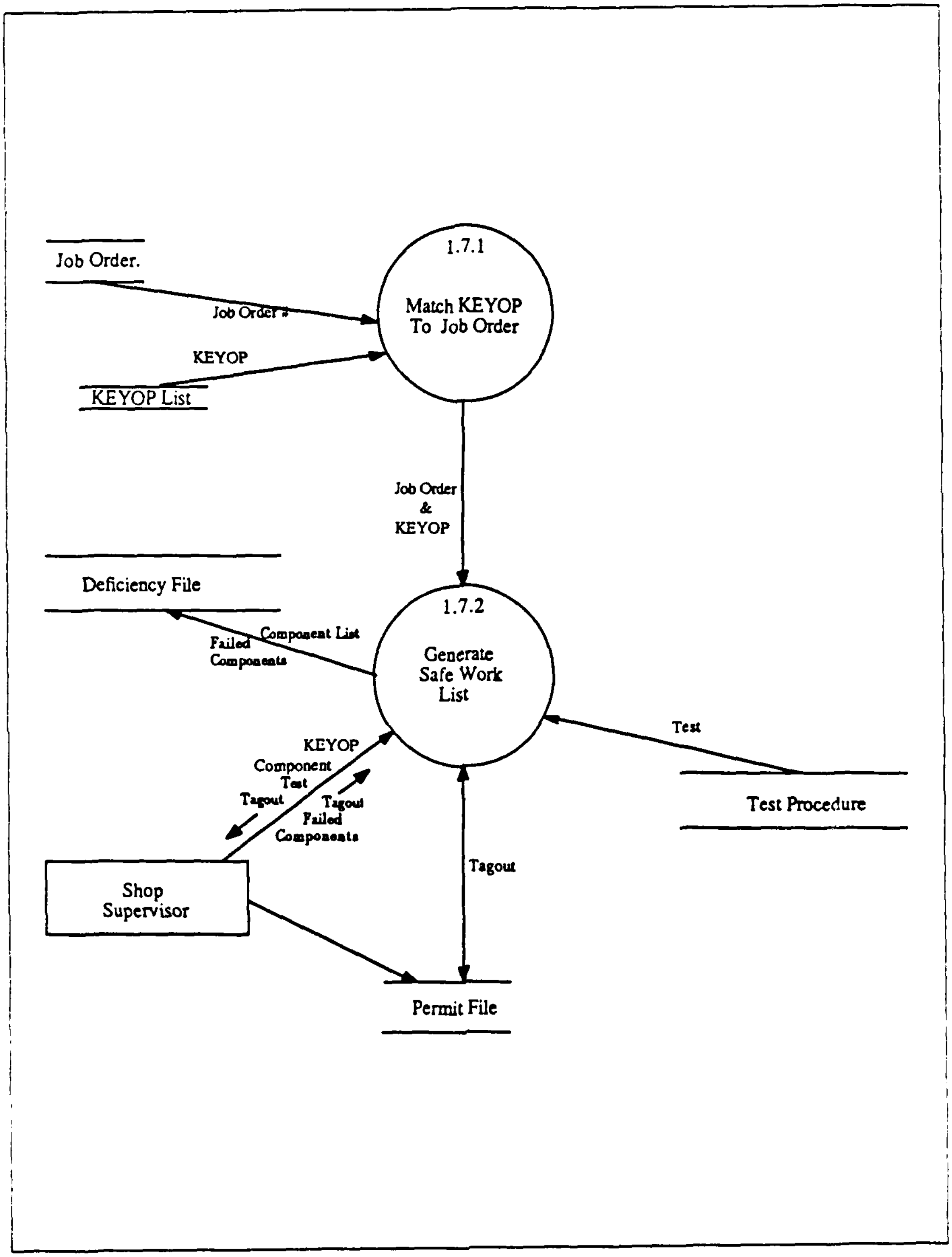

Figure A.2h Level 2 - Ship Work Control System (SWCS)

