THE EFFECT OF IMPLEMENTING NEW TECHNOLOGY INTO AN EXISTING PRODUCTION PROCESS

by

Warren Kenneth Vaneman

Report submitted to the Faculty of the
Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree of

MASTERS OF SCIENCE

in

Systems Engineering

Dr. K.P. Triantis, Chairman

Dr. H. Robins

Mr. S.J. Debrecht

April, 1997
Falls Church, Virginia

Keywords: System Implementation, Learning Curve, Data Envelopment Analysis, Process Improvement, Systems Engineering

THE EFFECT OF IMPLEMENTING NEW TECHNOLOGY INTO AN EXISTING PRODUCTION PROCESS

by

Warren Kenneth Vaneman

Committee Chairman: Dr. K.P. Triantis
Industrial and Systems Engineering

(ABSTRACT)

Estimating the effect of productivity when implementing new technology into an existing production process can guide a development team during the research and design phase of the system's life-cycle. The study employs two productivity tools: Data Envelopment Analysis (DEA) to evaluate the current system's efficiency; and the time constant learning curve to project productivity of the new system.

Productivity measurement and evaluation of the current system is paramount to increasing efficiency over long periods. DEA was used for this evaluation because of its ability to handle units with multiple inputs and outputs and make comparisons of their relative efficiencies. Correcting inefficient practices before the system implementation phase begins will potentially allow greater initial productivity from the new technology.

Future productivity can be projected using the time constant learning curve. This model allows for the estimation of productivity based on initial and steady state processing times, and the expected quanitly of inputs and outputs. Based on this data, the system development team can make necessary changes to the system's design to allow for greater productivity. These changes can be made early in the system's life-cycle to

prevent extensive rework after implementation. The method also allows for the production element to anticipate and plan for changes in its operational practices.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1
PROJECT BACKGROUND & OBJECTIVES

1.1 Current and Planned Navigation Systems

Since 1869, the Navigation Department has been supplying the world maritime community with safety of navigation information. The primary vehicle for supplying this information is the weekly Notice to Mariners (NTM) publication. The information in this publication has grown in importance, becoming the Government Printing Office's number two priority for printing, following only the Congressional Record. Over the years, the production of this critical document has been improved upon through automation. The current production flow employs a wide variety of independent computers. A recent effort has been undertaken to combine all existent computer systems into one system.

This new system will be required to perform all of the current systems' functions and assume some new capabilities. The NTM Editor[1] will no longer have to assemble the NTM information using multiple incompatible systems, but will be able to work solely within the Navigation Safety System (NSS).

With this new technology comes a certain risk: the risk that productivity will suffer if the new system is not planned and designed properly. If this occurs, critical marine safety information will not be disseminated to the world maritime community in a timely fashion. If the NSS does not work as planned, it could be an invitation for disaster.

[1] See Chapter 3

The purpose of this chapter is to describe the Navigation Department's current computer systems, provide insight into the planned NSS, present the research objectives, and describe how this relates to the subject of systems engineering.

1.1.1 Heritage System

The Navigation Department currently relies on the Heritage System for all production. The term Heritage System was adopted to include all of the current navigation systems. Since the present-day production process has evolved over the course of the last 15 years, the Heritage System is a hodgepodge of several stand alone systems. These systems include the Consolidated Navigation System (CNS), the Navigation Information Network (NAVINFONET), and several independent Macintosh and IBM-compatible personal computers.

The CNS and the NAVINFONET are PRIME mini-computers connected via a network. Together these two systems form the Automatic NTM System (ANMS), which is the backbone of the Marine Navigation Department's computer systems.

The production workhorse for the department is the CNS. Many of the department's analysts use this system to process navigational sources for updates to hydrographic charts, and navigational lights and radio aid updates. The main product supported by these efforts is the weekly NTM publication. As the analyst compiles the updates for the NTM, the system's databases are being updated. Data is then extracted from the databases to produce the five volumes of the Summary of Corrections, seven List of Lights Publications, and portions of the Radio Navigational Aids Publication (PUB 117). Since all of the processing is done for the NTM, with the other publications bonusing from these efforts, the NTM production will be the topic of this research.

Once a week all of the updates for the NTM are assembled and placed in printed form. As this is occurring, CNS is updating the master files on NAVINFONET. This system serves as an on-line bulletin board service (BBS) that supplies the world maritime community with safety of navigation information (i.e. hydrographic chart and List of Lights updates, and the status of various radio navigation systems, to name a few). Although NAVINFONET does not have a role in the production process, it is closely tied to CNS, and the discussion of the Heritage System would not be complete without it.

Miscellaneous information for the publication of the NTM is compiled on an assortment of Macintosh and personal computers. This information includes the publication cover, miscellaneous marine information, and boilerplate materials.

While the current production method manages to produce media from which a NTM is printed every week, the assortment of computer systems does not allow for a smooth transition of information throughout the production flow.

1.1.2 Navigation Safety System

The Navigation Safety System (NSS), which is in the detail design phase of its life-cycle, is being designed to replace the aging Heritage System. It will consolidate existing functionality onto one platform and support the emergence of digital nautical products. The NSS will be a UNIX-based geographic information system (GIS). In addition to serving as a production platform, the NSS will house an Internet web site as well as the NAVINFONET BBS.

The most significant change in the production environment will be transitioning from the current text-based system to a feature-based system. The main difference is that instead of preparing a textual update for a hardcopy product, as is done today, updates will be made to features within a database. These feature updates will in turn cause the generation of hardcopy products.

In addition to supporting hardcopy products, the NSS will be required to populate, maintain, and store the Navigation Feature Layer (NFL) of the Master Seafloor Digital Database (MSDDB). The MSDDB is a multi-level model that will represent the world's waterways from the seafloor to the surface, including navigational features along the shoreline. The Hydrographic Source Assessment System (HYSAS) is being developed to store the vast majority of this data. However, the NSS will be responsible for the NFL and will maintain a link to HYSAS.

The NFL will consist of the world's navigational features including but not limited to: lighted navigational aids; radio navigational aids; charted wrecks; and dangerous depth soundings. The NFL will also contain world-wide shoreline data.

1.2 Project Approach & Objectives

The objectives of this research project are to determine the productivity of the current Marine Navigation Department Production System, and to project and provide a critical evaluation of the productivity of the NSS. Although the Marine Navigation Department compiles and supports a wide variety of marine navigation products, this research will focus only on the production of features contained in the weekly NTM. The NTM publication was selected because of its importance to the safety of life at sea for the worldwide maritime community.

A fundamental rule in navigation is, "before you can predict where you are going, you must know where you are." This rule can also be applied to predicting the productivity of a new system. Therefore, the first step in this project was to establish a baseline of general knowledge of the Heritage System and determine its productivity.

The Heritage System is an interesting case study in productivity since it has been in operation for about two decades, and can be assumed to be operating in steady state. However, just because a system is operating in steady state, does not mean that enhancements to the production process cannot improve productivity. Therefore, a subset of determining the productivity of the Heritage System will be to identify areas where productivity can be improved.

The productivity of the Heritage System will be determined by a comprehensive study of the production process and the associated inputs and outputs. The weekly data from calendar year 1996 has been chosen as the test set for this study.

After the productivity of the Heritage System has been determined, the next step is to relate the productivity to that of the NSS. This task will prove to be challenging since new, unproved technology is involved. Additional inputs and outputs, along with a change in the production process, will create additional hurdles to overcome.

The implementation of the NSS, and the phasing out of the Heritage System, will take place during two distinct steps. The first step will be the six-month period of parallel operations. During this period production will be performed jointly on the Heritage and Navigation Safety Systems. It is expected that productivity will show a sharp decrease while parallel operations are being conducted because each source will have to be processed twice. Since a certain amount of learning will be taking place on the NSS, it is hypothesized that less than half of the incoming sources will be processed during a notice cycle. Predicting the productivity of the systems during this period will pose a significant challenge.

The second step in the implementation of the NSS will be stand-alone operations. Stand-alone operations will occur after the six months of parallel operations. It is during this period that the NSS must prove itself as a production workhorse. Since production data will not be available for this system until after it arrives, the data will be estimated. The productivity of the NSS will be established using the estimated data inputs processed through a time-constant learning curve model. Based on these predictions, changes to the production process, and possibly changes to the system design, can be suggested to improve productivity.

Once completed, the results derived from the learning curve model can serve as a baseline to evaluate the actual progress of this critical system.

1.3 The Project & Report and How it Relates to Systems Engineering

This project was selected because of the importance of reducing the length of time it takes for the introduction of new technology to prove itself productive. As new systems are implemented into a production flow, modifications to the system, the process, or both are often required. The NSS will probably not be an exception to this rule. This research has the potential to forecast potential production problems while the system is in the development stages.

Being able to impact the system in the design phase is only one of the areas where this research has the potential of affecting the system's life-cycle (Figure 1-1). The implementation phase in the system's life-cycle is another. Agencies or corporations frequently run into problems in effectively integrating new technology into a production environment. Poor planning with respect to training, facilities, or understanding the capabilities and weaknesses of new technology are often the cause. While this research will not consider the facilities problems that can occur, the system efficiency results will touch upon training and understanding the system's capabilities and weaknesses.

Another portion of the system's life-cycle that will be examined is the system utilization and life-cycle support phase. With the critical mission of the system, the faster the production process can achieve steady state, the better the world maritime community will be served. Given the fact that navigational sources will be received at a constant rate, the ramifications of an extended period before steady state operations can be achieved could be devastating. Early planning is necessary to reduce this time. This research should facilitate that planning process.

The retirement phase of the system life-cycle will also be discussed. Following implementation of the NSS, the Heritage System will start a six-month retirement process. Parallel operations will certainly reduce productivity during those six months. However, if changes are made to the current production process and potential changes to the future system and production processes are addressed during the design phase, parallel operations may be completed in less than six months, thereby speeding the retirement of the Heritage System.

Addressing potential production bottlenecks up front can lead to a more efficient and cost effective system. This can only be done if the system is designed for quality (i.e. being able to perform the tasks for which it is designed) and productivity. The purpose of this research is to test the NSS against this criterion.

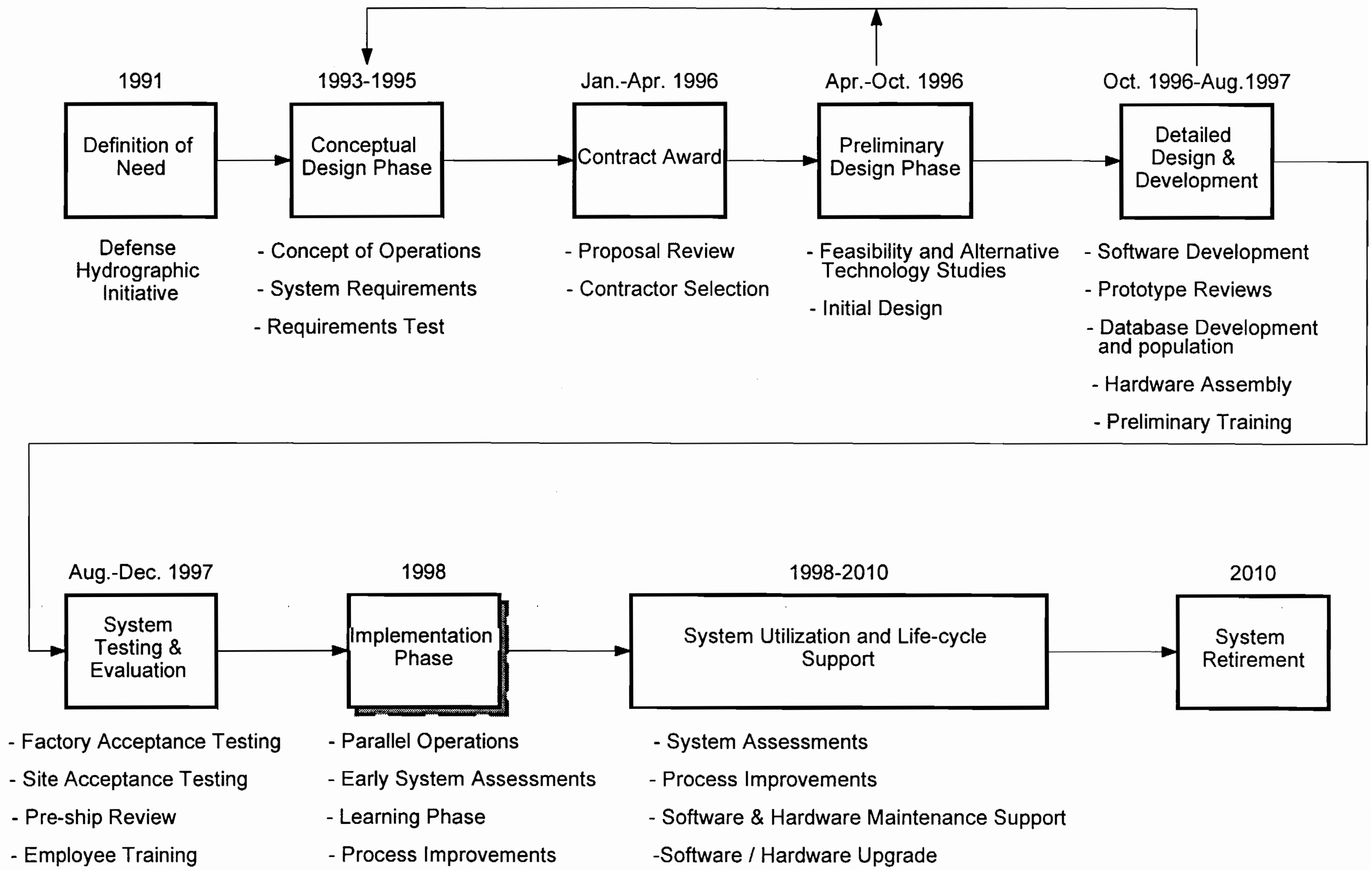

Figure 1-1. NSS Life-cycle

CHAPTER 2
NTM PRODUCTION SYSTEMS PROCESSING

As the Marine Navigation Department makes the transition from producing the NTM on the Heritage System to using the NSS, the production process will change drastically. New tasks will be fulfilled using innovative technology. The objective of this chapter is to provide an overview of the current and future production processes, and discuss the differences between them.

2.1 Heritage System Production Process

2.1.1 Heritage System Production Process Overview

The production process that employs the Heritage System has been in effect for 22 years. The first step to automate the NTM process was taken in 1975 when the Marine Navigation Department procured its first computer system. During those early years, small changes were made to transition to the automated methods. The NTM Writers, Checkers, Senior Reviewers, and Editors had to adapt to new formatting procedures to facilitate easy data entry for the input clerks.

In 1991, the input clerks were phased out as workstations were given to each individual involved with the NTM process. Again, minor changes were made to introduce the new system, but the production flow remained basically the same.

A high level overview of the Navigation Production Process today is illustrated in Figure 2-1. The Marine Navigation Department receives navigational source material from more than 50 countries, the U.S. Coast Guard, the National Ocean Service (NOS), the U.S. Army Corps of Engineers, the International Maritime Organization (IMO), and reports from mariners to name a few. This information is received by the source manager, who determines which NTM Production Area is best suited to analyze it. He then forwards it to the appropriate area.

Sources involving information that could be critical to the actual practice of navigation, are forwarded to the appropriate NTM Writer. This analyst is responsible for evaluating the source and determining if action is required to maintain the currency of relevant nautical charts or the List of Lights. Once the Writer completes this task, the source and data describing any action that was taken are forwarded to the NTM Checker.

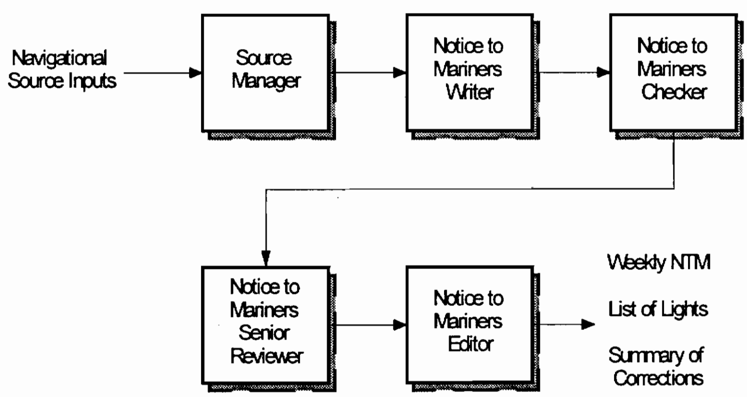

Figure 2-1. The Heritage System Production Process

The NTM Checker is responsible for reviewing the Writer's evaluation of the source and serves as a quality check for the accuracy of data that describes any action taken. In essence, the Checker mirrors the Writer's actions. Upon completion of the review, the Checker forwards any updates to the products to the Senior Reviewer.

The NTM Senior Reviewer ensures that the product update is in the proper format and that the information is relevant to the maritime community and Marine Navigation Department Policy. When satisfied that the information requires publication, the Senior Reviewer forwards the information to the NTM Editor.

The NTM Editor receives a variety of information to be incorporated in the NTM Publication. The Editor is responsible for giving each input a cursory check for format and than assembling the information into publication form. Once completed, the information is sent to a printing contractor, via 9-track tape, and distributed to the maritime community.

2.1.2 NTM Source Manager Production Process

The NTM Source Manager (Figure 2-2) receives navigation source materials from many contributors, both domestic and foreign, via the mail. Once the information is received, the Source Manager has the primary responsibility of recording receipt of that information in the Navigation Source Log.

Once the source material is recorded, the Source Manager reviews the material to determine which production area should receive the source for evaluation. If the information includes updates from North or South America, it is forwarded to Area 1. If the information has navigational updates for anywhere else in the world, it is forwarded to Area 2.

2.1.3 NTM Writer Production Process

Figure 2-3 depicts the NTM Writer production process. The NTM Writer production flow is the most important process in the navigation production system, because this position sets the tempo for determining how many features per cycle are produced.

The NTM Writer receives the navigational source material from the Source Manager. Since the vast majority of the sources that the Writer must evaluate are from foreign countries, the first decision that the Writer must make is whether a source needs to be translated. If it does, the Writer annotates those portions of the source that are relevant to U.S. charts, and then sends the information to a Government-contracted translator. The translation process usually entails a three-week turnaround time. Since translations are sent to and received from the translator on a weekly basis, a steady flow of sources is available for evaluation during any period.

Once translated sources are received by the Writer, a quality check must be made. This inspection usually involves ensuring that geographic coordinates were correctly transferred between the original source and the translation, and that navigational technical terms were translated correctly.

Once the source is legible in English, the NTM Writer evaluates each portion of the source (known as features) to determine if the information affects any U.S. chart or navigational aid in the List of Lights. This task is accomplished by determining the affected products, reviewing the best charted scale coverage of the area, and querying the List of Lights database resident on the CNS. If no adequate scale coverage exists on the charts, and if no action is required on the List of Lights, the NTM Writer marks the source accordingly and moves on to the next feature update.

If action on the source material is required, the NTM Writer must generate an Electronic Correction Card (ECC) to describe the update. The ECC is an electronic template, resident on CNS, and is used by the Writer to identify the chart number, describe the update, and display the geographic coordinates of that update. The ECC is generated by manually typing the information. Some automated aids exist to avoid excessive re-typing of text for multiple ECCs.

As the ECC is being generated, the NTM Writer is also updating the hardcopy nautical chart, which is performed by annotating the change on the chart by hand. When the chart and the ECC are completed, the ECC is saved in the CNS and forwarded electronically to the NTM Checker. The navigational source material and relevant chart(s) are hand-carried to the Checker's workstation.

It is important to note that updates to the List of Lights are handled in a similar manner to the chart updates. For each List of Lights correction, an ECC is generated and the hardcopy List of Lights is updated by hand. Again, the source, ECC, and hardcopy List of Lights are forwarded to the NTM Checker for review.

2.1.4 NTM Checker Production Process

The NTM Checker serves as a quality check for the work that the NTM Writer performs. To adequately accomplish this review function, the Checker basically mirrors the Writer's task. Figure 2-4 illustrates the Checker's production flow.

The first thing that the Checker must do is review the sources. If the source was translated, the Checker ensures that the translations were done properly (i.e. transferring of geographic coordinates and translation of navigational technical terms). The untranslated source must also be reviewed to make sure that the Writer did not miss a portion of the source that should have been translated.

The Checker then evaluates each feature in the source and decides if it is in agreement with the action(s) that the Writer took. Simultaneously, the ECCs are then electronically retrieved from the work file on the CNS. The ECCs are checked for content, format, and correctness of the geographic coordinates.

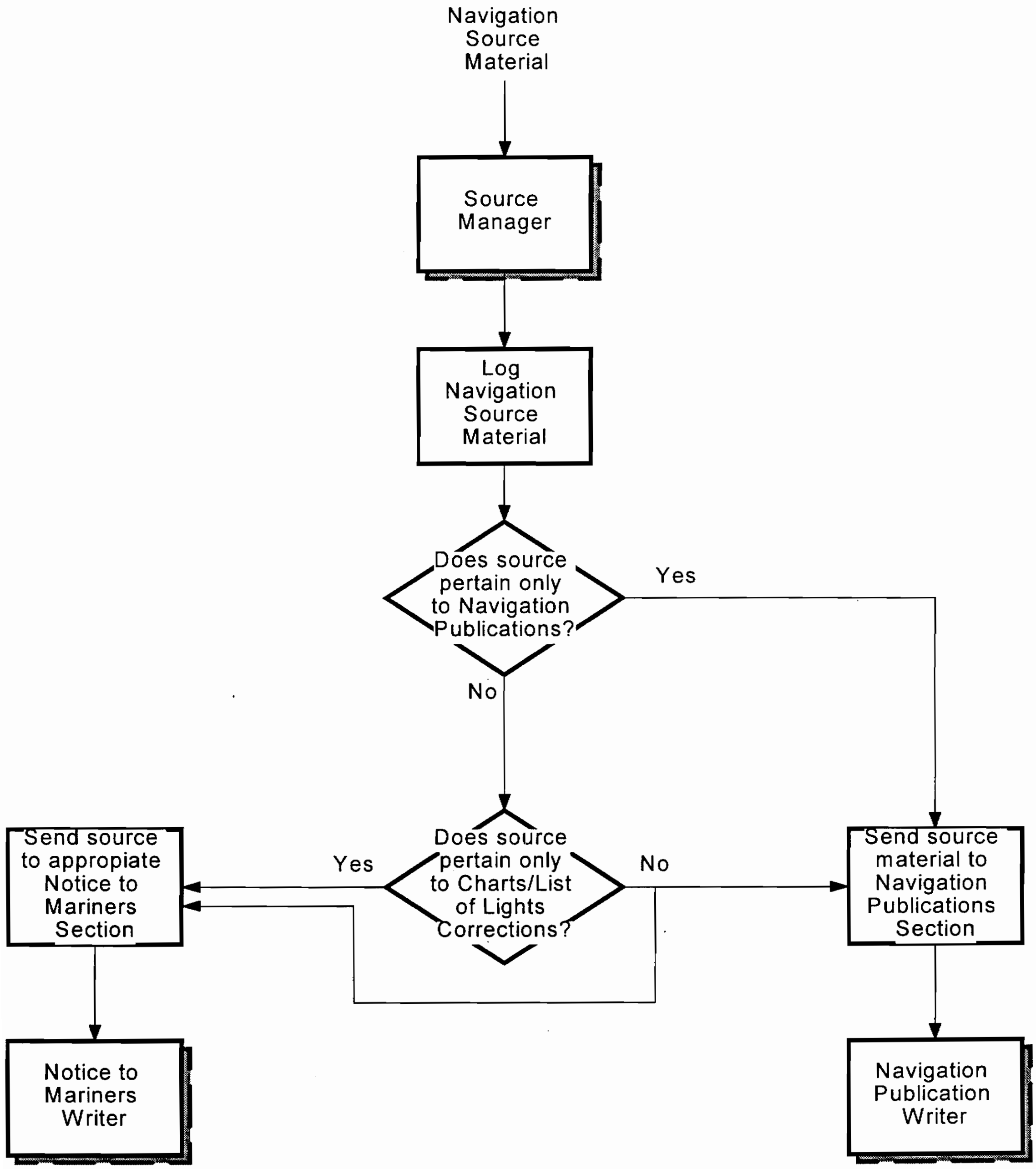

Figure 2-2. Source Manager Production Process

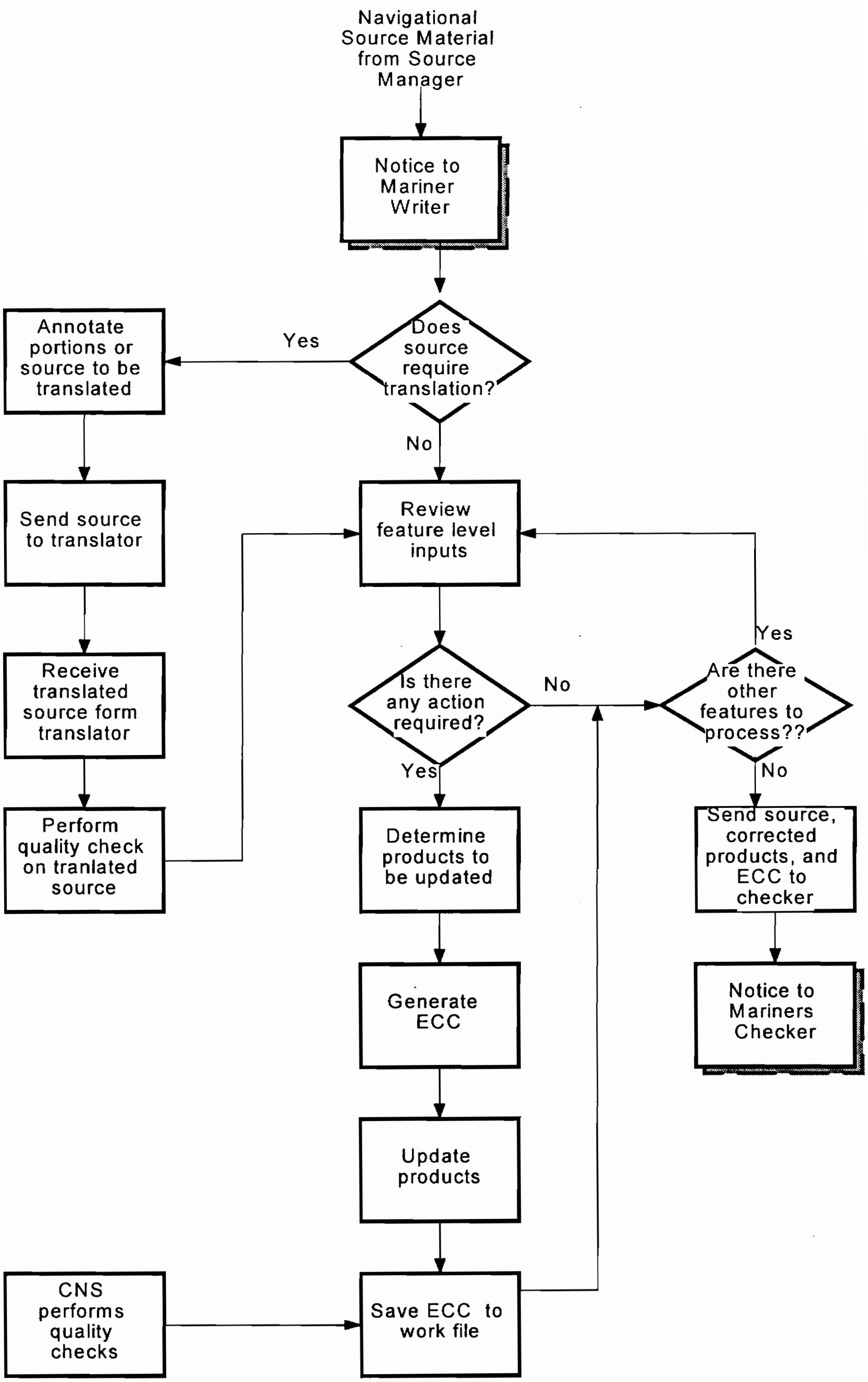

Figure 2-3. NTM Writer Production Process

As the ECCs are being checked, the chart or the List of Lights is also being checked. If the update on the chart, or in the List of Lights, corresponds with the information that is contained in the ECC, and if the information in the ECC agrees with the information in the navigational source material, the ECC is saved electronically and is sent to the NTM Senior Reviewer. The source, chart and List of Lights are filed.

If the source, ECC, and chart (or List of Lights) are not in agreement, the Checker must determine what action is required to make the three agree. If the action required is minor, the Checker may make the necessary correction and forward the ECC to the NTM Senior Reviewer. If extensive rework is required, the Checker returns the source, ECC, and chart (or List of Lights) to the Writer.

2.1.5 NTM Senior Reviewer Production Process

The function of the NTM Senior Reviewer is to check the ECC for format. Figure 2-5 shows the production flow for this position. The first thing that the Senior Reviewer must decide is whether additional research is needed to clarify the logic behind the update. If so, the chart, List of Lights and/or the navigational source are consulted.

The next step in the process is to decide if rework is required. If not, the ECC is forwarded to the NTM Editor. If rework is required, the section reviewer must decide at what level the work will be accomplished. Minor formatting modifications are generally made at this level. Major content changes are generally sent back to the Writer unless the Writer is absent or the Senior Reviewer feels that the Checker has a better understanding of the problem. If the ECC is electronically sent back to the Writer or Checker for rework, the ECC must follow the original production flow to get back to the Senior Reviewer.

When the Senior Reviewer is satisfied that the ECC is correct and properly formatted, the ECC is electronically sent to the NTM Editor.

2.1.6 NTM Editor Production Process

Figure 2-6 outlines the production flow for the NTM Editor. The Editor is responsible for assembling all of the material to be disseminated in the weekly NTM. Inputs are received from the NTM Senior Reviewer, navigation publication Editor, and from outside sources such as NOS and NIMA's distribution affiliate.

The majority of the NTM Editor's work involves reviewing the ECCs for format. The Editor's primary tool for conducting his business is a CNS terminal. As the final authority for all printed updates, the Editor may change the information on the ECC if he deems it necessary. If extensive rework is required, the Editor may choose to send the ECC back to the Senior Reviewer, Checker, or Writer.

The NTM Editor is also responsible for a variety of other updates that do not fall into the area of responsibility the NTM Production Areas. Updates such as those that appear in the hydrographic catalog must be made by the editorial staff. The inputs for these updates stem from NIMA Production Management data and NOS.

The Editorial staff is also responsible for compiling the Marine Miscellaneous Information portion of the NTM. The Marine Miscellaneous Information is information that may be of importance to the mariner including product announcements, general information pertaining to large geographic areas, and policy changes that affect the customer.

The Editor is also responsible for assembling the NTM cover and boilerplate information. Except for publishing dates, this information rarely changes and usually only requires retrieval from the Macintosh computer where it is stored.

When all corrections have been edited, the Editor writes the ECCs from the charts and List of Lights corrections to 9 track tape. As this routine is being executed, the charts, List of Lights, and U.S. Coast Guard databases are being update and posted on the Navigation Information Network Bulletin Board Service. The 9 track tape is sent to another system which produces camera ready proof pages. The Editor reviews these pages and then sends the information to a Government printing contractor for printing and distribution.

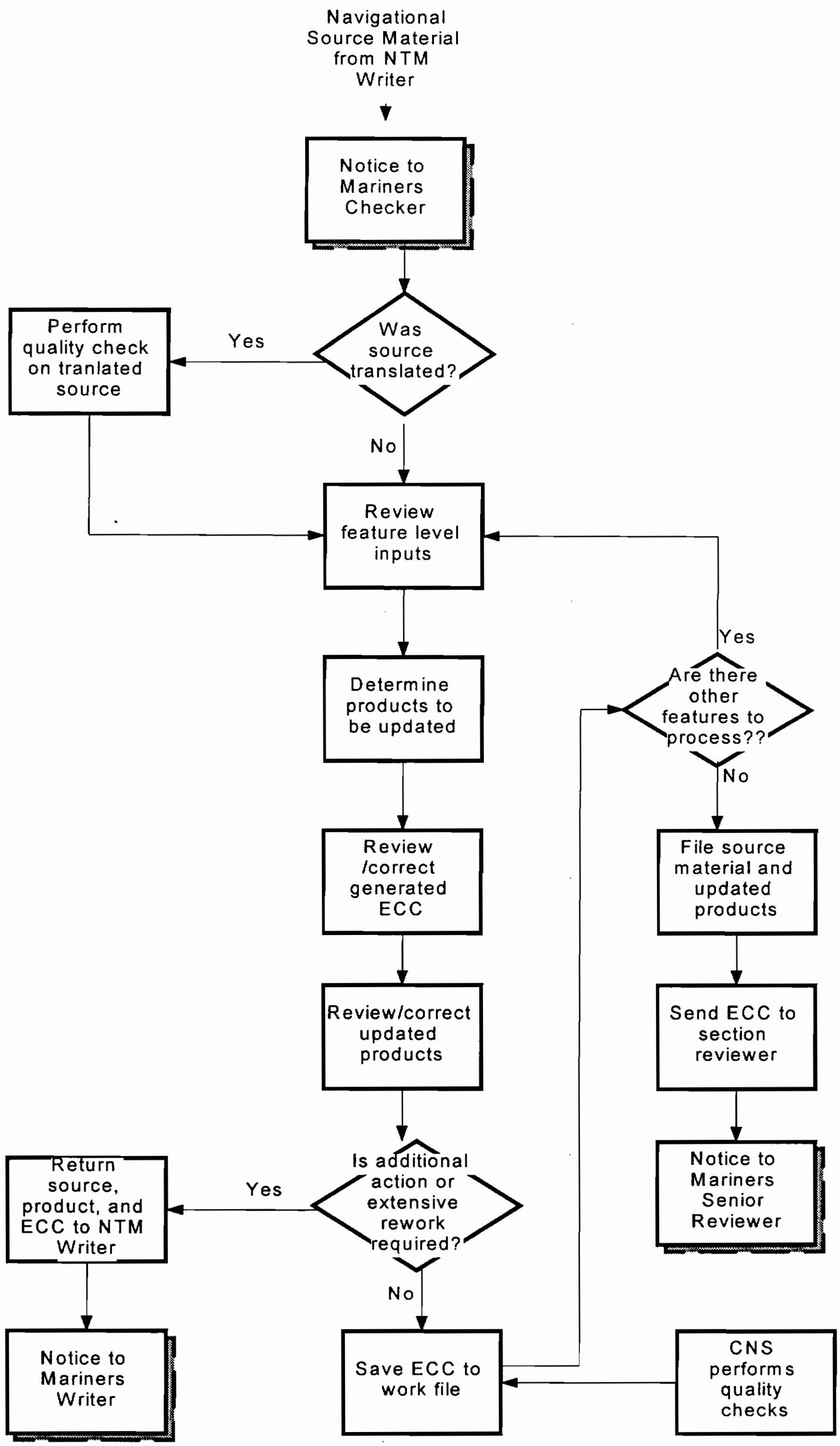

Figure 2-4. NTM Checker Production Process

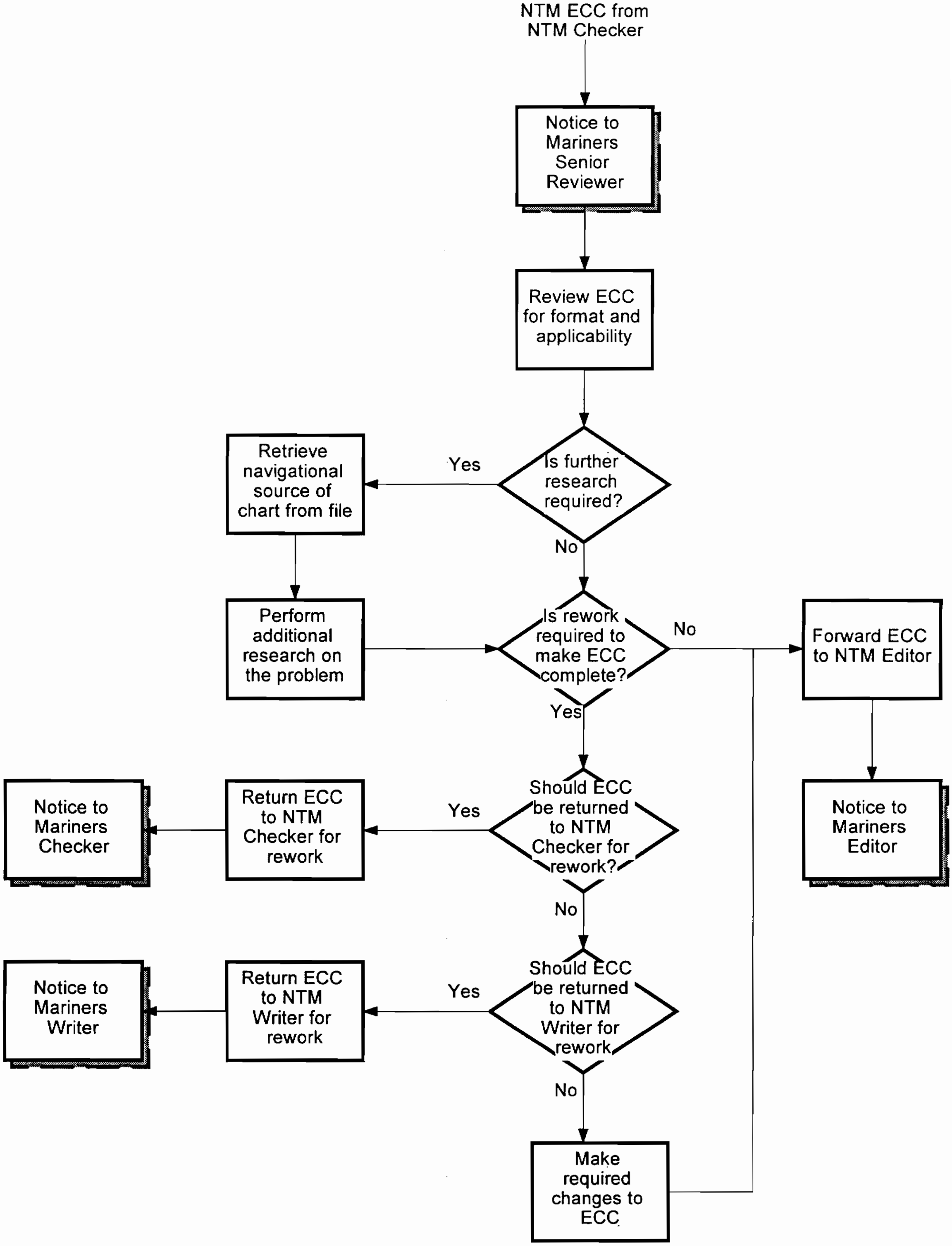

Figure 2-5. NTM Senior Reviewer Production Process

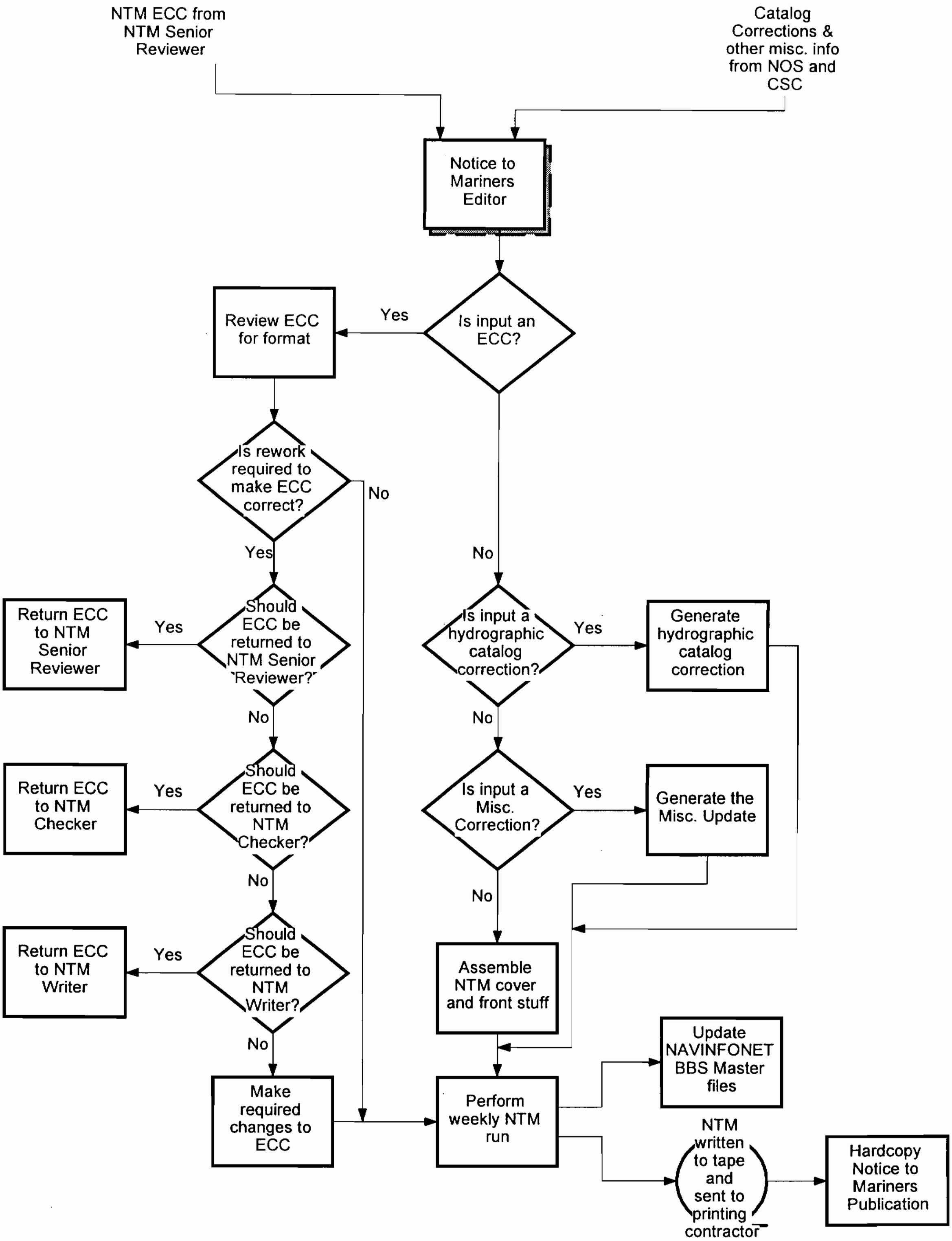

Figure 2-6. NTM Editor Production Process

2.2 NSS Production Flow

2.2.1 NSS Production Process Overview

The NSS production flow will retain many of the processes used in the Heritage System production flow, while performing additional functions. All personnel in the production process will have increased responsibilities, while portions of the work will be automated.

Figure 2-7 portrays the NSS high level production flow. The process is very similar to the production flow previously shown for the Heritage System (Figure 2-1). The additional system responsibilities are not apparent at this level but are described later in this chapter. However, the one change that is noticeable is the link between the Source Manager and the NTM Editor.

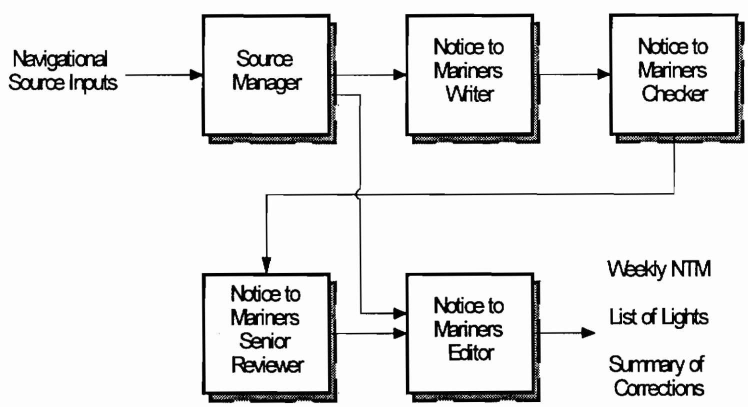

Figure 2-7. The NSS Production Process

The NSS will introduce the responsibility of populating and maintaining the Navigation Features Layer of the Master Seafloor Digital Database. This new requirement will force the Navigation Department Staff to learn and adapt to working in a

Geographic Information System (GIS) environment, which will represent a significant paradigm shift after residing in a text-based environment for over 125 years.

The end result will basically remain the same. The hardcopy NTM will continue to exist, as well as the NAVINFONET BBS. In addition, information will be posted on an Internet web site resident on the system. Instead of the NTM information being written to a 9-track tape for processing into camera ready proof prints (via another external system) to be sent to the printing contractor, the information will be written to magnetic/optical media and provided to the printing contractor, thus eliminating the need to rely on an external system.

2.2.2 NSS Source Manager Production Process

The NSS Source Manager position will undergo a significant change with the implementation of the NSS. This position will require an individual with greater computer skills than required for the Heritage System Source Manager. Figure 2-8 shows the flow diagram for the NSS Source Manager's responsibilities.

The NSS Source Manager will be responsible for tracking all sources that arrive in the Navigation Department from source arrival to filing after processing. The NSS will provide assistance by tracking each source as it progresses through the production flow. This is quite a change to the Heritage System where the Source Manager is only responsible for maintaining a hardcopy log to indicate receipt of a source, and for disseminating the information to the proper sections for action.

Another change for the Source Manager is the handling of magnetic media. Currently all information arrives in the Navigation Department in printed form. Recent developments indicate that many of the foreign countries that supply navigational source materials are going to start doing so in softcopy. This will present a challenge to the Source Manager because it will be his or her responsibility to convert this information into an NSS-internal format.

If the information is received in hardcopy, the current plan is to forward it to the appropriate section for action in the printed form, although a scan capability might be used to render hardcopy source in digital form. Softcopy information will be forwarded electronically.

2.2.3 NSS NTM Writer Production Process

Figures 2-9 (a and b) depict the process flow for the NSS NTM Writer. This position will also require a large transition of knowledge and skills from those required for the Heritage System. Unlike the current text-based system, the Writer will be required to possess the knowledge to edit features in a GIS environment.

Similar to the Heritage System production process, the Writer will receive the navigational source material from the Source Manager. If the source requires translation, the Writer will annotate the appropriate sources and forward the information back to the Source Manager, who will submit it to the translation contractor.

One of the Writer's largest responsibilities relative to NSS will be the maintenance of the NFL. Virtually all of the feature data that is made available to the Navigation Department will require some sort of integration into the NFL, whether it will be used to maintain a hardcopy product or not. With this in mind, the first task that the Writer must accomplish is to update the feature representation in the NFL.

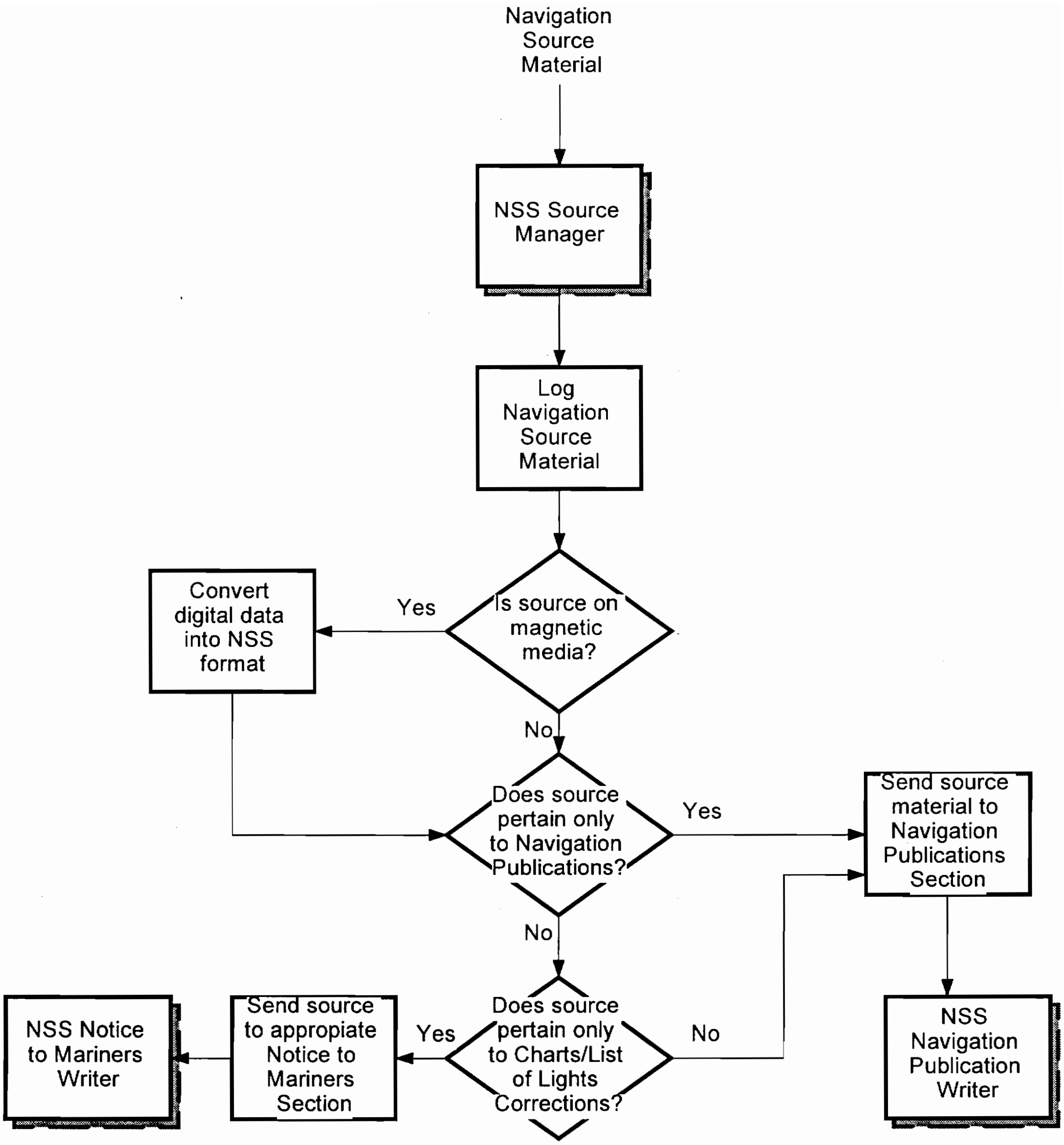

Figure 2-8. NSS Source Manager Production Process

Once the NFL has been updated, the Writer will be concerned with which products need to be updated. Based on the geographic position for the feature found during the NFL update, the NSS will provide the Writer with a list of potential products that may require revision. At this point the Writer must examine the hardcopy products to verify that an update is required. If so, the Writer will select the products that require updating, and the NSS will automatically provide the corrective text. The Writer will then update the hardcopy products by hand as done with the Heritage System.

After all of the features for a source have been completed, the Writer will combine all of the computer generated update text for an individual product into an ECC and save the changes. Like the CNS, the NSS will provide a certain degree of quality checking. Once completed, the Writer will forward the sources, ECCs, and hardcopy products to the NSS NTM Checker for review.

2.2.4 NSS NTM Checker Production Process

The NSS NTM Checker's process flow will be impacted by the NSS, but not to the degree that the Writer's will be. Like the Writer, the Checker will be required to be proficient in a GIS environment. The NSS NTM Checker's process flow is shown in Figure 2-10.

Once the navigational source is received, the Checker will verify the information. For most features an NFL update will occur and will therefore be subjected to a quality check. Modifications to the NFL must be carefully evaluated since the generation of the update text stems directly from this database. If quality problems are found, the source, ECC, and hardcopy product must be returned to the NSS NTM Writer for rework.

If the modifications to the NFL were completed satisfactorily, the Checker will then check the ECCs and hardcopy products. Minor edits can be made to correct formatting problems on the ECC, but content errors will have to be returned to the Writer for rework, since the content of the update must stem directly from the NFL.

Once the review is completed, the source material and hardcopy products are filed, and the ECCs are forwarded to the NSS NTM Senior Reviewer.

2.2.5 NSS NTM Senior Reviewer Production Process

The process flow diagram (Figure 2-11) for the NSS NTM Senior Reviewer does not really show the extent to which the workload for this position will increase. The Senior Reviewer's responsibilities with the Heritage System can be summed up as reviewing ECCs for formatting errors. NSS will force the Senior Reviewer to do this and more.

In addition to reviewing the ECCs for formatting errors, the NSS NTM Senior Reviewer will be required to review the NFL feature updates. As in the Checker stage, any NFL edit problems have the potential of affecting the ECC update text, and should be returned to the Writer for rework.

If the NFL feature updates are satisfactory, the Senior Reviewer inspects the ECCs for formatting errors. Minor formatting errors can be fixed by the reviewer, or can be returned to the Checker for rework. Major changes will have to be returned to the Writer because of their direct relationship to the original NFL feature updates.

Once satisfied with the quality of the NFL and ECC updates, the senior reviewer forwards the ECCs to the NSS NTM Editor. The NFL has received its final inspection for the cycle.

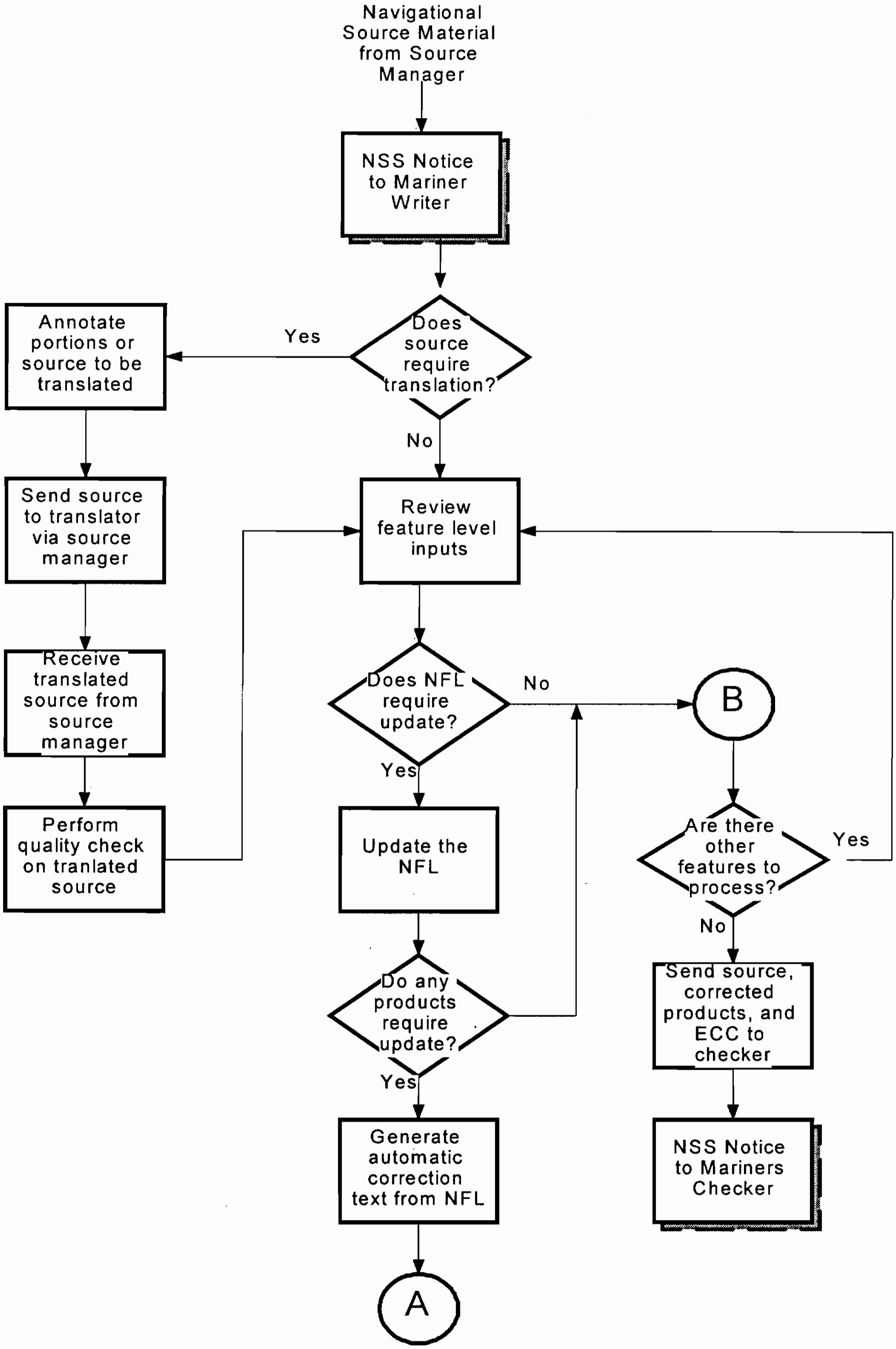

Figure 2-9.a. NSS NTM Writer Production Process

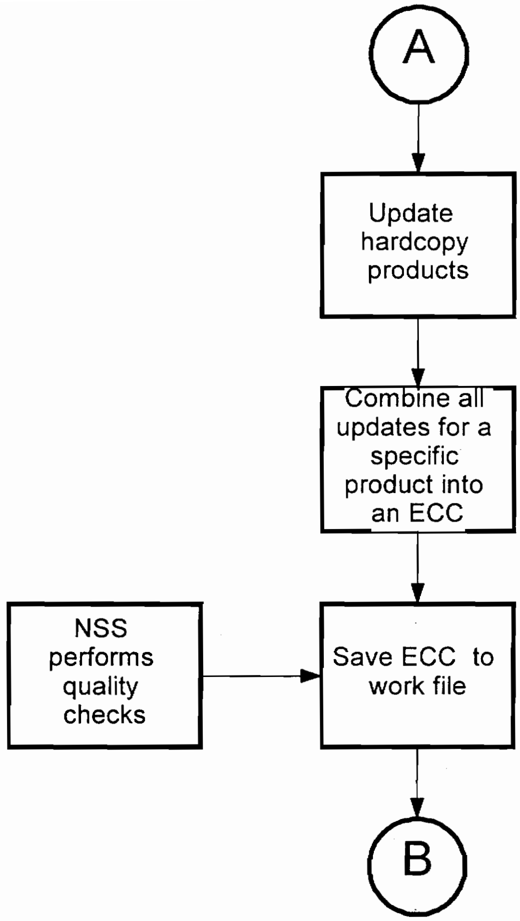

Figure 2-9.b. NSS NTM Writer Production Process (continued)

2.2.6 NSS NTM Editor Production Process

The NSS NTM Editor will be impacted the least in the production flow. Unlike every other position, except the Source Manager, the Editor will not be required to work within the NFL. The NSS NTM Editor's production flow is shown in Figure 2-12.

The Editorial staff not having any involvement with the NFL is very positive from the training aspect. These individuals will not be required to be proficient in the GIS environment, a potentially large savings in "learning time." However, not having access to the NFL will limit the Editor's options for correcting mistakes on the ECC.

Essentially, all incorrect ECCs will have to be sent back to the NTM Writer, Checker, or Senior Reviewer for correction.

The NSS source log will be a big advantage to the Editorial staff. Currently hydrographic catalog corrections and marine miscellaneous information are submitted to the Editor piecemeal, with no automated tracking system. After the startup of NSS, all sources will come to the Editor via either the NTM Senior Reviewer or the NTM Source Manager.

Another advantage that NSS will bring to the Editorial section is having all inputs for the NTM publication on one system. The current method forces the Editorial staff to work with a hodgepodge of systems to extract and assemble the publication.

The weekly production run will be a great enhancement over that of the Heritage System. Instead of sending the chart correction information to another system for processing into camera-ready proof prints, the NSS will be able to write all of the NTM information to media which can be sent directly to the printing contractor. This is potentially a huge time and cost savings.

As with the Heritage System, the NTM Editor will update the NAVINFONET BBS when the weekly production run is initiated. The weekly production run on NSS will also update the Navigation web site.