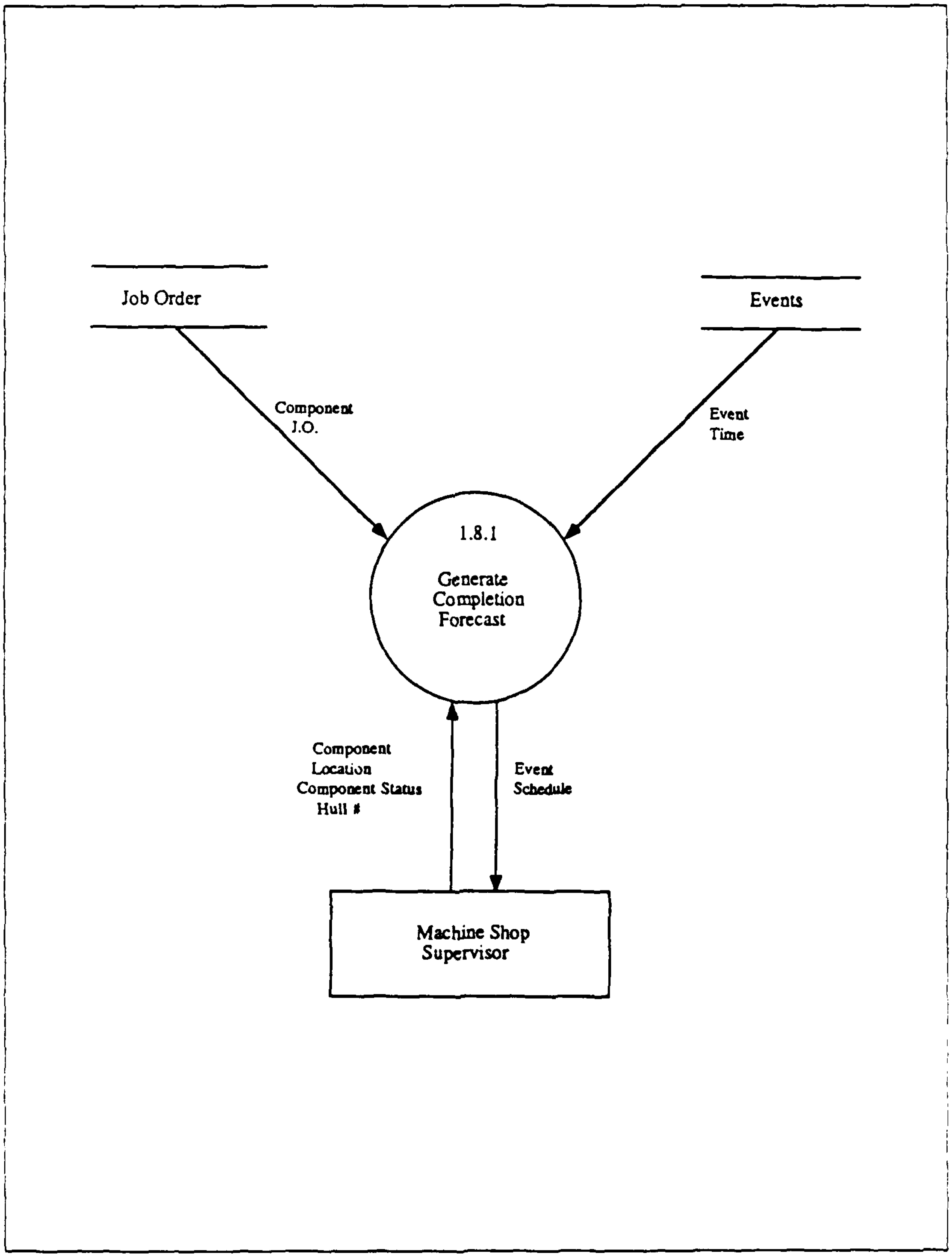

Figure A.2i Level 2 - Machine Shop Tracking System (MSTS)

APPENDIX B
PRELIMINARY DATA DICTIONARY

This Data Dictionary is amplification of the data stores of the level one data flow diagram identified in appendix A. It is divided into two sections: data stores and data elements. A data element is dynamic in that it describes information that is transferred from one process to the next. Files are static and describe data that is at rest waiting to be called by a process.

A. Data Elements

1. Authorized work = KEYOP + job order + mandays + description + approval flag + shop
2. Budget = Overhaul dollars + department + date + charges + credits + balance
3. Completion status = Job order + hull no. + progress + mandays finished flag
4. Component ID = KEYOP + item number + description + job order
5. Component history = Component ID + date installed + hull no. component status
6. Component location = Component ID + shop + storage point + issue date
7. Component test = Component ID + shop + date tested + mandays + specification
8. Component status = Component ID + mandays + completion status
9. Cost = Mandays + labor rate + job order + hull no. + component status
10. Cumulative labor charges = Mandays + KEYOP + shop + job order + report date
11. Design report = KEYOP + drawing no. + hull no. + job order + [manual no.] + [plan] + [test]
12. Employee = ID no. + name
13. Equipment description = ID no. + part no. + [vendor]
14. Event schedule = Component location + work area
15. Hull # = Name + unit no.
16. Inspection date = Inspection name + date scheduled
17. KEYOP = Sub-KEYOPS + estimated mandays + shop + lead shop
18. KEYOP schedule = KEYOP + start date
19. KEYOP status = KEYOP + completion status

20. KEYOP report = KEYOP status
21. Job order # = Hull # + shop + charge number
22. Mandays = Hours worked
23. Material = Component ID
24. NDT results = KEYOP + component test
25. Overhaul items = KEYOP + item description + authorized work
26. PERT = Hull no. + KEYOP + start date + sequence + planned mandays + completion date
27. Reports = RADCON + training + muster + leave + union apprentice list
28. SARP = KEYOP + job order + sub-KEYOP + shop + mandays + component description
29. SARP update = SARP
30. Scheduled progress = Hull # + KEYOP + completion status
31. Start date = Hull # + date + type availability + milestones completion date
32. Tagout = Component ID + set date + safe flag + tag no.
33. Variance = KEYOP + job order + completion status + scheduled progress difference

B. Data Stores

1. Job order = Hull # + shop + charge number + cost
2. KEYOP list = Sub-KEYOPS + estimated mandays + shop + lead shop + KEYOP
3. KEYOP progress = Job order + hull # + progress + mandays + finished flag + KEYOP
4. Ship work file = Hull # + ARP

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