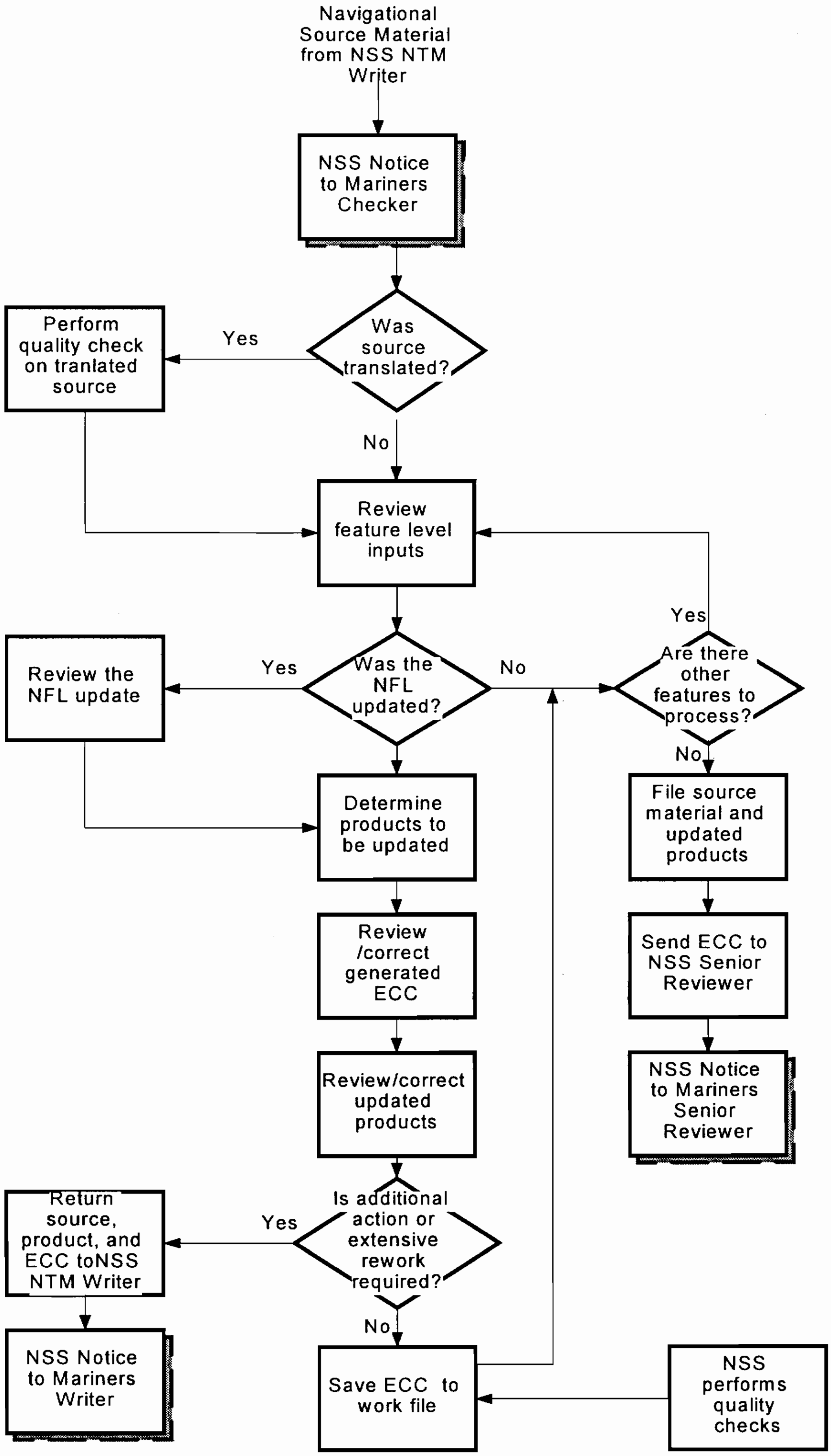

Figure 2-10. NSS NTM Checker Production Process

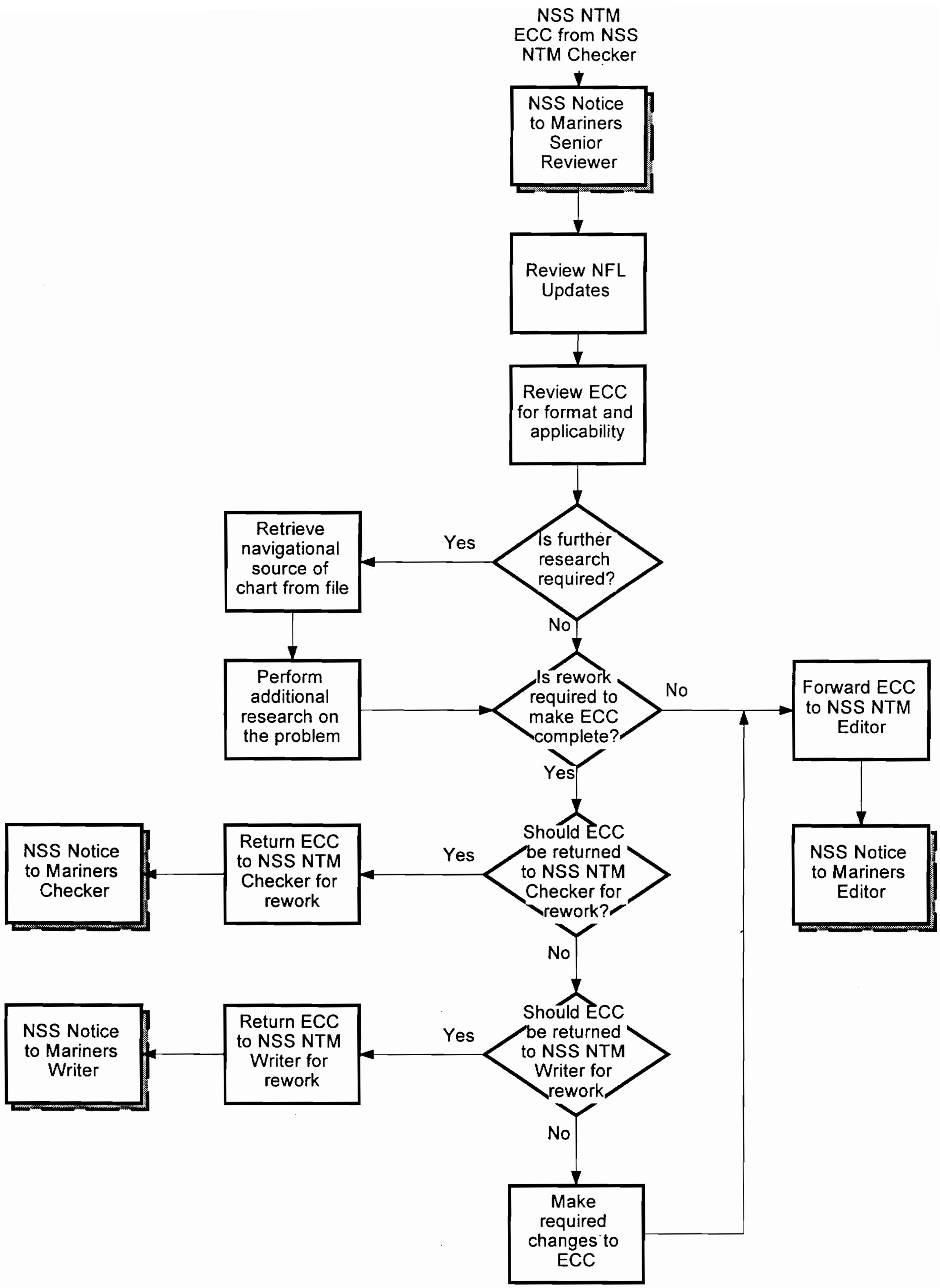

Figure 2-11. NSS NTM Senior Reviewer Production Process

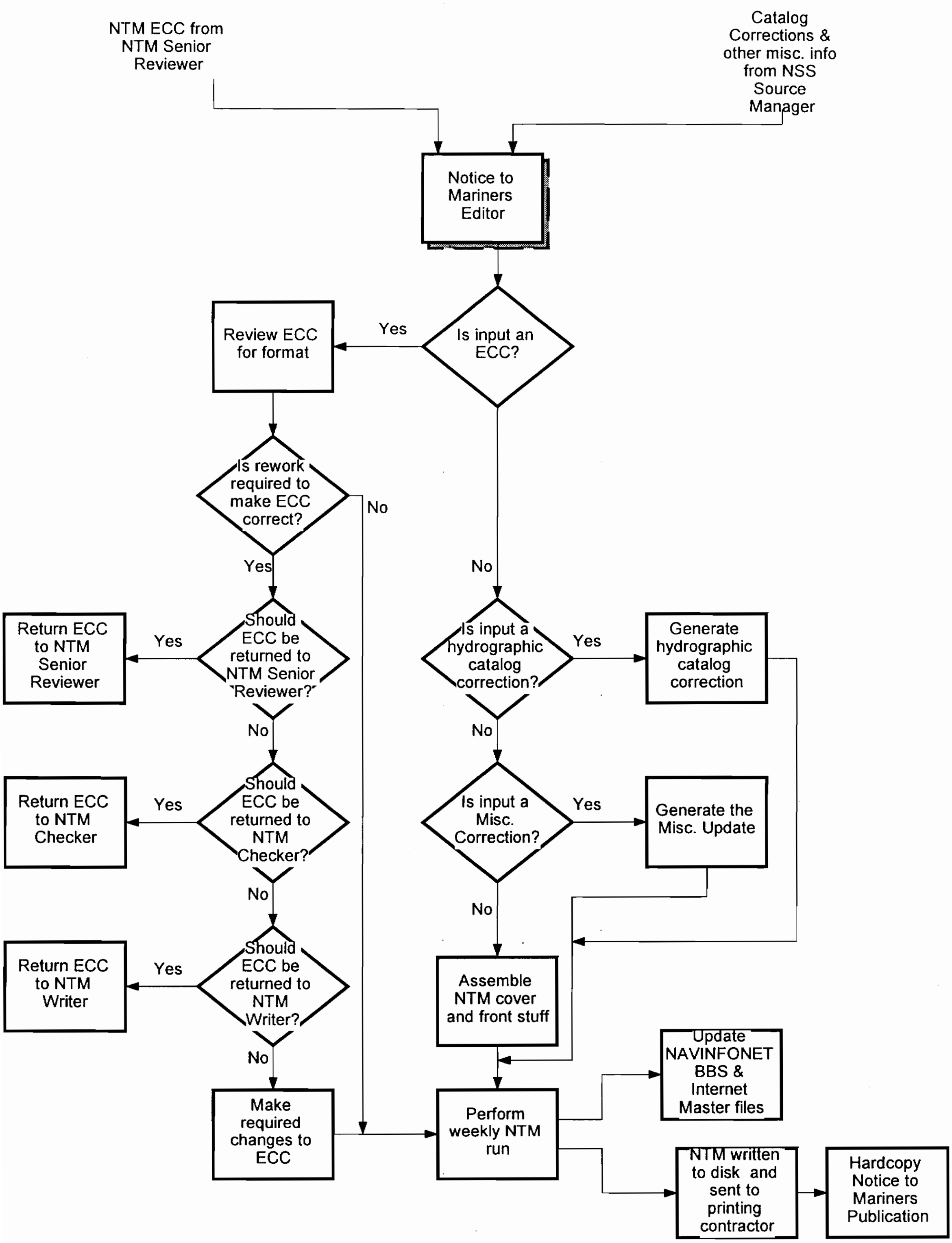

Figure 2-12. NSS NTM Editor Production Process

CHAPTER 3

NAVIGATION PRODUCTION SYSTEMS INPUTS & OUTPUTS

Selecting metrics for inputs and outputs that apply to both the Marine Navigation Department's text based Heritage Systems and the feature based NSS posed the most challenging aspect of this research, because research of this magnitude has never been attempted. An in-depth study of the production process (Chapter 2) identified metrics important to both systems. Inputs and outputs for the Heritage Systems are based on the weekly production Figures for the year 1996. Inputs for the NSS are based on projections made by the Marine Navigation Department from the actual and projected production figures. NSS outputs are computed, and shown in Chapter 5, using the learning curve.

3.1 Source Inputs to the Heritage System and NSS

The source inputs will undergo only minor changes as the Marine Navigation Department transitions from the Heritage Systems to the Navigation Safety System. International agreements govern the exchange of navigational safety information between the world's maritime nations. The sources arrive in a variety of forms and formats (i.e. foreign NTM, foreign hydrographic charts, U.S.C.G., Local NTM, etc.). Deciding on a common denominator to serve as a metric for every source posed quite a challenge. The "feature" was discovered to be that common link.

A feature can be described as a navigationally significant point or locus of points on Earth that is positioned by geographic coordinates and represented by a symbol on a nautical chart, or in a spatial database (i.e. light houses, buoys, charted wrecks, etc.).

An analysis was conducted to estimate the average source inputs on a weekly and yearly basis for the Heritage Systems. The results of analysis have been consolidated and are shown in Table 3-1.

Table 3-1. Average Weekly and Annual Source Inputs to the Heritage System

Source	Source/yr	Source/wk	Feat/source	Feat/yr	Feat/wk
FNTM-Text	1,768	34.00	17.2	30,329	583.25
Foreign Charts	780	15.00	6.7	5,230	100.58
Ship Reports	226	4.35	1	226	4.35
NOS Data	270	1.00	1	270	5.19
USACE	8	0.15	22	176	3.38
IMO Data	12	0.23	20	240	4.62
USCG Local NTM	456	8.77	13.3	6,042	116.19
USCG Light List	52	1.00	74.7	3,884	74.69
Misc. Updates	1,404	27.00	1	1,404	27.00
Totals	4,976	91.50		47,801	919.25

The arrival of the Navigation Safety System will bring source inputs from additional, newly-implemented systems as well as those that are currently received from the international maritime community. The frequency and number of these new inputs have been estimated for the purposes of this research. Table 3-2 shows the average weekly and yearly source inputs for the Navigation Safety System.

3.1.1 Foreign NTM

The largest sources of information for the Marine Navigation Department's production process are the foreign NTMs. The Marine Navigation Department receives over 1,700 foreign NTMs per year from approximately 59 countries. Table 3-3 lists the countries that exchange information with the United States and the average number of sources and features supplied per year.

Table 3-2. Average Weekly and Annual Source Inputs to the NSS

Source	Source/yr	Source/w	Feat/sourc	Feat/yr	Feat/wk
FNTM-Text	1,768	34.00	25	44,200	850.00
Foreign Charts	780	15.00	10	7,800	150.00
Ship Reports	988	19.00	2	1,976	38.00
NOS Data	676	13.00	1	676	13.00
USACE	8	0.15	20	160	3.08
IMO Data	12	0.23	20	240	4.62
USCG Local NT	456	8.77	20	9,120	175.38
USCG Light List	52	1.00	107	5,564	107.00
Canidate Hazard	285	5.48	100	28,500	548.08
Misc. Updates	1,404	27.00	1	1,404	27.00
Significant Featur	780	15.00	7	5,460	105.00
Totals	7,209	138.63		105,100	2,021.15

More than 40 percent of the foreign NTMs must be translated before they can be processed. These translations are performed by a Government contractor, which causes a delay of approximately three weeks before the source can be processed. Therefore, inputs received for processing during a given week will be the number of foreign NTMs arriving in English plus the number of translated foreign NTMs received.

The number of features received per week can be represented by equation 3.1:

$$F_{rwkn} = \sum_{n=1}^{\infty} F_{xxxn} \tag{3.1}$$

where:

F_{xxxn} = Number of features in foreign NTM n for country xxx;

F_{rwkn} = Total number of foreign NTM features received for week n.

n = The foreign NTM number[1]

[1] The periodicity of the Foreign NTMs is determined by each nation, and is not necessarily weekly.

The actual number of foreign NTM features that serve as inputs can be greater than those received because there may be a backlog from the prior week. Equation 3.2 better describes the foreign NTM inputs for a given week:

$$F_{wkn} = \left[\ F_{rwkn} + \left(F_{wn(n-1)} - F_{pwk(n-1)}\right)\ \right] \tag{3.2}$$

where:

F_{wkn} = Total number of foreign NTM features that are inputs for week n;

$F_{wk(n-1)}$ = Total number of foreign NTM features that are inputs for week n-1;

$F_{pwk(n-1)}$ = Total number of foreign NTM features processed for week n-1.

3.1.2 U.S.C.G. Local NTM

The second largest source of information to the Marine Navigation Department's production process is U.S.C.G. Local NTM. The Marine Navigation Department receives approximately 456 local NTMs, containing approximately 9,120 features, per year.

Similar to the foreign NTM, the U.S.C.G. Local NTM weekly inputs can be calculated using equations 3.3 and 3.4:

$$L_{rwkn} = \sum_{n-1}^{52} L_{xxn} \tag{3.3}$$

where:

L_{xxn} = Number of features in local NTM for week n, for district xx;

L_{rwkn} = Total number of local NTM features received for week n.

$$L_{wkn} = \left[\ L_{rwkn} + \left(L_{rwk(n-1)} - L_{pwk(n-1)}\right)\ \right] \tag{3.4}$$

where:

L_{wkn} = Total number of local NTM features for week n;

$L_{wn(n-1)}$ = Total number of local NTM features for week n-1;

$L_{pwk(n-1)}$ = Total number of local NTM processed during week n-1.

3.1.3 Foreign Charts

Foreign nautical charts provide another large source of information for the Marine Navigation Department. New editions of foreign nautical charts are distributed from the world's hydrographic offices. The information on these nautical charts is relevant to the Marine Navigation Department because they include results of new hydrographic surveys. Changes in ports, shorelines, and navigational aids can be extracted to update U.S. hydrographic products. The Marine Navigation Department receives approximately 780 foreign nautical charts annually, from which data pertaining to an average of 15 features per chart is extracted.

3.1.4 Ship Reports

Ship reports are another important source of information. These reports, from ship's masters and navigators, describe differences between the information portrayed on the nautical charts and what is actually observed. These sources are important because they often report navigational changes from countries who do not have a reliable marine safety program.

Approximately 1,000 ship reports are received per year. The mean number of features extracted from this source is two: therefore, the ship reports provide about 2,000 inputs per year.

3.1.5 National Ocean Service (NOS) Data

The National Ocean Service (NOS) provides the Marine Navigation Department with updates for the charts that they produce (i.e. nautical charts in U.S. waters). These updates, in conjunction with the updates derived from the U.S.C.G Local NTM and the U.S. Army Corps of Engineers (USACE), allow the NTM Writers to keep the nautical charts covering U.S. waters up-to-date. NOS provides approximately 680 features per year as inputs to the NTM process.

3.1.6 U.S. Army Corps of Engineers Data

The U.S. Army Corps of Engineers provides the Marine Navigation Department with dredging and survey data for various U.S. ports. These inputs are received infrequently and account for less than 200 features per year.

3.1.7 International Maritime Organization (IMO) Data

Several times a year the International Maritime Organization (IMO) makes changes to navigational areas within their control. These changes typically involve changing traffic separation schemes, which maintain order for shipping traffic in the world's busiest ports and waterways. These changes usually add an average of 240 features per year to the system's inputs.

Table 3-3. Foreign NTM Sources

COUNTRY	NOTICES/YEAR	FEATURES/NOTICE	TOTAL
*Algeria	24	20	480
*Argentina	24	20	480
Australia	52	12	624
Bahrain	57	20	1140
*Belgium	26	20	520
Brazil	24	20	480
British Admiralty	52	58	3016
Canada	25	122	3050
Chile	24	20	480
China	24	20	480
*Colombia	10	20	200
Crotia	12	7	84
*Cuba	12	20	240
*Denmark	52	21	1092
*Equador	10	20	200
Eqypt	8	5	40
Estonia	12	7	84
*Finland	34	36	1224
*France	52	20	1040
French Polynesia	18	20	360
*Germany	52	32	1664
*Greece	12	25	300
Hong Kong	112	1	112
Iceland	12	20	240
India	24	20	480
Indonesia	51	20	1020
Israel	1	1	1
*Italy	25	13	325
Japan	51	35	1785
South Korea	36	20	720
North Korea	12	20	240
*Latvia	26	20	520
Malaysia	6	1	6
Royal Malaysia	1	1	1
*Mexico	17	7	119
Mynamar	19	20	380
*Netherlands	52	16	832
New Zealand	50	5	250
Norway	24	20	480
Pakistan	52	1	52
Paraguay	12	20	240
*Peru	12	10	120
Phillippines	13	20	260
*Poland	52	14	728
*Portugal	25	6	150
Romania	12	20	240
Russia	53	26	1378
St. Lucia	1	1	1
Singapore	12	20	240
South Africa	12	13	156
*Spain	52	48	2496
*Sweden	52	20	1040
Taiwan	57	12	684
Thailand	4	7	28
*Tunisia	25	20	500
*Turkey	51	6	306
*Uruguay	12	16	192
*Venezuala	100	1	100

* Indicates source must be translated before processing.

3.1.8 U.S.C.G. Light List Information

The Coast Guard inputs their Light List information directly into the Heritage System. Therefore the features contained in this portion of the NTM cannot be included in the efficiency models as outputs. However, each navigational aid that the Coast Guard inputs requires the NTM Writers to take action to ensure that the navigational aid on the nautical chart agrees with the information published in the Light List. More than 5,500 features are added to the input queue annually.

3.1.9 Candidate Hazards

The candidate hazards will be a new input to the NTM process with the delivery of the NSS. These inputs will contain bathymetric features that could potentially pose a threat to surface shipping. The inputs will originate from the analysis of bathymetric surveys on the Hydrographic Source Assessment System's (HYSAS) analysis of bathymetric surveys. New algorithms to process the bathymetric data suggest that HYSAS will supply NSS with approximately 28,500 candidate hazards annually (approximately 550 features per week).

3.2 Heritage System Source Inputs and Outputs Mapped to the Production Flow

A graphical overview of the Heritage System Production Process was presented in Figure 2-1. Taking Figure 2-1 one step further, the source inputs and outputs are superimposed on the production flows in Figure 3-1. The inputs are shown entering each step of the process from the left. Outputs exit each box from the right.

The navigational source materials enter the system from a variety of outside sources through the Source Manager. The Source Manager enters the material into the source log and forwards the navigational source material to the NTM Writer.

The NTM Writer is the driving force in the production flow with respect to generating output. The NTM Writer converts the navigational source features into updated features for U.S. Hydrographic Charts and Publications (e.g. chart corrections, List of Lights corrections, etc.). The navigational source materials and the updated navigational features are then forwarded to the NTM Checker as source inputs.

The Checker processes the inputs received from the Writer. The outputs from this stage include the quality-checked navigational features and the navigational source materials. The quality-checked navigational features are forwarded to the NTM Senior Reviewer as inputs and the navigational source materials are filed for archival purposes.

The NTM Senior Reviewer processes the quality-checked features and outputs them to the NTM Editor as senior-reviewed features. The NTM Editor then processes the senior-reviewed features into features published in the NTM.

3.3 Other Heritage Systems Inputs

Navigation significant features are the largest source of inputs to the NTM Production Process. However, other inputs are required to process this raw data into usable information for the customers at sea. The Heritage System hardware and software, and the department's personnel are critical in the production process. The cost of overhead (in terms of hours used) must also be accounted for in the production process. These inputs will be discussed in the following sections.

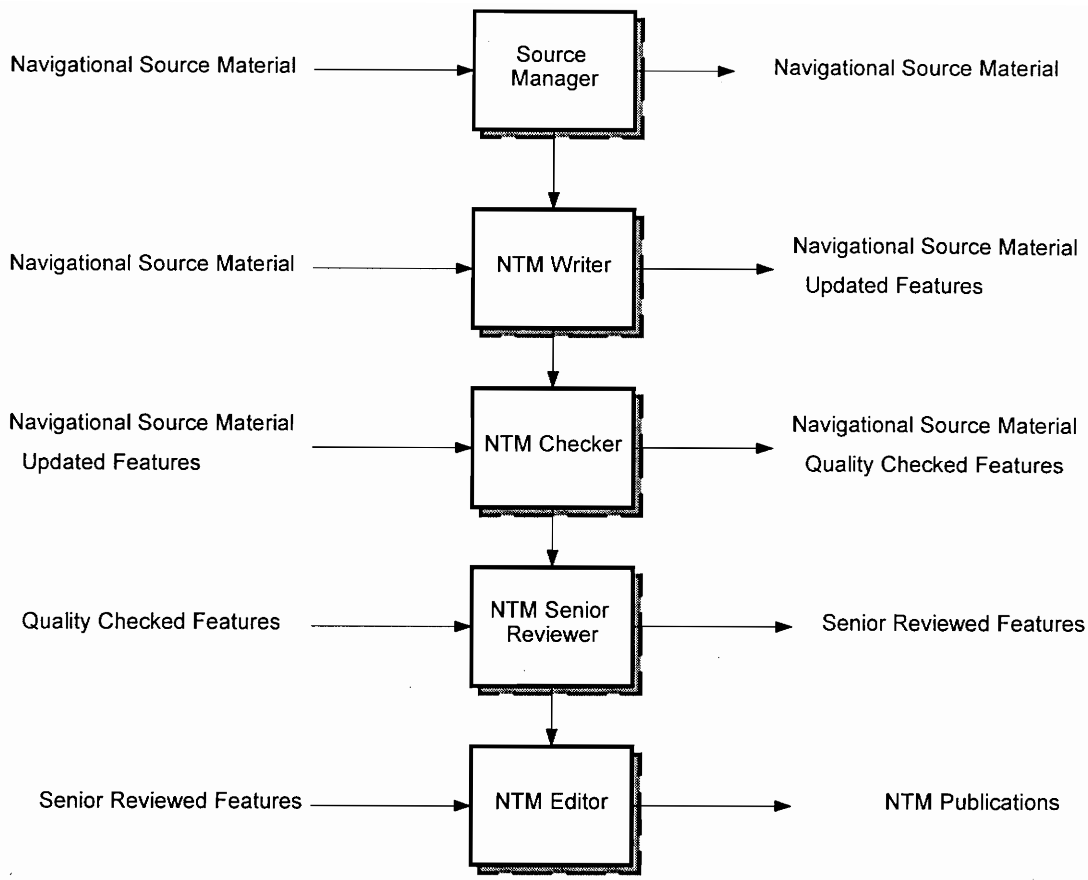

Figure 3-1 The Heritage System Production Flow with Inputs and Outputs Superimposed

3.3.1 Heritage System Workstations

The Heritage System is composed of two mini-computers that support 27 NTM workstations. Unlike the NSS, the Heritage System has only one type of workstation.

When using the workstations as a metric in the productivity model, 27 workstations was considered the optimum weekly input. The system logs were reviewed for periods of maintenance downtime during the 1996 NTM year. From these Figures, the number of workstations that were considered as inputs during a given week was calculated. This calculation is shown mathematically in equation 3.5.

$$Workstations = \frac{40hours - downtime}{40hours}(27Workstations) \qquad (3.5)$$

The weekly workstation values are tabulated in Table C-1.

3.3.2 Production Labor Hours

The primary input to the NTM process, that is not a source, is the production labor hours. For this input, hours of direct support to the production process were compiled from agency production management time sheets for the 1996 NTM year. Although this data was taken from agency records, a small amount of error may have been introduced because administrative time (time that the manager takes the analyst away from production to complete administrative matters), is included in the production time. Although administrative time varies among analyst and production cycles, this error is assumed to be small. Therefore, it was not accounted for in the Heritage System inputs.

3.3.3 Overhead Hours

Overhead hours include annual, sick, military and administrative leave, federal holidays, technical support and managerial personnel, and time spent in training. With the exception of the technical support and managerial hours, the overhead does not contribute to production, but must be accounted for in the model to identify possible poor operating practices. The overhead values were extracted from the agency's production management time sheets and are tabulated in Table C-5.

3.4 Heritage System Outputs

The Heritage System outputs are measured by examining the features published in the Weekly NTM. Each geographic position listed in the chart correction section has been considered the equivalent of one feature. In addition, each light and radio aid listed in the List of Lights and radio aids sections, respectively, have been considered as a single feature. Table C-1 shows the outputs for each of the 52 NTM cycles.

3.5 NSS Source Inputs and Outputs Mapped to the Production Flow

Figure 3-2 shows the inputs and outputs superimposed on the NSS Production Process (Figure 2-1). In this Figure, everything is the same as in the Heritage System Production Process except that the Source Manager will collect special navigational sources that are not required to be processed by the NTM Writer, Checker and Senior Reviewer, and forward them directly to the NTM Editor. In the Heritage Production Process, those features are received by the NTM Editor directly from the source.

3.6 Inputs Specific to the Navigation Safety System

As with the Heritage System, the NSS' success will depend on the hardware, software, and personnel. These inputs offer the most controversial topics of future production. A miscalculation in the number of personnel and workstations required could leave the Marine Navigation Department over-staffed and with too many workstations. Or it could leave the department crippled with the inability to process all of its critical source inputs.

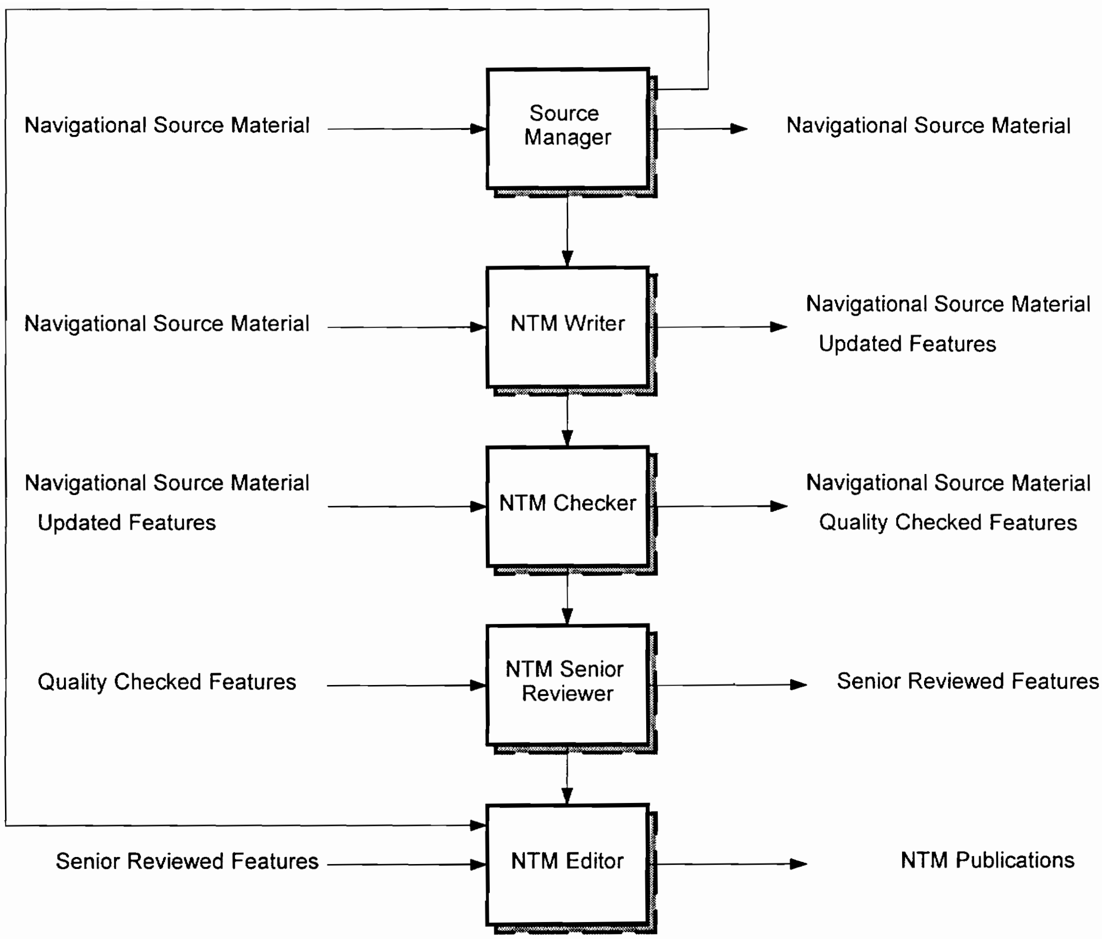

Figure 3-2 The NSS Production Flow with Inputs and Outputs Superimposed

3.6.1 Workstations

As noted above, One of the most critical inputs of the NSS is the size of the workstation pool as this input could potentially have the largest effect on the productivity of the new system. Having too few workstations will cause the source inputs to accumulate without being worked off. Too many workstations will incur an unnecessary cost and occupy much-needed space.

The NSS design supports three types of workstation (the NTM Workstation, navigation publication workstation, and the support workstation). The NTM Workstation is a dual-monitor workstation. This hardware configuration will allow the NTM Writers, Checkers, and Senior Reviewers to process feature data and to populate the Navigation Features Layer (NFL) - a spatial database. These workstations are the most important segments of the Navigation Safety System.

Similar to the NTM Workstations, the navigation publication workstations will be used by the NTM Editorial Staff to assemble the marine safety information for the Weekly NTM, the Summary of Corrections, and the List of Lights.

The last, and least critical, type of workstation is the Support Workstation. This is the workstation that the Source Manager and other support personnel will use to perform their roles in the NTM production flow.

Three solutions are being considered for the number of workstations to be included with the NSS delivery: the engineering solution, the contracted solution, and the space constraint solution. The number of workstations varies greatly for each solution.

This section will discuss the workstation solutions independent from the personnel who will operate them. However, the number of workstations and personnel can be considered synonymous for processing the inputs since the premise of the workstation model is the equivalent of one workstation for each person. The subject of NSS personnel inputs is discussed in Section 3.6.2.

Unlike the analysis of the Heritage System's Workstations, system maintenance downtime will not be modeled for the NSS Workstations. The reason for this is twofold: (1) the NSS contractor is required to deliver a system that has an operational availability of 0.995 (NSSRD, 1995); and, (2) the NSS workstation models are based on the total employee productive time (on average 6.2 hours out of an eight hour day), which allows time for conducting planned and unplanned maintenance. The employee productive time is explained in greater detail in Section B.1 of Appendix B.

3.6.1.1 The Engineering Solution

The NSS Workstation engineering solution was solved by a mathematical model and verified by a discrete process model. The mathematical model is included in this report as Appendix B.

The engineering solution was calculated for one and two shift operations. The following are the workstation configurations suggested by the model results:

One Shift Operation
NTM Workstations = 63
Navigation Publication Workstations = 4
Support Workstations = 1

Two Shift Operation
NTM Workstations = 31
Navigation Publication Workstations = 2
Support Workstations = 1

3.6.1.2 The Space Constrained Solution

The Space Constraint Solution has considered the amount of physical space that the Marine Navigation Department has available for new production hardware. Of the three solutions, this is the one most likely to occur. For NSS input purposes, two shifts will be assumed for the NTM Writers, Checkers, and Senior Reviewers. The Space Constraint solution yielded the following workstation configuration:

Two Shift Operation

NTM Workstations = 23

Navigation Publication Workstations = 4

Support Workstations = 1

3.6.1.3 The Contracted Solution

Due to budgetary constraints, the NSS contract limited the number of workstations. Since this solution yields a smaller number of workstations, a two shift operation will be assumed for all personnel, except for the Source Manager. The contracted solution yields:

Two Shift Operation

NTM Workstations = 15

Navigation Publication Workstations = 1

Support Workstations = 1

3.6.2 Personnel

The workstation model in Appendix B can also be used to predict the number of personnel needed to sustain the required production level. However, in an age of Government downsizing and budgetary constraints, acquiring extra personnel to meet the workstation model's projections may be the system's weak link.

In the absence of real production hour inputs, an average number of hours per week will be used as an input for each employee. The average production hours exclude all overhead values and time spent performing administrative tasks.

Labor hours data is contained in Appendix C.

3.7 NSS Outputs

The outputs for the Navigation Safety System are more extensive than the outputs for the Heritage System. Like the Heritage System, the primary output will be the features included in the NTM, which allows seafarers to update their hardcopy nautical charts. However, NSS will be required to do more than provide corrections to update the features on existing charts. The NSS will be required to maintain a database of the world's navigation significant features (contained in the Navigation Features Layer), regardless of whether they are portrayed on a hardcopy nautical chart.

The system is being designed so that, while the analyst is updating the features in the NFL, the system will query the database to determine if each feature resides on any hardcopy nautical chart or is in a feature-based publication such as the List of Lights. If it is determined that the feature does exist other than in the database, proposed correction text is automatically generated. Although this is a time-saving effort, the Marine Navigation Department will have to take action on every feature that it receives. Hence, a dramatic increase in outputs is expected.

The quantities of output for the NSS are determined by the learning curve models presented in Chapter 5.

CHAPTER 4
HERITAGE SYSTEM EFFICIENCY

To effectively implement new technology into an existing production process, a thorough understanding of the current systems efficiency is paramount. This knowledge will allow for a fair assessment of those operating practices that work well for an organization, and those that do not. The operating practices that work well for an organization can be models for improving the existing production system's efficiency, and can serve as the basis for deciding which practices may aid in a smooth transition to the new technology.

The Data Envelopment Analysis (DEA) Model was selected for determining the productivity of the Heritage System Production Process because of its ability to handle multiple inputs and outputs and always evaluate them in the best possible light. This model is well suited for use in evaluating the current production process because of the model's ability to compare one NTM against another. Inefficient NTMs are identified and compared to similar efficient cycles.

4.1 The Data Envelopment Analysis Model

In its simplest form, efficiency is defined as:

$$Efficiency = \frac{Output}{Input} \qquad (4.1)$$

This model would be adequate if there was only one input and one output. However, for most applications there are multiple inputs and outputs, and each has its own level of importance, and therefore needs to have a weight assigned. Taking equation 4.1 one step further by assigning a weighting structure for each input and output, yields:

$$Efficiency = \frac{Weighted\_sum\_of\_outputs}{Weighted\_sum\_of\_inputs} \qquad (4.2)$$

(Boussofiane, Dyson and Thanassoulis, 1991).

The difficulty in applying equation 4.2 arises in attempting to determine the assignment of weights. In any process certain inputs and outputs are more important than others, but being able to assign a numerical weighting value to each is not possible in many industrial engineering problems. The Heritage System Production Process certainly fits this mold.

In 1978, Charnes, Cooper and Rhodes, suggested an efficiency model that will solve the problem of assigning weights to individual units (Boussofiane, Dyson, and Thanassoulis, 1991). The model, based on linear programming techniques, finds the optimal set of weights to make the efficiency maximum for each unit. Thus the model assumes that each unit may have its individual weighting structure. The model is:

$$MaxH_o = \frac{\sum u_r y_{rj0}}{\sum v_i x_{ij0}} \qquad (4.3)$$

subject to

$$\frac{\sum u_r y_{rj}}{\sum v_i x_{ij}} \leq 1, j=1,2,...,n$$

$$u_r,\ v_i \geq \varepsilon,\ \forall\ r=1,2,...,m,\ I=1,2,...,s$$

where:

H_o is the measure of efficiency

j_0 is the Decision Making Unit (DMU)[1]

y_{rj0} is output of r from unit j

x_{ij0} is input of i to unit j

u_r is the weight assigned to output r

v_i is the weight assigned to input i

n is the number of units

s is the number of outputs

m is the number of inputs

ε is an infinitesimally small positive number to positively ensure all of the weights of all inputs and outputs

The weights assigned to the inputs and outputs are treated as unknowns in this model. The efficiency of individual units will equal either one for an efficient unit, or less than one for an inefficient unit.

Equation 4.3 requires manipulation before it can be solved by linear programming methods (Boussofiane, Dyson and Thanassoulis, 1991). In linear programming model 4.4, the output is being maximized, and the denominator has been set to an arbitrary constant value of 100 (Boussofiane, Dyson, Thanassoulis, 1991).

$$MaxH_o = \sum u_r y_{rj0} \qquad (4.4)$$

subject to

$$\sum v_i x_{ij0} = 100$$

$$\sum u_r y_{rj} - \sum v_i x_{ij} \leq 0, j=1,2,...,n$$

$$u_r \geq \varepsilon, \forall r$$

[1] For the purposes of this study, a DMU is defined as one Weekly Notice to Mariner Cycle.

$v_i \geq \forall i$

While the model presented in equation 4.4 can be used to derive the efficiency of each unit, solving the dual of this model can provide greater insight into the unit's efficiency. The dual of model 4.4 is presented in equation 4.5 (Boussofiane, Dyson, Thanassoulis, 1991).

$$Min 100Z_0 - \varepsilon \sum s_r^+ - \varepsilon \sum s_i^- \qquad (4.5)$$

subject to

$x_{ij0}Z_0 - s^- - \sum x_{ij}\lambda_j = 0$, i=1,2,...,m

$-s_r^+ + \sum y_{rj}\lambda_j = y_{rj0}$, r=1,2,...,s,

$\lambda_j, s_i^-, s_r^+ \geq 0$, $\forall j$, r and I

Z_0 unconstrained.

(Boussofiane, Dyson, Thanassoulis, 1991)

where:

λ is the proportion of the input output levels of the peer unit going into the composite unit

Z_0 is the maximum proportion of the input levels of j_0

When solving the dual, the model attempts to find values of λ that will outperform unit j_0. If Z_0 is equal to one, and the slacks are equal to zero, then unit j_0 is efficient and it is impossible to construct a composite unit. If Z_0 does not equal one and/or the slacks are positive, then unit j_0 is inefficient. When this occurs, the optimal values of λ form a composite unit that outperforms j_0, and provides target values that unit j_0 should work towards (Boussofiane, Dyson, Thanassoulis, 1991).

4.2 Heritage System Efficiency Results

The Warwick DEA Software was used to compute the solution of model 4.4 to determine the relative efficiencies of each NTM cycle. The model's parameters were set so that it would solve for maximizing the outputs with constant returns to scale. The following parameters were set in this model:

- Improvement Model was set to the radial model (RM)
- Radial Objectives was to output maximizing (OM)
- Returns to Scale was set to constant returns to scale (DB)
- Target gains was set to relative gains (RG)
- Own Unit as Comparator was set to unit being assessed in included as a comparator (IX)
- Specified Priorities was set to (PU)
- Efficiency Value was set to give the radial efficiencies
- Since the RM setting was set (AE).(Warwick, 1989)

The input and output data, as well as the model results are contained in Appendix D. Of the fifty-two units evaluated, thirty-four were found to be efficient. The model results are tabulated in Table D-2 of Appendix D, and shown graphically in Figure 4-1.

4.3 Peer Groups and Target Setting

While the model presented in equation 4.4 finds the relative efficiencies of each unit, the DEA model can used to determine the peer units of each inefficient unit. Model 4.5 solves the model and forms a composite unit for each inefficient unit.

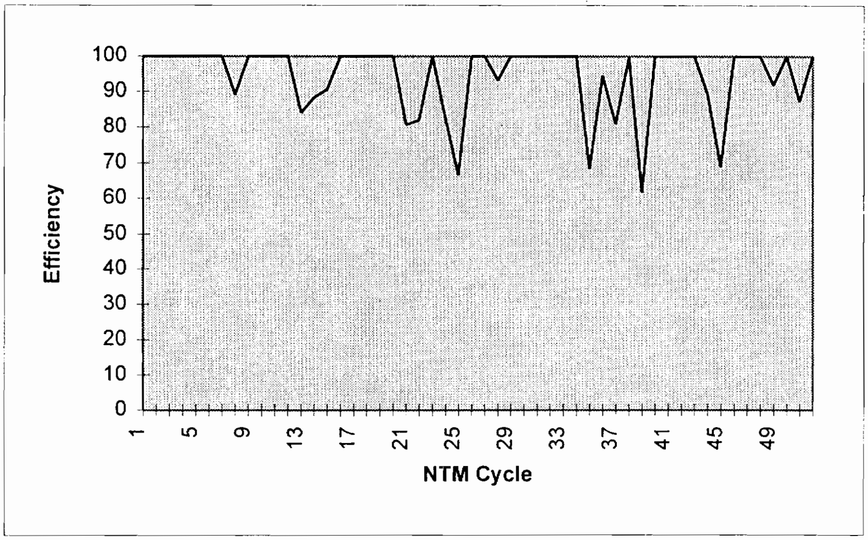

Figure 4-1. Relative Efficiency of the 52 NTM Cycles

Peer units are extremely useful in efficiency analysis because the inefficient unit is compared against one or more efficient units with similar operating practices. The similar operating practices are derived from the weights assigned to the inputs and outputs. The concept of the composite unit is important here.

The composite unit is made up of the similar efficient units. The value of λ is the proportion of the input and output levels of the peer unit that is going to the composite unit. Therefore, the most important units contributing to the composite unit can be identified by the larger λ values. The Warwick DEA Software also shows to what degree the efficient unit's data are scaled to make it easier to compare to the inefficient unit (Boussofiane, Dyson, Thanassoulis, 1991).

To illustrate the concept of peer units from an output perspective, a production system can be considered that yields two outputs (*y1* and *y2*) from one input *x*, as shown graphically in Figure 4-2 (adopted from Triantis, 1995).

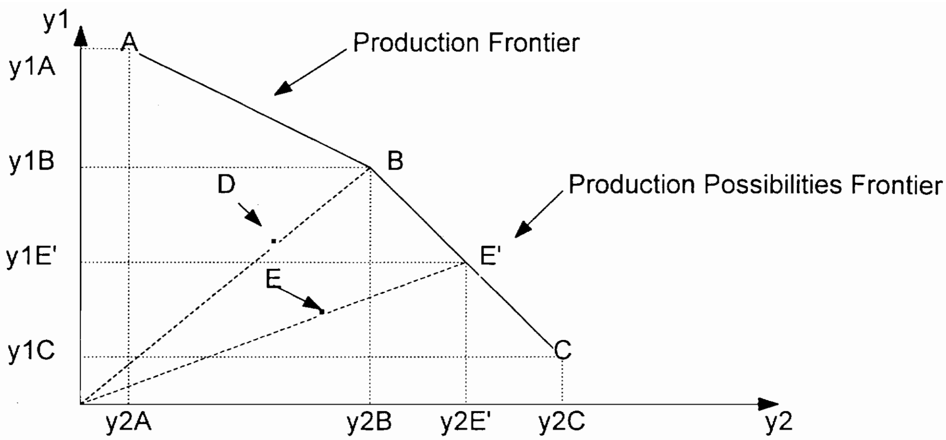

Figure 4-2. Graphical Representation of Efficiency from the Output Perspective

In Figure 4-2, there are three efficient Decision Making Units (DMUs) (A,B,and C) that lie on the production frontier. Each DMU produces a different number of outputs *y1* and *y2* from the same quantity of input, but remains efficient. A DMU producing a different output mix does not render a unit inefficient as long as the input is used efficiently. A different output mix simply shows that each DMU has a different set of operating priorities.

DMU D uses the same amount of input as DMU B, but produces less of both *y1* and *y2*, and can therefore be deemed inefficient. DMU B serves as the peer unit and target efficiency for DMU D.

DMU E can also be declared inefficient because it lies to the southwest of the production frontier. DMU E uses the same amount of input as the efficient units, but produces less output. A composite unit can be formed for DMU E by using DMUs B and C as peer units. By taking weighted averages of the efficient DMUs B and C, the Warwick DEA Software will generate a theoretical composite DMU (E')for the inefficient unit and place it on the production frontier. This hypothetical point is known as the production possibilities frontier and serves as a target for DMU E.

Target setting is also possible through the composite unit. In Figure 4-2, DMU E' represents the efficient composite unit of the inefficient DMU E, formed by similar DMUs B and C. DMU E' also represents the output level that can be achieved, or the target, if the inputs were used efficiently. The point on the production possibilities frontier is not the only efficient solution, or the only target that can be set (Boussofiane, Dyson, Thanassoulis, 1991). Any combination of DMUs B and C that lie on the line segment BC can be considered efficient and therefore a productivity target.

4.4 Virtual Inputs and Outputs

The Warwick DEA Software was also used to compute the virtual inputs and outputs of the 52 NTM Cycles in this research. The virtual input and output values convey information on the importance a unit attaches to particular inputs and outputs in order to attain its maximum efficiency rating (Boussofiane, Dyson, Thanassoulis, 1991). This importance can be realized because the virtual inputs and outputs that have the largest values represent the actual inputs and outputs that played the greatest role in allowing that unit to achieve its highest efficiency rating.

When evaluating efficient DMUs, the virtual inputs and outputs can be used to determine which practices allow that unit to become efficient. Once this information is known, changes to operating practices can be explored for other DMUs (both efficient and inefficient).

4.5 Evaluation of the Heritage System Efficiency

In section 4.2 the Heritage System's efficiency results were presented. However, for a clear understanding of the most successful operating scenarios, the results produced from the solution of model 4.5 must be examined. The analysis of the NTM Cycles will be conducted in two steps: (1) Analyze the peer groups to determine which efficient NTM Cycles have the greatest influence on the inefficient NTM Cycles, and why, and ; (2) Study the inefficient NTM Cycles to ascertain possible poor practices by comparing them to efficient units with similar operating practices.

4.5.1 Analysis of Efficiency Based on Peer Groups.

Eighteen NTM Cycles were determined to be inefficient using the Warwick DEA Software. Peer groups were computed for each of these inefficient units, and the results are shown in Table D-3.

Since the peer groups enable comparison of the inefficient units with similar, but efficient units, a keen insight can be gained into standard production cycles. Reviewing the data in Table D-3, the dominant efficient NTM Cycles were determined. The results are shown graphically in Figure 4-3.

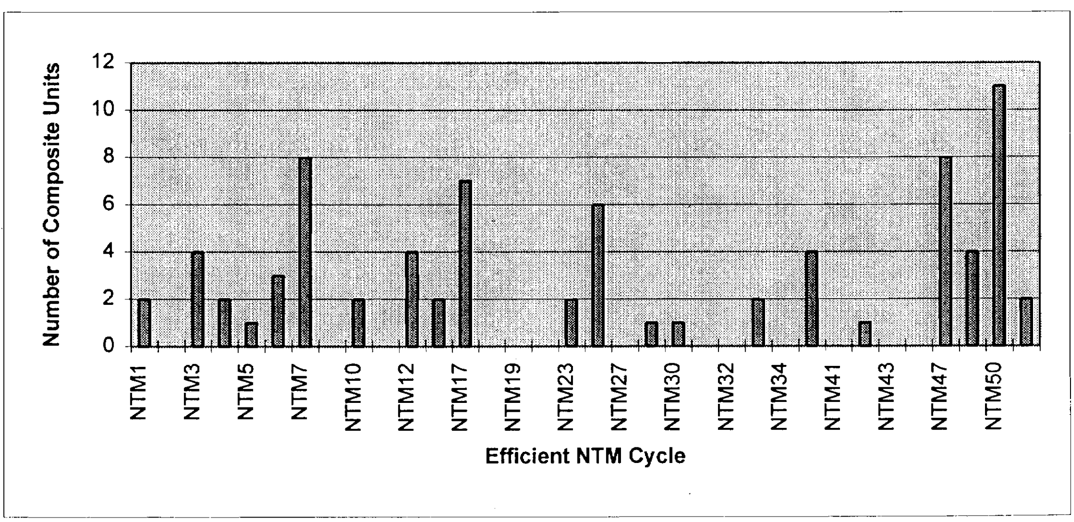

Figure 4-3. Dominant DMUs in Composite Units.

From Table D-3, NTM Cycle 50 is the efficient unit that appears to best represent the common operating practices of the Heritage System. This unit is included in 11 of the 18 composite units A more significant point is that NTM Cycle 50 has high λ values in 10 of the 11 composite units. This indicates the importance that this unit has in the comparison of inefficient units and the operating practices of the Marine Navigation overall.

Figure 4-3 also shows that NTM Cycles 7 and 47 exhibit good examples of operating practices, as they are included in eight of the 18 composite units. NTM Cycle 47 is the dominant of the two, by significantly contributing five of its eight composite units. NTM Cycle 7 significantly contributes to only four of the composite units it belongs to.

NTM Cycle 17 makes up part of seven composite units. However, this DMU does not appear to offer as significant contributions as the previous three, because it only has relatively high λ values in two composite units.

NTM Cycle 26 is included in one third of the composite units. With its relatively low λ values in four of the six composite units, the operating practices of this DMU appear to have played only a minor part in the average operating scenarios.

Although the remainder of the efficient units have good operating practices, they are not necessarily representative of the average production cycle. As Figure 4-3 shows, some of the efficient units are not part of any composite units.

A review of the virtual inputs and outputs (Table D-4) for NTM Cycles 50, 47, 7, 17 and 26 reveals why their operating practices serve as a model for the inefficient DMUs. The virtual inputs and outputs for NTM Cycle 50 indicate an excellent use of all inputs equally. The success of this DMU is realized because of a greater than average number of productive hours and less than average navigational source inputs. While the number of navigational source inputs were less than those of an average week across the spectrum, the department was required to do a more than an average amount of processing, as evidenced by the larger number of chart features and light list features produced. A significantly lower than average amount of overhead indicates that employee leave and training were at a minimum during this cycle.

The operating practices found during NTM Cycles 7 and 47 result in equivalent inputs and outputs. However, after making a comparison of these DMUs with the raw data in Tables D-1, NTM Cycle 47 appears to have the better operating practice. NTM Cycle 47 has fewer navigational source inputs than NTM Cycle 7, but is required to perform a greater amount of processing as shown by the greater number of outputs. The key difference between these DMUs appears to be the use of the employee productive time. NTM Cycle 7 has overtime hours figured into its production hours, where NTM Cycle 47 does not. However, NTM Cycle 7 was hindered by Heritage System maintenance where NTM Cycle 47 was not.

The virtual inputs and outputs for NTM Cycle 17 also show good operating practices throughout. This DMU produces the year's largest number of chart features and an above average number of light list features, without overtime.

NTM Cycle 26 shows higher than average navigational source material inputs and chart features output with a minimal amount of overtime.

4.5.2 Possible Causes of Poor Efficiency

The NTM Cycles determined to be inefficient using the Warwick DEA Software were reviewed to determine possible causes of poor productivity. Three factors immediately presented themselves for further evaluation. Those factors are: the amount of overhead during the cycle; the amount of overtime during the cycle; and equipment availability.

The overhead inputs includes the management and technical support hours, plus employee leave and training time. In the computation of overhead hours, the management and technical support time is treated as a constant, and employee leave and training hours are treated as variables.

The overhead hours were immediately suspect when reviewing the inefficient DMUs. This review found that 17 out of 18 inefficient NTM Cycles had a large number of overhead hours associated with them. In comparison, only 13 of the 34 efficient DMUs had high overhead figures. This analysis seems to prove that having an efficient cycle with high overhead hours is possible, but how?

The first four cycles in this study are relatively efficient but have an extremely high overhead. The reason for the efficiencies enjoyed by the first three cycles may because of the amount of planned leave associated with the Christmas Holidays. Usually when an employee plans an extended period of leave (such as around a holiday season or for a vacation), that employee attempts to push some of the inputs from an earlier week into the cycle where the leave is taken. This gives a false indication of productivity for the cycle where the inputs arrived and for the cycle where the outputs were placed. Although a false possible efficiency rating may result, this proves to be a good operating practice because it helps to keep a relatively constant output. This provides the customer with a steady stream of feature data that must be applied by hand. In addition to the prior leave planning, during large leave periods the employees that don't take leave are especially mindful of the high absenteeism and may put in an extra effort.

Equipment problems were the next highest source of concern when reviewing inefficient units. Four of the 18 inefficient cycles were found to have equipment availability problems. In comparison, an equivalent percentage of efficient cycles were stricken with equipment availability problems. This suggest the equipment availability problems were no worse with the inefficient units than with the efficient unit. Therefore, workstation availability is being ruled out as a major contributor of poor productivity.

The last factor examined was overtime for production. Overtime played an important role in the efficiency of more than one third of the efficient units. Conversely, five of the eighteen inefficient cycles had overtime hours assigned for production. These results are inconclusive since approximately the same percentage of efficient and inefficient cycles contained overtime hours. Another method of testing this problem is through the use of regression analysis.

CHAPTER 5

ESTIMATING THE NAVIGATION SAFETY SYSTEM PRODUCTIVITY USING THE LEARNING CURVE MODEL

The learning curve is based on the assumption of more efficient production with increased experience. The foundation of this assumption is that processing time decreases during each production cycle (Towill, 1990, Pine 1996). Hence, an increase in productivity is realized.

Research has suggested several explanations of the learning curve phenomenon. The three most prevalent reasons are technological, organizational, and attitudinal (Towill, 1990). Each of these explanations will be considered when reviewing the NSS learning curve, and when making recommendations for efficiency improvements throughout this report.

The learning curve model was selected for evaluating the NSS because when a new system is implemented, productivity suffers for a period of time. This methodology allows for the estimation of outputs from the start of operations to the point at which the system reaches a steady state of production. This model is also a good tool for evaluating the number of workstations proposed and how it will affect the Marine Navigation Department's ability to accomplish its mission.

5.1 The Time Constant Model

Various learning curve models were evaluated for applicability to the NSS. The time constant model was selected because of its extremely high reliability and the relative ease of relating the NSS production problem to the model parameters. Research to evaluate 14 different learning curve models (Towill and Cherrington, 1993) found the time constant model to be applicable in 88% of the cases, while its closest competitor was found reliable in only 40% of the test cases (Towill, 1990).

Towill (1990) expresses the time constant model as:

$$Y_m(t) = Y_c + Y_f(1 - e^{-t/\tau}) \tag{5.1}$$

where:

$Y_m(t)$ is the system output at time t

Y_c is the initial rate of production

Y_f is the dynamic gain

τ is the model time constant

t is the unit of time.

Figure 5.1 (modified from Towill, 1985) shows the relationship between the various model parameters. A plot of equation 5.1 shows productivity increasing exponentially from t=0 until a time when the upper limit of technical performance of the system is achieved. This productivity milestone is known as the steady state performance and can be described by $Y_c + Y_f$.

The time constant (τ) is the most difficult parameter of this model to grasp, because it represents the rate at which learning occurs. Learning rates can be predicted based on historical data from similar systems. When evaluating the learning rate of a system that has already been placed in the production environment, the learning rate can be estimated based on initial production results. In the absence of raw data acquired from production or historical information, the learning rate must be based on a "best-guess" (Fauber, 1989). As data becomes available, the rate of learning should be re-evaluated, and τ recalculated.

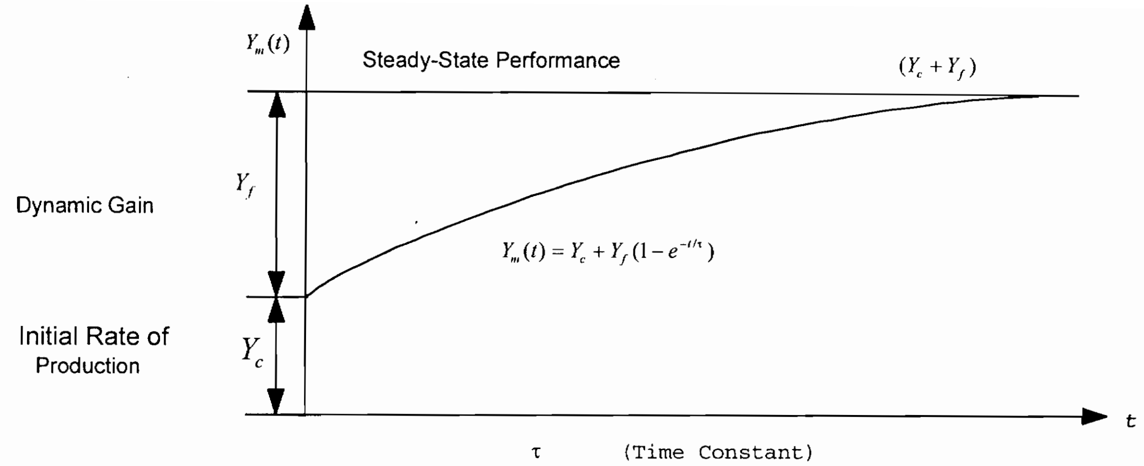

Figure 5-1. The Learning Curve

To determine τ, equation 5.1 can be transformed into

$$e^{-t/\tau} = 1 - \left[\frac{Y_m - Y_c}{Y_f}\right]$$

When the logarithm of both sides of this equation is applied, equation 5.2 (Towill and Naim, 1993) results

$$-\frac{t}{\tau}\log_{10} e = \log_{10}\left[1 - \left(\frac{Y_m - Y_c}{Y_f}\right)\right] \qquad (5.2).$$

If a plot of $1-(Y_m - Y_c)/Y_f$ vs. τ is made on a log-linear graph, a straight line results, and the slope can be determined. The slope of the line represents the percentage increase of the dynamic gain (Towill, 1985). For example, when t/τ=.25, the dynamic gain (Y_f) realizes a 22% increase.

Once the slope is known, τ can be calculated by

$$\tau \approx \frac{\log_{10} e}{slope} \qquad (5.3)(\text{Towill and Naim, 1993})$$

Figure 5.2 (modified from Towill and Naim, 1993) shows the relationships of the various parameters used in calculating t.

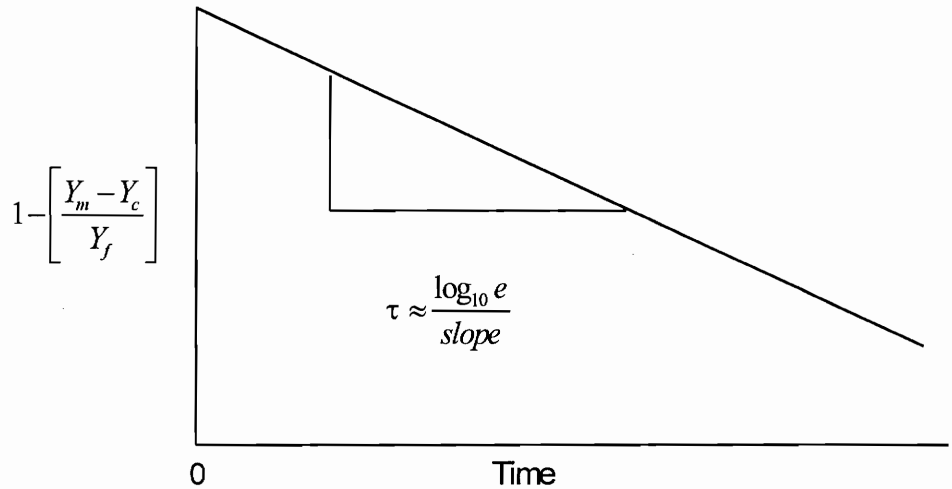

Figure 5-2. Log-Linear Learning Curve Plot

5.2 Using the Learning Curve to Evaluate Productivity

The learning curve has many applications in evaluating productivity. When applied properly, these curves can be used by management to facilitate decisions that will improve the system's efficiency. Towill (1990) presents several examples of learning curve applicability. The cases that can potentially apply to the NSS have been selected and will be discussed.

Figure 5.3 (modified from Towill, 1990), has two examples of how the learning curve can be used as a tool to evaluate productivity. The first example shows how productivity is affected during normal startup of a new production system. The area above the learning curve and below the steady state performance line shows how much productivity can be lost from the initiation of the system (t=0) to the point when the system reaches steady state performance.

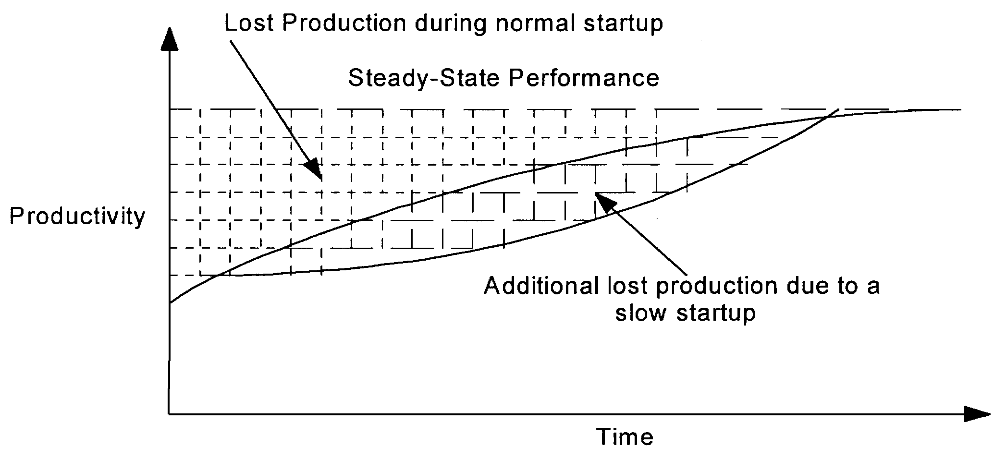

Figure 5-3. Lost Production due to the Learning Curve Phenomenon

The second example that Figure 5.3 presents is additional lost production due to a slow system startup. Slow system startup can be attributed to many factors, such as problems with the system design that were not discovered before the system is integrated into the production environment. This example may be especially applicable to the NSS, since it is based on cutting-edge technology. An unusually high number of discrepancy reports (DRs) on the system could warn the department's management that this condition may exist.

In a computer production system, a technologically limited plateau can occur when there are limitations in software and/or hardware, or in the lack of skills and knowledge of the operator. Figure 5.4 (modified from Towill, 1990) graphically displays the problem of a technologically limited plateau. Examples of this problem, applied to the NSS, will be demonstrated later in this chapter.

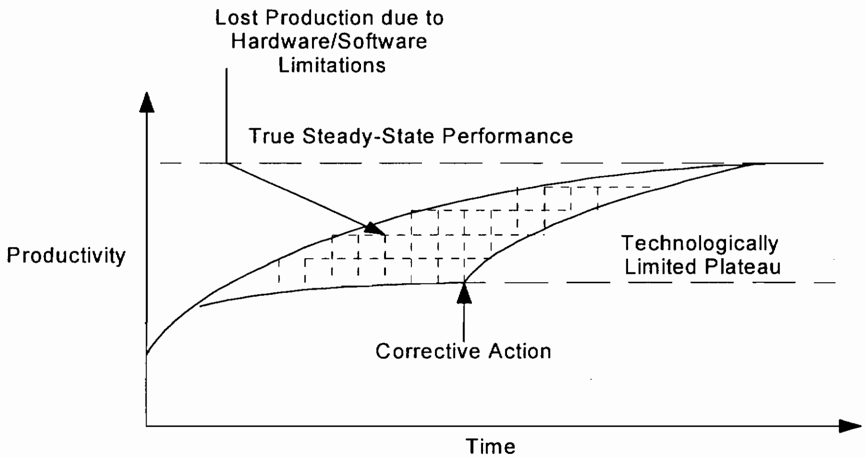

Figure 5-4. Lost Production due to Technological Limitations

5.3 Applying the Learning Curve to NSS

Certain assumptions must be made to predict the output of NSS. These assumptions are based on estimated values derived by the NSS Development Team, and are stated here:

1. During parallel operations, each feature will be processed on the Heritage System and then on the NSS so that outputs can be compared. Therefore, an equal number of features will be processed on each system;
2. Parallel operations will be in effect for six months;
3. The CNS has a constant processing time of 10 minutes per feature;
4. The NSS NTM Writer, Checkers, and Senior Reviewers will have initial estimated processing times of 50 minutes, 25 minutes, and 10 minutes per feature respectively, which equates to a 5:1 initial NSS-to-CNS processing time ratio;

5. The NSS NTM Writer, Checkers, and Senior Reviewers will have steady state processing times of 27 minutes, 13 minutes, and 5 minutes per feature respectively;
6. Each employee spends an average of 23.95 hours per week on production;
7. The learning curve will be based on an 80% slope.

This 80% learning rate has been suggested for the NSS because of the experience level of the department's staff. Drastic changes are not being made to the products generated. The existing staff will therefore only have to learn the new software and hardware processes. Consideration was given to making the NSS learning rate greater, but with the new production requirements imposed on the Marine Navigation Department, additional personnel will have to be hired, reducing the learning rate somewhat. The 80% slope is only meant to predict the initial NSS output. Once the system is operational, actual production data can be collected, the learning rate re-evaluated, and new production curves generated.

5.3.1 Scenario 1 - The Engineering Solution

The engineering solutions that were discussed in Section 3.6.1.1 reflect the number of workstations and personnel mathematically required to process all inputs received during a given week. The one-shift and two-shift numbers are equivalent and will therefore be treated only once.

The engineering solution requires the equivalent of 63 employees and NTM Workstations to achieve steady state production. Of the 63 employees, there will be 37 Writers, 18 Checkers, and 8 Senior Reviewers. Using the assumptions of an NSS-to-CNS initial processing time ratio of 5:1, and an equal number of features processed on

NSS and CNS, the initial output can be determined to be 882 features. The model results are shown in Table E-1 of Appendix E and are illustrated in Figures 5-5 and 5-6.

Figure 5-5 depicts the number of features processed vs. the NTM cycle. Note that there is a significant increase in the number of features processed after NTM Cycle 24. This corresponds with the end of parallel operations. The model approaches steady state production during NTM cycle 25. This Figure also serves as proof that based on the department's current organizational structure and the proposed production flow, the equivalent of 63 workstations and employees will be required to accomplish the assigned mission.

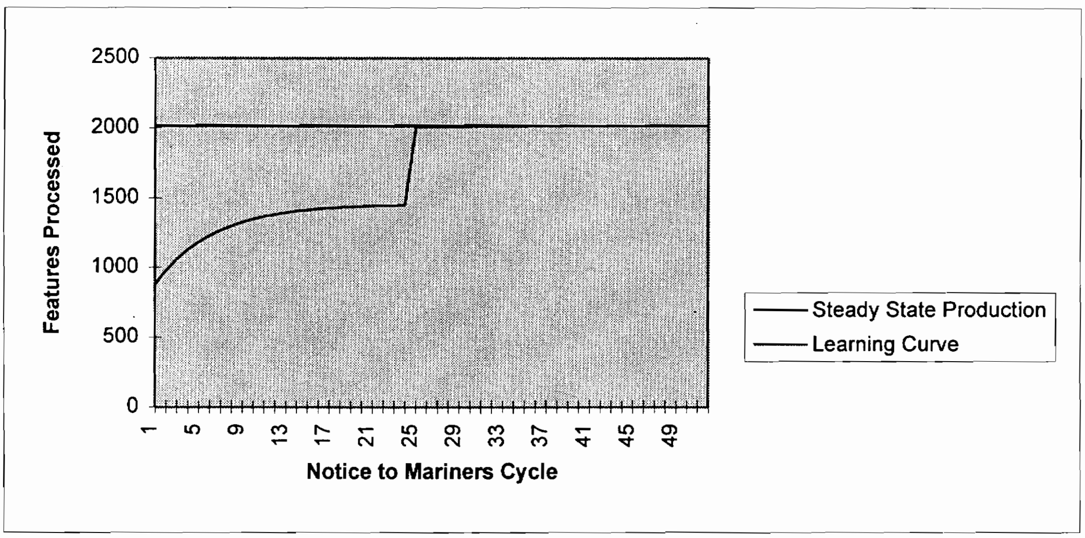

Figure 5-5. NSS Feature Outputs Based on the Engineering Solution

Figure 5-6 illustrates the feature backlog vs. NTM cycle. The feature backlog is the cumulative number of features received but not processed during a cycle. The features not processed during the cycle in which they were received are added to a queue to be worked off at a later date. Relating Figure 5-6 to Figure 5-5, the feature backlog is derived from the area above the learning curve and below the steady state performance line. The feature backlog levels off after the system reaches steady state. These features can then be processed using corrective actions decided upon by management.

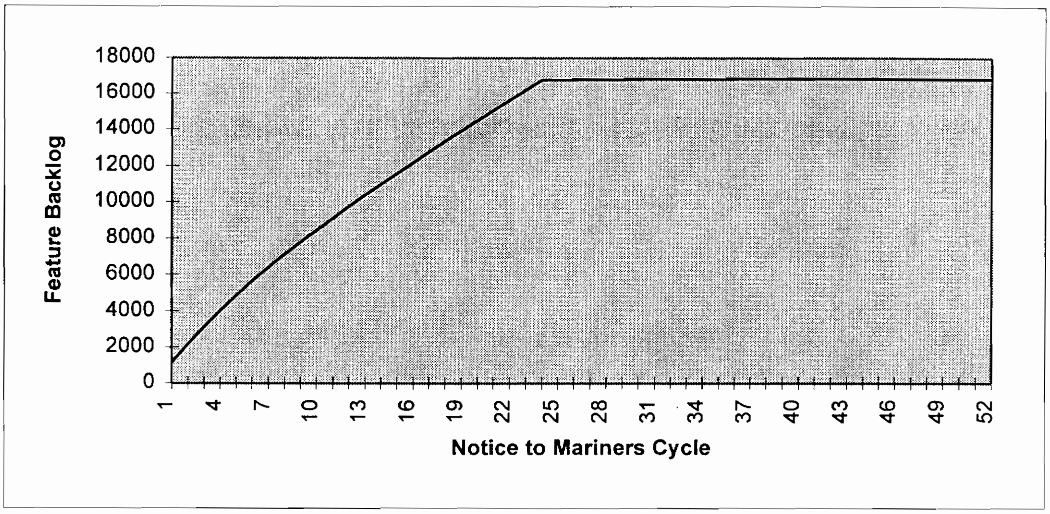

Figure 5-6. NSS Feature Backlog Based on the Engineering Solution

5.3.2 Scenario 2 - The Space Constrained Solution

The space constrained solution addresses the situation where only the number of NTM workstations that can be placed in the existing Marine Navigation Department's spaces are available. It was determined that 23 NTM workstations can be accommodated within the available space. As discussed in the previous section, the engineering solution suggests that the equivalent of 63 employees and NTM workstations are needed to achieve steady state production. The space constrained solution will assume 23 NTM workstations, and 46 employees working two shifts. Of the 46 employees, 27 will be Writers, 13 will be Checkers, and six will be Senior Reviewers.

As in scenario one, this model assumes an initial NSS to CNS processing time ratio of 5:1, and that an equal number of features will be processed on both systems during the parallel operations phase. The initial feature output for this model has been determined to be 647 features. The model results are contained in Table F-2 of Appendix E, and are shown graphically in Figures 5-7 and 5-8.

Figure 5-7 is an illustration of a system that has a technologically limited plateau due to the system's inability to process features faster, or not having a suitable amount of workstations available. The system reaches a maximum production rate of 1,437 features shortly after parallel operations end.

Figure 5-8 portrays the feature backlog over the course of four years. Since the learning curve never achieves steady state production, the feature backlog never stabilizes but continues to grow.

Fortunately, there are several workable solutions to this problem. First, organizational or process changes are always possible. However, it is debatable if process changes will contribute enough to make a significant difference.

The second option is to institute a third shift. As was shown in the engineering solution, the equivalent to 63 NTM workstations is needed to sustain production. Three shifts will clearly meet this requirement. However, since the department is only supporting one shift today, certain attitudinal issues are bound to arise. This problem will be discussed further in Chapter 7.

Another possible solution is mandatory overtime. The primary problem associated with this approach is employee fatigue. It can be argued that as fatigue increases, productivity decreases. The overtime approach has the additional problem that the amount required is so large that it may be difficult for management to support the requirement fully and still remain within the Agency's overtime guidelines. Too little overtime is also a danger since the workforce will not see the backlog decrease.

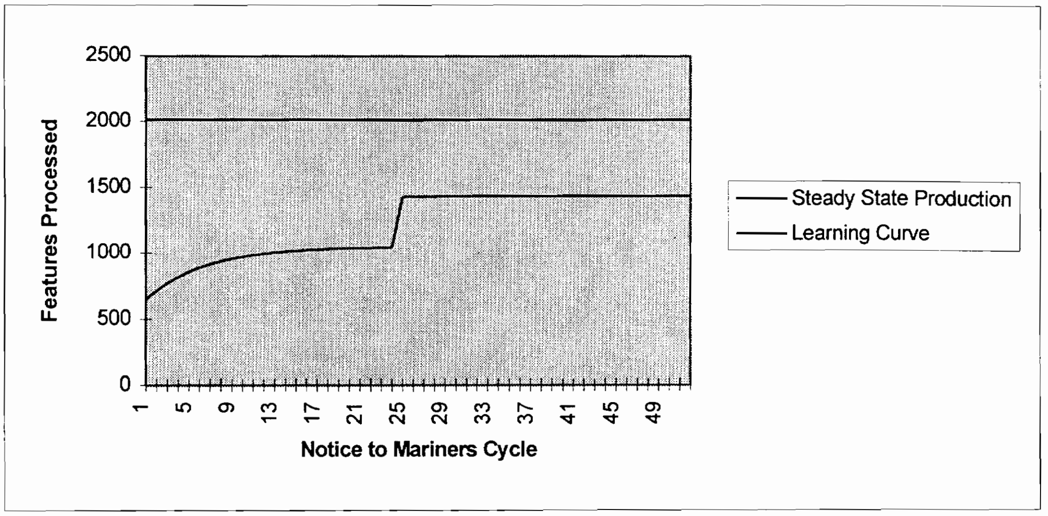

Figure 5-7. NSS Feature Outputs Based on the Space Constrained Solution

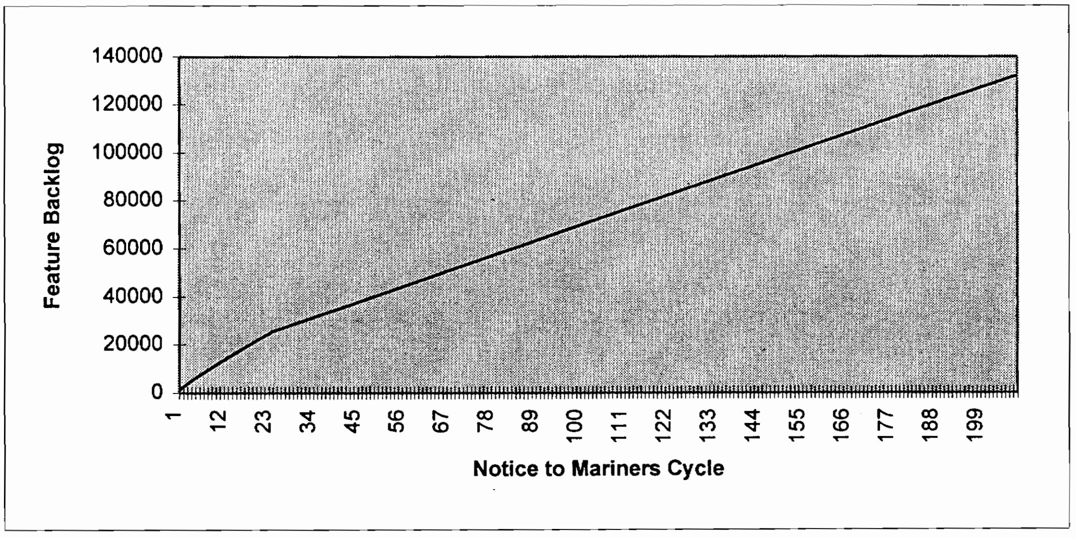

Figure 5-8. NSS Feature Backlog Based on the Space Constrained Solution

Lastly, the possibility of acquiring additional space and purchasing enough workstations to support steady state production in one or two shifts can be explored.

5.3.3 Scenario 3 - The Contracted Solution

The contracted solutions that were discussed in Section 3.6.1.2 specify that NSS will have 15 NTM workstations. With this solution, the Marine Navigation Department will be required to add a second shift so that there will be an equivalent of 30 NTM workstations.

Assuming an NSS-to-CNS initial processing time ratio of 5:1, and that an equal number of features will be processed on NSS and CNS, the initial feature output is determined to be 407 features. The model results are shown in Table E-3 of Appendix E, and are illustrated in Figures 5-9 and 5-10.

As is shown in Figure 5-9, the system approaches its maximum output of 905 features during cycle 25. This scenario is a prime example of a system that has a technologically limited plateau since its peak performance yields an output well below the steady state performance level

Figure 5-10 shows the feature backlog over a four year period. At the end of four years, the backlog approaches a quarter million features. Unfortunately, large corrective actions, including the addition of more workstations, would have to be taken to meet the assigned mission.

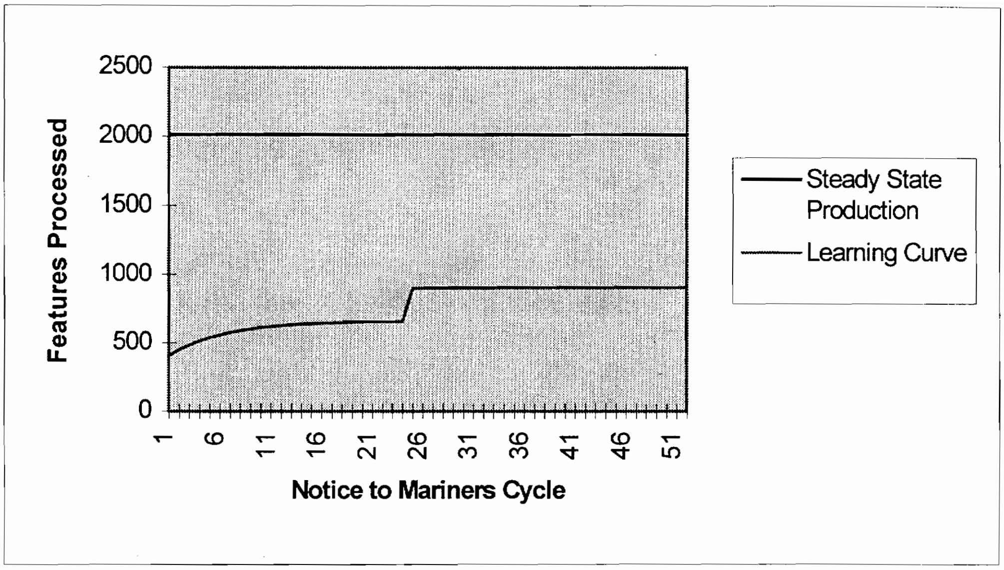

Figure 5-9. NSS Feature Outputs Based on the Contracted Solution

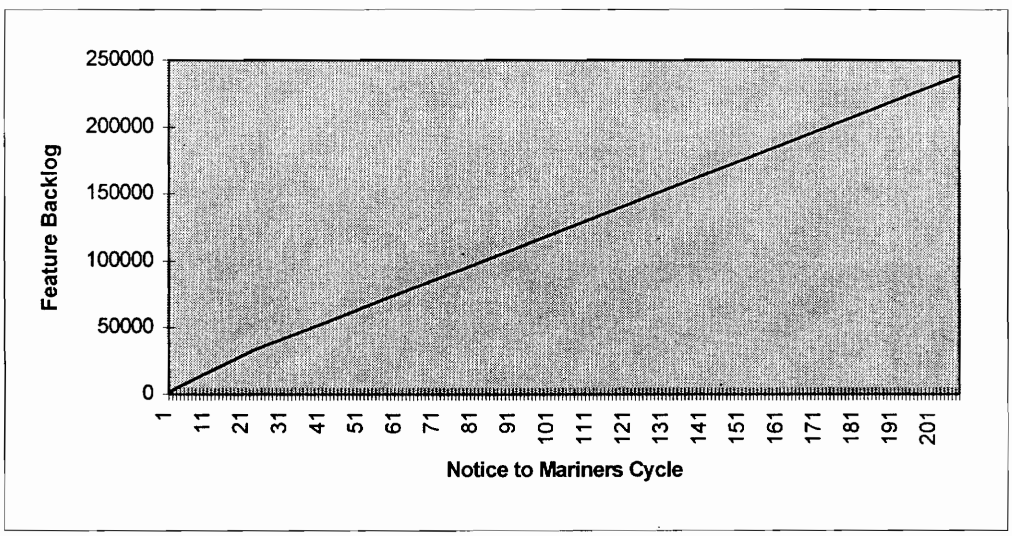

Figure 5-10. NSS Feature Backlog Based on the Contracted Solution

CHAPTER 6
OPTIONS FOR IMPROVEMENT AND IMPLEMENTATION

While reviewing the results of the learning curve models in Chapter 5, it became evident that certain changes are necessary to make the NSS work more effectively. The importance of these changes grows as budgetary and personnel constraints take a larger toll on the new system. This chapter will discuss the areas where improvements can be made to aid in a smooth transition from one production process to another.

6.1 Eliminate the Senior Review Position

The quality of the feature data produced by the Marine Navigation Department is of the utmost importance because the safety of lives and property at sea depend on it. Realizing this importance, the Marine Navigation Department has a series of quality checks built in. Before an updated feature is published in the Weekly Notice to Mariners, it goes through three sets of quality checks. This extensive quality system started long before the Notice to Mariners Process was automated.

The Heritage System performs a limited number of quality checks on each feature during each step of the production process. In addition, each employee has a copy of the Notice to Mariners Format Guide, to assist them in processing difficult updates.

The NSS will not only have more extensive quality checks built in, the majority of correction text that will be published in the NTM will be automatically generated from the feature change.

The senior reviewer position is believed to represent a quality overkill that allows analysts to become complacent in their responsibilities. The state occurs because the analyst has the knowledge that their work will be reviewed, and corrected if necessary during the extensive review process. Creating writer/checker teams, composed of a senior analyst paired with a junior analyst, could eliminate the need for the senior reviewer without impacting quality.

The impact of eliminating the senior reviewer will be significant. First, it will require a major cultural change in a population (former mariners) that traditionally resists change. In addition, if implemented while the Heritage System is the one primarily used for production, software changes will have to be made to circumvent that quality check. The software modifications would be made by an in-house programmer. Cost is therefore not a factor.

The benefits of eliminating this position can be realized immediately. The largest benefit for the Heritage System will be the time savings in processing each feature. This will virtually eliminate the need for overtime, and allow time for the employee to receive training for the NSS, without impacting production.

The elimination of this position will reduce the numbers of workstations/personnel required to achieve steady state operations to 55. In this era of budget constraints and downsizing, eliminating this position makes sense.

6.2 Reduce the Parallel Operations Windows

As was discovered in Chapter 5, the six-month parallel operation period appears to represent a large obstacle in processing the number of required features, and hence contributed to the large backlogs. Additional analysis, shortening the parallel operations window to four weeks, was conducted for each workstation scenario.

In the engineering solution, the equivalent of 63 workstations is used to calculate the NSS feature output. Shortening the parallel operations window to four weeks dramatically increases the number of features processed. More importantly, the feature backlog is drastically reduced by ending parallel operations early. Figure 6-1 shows a comparison of feature outputs produced during one-month and six-month parallel operations periods. Figure 6-2 shows a comparison of the feature backlog when conducting parallel operations as planned, and by reducing the parallel operations period to one month.

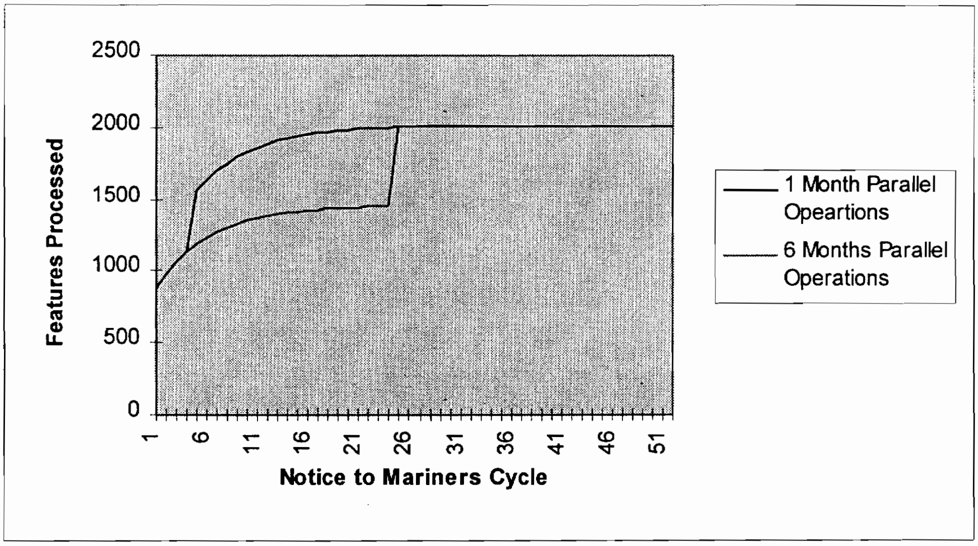

Figure 6-1. Comparison of Feature Outputs Produced During One-Month and Six-Month Parallel Operations Based on the Engineering Solution

Although reducing the parallel operations period to four weeks will have a greater output yield, learning does not occur any faster. Both learning curves approach steady state operations at week 25.

Figure 6.2 shows that the feature backlog for a one month parallel operations period will be approximately 10,000 features less than the feature backlog after six months of parallel operations.

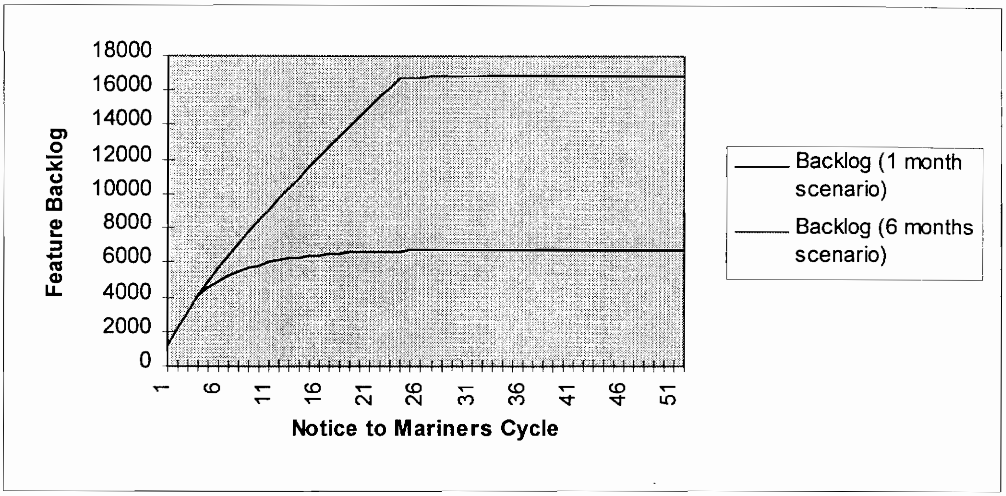

Figure 6-2. Comparison of Feature Backlog for One-Month and Six-Month Parallel Operations Based on the Engineering Solution

The space constraint solution entails the equivalent of 46 NTM Workstations (23 workstations supporting two shifts). Again, the learning curve model was employed to make a comparison of features produced and features backlogged, for one-month and six-month parallel operations. Figure 6-3 shows the comparison of features produced, and figure 6-4 shows the comparison of the features backlogged.

Although reducing parallel operations to a one-month period will increase the number of features processed during the learning period, the end result is the same as found in Chapter 5: steady state operations are never achieved.

The prognosis for the feature backlog by reducing the parallel operations window to one month isn't very good, but is still better than the feature backlog after six months of parallel operations. The one-month parallel operations realizes a reduction of more than 7,000 features over four years. Considering the length of time involved and the magnitude of the backlog, reducing the parallel operations to one month is irrelevant in this scenario.

The number of features produced using the equivalent of 30 NTM Workstations was also computed for a one month parallel operations period. The results are shown in figures 6-5 and 6-6.

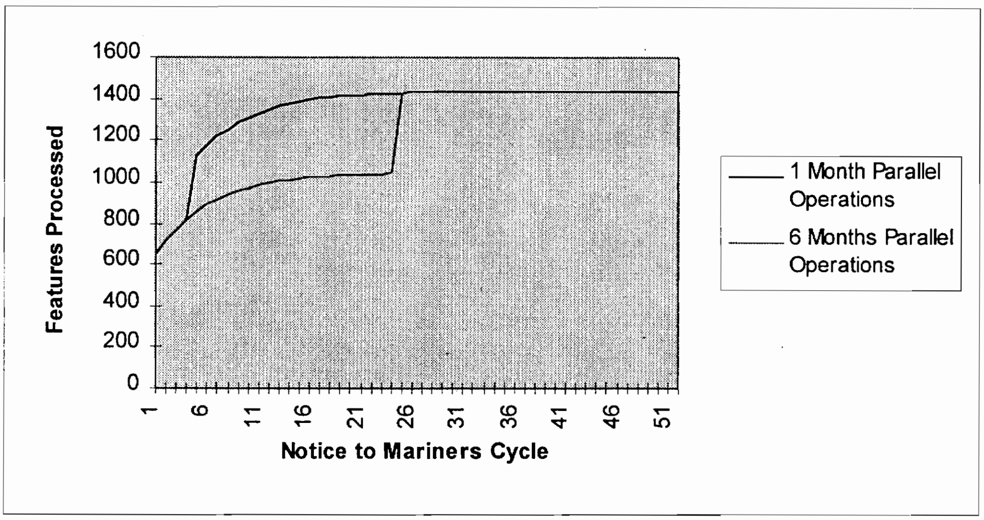

Figure 6-3. Comparison of Feature Outputs Produced During One-Month and Six-Month Parallel Operations Based on the Space Constraint Solution

Reducing parallel operations to a one month duration would prove to be fruitless in the contracted solution. The number of features processed during the learning period would show an increase over the six-month parallel operations scenario, but not a significant one. The feature backlog will vary by approximately 4,000 features over a four-week period. Considering the magnitude of the feature backlog during that period, 4,000 features is inconsequential.

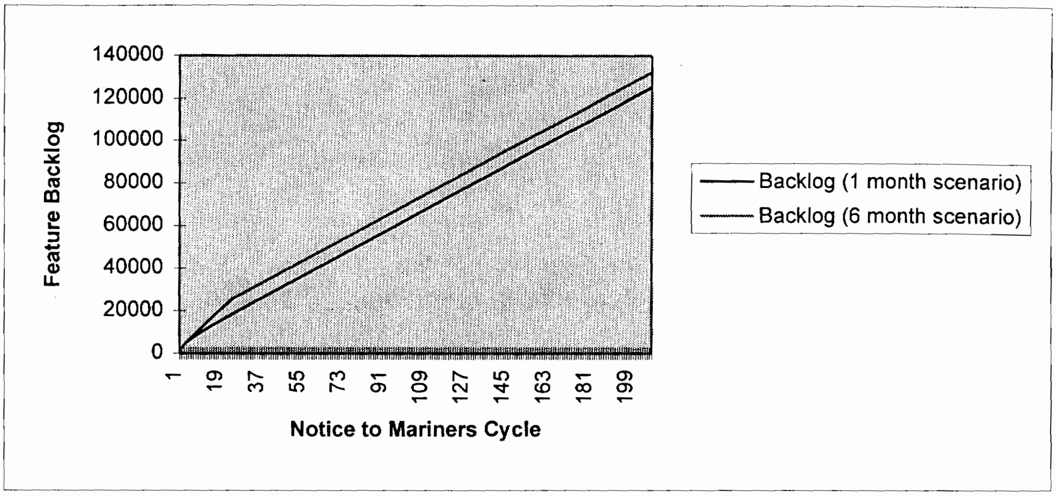

Figure 6-4. Comparison of Feature Backlog for One-Month and Six-Month Parallel Operations Based on the Space Constrained Solution

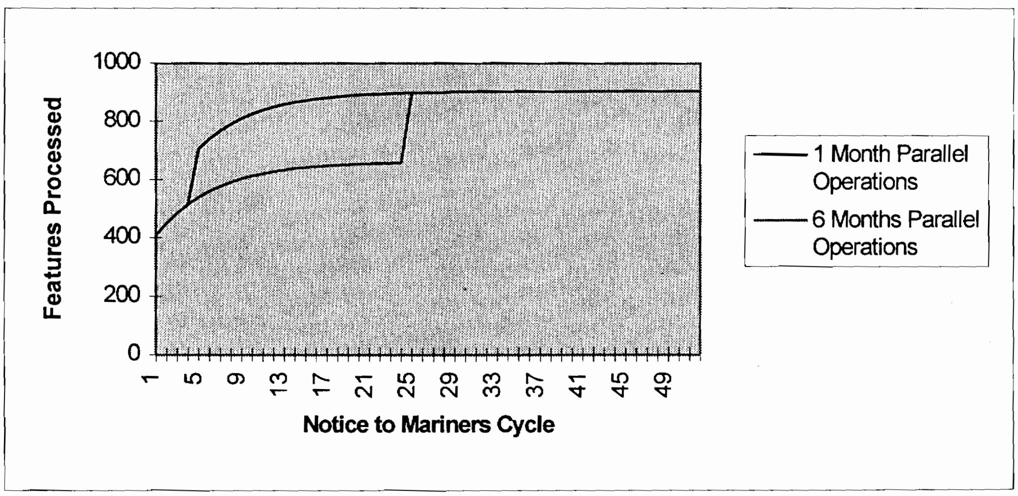

Figure 6-5. Comparison of Feature Outputs Produced During One-Month and Six-Month Parallel Operations Based on the Contracted Solution

Reducing the parallel operations to one month in duration is a good strategy if the proper number of workstations (and personnel to operate them) is in place. If the proper number of workstations is not in place, then the length of parallel operations is of little relevance in the long run.

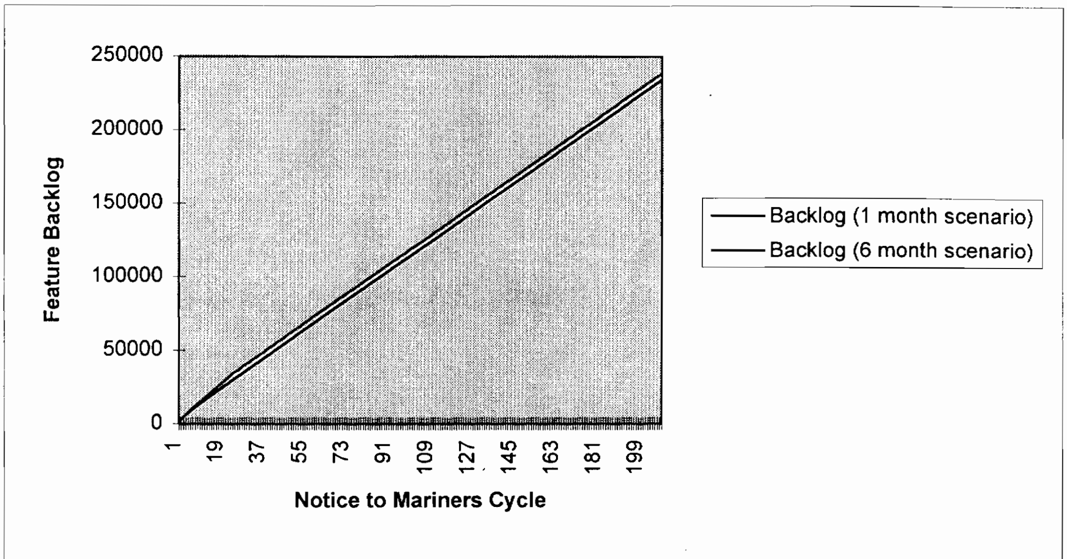

Figure 6-6. Comparison of Feature Backlog for One-Month and Six-Month Parallel Operations Based on the Contracted Solution

Reducing the parallel operations period to one month will involve significant initial cost in time. First, the system must be practically error-free when it is introduced into the production environment. This will involve a substantial investment in the time taken to test the system. Two NSS test periods have been identified (Factory Acceptance Test and Site Acceptance Test). The test must be extensive enough to check all criteria that the system will handle. A decision to implement the system into the production cycle must also be delayed until the system passes all tests.

6.3 Process Only the Features that are Currently Processed

Currently, the only features that are processed are those depicted on one or more hardcopy products, or those that will make the hardcopy product more navigationally complete. Features that are along navigable bodies of water, but where ocean-going vessels cannot travel, are disregarded. In the future, the Marine Navigation Department will be required to process all features along navigable bodies of water to support the Navigation Feature Layer of the Master Seafloor Digital Data Base.

Processing only the features that are currently processed is another option that the Marine Navigation Department must explore. With this option approximately 1,200 features per week will be updated in the NFL and on the hardcopy products. This option will require the equivalent of 49 NTM Workstations (29 writers, 15 checkers, and 5 senior reviewers).

While this option reduces the number of workstations and personnel required, the quality of the NFL is likely to suffer. On a grander scheme, with an incomplete NFL, the Master Seafloor Digital Database (MSDDB) will also be incomplete.

6.4 Operating With the Most Favorable Solution

Finding the delicate balance for the production operations of NSS, where productivity, budgetary constraints, and personnel are key issues, is difficult. Several partial solutions have been identified in the previous sections of this chapter. This section combines those partial solutions.

One approach to finding the delicate balance is to set priorities. The number one priority of the Marine Navigation Department is providing the mariner the navigational safety information required to safely make any transit. Two courses of action can be taken to ensure that this happens: (1) process only the features that are processed today; and (2) limit parallel operations to a one-month duration. By taking this course, the mariner is guaranteed to receive the critical safety information. However, the NFL will only contain these navigationally significant features, which severely limits the Agency's goal of a world wide geospatial database.

The solution to restrict parallel operations to a one month period and processing only the navigational significant features relieves the next set of system restrictions. Budgetary constraints could limit the size of the workstations pool. Equally important, hiring restrictions will make it difficult to hire the additional staff needed. This problem can be aided by the elimination of the senior review position.

Combining the solutions, 44 NTM Workstations and analysts will be required to process the features that are navigationally significant. These features will be processed by a NTM Writer and Checker, with additional automated quality checks performed by the NSS. Additionally, the NTM Editor, using a Navigation Publication Workstation, will review the text of all feature corrections.

6.5 Productivity Figures-of-Merit

While DEA and other productivity measurement systems work extremely well for evaluating production systems that have achieved steady state, they have a limited utility for measuring the efficiency of a system on the learning curve. The reason for this is that these systems compare one DMU against another and a relative efficiency is realized. By definition, production along the learning curve will require less inputs to produce the same quantity of outputs as each cycle is achieved. Hence, each cycle along the learning curve will be deemed more efficient than the previous one, until steady state is reached.

The progress of the NSS can be measured by normalizing the measured data against the learning curve model. Normalizing the raw production data is extremely important because the learning curve model is based on average inputs and outputs. Without normalization, false productivity results may be calculated.

During the initial cycles, the actual data can be compared against the theoretical learning curve model, presented in Chapter 5, to measure the system's progress. As the cycles increase, the learning curve model can be adjusted to reflect the measured rate of learning. Updating the learning curve model and normalizing the actual data for a comparison against the learning curve model should be an iterative process until steady state is realized.

Measuring the productivity of the NSS during the start-up period will allow management to evaluate the progress on a weekly basis and make changes as necessary. The effects of those changes can then be immediately realized.

CHAPTER 7
FURTHER RESEARCH NEEDS

As this research progressed, it became evident that several other uncharted avenues of research exist. While this additional research is outside the scope of this report, this chapter will discuss the following areas where additional worthwhile research is needed:

(1) Role of Overtime

(2) Learning as a Variable rate

(3) Role of Learning When Introducing a Two-shift Production Environment

7.1 Investigate the Role of Overtime

This study did not differentiate between production hours worked during regular hours and those performed on overtime. In Chapter 4, overtime was flagged as being of questionable value in contributing to productivity. Overtime played an important role in more than one third of the efficient Heritage System NTM Cycles, and five of the 18 inefficient cycles.

Depending on the number of workstations procured, and the number of personnel assigned, overtime may become a necessity in the NSS Production Environment. It would certainly behoove the Marine Navigation Department to have an intimate knowledge of the attitudinal effects of overtime on productivity.

Key questions that require answers to the question of overtime's effect on productivity are: (1) How does efficiency realized during overtime compare with efficiency during regular hours, over long periods of time?; (2) How do extended periods of overtime affect efficiency during regular hours?; and, (3) At what point does overtime become a detriment to efficiency?

7.2 Research the Learning Rate as a Variable

This report assumed a constant learning rate of 80%. However, due to different skill levels of personnel and other factors (such as time away from the job), the learning rate may be better expressed as a variable. Carlson (1987) suggests that learning takes place at a variable rate.

Initially there may be apprehension to working with the new equipment, which may cause learning to occur at a slower rate than anticipated. As the analyst becomes more familiar with the equipment, learning starts to take place faster. Finally, as the level of production knowledge approaches its maximum, learning again takes place at a slower rate. Figure 7-1 (adopted from Carlson, 1987) illustrates the variable stages of the learning curve versus the constant learning curve.

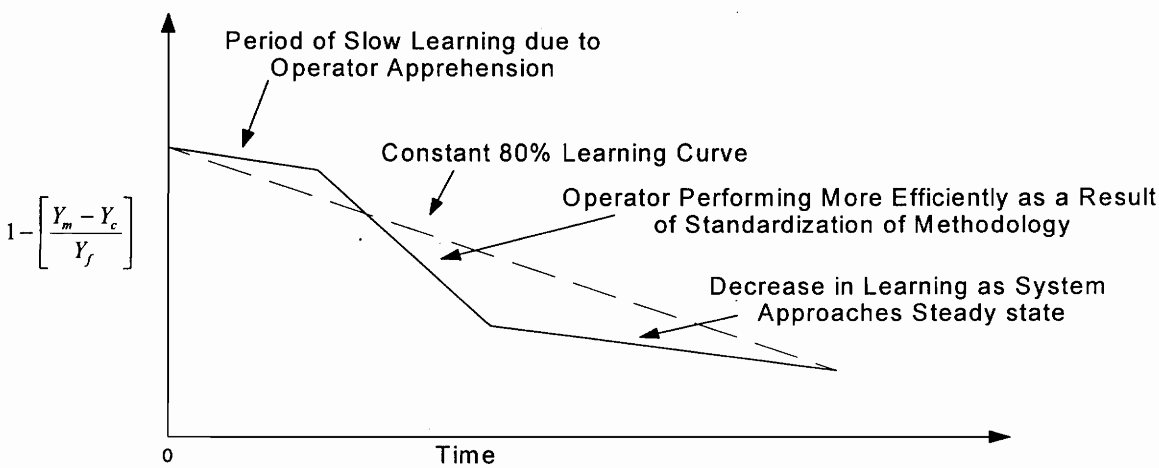

Figure 7-1. Variable Stages of the Learning Curve

The variable learning curve was impractical for use in this report because of the absence of real data. However, the introduction of the NSS presents the opportunity to study this phenomenon in great detail. By evaluating each individual's rate of learning during each day of the cycle, insight can be gained into ways that time away from work and familiarity of the equipment affect the learning rate. Each individual learning rate can then be averaged in the organizations learning rate for each cycle. This averaged data can be used in similar applications for different systems to more accurately predict the start-up impact.

7.3 Study the Role of Learning After Introducing a Two-Shift Production Environment

A limited amount of research has been conducted by Epple, Argote, and Murphy (1996) regarding the transfer of knowledge between organizations and shifts. The premise of their research is that knowledge gained by one shift is not necessarily realized by additional shifts.

Again, with the introduction of the NSS, this concept is ripe for research. Potentially, the Marine Navigation Department will be required to convert from a one-shift operation to a two-shift operation. Collecting data from both shifts could lead to some definite conclusions about the learning theories that Epple, Argote, and Murphy (1996) present. The results of this further investigation could serve as a baseline for other organizations within the Agency that are experiencing similar changes.

CHAPTER 8
CONCLUSION

The purpose of this research was to study the impacts to production caused by the implementation of new technology. Before any conclusions could be reached about future productivity, the current system's efficiency had to be studied.

The research has found that the current organization is relatively efficient. However, changes in the production process must be made prior to transitioning to the NSS. These changes will not initially be easy because of the population's resistance to cultural change.

While many changes are needed, the largest cultural change may be the elimination of the Senior Reviewer. This change, although apparently necessary, may cause productivity, and perhaps quality, to suffer for a period of time. Although this change will be difficult, the best time to make this change is now - well before the NSS is implemented. Waiting too long to change could potentially have a dramatic effect on the learning rate associated with the NSS because of attitudinal factors.

Another change that must be realized is the possibility of two shifts. There is really no way to prepare for this dramatic change, except to maintain open communication between management and the workforce. Like the elimination of the Senior Reviewer, the attitudinal effect must be minimized.

The introduction of the NFL will also bring massive changes to the production process. Employee education is the key for making this a smooth transition. Familiarity with the software and hardware must be taught at the proper time (and at the appropriate length) to ensure that each employee is ready to start production on the day that the system is fully operational. Highly effective training can help to increase the learning rate and hence increase production.

The factor that has the potential of having the largest impact on the new system's production capability is the system design. Ensuring that the system will fully meet the department's operational needs when implemented is paramount in this effort. This can be accomplished by establishing an extensive and stringent test plan, by implementing the system into production only after the "bugs" are worked out, and by providing the proper amount of workstations and personnel to accomplish the assigned tasks. The time for working off discrepancies is before the system is placed into production. Failure to do this will undoubtedly result in a slower learning rate and larger feature backlog than originally expected.

The NSS has the potential to revolutionize the way that the weekly Notice to Mariners is compiled. However, to be successful, sound concurrent engineering practices must be followed. Failure to look at the entire system life-cycle early will possibly cause major problems later. Preparation for the NSS is the key to its success.

BIBLIOGRAPHY

Blanchard, B. S., & Fabrycky, W. J., (1990). Systems Engineering and Analysis (2nd ed.). Englewood Cliffs, N. J.: Prentice-Hall.

Boussofiane, A., Dyson, R. G., & Thanassoulis, E., (1991). Applied Data Envelopment Analysis. European Journal of Operational Research, 52, 1-15.

Burden, T. H. A. (1993). Combined Company Profiling. In D. R. Towill & J. E. Cherrington (Eds.), A Systems Approach to AMT Deployment (pp. 35-55). London: Springer-Verlag.

Cardinali, R. (1994) Productivity Improvements Through the Use of Graphic User Interface. Industrial Management & Data Systems, 94 (4), 3-7.

Carlson, J. G., (1987). Improvement Curve Analysis of Changeovers in JIT Environment. Engineering Costs and Publication Economics, 12, 259-266.

Cherrington, J. E. & Coward, D. G. (1993). General Methodology for Smoothing the Introduction of AMT. In D. R. Towill & J. E. Cherrington (Eds.), A Systems Approach to AMT Deployment (pp. 205-219). London: Springer-Verlag.

Coward, D. G. & Cherrington, J. E. (1993). Case Studies Based on Three AMT Users. In D. R. Towill & J. E. Cherrington (Eds.), A Systems Approach to AMT Deployment (pp. 141-174). London: Springer-Verlag.

Coward, D. G. and Schott, E. (1993). Organizational Factors Affecting the Introduction and Efficiency of AMT Operation in Small Firms. In D. R. Towill & J. E.

Cherrington (Eds.), A Systems Approach to AMT Deployment (pp. 19-34). London: Springer-Verlag

Davies, A. and Lewis, H. (1993). Dynamics of AMT Capacity Planning. In D. R. Towill & J. E. Cherrington (Eds.), A Systems Approach to AMT Deployment (pp. 91-108). London: Springer-Verlag.

Defense Mapping Agency. (May, 1995). Navigation Safety System Requirements Document (NSSRD). Bethesda, MD.

Defense Systems Management College. (1989). Managing Quality and Productivity In Aerospace and Defense. Washington, DC: U.S. Government Printing Office.

Defense Systems Management College. (1989). Risk Management Concepts and Guidance. Washington, DC: U.S. Government Printing Office.

Defense Systems Management College. (1990). Systems Engineering Management Guide. Washington, DC: U.S. Government Printing Office.

Dileepan, P., & Ettkin, L. P. (1988). Learning: The Missing Ingredient in Production Spreadsheet Models. Production and Inventory Management Journal, Third Quarter, 32-35.

Drew, D. R., (1994). Systems Dynamics: Modeling and Applications. Unpublished manuscript, Virginia Polytechnic and State University at Blacksburg.

Epple, D., Argote, L., & Murphy, K., (1996, January-February). An Empirical Investigation of the Microstructure of Knowledge Acquisition and Transfer Through Learning By Doing. Operation Research, 44(1), 77-86.

Fauber, C. E. (1989). Use of Improvement (Learning) Curves to Predict Learning Costs. Production and Inventory Management Journal, 30(3), 57-60.

Hillier, F. S., & Lieberman, G. J., Introduction to Operations Research. (6th ed.). New York: McGraw-Hill.

Juran, J. M., & Gryna, F. M., (1993). Quality Planning and Analysis. (3rd ed.) . New York: McGraw-Hill.

Naim, M. M. & Hoh, S. M. (1993). Use of Discrete Event Simulation in Evaluating FMS Performance. In D. R. Towill & J. E. Cherrington (Eds.), A Systems Approach to AMT Deployment (pp. 109-123). London: Springer-Verlag.

Ott, R. L., (1993). An Introduction to Statistical Methods and Data Analysis. (4th ed.). Belmont, CA: Wadsworth.

Pine, D. J., (1996, March). Project Cost Estimating. Paper presented in Program and Project Management, Course ISE-5984, Virginia Polytechnic Institute and State University, Falls Church, VA.

Roll, Y., Cook, W. D., & Golany, B. (1991). Controlling Factor Weights in Data Envelopment Analysis. IIE Transactions, 23(1), 2-9.

Sink, D.S. (1985). Productivity Management: Planning, Measurement and Evaluation, Control and Improvement. New York: John Wiley.

Sink, D.S. and Tuttle, T.C. (1989). Planning and Measurement in Your Organization of the Future. Norcross, GA: Industrial Engineering and Management Press.

Sumanth, David J. (1984) Productivity Engineering and Management. New York: McGraw-Hill Book Company.

Tanner, J. P., (1985). The Learning Curve. Production Engineering, 32 (5), 72-78.

Towill, D. R., (1985). The Use of Learning Curve Models for Prediction of Batch Production Performance. International Journal of Operations & Production Management, 5 (2), 13-24.

Towill, D. R., (1990). Forecasting Learning Curves. International Journal of Forecasting, 6, 25-38.

Towill, D. R. and Cherrington, J. E. (1993). Learning Curve Models. In D. R. Towill and J. E. Cherrington (Eds.), A Systems Approach to AMT Deployment (pp. 57-75). London: Springer-Verlag.

Towill, D. R. and Naim, M. M.. (1993). Forecasting via Learning Curves. In D. R. Towill and J. E. Cherrington (Eds.), A Systems Approach to AMT Deployment, (pp. 77-90). London: Springer-Verlag.

Triantis, K. P., (1995, Spring Semester). Performance and Productivity Measurement and Evaluation. Class Notes presented in Course ISE-5144, Virginia Polytechnic Institute and State University, Fall Church, VA.

Warwick DEA Software, (1989), c/o Thanassoulis, E., Warwick Business School, Warwick University, Coventry, UK.

Appendix A
LITERATURE REVIEW

The purpose of this Appendix is to review the literature that served as primary sources of methodology for this report.

A.1 Applied Data Envelopment Analysis (1991), by A. Boussofiane, R.G. Dyson and E. Thanassoulis

DEA was selected for evaluating the Heritage System productivity because of its ability to assess an organization's relative efficiency when there are multiple inputs and outputs. In this article, the authors thoroughly explain the DEA model, and suggest methods to extract specific information from it.

The selection of inputs and outputs is an important aspect of this article. The DEA model allows for the measurement of every possible input and output, including difficult factors such as environmental influences. This section of the article is one of the guiding sources during the lengthy input and output selection phase.

An understanding of the model outputs was also gleaned from this article. Peer groups and lambda values, target setting, and virtual inputs and outputs are the strategies used evaluating the Heritage System. For each of these strategies, the authors convey methods to identify inefficient units.

Peer groups are used by DEA to identify corresponding efficient units for each inefficient unit. The analyst can then study the practices used in the efficient units and those of inefficient units. Changes can then be implemented to improve the efficiency of the inefficient unit.

The authors describe ways to improve the efficiency of inefficient units by target setting. The DEA model yields targets which the inefficient units can use as a benchmark to monitor their performance while improving. The shortfall of this option is targets are not set for efficient units, thus making it difficult to set realistic goals for improving units that are already operating well. The authors did not address this shortcoming.

The analysis of virtual inputs and outputs was also presented in the literature. This information proved to be useful because virtual inputs and outputs convey information on the importance a unit attaches to a particular input or output to attain its maximum efficiency ratios. This information allowed the determination of why units were efficient. Comparison between relatively efficient units can increase the efficiency of those units further.

A.2 Time Constant Learning Curve Literature

Technical articles written by D.R. Towill provided the framework for the learning curve research in this study. Each article has a certain degree of commonalty and uniqueness. The commonalty will be reviewed generally, and the uniqueness will be discussed by individual articles.

A.2.1 Commonalty Among Towill's Writings

Each of Towill's time constant learning curve articles begin by discussing the model. While each presents the basic model, each article provides needed ingredients for effectively developing and implementing the time constant learning curve model in Chapter 5. The one element of the learning curve model that was a source of great confusion is the parameter τ. "The Use of Learning Curve Models for Prediction of Batch Production Performance" is the only time constant learning curve model article that presented the calculation of τ; however, the time constant calculation was covered adequately in an article written by Towill and Naim.

Towill's research has been in predicting the system productivity after a period when initial raw data can be collected (in "Forecasting Learning Curves," Towill recommends collecting data "only after 20 consecutive tasks have been performed without fumbles."). This is a distinct contrast to the approach taken in this research, where only projected data is available.

Towill's model has proven useful for evaluating a firm's productivity progress after the implementation of new technology; however, only using real data prevents system changes in the design phase. When applying a life-cycle approach to a system, the learning curve should be evaluated with theoretical data during the design phase, and modified from data during the start-up phase.

A.2.2 Learning Curve Models (1993), by D.R. Towill and J.E. Cherrington

In addition to the presentation of the time constant learning curve model, this article covered several paradigms of lost production in system start-up. Six paradigms were presented and considered when developing the learning curve model in Chapter 5.

"The paradigm of planned maintenance," the "paradigm of lost energy," and the "paradigm of maximum productivity," were considered first. The paradigm of lost energy" describes the system's lost productivity due to the equipment not being used for its maximum time. This problem was first addressed in Appendix B, when calculating the number of workstations required for the engineering. The NSS solution accounts for lost productivity by introducing a factor that offsets lost time due to system inactivity.

The "paradigm of planned maintenance" states that while planned maintenance consumes production time, it pays dividends in the long run by helping to prevent major system failures. This paradigm was considered, and while not specifically accounted for in the model, can be accomplished during the times of inactivity.

The "paradigm of maximum productivity" was considered but was not formally included in the modeling efforts. This paradigm states that the theoretical maximum productivity rate will never be achieved, and is more dependent on managerial policies than on technology. Although not modeled, it is understood that management will play a large role in the successful implementation of the system, as stated in Chapter 6.

The learning curve is based on the "paradigm of increasing productivity." The phenomenon that the rate of increase in productivity will decrease with time is the premise used in this research.

The "paradigm of daily variability" was considered. This paradigm states that a daily variability exists and can disrupt normal production and skew the results of the learning curve. The model developed in this report does not use raw data, and it would therefore would be difficult to predict the cycle variability.

The last paradigm examined is the "paradigm of lights off." This paradigm falls foursquare with the results found in this research, by stating that a major loss of productivity can occur due to shortages of equipment.

A.2.3 Forecasting Learning Curves (1990), by D.R. Towill

"Forecasting Learning Curves" was important to this research because several learning curve models were presented. Towill writes "it is preferable to opt for the simplest adequate model" when selecting a learning curve model. Other models were tested during this research, and the time constant learning curve model proved to be the best suited for this application. This article cites Hackett (1983), who performed a detailed comparison of 14 alternative learning curve models.

Towill also confirms an initial hypothesis, of this research, that learning can be affected by three factors: (1) technological; (2) organizational; (3) attitudinal. These three factors were considered.

This article also presents and explains several graphical examples of start-up operations. The interpretation of the results applied in Chapter 5, where the NSS Learning Curve Solution resembled three of the conditions.

A.2.4 Forecasting via Learning Curves (1993), by D.R. Towill and M.M. Naim

This article proved to be important to this research because it correlated the rate of learning to the time constant (τ). Other sources that explore the learning curve suggest that an 80 percent learning rate is the norm. Without real data this learning rate was adopted.

The knowledge of how to transform the learning rate to the time constant was gleaned from this article, and was the basis for some of the information presented in Chapter 5.

More advanced learning curve models were also presented. However, after careful consideration, these models were dismissed as being applicable for the NSS Study because they require raw data to be effective.

APPENDIX B
NSS WORKSTATION MODEL

The engineering model was developed through a joint Government/NSS contractor effort. This model solves the NSS workstation problem for steady state operations through the use of average feature and labor hours inputs.

B.1 Employee Productive Time

This portion of the model is used to determine the total productive time for each employee per year.

The Government defines the work year as 2,088 hours. Subtracting the time used for annual, sick, and administrative (snow days, federal holidays, etc.) leave yields the Government's definition of a man-year. The man-year is defined as 1,607 hours.

Assuming that each employee spends 6.2 hours per day in production and 1.8 hours per day performing administrative functions (i.e. non-production-related paperwork, training, security briefs, etc.), the total productive time for each employee can be calculated as:

$$EPT = (MY)(PHR) \qquad \text{(B.1)}$$

$$EPT = (1)(6.2 / 8)$$

$$EPT = 1{,}245.4 \, hours / year$$

where:

EPT is employee productive time per year

MY is one man-year

PHR is the productive hours per day ratio

B.2 Production Processing Time

This portion of the model considers the total number of inputs and associated processing time. The processing times are based on the expected technological limit of the NSS software. To calculate the processing time for each position, the following equations are used:

$$T_{sm} = \sum I_{sm}(pt_{sm}) \quad \text{(B.2)}$$

$$T_{ntmw} = \sum I_{ntmw}(pt_{ntmw}) \quad \text{(B.3)}$$

$$T_{ntmc} = \sum I_{ntmc}(pt_{ntmc}) \quad \text{(B.3)}$$

$$T_{ntmsr} = \sum I_{ntmsr}(pt_{ntmsr}) \quad \text{(B.4)}$$

$$T_{ntme} = \sum I_{ntme}(pt_{ntme}) \quad \text{(B.5)}$$

where:

T_{xxx} is total processing time

I_{xxx} is inputs for given position

pt_{xxxx} is average processing time for each feature

X_{sm} is the source manager

X_{ntmw} is the Notice to Mariners Writer

X_{ntmc} is the Notice to Mariners Checker

X_{ntmsr} is the Notice to Mariners Senior Reviewer

X_{ntme} is the Notice to Mariners Editor.

The next step is to calculate the product processing time for each type of workstation. This determination can be best expressed by:

$$T_{ntm} = T_{ntmw} + T_{ntmc} + T_{ntmsr} \quad \text{(B.6)}$$

$$T_{np} = T_{ntme} \quad \text{(B.7)}$$

$$T_s = T_{\sup} + T_{sm} \quad \text{(B.8)}$$

where:

T_{ntm} is the total processing time for the NTM workstation

T_{np} is the total processing time for the Navigation Publications workstation

T_s is the total processing time for the support workstation

$T_{\sup}$ is the constant workstation time needed by system administrators and programmers, and department managers.

B.3 Workstation Determination

This portion of the model is used to determine the number of workstations needed to accomplish the Marine Navigation Department's assigned tasks.

Now that the product processing time and workstation productive time are known, the number of each workstations can be calculated by:

$$WS_{ntm} = T_{ntm} / EPT \quad \text{(B.9)}$$

$$WS_{np} = T_{np} / EPT \quad \text{(B.10)}$$

$$WS_s = T_s / EPT \quad \text{(B.11)}$$

where:

WS_{xxx} is the number of each type of workstation

APPENDIX C
HERITAGE SYSTEM DATA

This Appendix contains the following Heritage System Data collected from the Marine Navigation Department.

Table C-1 Heritage System Consolidated Production Data

Table C-2 Foreign NTM Data by Feature

Table C-3 Foreign NTM Data by Notice Number

Table C-4 U.S. Coast Guard Local NTM Feature Data

Table C-5 Labor Data for Heritage System

Table C-1. Heritage System Production Data[1]

Dates	NTM #	-FNTM-Text	-Foreign Charts	-USCG-LNTM	-USCG-LL	-NOS Data	-USACE	-Ship Reports
12/14-12/20	1	614	75	31	78	3	0	5
12/21-12/27	2	303	63	158	62	6	0	0
12/28-1/3	3	861	215	94	48	1	0	8
1/4-1/10	4	920	0	104	17	9	0	2
1/11-1/17	5	299	52	26	49	1	0	2
1/18-1/24	6	426	49	27	73	2	0	1
1/25-1/31	7	586	26	196	39	1	0	4
2/1-2/7	8	430	156	206	39	8	0	3
2/8-2/14	9	747	17	113	30	4	27	5
2/15-2/21	10	731	77	0	29	18	0	5
2/22-2/28	11	485	85	293	29	7	0	7
2/29-3/6	12	747	105	123	17	0	0	9
3/7-3/13	13	519	148	66	16	2	0	8
3/14-3/20	14	600	152	81	154	0	0	3
3/21-3/27	15	663	79	102	113	27	0	9
3/28-4/3	16	522	112	167	66	12	0	5
4/4-4/10	17	678	154	103	44	19	0	2
4/11-4/17	18	379	125	149	132	1	38	10
4/18-4/24	19	874	17	50	48	3	0	12
4/25-5/1	20	751	98	0	52	3	0	4
5/2-5/8	21	389	61	163	57	3	0	1
5/9-5/15	22	616	94	137	88	0	0	5
5/16-5/22	23	603	115	24	0	0	0	2
5/23-5/29	24	803	107	70	176	4	0	3
5/30-6/5	25	523	126	123	66	8	0	4
6/6-6/12	26	637	57	235	180	6	0	8
6/13-6-19	27	626	124	199	235	3	19	2
6/20-6/26	28	533	46	204	97	1	0	2
6/27-7/3	29	685	74	147	88	0	0	2
7/4-7/10	30	399	0	93	122	3	0	4
7/11-7/17	31	582	216	177	181	0	0	5
7/18-7/24	32	664	32	11	45	7	0	4
7/25-7/31	33	343	35	93	77	17	0	1
8/1-8/7	34	884	64	232	32	1	0	6
8/8-8/14	35	739	98	145	36	2	0	6
8/15-8/21	36	581	20	143	199	9	23	6
8/22-8/28	37	533	189	101	58	2	0	10
8/29-9/4	38	539	204	71	45	14	0	6
9/5-9/11	39	459	111	148	30	1	0	5
9/12-9/18	40	706	200	76	268	3	0	2
9/19-9/25	41	230	162	77	37	10	0	2
9/26-10/2	42	500	153	61	9	6	25	5
10/3-10/9	43	615	198	70	73	4	0	0
10/10-10/16	44	674	132	108	44	6	0	3
10/17-10/23	45	567	110	145	92	8	11	3
10/24-10/30	46	476	48	135	137	12	0	0
10/31-11/6	47	418	76	219	9	4	0	1
11/7-11/13	48	434	128	132	24	2	0	2
11/14-11/20	49	728	164	186	149	2	0	4
11/21-11/27	50	474	96	19	28	0	0	4
11/28-12/4	51	463	158	111	41	4	0	4
12/5-12/11	52	771	27	98	26	1	33	10
Totals		30329	5230	6042	3884	270	176	226

[1] A "-" indicates the variable is an input, and a "+" indicates that the variable is an output.

Table C-1. Heritage System Production Data (continued)

NTM #	-IMO Data	-Prod. Hrs	-Overhead	-Workstations	-Chart NTM	+Chart Features	+LL Featur
1	0	778.2	608.8	27	210	1082	86
2	0	537.6	825.6	27	111	445	54
3	0	462	896.4	26.325	177	905	60
4	0	299.4	1093.6	27	119	660	131
5	0	949.8	398.2	27	164	878	69
6	0	1055.4	301.8	21.6	171	1012	120
7	0	1038	413.6	24.3	219	1288	254
8	0	960	292.2	27	255	1124	140
9	0	1024.2	417	27	184	1231	62
10	0	879	572.8	24.3	179	1137	114
11	0	1076.4	321	27	250	1163	250
12	0	1018.4	368.4	27	241	1291	63
13	0	913.6	420.8	25.988	249	990	104
14	0	976.6	433.4	26.325	216	1023	44
15	0	1107.6	370.6	27	257	1252	87
16	0	1054.8	300.2	27	282	1457	270
17	0	924	295.6	27	298	1570	146
18	0	937.2	377.2	25.65	233	1228	162
19	0	937.2	400.8	24.795	185	751	71
20	0	787.2	607.4	25.65	155	922	70
21	0	982.8	344.6	25.313	187	893	82
22	0	979.2	333.6	25.65	212	989	105
23	0	969.6	356.6	27	233	1101	102
24	0	561	675.4	27	141	734	77
25	0	1036.8	335.3	27	190	934	82
26	0	976.4	310.4	27	279	1477	116
27	0	1007.4	299.2	27	266	1465	542
28	0	984.6	313.2	27	208	918	73
29	0	1032	324	27	217	955	115
30	0	756.6	511.6	27	192	949	113
31	0	975.2	380.8	27	215	1002	159
32	0	930	360	27	174	988	69
33	0	977.4	369.8	25.785	210	1109	350
34	0	898.8	437	27	248	1214	76
35	0	963.6	346.2	27	173	889	47
36	0	849.6	504.9	27	257	1109	65
37	0	1015.2	333.3	27	218	1081	81
38	0	730.8	573.2	27	233	1196	60
39	0	1030.2	365.6	27	156	786	74
40	0	1023	294.9	27	248	1449	88
41	0	1018.2	371.2	27	141	815	55
42	0	995.4	361.2	27	318	1483	135
43	0	999	394.6	27	141	875	79
44	0	774	602.9	27	197	1082	103
45	0	1000.8	374.6	27	228	992	200
46	0	1000.2	372.5	27	206	978	98
47	0	926.4	355.3	27	236	1324	96
48	0	795	573.9	27	203	1182	129
49	0	994.8	339.6	27	234	1249	101
50	0	1014	271.6	27	262	1263	161
51	0	600	658.2	27	157	838	75
52	0	957	341.4	23.963	250	1360	141
	0	47471.6	22502	1378.644	10985	56088	6206

Table C-2 Foreign NTM Data by Feature

	12/14-12/20	12/21-12/27	12/28-1/3	1/4-1/10	1/11-1/17	1/18-1/24	1/25-1/31	2/1-2/7
	1	2	3	4	5	6	7	8
COUNTRY								
*Algeria		19					44	16
*Argentina	44				16		24	
Australia	20	11		30		10	12	
Bahrain				42			28	82
*Belgium	25				13			
Brazil	24					56	28	
British Admiralty	56	62	65		103	51	44	59
Canada			152	171				
Chile	45				21	24	15	
China						53		0
*Colombia				28				
Crotia	2					0		17
*Cuba							36	
*Denmark	22	26	18	21	25		17	68
*Equador								
Eqypt								
Estonia						2		
*Finland			72					
*France	33		84	25		21		
French Polynesia						4	24	
*Germany			107	105				
*Greece			25					
Hong Kong	8						3	2
Iceland	28						13	
India								
Indonesia				103				
Israel								
*Italy			113		27			
Japan	78		34	38		27	72	41
South Korea						44	21	
North Korea								
*Latvia			21	18			20	26
Malaysia								
Royal Malaysia			1					
*Mexico	6							
Mynamar		20			21		18	
*Netherlands	16		32		34			14
New Zealand		10			7		3	5
Norway		21		20		18		
Pakistan		1		3		2	2	
Paraguay		17					20	
*Peru							45	
Phillippines								40
*Poland		42		44	28			
*Portugal				12				
Romania	16							
Russia	52			55				
St. Lucia								
Singapore		16		24				
South Africa						13		
*Spain	50		52	107		24	51	50
*Sweden	22	18	20	47		15	37	
Taiwan	36	24	47			62		
Thailand								
*Tunisia	18			21				
*Turkey	13		18	6	4		9	10
*Uruguay		16						
*Venezuala								
Totals	614	303	861	920	299	426	586	430

Table C-2 Foreign NTM Data by Feature (continued)

	2/8-2/14	2/15-2/21	2/22-2/28	2/29-3/6	3/7-3/13	3/14-3/20	3/21-3/27	3/28-4/3
	9	10	11	12	13	14	15	16
COUNTRY								
*Algeria		20		18	17			
*Argentina								
Australia	15	20	25	21	11	13	12	10
Bahrain	35	33	60			92		
*Belgium		2		67				
Brazil				20				42
British Admiralty	30	58	76	85	54	57	73	42
Canada	96			106				
Chile	9			24			46	12
China	25		26			47		
*Colombia					36			
Crotia						10		
*Cuba								
*Denmark	24	22	20		37		29	32
*Equador					17			
Eqypt								
Estonia		16						
*Finland				78	65	74		
*France		19	17	43	20	17	26	21
French Polynesia			5					
*Germany	65	116	35		26	64	38	26
*Greece					52			21
Hong Kong		7				6		
Iceland				42				
India	108	46					43	3,4
Indonesia		124						39
Israel								
*Italy		18		7		13	14	
Japan	36	24	35	38	39		88	
South Korea	16	25		21	13		20	19
North Korea								
*Latvia	22			17	12			35
Malaysia	2					1		
Royal Malaysia								
*Mexico		8				7		
Mynamar					21		25	
*Netherlands	38	16	17		15	29	20	18
New Zealand		11	6	5			17	4
Norway	22	20			24		30	24
Pakistan	2		3			2		
Paraguay			19				22	
*Peru								
Phillippines								
*Poland	14		12	25	13	32	28	
*Portugal	6			13				
Romania				42		12		
Russia								27
St. Lucia						1		
Singapore		20					25	
South Africa		15					10	
*Spain	46	48	45	47		39	90	45
*Sweden	21		24		28	60		20
Taiwan	37		60	24		18		62
Thailand								
*Tunisia	60	15			19			23
*Turkey		10		4		6	7	
*Uruguay	18	17						
*Venezuala		1						
Totals	747	731	485	747	519	600	663	522

Table C-2 Foreign NTM Data by Feature (continued)

	4/4-4/10	4/11-4/17	4/18-4/24	4/25-5/1	5/2-5/8	5/9-5/15	5/16-5/22	5/23-5/29
	17	**18**	**19**	**20**	**21**	**22**	**23**	**24**
COUNTRY								
*Algeria				45			20	
*Argentina			85	17			48	18
Australia	20		24				39	8
Bahrain								126
*Belgium	25	32	15	18			26	
Brazil	48		24	17		28		11
British Admiralty	85	74	72	65	67	55	57	56
Canada			159			125		
Chile				15				48
China	16			10				5
*Colombia				5				
Crotia	17							
*Cuba	38							
*Denmark	24	20	60	54	23	16	18	
*Equador							33	
Eqypt								
Estonia			21				10	
*Finland				92	26			
*France	14		75		54	40		
French Polynesia		17						
*Germany		32	35			98	67	31
*Greece					56			
Hong Kong	4			3			5	
Iceland								
India				38				
Indonesia				41				
Israel								
*Italy	20			12		19		17
Japan	84		87	42	26	34	36	21
South Korea	27		25		13	20		24
North Korea								80
*Latvia		40			18		19	
Malaysia			1					
Royal Malaysia								
*Mexico		12				6		
Mynamar			20			21	18	
*Netherlands		33		31		14	39	
New Zealand		9	5	8		5	10	
Norway			15			17		
Pakistan	2	1	2	2				2
Paraguay			18					40
*Peru	37							
Phillippines		56						42
*Poland	45		10	9	27		62	
*Portugal	21		10			4		
Romania			20					21
Russia				54		49		78
St. Lucia								
Singapore	20							18
South Africa		9						
*Spain	47	32	24	59	29	45	48	97
*Sweden	17	12	19	20	24	20	24	23
Taiwan			48	53			24	37
Thailand								
*Tunisia	19			29	20			
*Turkey	24				6			
*Uruguay	11			12				
*Venezuala	13							
Totals	678	379	874	751	389	616	603	803

Table C-2 Foreign NTM Data by Feature (continued)

	5/30-6/5	6/6-6/12	6/13-6/19	6/20-6/26	6/27-7/3	7/4-7/10	7/11-7/17	7/18-7/24
	25	26	27	28	29	30	31	32
COUNTRY								
*Algeria		20		21		36		
*Argentina			19	20			20	
Australia	11	29	22		12	15	15	14
Bahrain		71	45					90
*Belgium	20	21				24		
Brazil					46		15	
British Admiralty	64	52	39	106	54	51	67	52
Canada			133				122	
Chile				14	19		20	
China		29		43				28
*Colombia				41			23	
Crotia		7						
*Cuba		21					46	
*Denmark	24	21	20	46	25	17		39
*Equador			6					
Eqypt			1					
Estonia								4
*Finland		108	36		54			35
*France	67		20		40	42		47
French Polynesia						21	8	
*Germany		37	63		32	25		57
*Greece					25			
Hong Kong	7					3		8
Iceland				40				47
India		37						
Indonesia		44						
Israel								
*Italy	20			12	21		13	
Japan	35	56	25	36	38	42	34	35
South Korea	13		49		25	20		24
North Korea								
*Latvia			24		28			
Malaysia								
Royal Malaysia				1				
*Mexico			3				6	
Mynamar							39	
*Netherlands	12	17	21	20	12	14	16	33
New Zealand	10		4	12	10	6	5	
Norway	56	24		21		22		20
Pakistan		3		1	4		2	
Paraguay								
*Peru	20				26			
Phillippines								
*Poland			14	15	17		12	40
*Portugal	8					12		6
Romania				25				14
Russia								
St. Lucia	1							
Singapore			19				22	
South Africa				26			13	
*Spain	48		46		138		47	48
*Sweden	28	40		21	25	15	21	23
Taiwan				12			16	
Thailand								
*Tunisia	43		17			20		
*Turkey	21				6			
*Uruguay					28			
*Venezuala	15					14		
Totals	523	637	626	533	685	399	582	664

Table C-2 Foreign NTM Data by Feature (continued)

	7/25-7/31	8/1-8/7	8/8-8/14	8/15-8/21	8/22-8/28	8/29-9/4	9/5-9/11	9/12-9/18
	33	34	35	36	37	38	39	40
COUNTRY								
*Algeria	15			11		19		
*Argentina		21		29				
Australia		25		21	17		16	
Bahrain	16		59	20		17		
*Belgium	19	37			25		24	
Brazil		20	26		21		15	
British Admiralty	58	63	62	69	64	65	66	62
Canada		131						123
Chile		24	17		26		28	
China			69					36
*Colombia			72					
Crotia			24					
*Cuba								
*Denmark		42		49	17	32	21	25
*Equador		12						
Eqypt	7						4	2
Estonia	8				11			
*Finland		75	71		26			21
*France	16	34	25		52	21		20
French Polynesia					25			31
*Germany		65		33	36	72		32
*Greece			19			27		
Hong Kong			8			7		
Iceland								
India				94		40		
Indonesia					17	69		
Israel								
*Italy		14	10			23		13
Japan	39	40	26	37	39	42	43	40
South Korea		16	19		22			68
North Korea								
*Latvia		20	17			17		24
Malaysia								
Royal Malaysia								
*Mexico			8				5	
Mynamar								
*Netherlands	15	16		31		39		14
New Zealand	8		12	5		5	14	6
Norway		28		21			35	18
Pakistan	2				2	3		
Paraguay		21				20		18
*Peru	15		20					
Phillippines								
*Poland			37	28			14	
*Portugal				5			13	
Romania								
Russia		115						42
St. Lucia								
Singapore			20					21
South Africa								
*Spain	47		46	92	45		101	24
*Sweden	25	21	42		21	20	20	32
Taiwan	34			36	51			34
Thailand								
*Tunisia	19	15					40	
*Turkey		5	30					
*Uruguay		24			16			
*Venezuala						1		
Totals	343	884	739	581	533	539	459	706

Table C-2 Foreign NTM Data by Feature (continued)

	9/19-9/25	9/26-10/2	10/3-10/9	10/10-10/16	10/17-10/23	10/24-10/30	10/31-11/6	11/7-11/13
	41	**42**	**43**	**44**	**45**	**46**	**47**	**48**
COUNTRY								
*Algeria		48					40	
*Argentina								
Australia		28		22				12
Bahrain								
*Belgium				21	22			17
Brazil						26	17	22
British Admiralty	58	51	45	57	53	58	51	50
Canada				106				
Chile				17			52	
China						24		17
*Colombia								
Crotia					9			
*Cuba				87				
*Denmark	19	17	25	51	53	14	21	
*Equador								
Egypt				1				
Estonia		15	7					
*Finland			86		31			61
*France	49		62		68			43
French Polynesia				13				
*Germany		62	34		61	50	31	32
*Greece					25			
Hong Kong		3				3		
Iceland					53			
India			46					
Indonesia			72					
Israel								
*Italy		12		14	21		17	
Japan		81		73		34	68	
South Korea		20		19		20	29	24
North Korea								
*Latvia		21	18			25		
Malaysia	9						5	
Royal Malaysia								
*Mexico			6					10
Mynamar	20		21	27				
*Netherlands	35	16		32	31			15
New Zealand		10	6	4	5	7	5	
Norway					24	21		15
Pakistan		2	2	2				2
Paraguay						19		
*Peru					20			
Phillippines								
*Poland	16	26	14	20	15		39	
*Portugal		6						15
Romania								
Russia								
St. Lucia								
Singapore			20					
South Africa			15	15	17			
*Spain		48	47	38	59	47	43	42
*Sweden		14	20	43		48		37
Taiwan			37			62		
Thailand								
*Tunisia		20	21			18		20
*Turkey	24			12				
*Uruguay			11					
*Venezuala								
Totals	230	500	615	674	567	476	418	434

Table C-2 Foreign NTM Data by Feature (continued)

	11/14-11/20	11/21-11/27	11/28-12/4	12/5-12/11
	49	**50**	**51**	**52**
COUNTRY				
*Algeria		20		25
*Argentina	16	98		21
Australia			5	13
Bahrain	23			21
*Belgium	24	20		16
Brazil			22	13
British Admiralty	58	56		127
Canada	89			
Chile	16		13	
China				42
*Colombia				
Crotia				7
*Cuba				
*Denmark	20	22	43	20
*Equador	15	20		66
Eqypt	3			
Estonia	5			
*Finland			104	
*France	21		16	39
French Polynesia	28	21	85	
*Germany	36	25		56
*Greece		24		
Hong Kong			8	3
Iceland	48			
India				
Indonesia				
Israel				
*Italy		15		9
Japan	72		38	31
South Korea	20			18
North Korea				
*Latvia	13		24	
Malaysia				
Royal Malaysia		1		
*Mexico				
Mynamar			18	
*Netherlands	16	16	14	16
New Zealand		5	12	21
Norway		20		
Pakistan		2	2	
Paraguay		21		
*Peru				
Phillippines				
*Poland	31		29	
*Portugal				12
Romania				
Russia				
St. Lucia				
Singapore	24			15
South Africa	11			
*Spain	48	41		102
*Sweden	20	23	20	19
Taiwan				25
Thailand	63			
*Tunisia		24		21
*Turkey	8		10	13
*Uruguay				
*Venezuala				
Totals	728	474	463	771

Table C-3 Foreign NTM Data by Notice Number

	12/14-12/20	12/21-12/27	12/28-1/3	1/4-1/10	1/11-1/17	1/18-1/24	1/25-1/31	2/1-2/7
	1	2	3	4	5	6	7	8
COUNTRY								
*Algeria		19					1,2	21
*Argentina	21,22				23		24	
Australia	47	48		49,50		1	2	
Bahrain				51,52			53	1,2,3,4
*Belgium	23				25			
Brazil	21					22,23	24,1	
British Admiralty	48	49	50		1,2	3	4	5
Canada			25	1				
Chile	20,21				22	23	24	
China						23,24		1
*Colombia				9,10				
Crotia	9					10		11
*Cuba							11,12	
*Denmark	45	46	47	48	49		50	51,52,1
*Equador								
Eqypt								
Estonia						11		
*Finland			31,32					
*France	42		43,44,45	46		47		
French Polynesia						1,2	3	
*Germany			42,43,44	45,46				
*Greece			9					
Hong Kong	93-100						1,2,3	4,5
Iceland	11						12	
India								
Indonesia				48-49				
Israel								
*Italy			23		24,25			
Japan	49,50		51	1		2	3,4	5
South Korea						36,1	3	
North Korea								
*Latvia			23	24			25	26
Malaysia								
Royal Malaysia			11					
*Mexico	10							
Mynamar		17			18		19	
*Netherlands	48		49,50		51,52			2
New Zealand		49,50			1		2	3
Norway		23		24		1		
Pakistan		45		46-48		49,50	51,52	
Paraguay		11					12	
*Peru							10,11	
Phillippines								12,13
*Poland		39-41		42-44	45,46			
*Portugal				21,22				
Romania	11							
Russia	23,24			25,26				
St. Lucia								
Singapore		12		1				
South Africa						12		
*Spain	46		47	48,49		51	52	1
*Sweden	45	46	47	48,49		50	51/52,1	
Taiwan	49-51	52,53	54-56			57,1,2		
Thailand								
*Tunisia	21			22				
*Turkey	41,43		42,45,46	47	48		49	50
*Uruguay		9						
*Venezuala								

Table C-3 Foreign NTM Data by Notice Number (continued)

	2/8-2/14	2/15-2/21	2/22-2/28	2/29-3/6	3/7-3/13	3/14-3/20	3/21-3/27	3/28-4/3
	9	**10**	**11**	**12**	**13**	**14**	**15**	**16**
COUNTRY								
*Algeria		22		23	24			
*Argentina								
Australia	3	4	5	6	7	8	9	10
Bahrain	5,6	10,11	7,8,9			12,13,14,15		
*Belgium		26		1,2/3				
Brazil				2				3,4
British Admiralty	6	7	8	9	10	11	12	13
Canada	2			3				
Chile	1			2			3,4	5
China	2		3			4,5		
*Colombia					1			
Crotia						12		
*Cuba								
*Denmark	2	3	4		5,6		7	8
*Equador				10,11				
Eqypt								
Estonia		12,2						
*Finland				33,34	1,2	3,4		
*France		50	2	48,51	1	52	3	4
French Polynesia			4					
*Germany	47,49	48,50,51,52	1		2	3,4	5	6
*Greece					10,11			12
Hong Kong		6,7-12				13-19		
Iceland				1,2				
India	19,20,21,22	1,2					23,24	3,4
Indonesia		43-47;50-52,1,2						3,4
Israel								
*Italy		1		2		3	4	
Japan	6	7	8	9	10		11,12	
South Korea	4	5		6	7		8	9
North Korea								
*Latvia	1			2	4			5
Malaysia	1,2					3		
Royal Malaysia								
*Mexico		11				12		
Mynamar					1		2	
*Netherlands	1,3	4	5		6	7,8	9	10
New Zealand		4,5	6	7			8,9,10	11
Norway	2	3			4		5	6
Pakistan	1,2		3,4,5			6,7		
Paraguay			1				2	
*Peru								
Phillippines								
*Poland	47		48	49,50	51	52,1	2,3	
*Portugal	23			24,25				
Romania				12,1		2		
Russia								1
St. Lucia						2		
Singapore		2					3	
South Africa		1					2	
*Spain	2	3	4	5		6	7,8	9
*Sweden	2		3,.4		5	6,7,8		9
Taiwan	3,4,5,6,7		8,9,10,11	12,13,14		15,16		17-24
Thailand								
*Tunisia	23-25	1			2			3
*Turkey		51,1		2		4	5	
*Uruguay	10	11						
*Venezuala		1						

Table C-3 Foreign NTM Data by Notice Number (continued)

	4/4-4/10	4/11-4/17	4/18-4/24	4/25-5/1	5/2-5/8	5/9-5/15	5/16-5/22	5/23-5/29
	17	18	19	20	21	22	23	24
COUNTRY								
*Algeria				3,4			5	
*Argentina			1,2,3/4	5			6,7	8
Australia	11		12,13				15,16,17	18
Bahrain								17-23
*Belgium	4	5	6	7			8	
Brazil	5		6	7		8		9
British Admiralty	14	15	16	17	18	19	20	21
Canada			4			5		
Chile				6				7,8
China	6			7				8
*Colombia				6				
Crotia	1,2							
*Cuba	1,2							
*Denmark	9	10	11,12	13	14	15	16	
*Equador							1,2	
Eqypt								
Estonia			1,3				4	
*Finland				6,7	5			
*France	5		6,7,8		9,11	10,12		
French Polynesia		5						
*Germany		8	7			9,10,11	12,13	14
*Greece					1,2			
Hong Kong	20-23			27-29			30-34	
Iceland								
India				5,6				
Indonesia				5,6				
Israel								
*Italy	5			6		7		8
Japan	13,14		15,16	17	18	19	20	21
South Korea	10		11		12	13		14
North Korea								10,12,1,2
*Latvia		3,6			8		9	
Malaysia			4					
Royal Malaysia								
*Mexico		1,2				3		
Mynamar			3			4	5	
*Netherlands		11,12		13,14		15	16,17	
New Zealand		12,13	14	15		17	16,18	
Norway			7			8		
Pakistan	9,10	8	11,12	13,14				15,16
Paraguay			3					4,5
*Peru	12,1							
Phillippines		11,1,2						3,4
*Poland	4,5,6		7	10	8,9		11,12,14,14	
*Portugal	1,2,3		4,5			6		
Romania			3					4
Russia				2,3		4,5		6,7
St. Lucia								
Singapore	4							5
South Africa		3						
*Spain	10	11	12	13	14	15	16	17,18
*Sweden	10	11	12	13	14	15	16	17
Taiwan			25-28	29-31			32,33	34-36
Thailand								
*Tunisia	4			5	6			
*Turkey	3,6,7,8				9			
*Uruguay	12			1				
*Venezuala	9:-21							

Table C-3 Foreign NTM Data by Notice Number (continued)

	5/30-6/5	6/6-6/12	6/13-6/19	6/20-6/26	6/27-7/3	7/4-7/10	7/11-7/17	7/18-7/24
	25	**26**	**27**	**28**	**29**	**30**	**31**	**32**
COUNTRY								
*Algeria		6		7		8,9		
*Argentina			9	10			11	
Australia	19	20,21	22		23	24	25	26
Bahrain		24-27	28,29					30-34
*Belgium	9	10				11		
Brazil					10,11		12	
British Admiralty	22	23	24	25	26	27	28	29
Canada			6				7	
Chile				9	10		11	
China		9		10,11				12,13
*Colombia				8,9			10	
Crotia		3						
*Cuba		3,4					5	
*Denmark	17	18	19	20,21	22	23		24,25
*Equador			3					
Eqypt			2					
Estonia								5
*Finland		8,9,10,11	12		13/14			15
*France	13,14,16		15		17,19	18,20		23
French Polynesia						6	7	
*Germany		16	15,17		18	19		21,22
*Greece					3			
Hong Kong	35-41					42-44		45-52
Iceland				3,4				5,6
India		7,8						
Indonesia		7,8						
Israel								
*Italy	9			10	11		12	
Japan	22	23	24	25	26	27	28	29
South Korea	15		16,17		18	19		20
North Korea								
*Latvia			10		11			
Malaysia								
Royal Malaysia				4				
*Mexico			4				5	
Mynamar							6,7	
*Netherlands	18	19	20	21	22	23	24	25,26
New Zealand	19,20		22	21,23	24	25	26	
Norway	9	10		11		12		13
Pakistan		17,18,19		20	21-23		24,25	
Paraguay								
*Peru	3				4			
Phillippines								
*Poland			15	16	18		19	17,20,21
*Portugal	7,8					9,10		11
Romania				5				6
Russia								
St. Lucia	3							
Singapore			6				7	
South Africa				4,5			6	
*Spain	19		20		21,22,23		24	25
*Sweden	18	19,20		21	22	23	24	25
Taiwan				37			40	
Thailand								
*Tunisia	7,8		9			10		
*Turkey	10,11,13,14				12			
*Uruguay					2,3			
*Venezuala	22-36					37-50		

Table C-3 Foreign NTM Data by Notice Number (continued)

	7/25-7/31	8/1-8/7	8/8-8/14	8/15-8/21	8/22-8/28	8/29-9/4	9/5-9/11	9/12-9/18
	33	34	35	36	37	38	39	40
COUNTRY								
*Algeria	10			11		12		
*Argentina		13		14				
Australia		27		28	29		30	
Bahrain	36		37,38,39	40		41		
*Belgium	12	13,14			15		16	
Brazil		13	14		15		16	
British Admiralty	30	31	32	33	34	35	36	37
Canada		8						9
Chile		12	13		14		15	
China			14,15					16,17
*Colombia			11,12,13					
Crotia			4,5,6					
*Cuba								
*Denmark		26,27		28,29	30	31	32	33
*Equador		4						
Eqypt	3						4	
Estonia	6				8			
*Finland		16/17	18/19		20			21/22
*France	24	21,22	25		26,28	27		32
French Polynesia					8,9			10,11
*Germany		23,24		25	26	27,28		30
*Greece			5			6		
Hong Kong			53-60			61-67		
Iceland								
India				9,10,11,12		13,14		
Indonesia				12-Sep		13-14		
Israel								
*Italy		13	14			15		16
Japan	30	31	32	33	34	35	36	37
South Korea		21	22		23			24,25,26
North Korea								
*Latvia		12	13			14		15
Malaysia								
Royal Malaysia								
*Mexico			6				7	
Mynamar								
*Netherlands	27	28		29,30		31,32		33
New Zealand	27,28		29,30	31		32	33,34	35
Norway		14		15			16	17
Pakistan	26,27				28,29	30-32		
Paraguay		6				7		8
*Peru	5		2					
Phillippines								
*Poland			22,23,24	25,26			27	
*Portugal				12			13,14	
Romania								
Russia	8:-14							15,16
St. Lucia								
Singapore			8					9
South Africa								
*Spain	26		28	27,29	30		31,32,33	34
*Sweden	26	27	28,29		30	31	32	33
Taiwan	41,42,43			44-46	47-50			51-54
Thailand								
*Tunisia	11	12					13,14	
*Turkey		22	15-19,23-25					
*Uruguay		4			6			
*Venezuala						63		

Table C-3 Foreign NTM Data by Notice Number (continued)

	9/19-9/25	9/26-10/2	10/3-10/9	10/10-10/16	10/17-10/23	10/24-10/30	10/31-11/6	11/7-11/13
	41	42	43	44	45	46	47	48
COUNTRY								
*Algeria		13,14					15,16	
*Argentina								
Australia		31		32				33
Bahrain								
*Belgium				17	18			20
Brazil						18	19	20
British Admiralty	38	39	40	41	42	43	44	45
Canada				10				
Chile				16			17,18	
China						18		19
*Colombia								
Crotia					8			
*Cuba				6,7,8				
*Denmark	24	34	35	36,37	38	39	40	
*Equador								
Eqypt				5				
Estonia		7,10	9					
*Finland			23/24		25			26/27
*France	29,31		30,33		34,35			36,38
French Polynesia				12				
*Germany		31,32	33		34,35	36	37	38
*Greece					7			
Hong Kong		68-70				71-73		
Iceland					7,8			
India			15,16					
Indonesia			15-16					
Israel								
*Italy		17		18	19		20	
Japan		38,39		40,41		42	43,44	
South Korea		27		28		29	30	31
North Korea								
*Latvia		16	17			18		
Malaysia	14-22						23-27	
Royal Malaysia								
*Mexico			8					9
Mynamar	8		9	10				
*Netherlands	34,35	36		37,38	39,40			42
New Zealand		36,37	38	39	40	41	42	
Norway					19	18		20
Pakistan		33,34	35,36	37,38				39,40
Paraguay						9		
*Peru					8			
Phillippines								
*Poland	28	29,30	31	33	32		34,35,36	
*Portugal		15						16,17
Romania								
Russia								
St. Lucia								
Singapore			10					
South Africa			7	9	8			
*Spain		35	36	37	38	39	40	41
*Sweden		35	37	34,38		39,40		41
Taiwan			55-57			59-60		
Thailand								
*Tunisia		15	16			17		18
*Turkey	26-29			30-31				
*Uruguay			7					

Table C-3 Foreign NTM Data by Notice Number (continued)

	11/14-11/20	11/21-11/27	11/28-12/4	12/5-12/11
	49	50	51	52
COUNTRY				
*Algeria		17		18
*Argentina	19	12,15,16,17,18		21
Australia			34	35
Bahrain	42			44
*Belgium	19	21		22
Brazil			21	22
British Admiralty	46	47		48,49
Canada	11			
Chile	19		20	
China				20,21
*Colombia				
Crotia				11
*Cuba				
*Denmark	41	42	43,44	452
*Equador	7	8		5,6,9
Eqypt	6			
Estonia	11			
*Finland			28,29,30	
*France	37		41	39,40
French Polynesia	13	14	15-19	
*Germany		39		41,42
*Greece		8		
Hong Kong			74-81	82-84
Iceland	9,10			
India				
Indonesia				
Israel				
*Italy		21		22
Japan	45,46		47	48
South Korea	32			33
North Korea				
*Latvia	19		20	
Malaysia				
Royal Malaysia		10		
*Mexico				
Mynamar			12	
*Netherlands	41	43	44	45
New Zealand		44	45	43,46,47
Norway		21		
Pakistan		41,42	43,44	
Paraguay		10		
*Peru				
Phillippines				
*Poland	37,38		39,40	
*Portugal				18
Romania				
Russia				
St. Lucia				
Singapore	11			12
South Africa	10			
*Spain	42	43		44,45
*Sweden	42	43	44	45
Taiwan				61-65
Thailand	1:-9			
*Tunisia		19		20
*Turkey	37		35,36	38,39
*Uruguay				
*Venezuala				

Table C-4 U.S. Coast Guard Local NTM Feature Data

	12/14-12/20	12/21-12/27	12/28-1/3	1/4-1/10	1/11-1/17	1/18-1/24	1/25-1/31
	1	2	3	4	5	6	7
USCG DISTRICT							
I	12	12		4	4	5	9
V		22	8	6		15	
VII		124	76	38			34
VIII							129
IX				44			1
XI	0		10	2	11	3	6
XIII	7		0		2	0	8
XIV	12		0	6	3		9
XVII				4	6	4	0
Totals	31	158	94	104	26	27	196

	2/1-2/7	2/8-2/14	2/15-2/21	2/22-2/28	2/29-3/6	3/7-3/13	3/14-3/20	3/21-3/27
	8	9	10	11	12	13	14	15
USCG DISTRICT								
I	0		0	22	7		8	10
V		9		12	17	13		6
VII	43	46		103	49	23		85
VIII	157	43		135	37	23	69	
IX								
XI	0	8		16	0	0		
XIII	3				1	5		
XIV	3	7			12			1
XVII	0	0		5		2	4	
Totals	206	113	0	293	123	66	81	102

	3/28-4/3	4/4-4/10	4/11-4/17	4/18-4/24	4/25-5/1	5/2-5/8	5/9-5/15	5/16-5/22
	16	17	18	19	20	21	22	23
USCG DISTRICT								
I	15	4	0			16		
V	4		25			18		
VII	37	45	71			56	78	
VIII	86	43	40	46			54	
IX						38	5	11
XI	14		6			9		3
XIII	0	6				8		
XIV	5	3		4		9		6
XVII	6	2	7			9		4
Totals	167	103	149	50	0	163	137	24

Table C-4 U.S. Coast Guard Local NTM Feature Data (continued)

	5/23-5/29	5/30-6/5	6/6-6/12	6/13-6/19	6/20-6/26	6/27-7/3	7/4-7/10	7/11-7/17
	24	**25**	**26**	**27**	**28**	**29**	**30**	**31**
USCG DISTRICT								
I	21		1	0	13		27	
V			45				16	6
VII	28	38	81	76	39		37	30
VIII		47	91	101	132	144	13	96
IX	15	18		9	4	1		22
XI	2	7		4	1		0	8
XIII	4	3	5	2		0		8
XIV		0	12		13	0	0	2
XVII		10	0	7	2	2		5
Totals	70	123	235	199	204	147	93	177

	7/18-7/24	7/25-7/31	8/1-8/7	8/8-8/14	8/15-8/21	8/22-8/28	8/29-9/4	9/5-9/11
	32	**33**	**34**	**35**	**36**	**37**	**38**	**39**
USCG DISTRICT								
I	3	12		8	4	4		0
V	5	8	5	14	8	16		3
VII			114	52	38	64		67
VIII		43	99	46	65		48	72
IX	0	5		21	11	15	16	
XI		9	1	0	0	0	2	0
XIII	0		5	4	8	0		0
XIV		16	4		3	2	5	3
XVII	3		4		6	0	0	3
Totals	11	93	232	145	143	101	71	148

	9/12-9/18	9/19-9/25	9/26-10/2	10/3-10/9	10/10-10/16	10/17-10/23	10/24-10/30
	40	**41**	**42**	**43**	**44**	**45**	**46**
USCG DISTRICT							
I	0			7	10	6	
V	0				17		23
VII						26	87
VIII	45	49	37	35	40	82	
IX	7	10	6		25	22	11
XI	10	6	5	2	3	6	4
XIII	13		0	16	3		2
XIV		12	3	5	10		3
XVII	1		10	5		3	5
Totals	76	77	61	70	108	145	135

Table C-4 U.S. Coast Guard Local NTM Feature Data (continued)

	10/31-11/6	11/7-11/13	11/14-11/20	11/21-11/27	11/28-12/4	12/5-12/11
	47	**48**	**49**	**50**	**51**	**52**
USCG DISTRICT						
I	12		8		47	
V	6	21	4	6		
VII	125	38	96			40
VIII	48	55	58		49	48
IX	18	4				
XI		11	17		7	1
XIII	4	1	1			9
XIV	6		2	7		
XVII		2		6	8	
Totals	219	132	186	19	111	98

Table C-5 Labor Data for Heritage System

			Branch 1					
Dates	**Production**	**AL**	**SL**	**Training**	**Support**	**Holiday**	**Other**	**Ttl. Misc.**
12/14-12/20	320	22	17	149	112	0	0	300
12/21-12/27	159	35	25	153	128	120	0	461
12/28-1/3	93	257	7.2	74.8	64	120	0	523
1/4-1/10	85.5	0	9	4.5	37	0	443	493.5
1/11-1/17	380.5	2.5	0	43	64	120	1	230.5
1/18-1/24	415.5	15	12	62.5	106	0	0	195.5
1/25-1/31	392	37	20	56	120	0	7	240
2/1-2/7	382	0	10.5	8.5	128	0	3	150
2/8-2/14	454	0	8	6.5	112	0	80	206.5
2/15-2/21	387.5	1	3	38	128	0	80	250
2/22-2/28	465	1	9	6.5	112	0	6	134.5
2/29-3/6	436.7	9	26	6.3	121	0	12.5	174.8
3/7-3/13	383.8	43	8.5	39.2	76	0	5.5	172.2
3/14-3/20	369.5	37	10	76.5	128	0	1	252.5
3/21-3/27	447.5	44.5	0	45	112	0	16	217.5
3/28-4/3	394	49	8	5	128	0	4	194
4/4-4/10	426	26	10	4	120	0	1.7	161.7
4/11-4/17	381	35	26	4	120	0	2	187
4/18-4/24	363.5	9	31.5	2	112	0	41.5	196
4/25-5/1	263	18	19	154	128	0	46	365
5/2-5/8	368	17	18	4	111	0	58	208
5/9-5/15	392.5	4	0	8	128	0	71.5	211.5
5/16-5/22	381.5	60	9	16	111	0	8.5	204.5
5/23-5/29	309.5	40	0	0	104	112	9.5	265.5
5/30-6/5	497.5	14	0	0	112	0	2.5	128.5
6/6-6/12	402.7	13.5	5	16	120	0	0.8	155.3
6/13-6-19	422.5	30	0	15	112	0	0	157
6/20-6/26	384.5	20	37	8	128	0	2.5	195.5
6/27-7/3	432	14	8	8	121	0	13	164
7/4-7/10	308	47	8	0	88	112	8	263
7/11-7/17	392.7	55	12	0	112	0	29	208
7/18-7/24	419	40	2	0	128	0	0	170
7/25-7/31	412	38	17	24	110	0	0	189
8/1-8/7	385	48	8	0	128	0	44	228
8/8-8/14	414	28	8	0	111	0	42	189
8/15-8/21	395.5	9	10.5	40	119	0	41	219.5
8/22-8/28	435.5	15	8.5	1	112	0	22	158.5
8/29-9/4	318	1	42.5	0	104	112	5	264.5
9/5-9/11	468.5	0	30.5	0	120	0	0	150.5
9/12-9/18	399.5	3.5	10	14	119	0	31	177.5
9/19-9/25	385.5	31	28	0	110	0	42.5	211.5
9/26-10/2	386	18.5	20	0	128	0	40.5	207
10/3-10/9	402	54	10	0	112	0	30	206
10/10-10/16	338	29	8	0	103	112	10	262
10/17-10/23	407	66	21	0	97	0	0	184
10/24-10/30	390.5	61.5	9	0	116.5	0	28.5	215.5
10/31-11/6	388	13	18	61	111	0	0	203
11/7-11/13	359.5	46	26	20	78	112	0	282
11/14-11/20	431	5	22	44	108	0	4	183
11/21-11/27	463.5	20	9	5.5	109	0	1	144.5
11/28-12/4	264	79	53	0	74	112	0	318
12/5-12/11	477	18	18	20	108	0	0	164
Totals	19629.4	1579	735.7	1242.8	5708.5	1032	1295	11593

Table C-5 Labor Data for Heritage System (continued)

			Branch 2					
Dates	Production	AL	SL	Training	Support	Holiday	Other	Ttl. Misc.
12/14-12/20	328.5	18.5	13	92	71	0	40	234.5
12/21-12/27	289	17.5	5.5	72	72	96	0	263
12/28-1/3	292	83	6	37	16	96	2	240
1/4-1/10	164	50	30	10	32	0	304	426
1/11-1/17	411	0	2	0	20	96	0	118
1/18-1/24	464	11	6	0	64	0	0	81
1/25-1/31	473	21	11	16	88	0	0	136
2/1-2/7	418	26.5	25	0	72	0	0	123.5
2/8-2/14	399.5	6.5	66.5	10	88	0	0	171
2/15-2/21	345	48.5	16	17.5	49	96	12.5	239.5
2/22-2/28	432	54	18	3	88	0	0	163
2/29-3/6	412	48	31	10	72	0	0	161
3/7-3/13	377.5	82.5	22	10	88	0	0	202.5
3/14-3/20	444.3	26.7	47	8	54	0	0	135.7
3/21-3/27	475.5	7.5	25	0	89	0	0	121.5
3/28-4/3	485	2	6	7	71	0	0	86
4/4-4/10	344	7	12	8	88	0	1	116
4/11-4/17	400	34	10	0	72	0	40	156
4/18-4/24	417.5	19	27.5	0	79	0	41	166.5
4/25-5/1	393	20	31	44	77	0	0	172
5/2-5/8	451	6	15	0	88	0	0	109
5/9-5/15	423.5	12.5	12	0	72	0	0	96.5
5/16-5/22	426.5	23.5	11	0	88	0	0	122.5
5/23-5/29	158	80	3	97	40	104	0	324
5/30-6/5	366.5	24	28.5	0	88.5	0	40	181
6/6-6/12	411	40	10	0	36	0	40	126
6/13-6-19	417	3.5	23.5	0	44	0	44	115
6/20-6/26	436	8	8	0	81	0	0	97
6/27-7/3	428	34	13	0	91	0	0	138
7/4-7/10	322.5	27.5	0	0	59	104	0	190.5
7/11-7/17	420	27.5	12	8.5	92	0	0	140
7/18-7/24	356	66	14	8	72	0	0	160
7/25-7/31	402.5	13.5	44	0	92	0	0	149.5
8/1-8/7	364	47	48	0	71	0	0	166
8/8-8/14	389	54.5	15.5	8	44	0	0	122
8/15-8/21	312.5	141	30.5	0	55.5	0	0	227
8/22-8/28	410.5	56.5	41	0	44.5	0	0	142
8/29-9/4	291	52	23	0	65	104	0	244
9/5-9/11	390	60	45	0	79	0	0	184
9/12-9/18	453	7	14	0	76.5	0	0	97.5
9/19-9/25	463	14	23	0	91	0	0	128
9/26-10/2	443.5	14.5	35	0	75	0	0	124.5
10/3-10/9	430.5	24	33.5	0	92	0	4	153.5
10/10-10/16	307	45	14	36	65.5	112	0	272.5
10/17-10/23	427	38	40	0	72	0	3	153
10/24-10/30	443	36.5	14.5	0	72	0	0	123
10/31-11/6	384	10	22	0	91.5	0	0	123.5
11/7-11/13	303	31.5	16.5	0	61.5	112	2	223.5
11/14-11/20	398	46.5	1.5	0	80	0	0	128
11/21-11/27	381.5	2	25.5	0	83	0	0	110.5
11/28-12/4	236	85	4	0	55	112	0	256
12/5-12/11	320.5	57	11.5		80	0	0	148.5
Totals	19930.3	1771.2	1062.5	502	3647.5	1032	573.5	8588.7

Table C-5 Labor Data for Heritage System (continued)

			Branch 3					
Dates	Production	AL	SL	Training	Support	Holiday	Other	Ttl. Misc.
12/14-12/20	129.7	8.1	6.0	48.2	4.0	0.0	8.0	74.3
12/21-12/27	89.6	10.5	6.1	45.0	4.0	36.0	0.0	101.6
12/28-1/3	77.0	68.0	2.6	22.4	4.0	36.0	0.4	133.4
1/4-1/10	49.9	10.0	7.8	2.9	4.0	0.0	149.4	174.1
1/11-1/17	158.3	0.5	0.4	8.6	4.0	36.0	0.2	49.7
1/18-1/24	175.9	5.2	3.6	12.5	4.0	0.0	0.0	25.3
1/25-1/31	173.0	11.6	6.2	14.4	4.0	0.0	1.4	37.6
2/1-2/7	160.0	5.3	7.1	1.7	4.0	0.0	0.6	18.7
2/8-2/14	170.7	1.3	14.9	3.3	4.0	0.0	16.0	39.5
2/15-2/21	146.5	9.9	3.8	11.1	4.0	36.0	18.5	83.3
2/22-2/28	179.4	11.0	5.4	1.9	4.0	0.0	1.2	23.5
2/29-3/6	169.7	11.4	11.4	3.3	4.0	0.0	2.5	32.6
3/7-3/13	152.3	25.1	6.1	9.8	4.0	0.0	1.1	46.1
3/14-3/20	162.8	12.7	11.4	16.9	4.0	0.0	0.2	45.2
3/21-3/27	184.6	10.4	5.0	9.0	4.0	0.0	3.2	31.6
3/28-4/3	175.8	10.2	2.8	2.4	4.0	0.0	0.8	20.2
4/4-4/10	154.0	6.6	4.4	2.4	4.0	0.0	0.5	17.9
4/11-4/17	156.2	13.8	7.2	0.8	4.0	0.0	8.4	34.2
4/18-4/24	156.2	5.6	11.8	0.4	4.0	0.0	16.5	38.3
4/25-5/1	131.2	7.6	10.0	39.6	4.0	0.0	9.2	70.4
5/2-5/8	163.8	4.6	6.6	0.8	4.0	0.0	11.6	27.6
5/9-5/15	163.2	3.3	2.4	1.6	4.0	0.0	14.3	25.6
5/16-5/22	161.6	16.7	4.0	3.2	4.0	0.0	1.7	29.6
5/23-5/29	93.5	24.0	0.6	19.4	4.0	36.0	1.9	85.9
5/30-6/5	172.8	7.6	5.7	0.0	4.0	0.0	8.5	25.8
6/6-6/12	162.7	10.7	3.0	3.2	4.0	0.0	8.2	29.1
6/13-6-19	167.9	6.7	4.7	3.0	4.0	0.0	8.8	27.2
6/20-6/26	164.1	5.6	9.0	1.6	4.0	0.0	0.5	20.7
6/27-7/3	172.0	9.6	4.2	1.6	4.0	0.0	2.6	22.0
7/4-7/10	126.1	14.9	1.6	0.0	4.0	36.0	1.6	58.1
7/11-7/17	162.5	16.5	4.8	1.7	4.0	0.0	5.8	32.8
7/18-7/24	155.0	21.2	3.2	1.6	4.0	0.0	0.0	30.0
7/25-7/31	162.9	10.3	12.2	4.8	4.0	0.0	0.0	31.3
8/1-8/7	149.8	19.0	11.2	0.0	4.0	0.0	8.8	43.0
8/8-8/14	160.6	16.5	4.7	1.6	4.0	0.0	8.4	35.2
8/15-8/21	141.6	30.0	8.2	8.0	4.0	0.0	8.2	58.4
8/22-8/28	169.2	14.3	9.9	0.2	4.0	0.0	4.4	32.8
8/29-9/4	121.8	10.6	13.1	0.0	4.0	36.0	1.0	64.7
9/5-9/11	171.7	12.0	15.1	0.0	4.0	0.0	0.0	31.1
9/12-9/18	170.5	2.1	4.8	2.8	4.0	0.0	6.2	19.9
9/19-9/25	169.7	9.0	10.2	0.0	4.0	0.0	8.5	31.7
9/26-10/2	165.9	6.6	11.0	0.0	4.0	0.0	8.1	29.7
10/3-10/9	166.5	15.6	8.7	0.0	4.0	0.0	6.8	35.1
10/10-10/16	129.0	14.8	4.4	7.2	4.0	36.0	2.0	68.4
10/17-10/23	166.8	20.8	12.2	0.0	4.0	0.0	0.6	37.6
10/24-10/30	166.7	19.6	4.7	0.0	4.0	0.0	5.7	34.0
10/31-11/6	154.4	4.6	8.0	12.2	4.0	0.0	0.0	28.8
11/7-11/13	132.5	15.5	8.5	4.0	4.0	36.0	0.4	68.4
11/14-11/20	165.8	10.3	4.7	8.8	4.0	0.0	0.8	28.6
11/21-11/27	169.0	4.4	6.9	1.1	4.0	0.0	0.2	16.6
11/28-12/4	100.0	32.8	11.4	0.0	4.0	36.0	0.0	84.2
12/5-12/11	159.5	15.0	5.9	4.0	4.0	0.0	0.0	28.9
Totals	7911.9	670.0	359.6	349.0	208.0	360.0	373.7	2320.3

Table C-5 Labor Data for Heritage System (continued)

			Departmental Totals					
Dates	Production	AL	SL	Training	Support	Holiday	Other	Ttl. Misc.
12/14-12/20	778.2	48.6	36.0	289.2	187.0	0.0	48.0	608.8
12/21-12/27	537.6	63.0	36.6	270.0	204.0	252.0	0.0	825.6
12/28-1/3	462.0	408.0	15.8	134.2	84.0	252.0	2.4	896.4
1/4-1/10	299.4	60.0	46.8	17.4	73.0	0.0	896.4	1093.6
1/11-1/17	949.8	3.0	2.4	51.6	88.0	252.0	1.2	398.2
1/18-1/24	1055.4	31.2	21.6	75.0	174.0	0.0	0.0	301.8
1/25-1/31	1038.0	69.6	37.2	86.4	212.0	0.0	8.4	413.6
2/1-2/7	960.0	31.8	42.6	10.2	204.0	0.0	3.6	292.2
2/8-2/14	1024.2	7.8	89.4	19.8	204.0	0.0	96.0	417.0
2/15-2/21	879.0	59.4	22.8	66.6	181.0	132.0	111.0	572.8
2/22-2/28	1076.4	66.0	32.4	11.4	204.0	0.0	7.2	321.0
2/29-3/6	1018.4	68.4	68.4	19.6	197.0	0.0	15.0	368.4
3/7-3/13	913.6	150.6	36.6	59.0	168.0	0.0	6.6	420.8
3/14-3/20	976.6	76.4	68.4	101.4	186.0	0.0	1.2	433.4
3/21-3/27	1107.6	62.4	30.0	54.0	205.0	0.0	19.2	370.6
3/28-4/3	1054.8	61.2	16.8	14.4	203.0	0.0	4.8	300.2
4/4-4/10	924.0	39.6	26.4	14.4	212.0	0.0	3.2	295.6
4/11-4/17	937.2	82.8	43.2	4.8	196.0	0.0	50.4	377.2
4/18-4/24	937.2	33.6	70.8	2.4	195.0	0.0	99.0	400.8
4/25-5/1	787.2	45.6	60.0	237.6	209.0	0.0	55.2	607.4
5/2-5/8	982.8	27.6	39.6	4.8	203.0	0.0	69.6	344.6
5/9-5/15	979.2	19.8	14.4	9.6	204.0	0.0	85.8	333.6
5/16-5/22	969.6	100.2	24.0	19.2	203.0	0.0	10.2	356.6
5/23-5/29	561.0	144.0	3.6	116.4	148.0	252.0	11.4	675.4
5/30-6/5	1036.8	45.6	34.2	0.0	204.5	0.0	51.0	335.3
6/6-6/12	976.4	64.2	18.0	19.2	160.0	0.0	49.0	310.4
6/13-6-19	1007.4	40.2	28.2	18.0	160.0	0.0	52.8	299.2
6/20-6/26	984.6	33.6	54.0	9.6	213.0	0.0	3.0	313.2
6/27-7/3	1032.0	57.6	25.2	9.6	216.0	0.0	15.6	324.0
7/4-7/10	756.6	89.4	9.6	0.0	151.0	252.0	9.6	511.6
7/11-7/17	975.2	99.0	28.8	10.2	208.0	0.0	34.8	380.8
7/18-7/24	930.0	127.2	19.2	9.6	204.0	0.0	0.0	360.0
7/25-7/31	977.4	61.8	73.2	28.8	206.0	0.0	0.0	369.8
8/1-8/7	898.8	114.0	67.2	0.0	203.0	0.0	52.8	437.0
8/8-8/14	963.6	99.0	28.2	9.6	159.0	0.0	50.4	346.2
8/15-8/21	849.6	180.0	49.2	48.0	178.5	0.0	49.2	504.9
8/22-8/28	1015.2	85.8	59.4	1.2	160.5	0.0	26.4	333.3
8/29-9/4	730.8	63.6	78.6	0.0	173.0	252.0	6.0	573.2
9/5-9/11	1030.2	72.0	90.6	0.0	203.0	0.0	0.0	365.6
9/12-9/18	1023.0	12.6	28.8	16.8	199.5	0.0	37.2	294.9
9/19-9/25	1018.2	54.0	61.2	0.0	205.0	0.0	51.0	371.2
9/26-10/2	995.4	39.6	66.0	0.0	207.0	0.0	48.6	361.2
10/3-10/9	999.0	93.6	52.2	0.0	208.0	0.0	40.8	394.6
10/10-10/16	774.0	88.8	26.4	43.2	172.5	260.0	12.0	602.9
10/17-10/23	1000.8	124.8	73.2	0.0	173.0	0.0	3.6	374.6
10/24-10/30	1000.2	117.6	28.2	0.0	192.5	0.0	34.2	372.5
10/31-11/6	926.4	27.6	48.0	73.2	206.5	0.0	0.0	355.3
11/7-11/13	795.0	93.0	51.0	24.0	143.5	260.0	2.4	573.9
11/14-11/20	994.8	61.8	28.2	52.8	192.0	0.0	4.8	339.6
11/21-11/27	1014.0	26.4	41.4	6.6	196.0	0.0	1.2	271.6
11/28-12/4	600.0	196.8	68.4	0.0	133.0	260.0	0.0	658.2
12/5-12/11	957.0	90.0	35.4	24.0	192.0	0.0	0.0	341.4
Totals	47471.6	4020.2	2157.8	2093.8	9564.0	2424.0	2242.2	22502.0

APPENDIX D
HERITAGE SYSTEM DEA RESULTS

This Appendix contains the input to, and the outputs from the Warwick DEA Software Model:

Table D-1 Heritage System Production Data
Table D-2 Table of Efficiencies
Table D-3 Peer Groups and Lambda Values
Table D-4 Unit Target Values
Table D-5 Virtual Inputs and Outputs

The data in Table D-1 are modified from the data found in Appendix D, and constitutes the input to the Warwick DEA Model. Although this table is being presented here as an Excel file for clarity, the data were input into the model as a text file.

The data in Tables D-2 through D-5 were output from the Warwick DEA Model as text files and were converted to Microsoft Word for formatting purposes.

Table D-1. Heritage System Production Data

	-FNTMTE	-FCHART	-USCGLN	-USCGLL	-NOSDAT	-USACE	-SHIPRE	-IMODAT	-PRODH	-OVRHD	+CHART	+LLFEAT
NTM1	614	75	31	78	3	0	5	0	778.2	608.8	1082	86
NTM2	303	63	158	62	6	0	0	0	537.6	825.6	445	54
NTM3	861	215	94	48	1	0	8	0	462	896.4	905	60
NTM4	920	0	104	17	9	0	2	0	299.4	1093.6	660	131
NTM5	299	52	26	49	1	0	2	0	949.8	398.2	878	69
NTM6	426	49	27	73	2	0	1	0	1055.4	301.8	1012	120
NTM7	586	26	196	39	1	0	4	0	1038	413.6	1288	254
NTM8	430	156	206	39	8	0	3	0	960	292.2	1124	140
NTM9	747	17	113	30	4	27	5	0	1024.2	417	1231	62
NTM10	731	77	0	29	18	0	5	0	879	572.8	1137	114
NTM11	485	85	293	29	7	0	7	0	1076.4	321	1163	250
NTM12	747	105	123	17	0	0	9	0	1018.4	368.4	1291	63
NTM13	519	148	66	16	2	0	8	0	913.6	420.8	990	104
NTM14	600	152	81	154	0	0	3	0	976.6	433.4	1023	44
NTM15	663	79	102	113	27	0	9	0	1107.6	370.6	1252	87
NTM16	522	112	167	66	12	0	5	0	1054.8	300.2	1457	270
NTM17	678	154	103	44	19	0	2	0	924	295.6	1570	146
NTM18	379	125	149	132	1	38	10	0	937.2	377.2	1228	162
NTM19	874	17	50	48	3	0	12	0	937.2	400.8	751	71
NTM20	751	98	0	52	3	0	4	0	787.2	607.4	922	70
NTM21	389	61	163	57	3	0	1	0	982.8	344.6	893	82
NTM22	616	94	137	88	0	0	5	0	979.2	333.6	989	105
NTM23	603	115	24	0	0	0	2	0	969.6	356.6	1101	102
NTM24	803	107	70	176	4	0	3	0	561	675.4	734	77
NTM25	523	126	123	66	8	0	4	0	1036.8	335.3	934	82
NTM26	637	57	235	180	6	0	8	0	976.4	310.4	1477	116

Table D-1. Heritage System Production Data (continued)

NTM27	626	124	199	235	3	19	2	0	1007.4	299.2	1465	542
NTM28	533	46	204	97	1	0	2	0	984.6	313.2	918	73
NTM29	685	74	147	88	0	0	2	0	1032	324	955	115
NTM30	399	0	93	122	3	0	4	0	756.6	511.6	949	113
NTM31	582	216	177	181	0	0	5	0	975.2	380.8	1002	159
NTM32	664	32	11	45	7	0	4	0	930	360	988	69
NTM33	343	35	93	77	17	0	1	0	977.4	369.8	1109	350
NTM34	884	64	232	32	1	0	6	0	898.8	437	1214	76
NTM35	739	98	145	36	2	0	6	0	963.6	346.2	889	47
NTM36	581	20	143	199	9	23	6	0	849.6	504.9	1109	65
NTM37	533	189	101	58	2	0	10	0	1015.2	333.3	1081	81
NTM38	539	204	71	45	14	0	6	0	730.8	573.2	1196	60
NTM39	459	111	148	30	1	0	5	0	1030.2	365.6	786	74
NTM40	706	200	76	268	3	0	2	0	1023	294.9	1449	88
NTM41	230	162	77	37	10	0	2	0	1018.2	371.2	815	55
NTM42	500	153	61	9	6	25	5	0	995.4	361.2	1483	135
NTM43	615	198	70	73	4	0	0	0	999	394.6	875	79
NTM44	674	132	108	44	6	0	3	0	774	602.9	1082	103
NTM45	567	110	145	92	8	11	3	0	1000.8	374.6	992	200
NTM46	476	48	135	137	12	0	0	0	1000.2	372.5	978	98
NTM47	418	76	219	9	4	0	1	0	926.4	355.3	1324	96
NTM48	434	128	132	24	2	0	2	0	795	573.9	1182	129
NTM49	728	164	186	149	2	0	4	0	994.8	339.6	1249	101
NTM50	474	96	19	28	0	0	4	0	1014	271.6	1263	161
NTM51	463	158	111	41	4	0	4	0	600	658.2	838	75
NTM52	771	27	98	26	1	33	10	0	957	341.4	1360	141
END												

Table D-2. Table of Efficiencies

```
Give the file name cnsdea.txt
Opening file cnsdea.txt for input
Data read with  13 variables and   52 units
Model at   04/MAR/1997 16:55:17
11 inputs    2 outputs 0 unused variables
  52 active units            0 unused units
   0 active constraints      0 unused constraints
Improvement model          RM radial
Radial objectives          OM outputs
Returns to scale           DB fixed
Target gains               RG Relative
Own unit as comparator     IX Included
Specified priorities       PU Uniform
Efficiency value           AE Related

Give command ( or ? ) TE
Table of efficiencies (radial)
 61.61 NTM39         66.64 NTM25         68.34 NTM35
 68.90 NTM45         80.70 NTM21         80.93 NTM37
 81.97 NTM22         82.25 NTM24         84.18 NTM13
 87.21 NTM51         88.30 NTM14         89.09 NTM8
 89.19 NTM44         90.63 NTM15         91.74 NTM49
 93.10 NTM28         94.49 NTM36         99.69 NTM38
100.00 NTM1         100.00 NTM10        100.00 NTM11
100.00 NTM12        100.00 NTM16        100.00 NTM17
100.00 NTM18        100.00 NTM19        100.00 NTM2
100.00 NTM20        100.00 NTM23        100.00 NTM26
100.00 NTM27        100.00 NTM29        100.00 NTM3
100.00 NTM30        100.00 NTM31        100.00 NTM32
100.00 NTM33        100.00 NTM34        100.00 NTM4
100.00 NTM40        100.00 NTM41        100.00 NTM42
100.00 NTM43        100.00 NTM46        100.00 NTM47
100.00 NTM48        100.00 NTM5         100.00 NTM50
100.00 NTM52        100.00 NTM6         100.00 NTM7
100.00 NTM9


Give command ( or ? ) EX
```

Table D-3. Peer Groups and Lambda Values

```
Give the file name cnsdea.txt
Opening file cnsdea.txt for input
Data read with  13 variables and   52 units
Model at   10/MAR/1997 13:42:41
11 inputs    2 outputs 0 unused variables
  52 active units              0 unused units
   0 active constraints        0 unused constraints
Improvement model          RM radial
Radial objectives          OM outputs
Returns to scale           DB fixed
Target gains               RG Relative
Own unit as comparator     IX Included
Specified priorities       PU Uniform
Efficiency value           AE Related
```

NTM8

Peers for Unit NTM8 efficiency 89.09% radial

NTM8		NTM16	NTM47
ACTUAL	LAMBDA	0.511	0.391
	SCALE	0.591	0.822
156.0	-FCHARTS	66.2	62.5
430.0	-FNTMTEXT	308.5	343.8
0.0	-IMODATA	0.0	0.0
8.0	-NOSDATA	7.1	3.3
292.2	-OVRHDHRS	177.4	292.2
960.0	-PRODHOURS	623.3	761.9
3.0	-SHIPREPORT	3.0	0.8
0.0	-USACE	0.0	0.0
39.0	-USCGLL	39.0	7.4
206.0	-USCGLNTM	98.7	180.1
27.000	-WORKSTA	15.955	22.205
1124.0	+CHARTFEAT	861.0	1088.9
140.0	+LLFEAT	159.5	79.0

NTM13

Peers for Unit NTM13 efficiency 84.18% radial

Peers 1 to 4 out of 6 for target NTM13

NTM13 ACTUAL		NTM17	NTM23	NTM47	NTM48
	LAMBDA	0.067	0.345	0.102	0.155
	SCALE	0.105	0.861	0.301	0.500
148.0	-FCHARTS	16.2	99.0	22.9	64.0
519.0	-FNTMTEXT	71.4	519.0	126.0	217.0
0.0	-IMODATA	0.0	0.0	0.0	0.0
2.0	-NOSDATA	2.0	0.0	1.2	1.0
420.8	-OVRHDHRS	31.1	306.9	107.1	287.0
913.6	-PRODHOURS	97.3	834.5	279.2	397.5
8.0	-SHIPREPORT	0.2	1.7	0.3	1.0
0.0	-USACE	0.0	0.0	0.0	0.0
16.0	-USCGLL	4.6	0.0	2.7	12.0
66.0	-USCGLNTM	10.8	20.7	66.0	66.0
25.988	-WORKSTA	2.842	23.239	8.137	13.500
990.0	+CHARTFEAT	165.3	947.6	399.0	591.0
104.0	+LLFEAT	15.4	87.8	28.9	64.5

Peers 5 to 6 out of 6 for target NTM13

NTM13 ACTUAL		NTM50	NTM7
	LAMBDA	0.282	0.014
	SCALE	0.571	0.337
148.0	-FCHARTS	54.9	8.8
519.0	-FNTMTEXT	270.9	197.3
0.0	-IMODATA	0.0	0.0
2.0	-NOSDATA	0.0	0.3
420.8	-OVRHDHRS	155.2	139.3
913.6	-PRODHOURS	579.4	349.5

8.0	-SHIPREPORT	2.3	1.3
0.0	-USACE	0.0	0.0
16.0	-USCGLL	16.0	13.1
66.0	-USCGLNTM	10.9	66.0
25.988	-WORKSTA	15.429	8.183
990.0	+CHARTFEAT	721.7	433.7
104.0	+LLFEAT	92.0	85.5

NTM14

Peers for Unit NTM14 efficiency 88.30% radial

NTM14		NTM23	NTM50
ACTUAL	LAMBDA	0.450	0.525
	SCALE	0.975	0.750
152.0	-FCHARTS	112.1	72.0
600.0	-FNTMTEXT	587.9	355.5
0.0	-IMODATA	0.0	0.0
0.0	-NOSDATA	0.0	0.0
433.4	-OVRHDHRS	347.7	203.7
976.6	-PRODHOURS	945.4	760.5
3.0	-SHIPREPORT	1.9	3.0
0.0	-USACE	0.0	0.0
154.0	-USCGLL	0.0	21.0
81.0	-USCGLNTM	23.4	14.3
26.325	-WORKSTA	26.325	20.250
1023.0	+CHARTFEAT	1073.5	947.3
44.0	+LLFEAT	99.5	120.8

NTM15

Peers for Unit NTM15 efficiency 90.63% radial

Peers 1 to 4 out of 5 for target NTM15

NTM15		NTM10	NTM17	NTM50	NTM6
ACTUAL	LAMBDA	0.033	0.213	0.215	0.287
	SCALE	0.647	0.513	0.823	1.049
79.0	-FCHARTS	49.8	79.0	79.0	51.4

```
      663.0 -FNTMTEXT           473.0          347.8
390.1        447.1
        0.0 -IMODATA              0.0            0.0
0.0          0.0
       27.0 -NOSDATA             11.6            9.7
0.0          2.1
      370.6 -OVRHDHRS           370.6          151.6
223.5        316.7
     1107.6 -PRODHOURS          568.7          474.0
834.4       1107.6
        9.0 -SHIPREPORT           3.2            1.0
3.3          1.0
        0.0 -USACE                0.0            0.0
0.0          0.0
      113.0 -USCGLL              18.8           22.6
23.0         76.6
      102.0 -USCGLNTM             0.0           52.8
15.6         28.3
     27.000 -WORKSTA           15.722         13.851
22.219       22.668
     1252.0 +CHARTFEAT          735.6          805.4
1039.3       1062.1
       87.0 +LLFEAT              73.8           74.9
132.5        125.9
Peer      5 out of     5 for target NTM15
       NTM15                     NTM7
      ACTUAL         LAMBDA     0.348
                      SCALE     0.520
       79.0 -FCHARTS             13.5
      663.0 -FNTMTEXT           305.0
        0.0 -IMODATA              0.0
       27.0 -NOSDATA              0.5
      370.6 -OVRHDHRS           215.2
     1107.6 -PRODHOURS          540.2
        9.0 -SHIPREPORT           2.1
        0.0 -USACE                0.0
      113.0 -USCGLL              20.3
      102.0 -USCGLNTM           102.0
     27.000 -WORKSTA           12.646
     1252.0 +CHARTFEAT          670.3
       87.0 +LLFEAT             132.2
```

NTM21

Peers for Unit NTM21 efficiency 80.70% radial

NTM21 ACTUAL		NTM33	NTM47	NTM6	NTM7
	LAMBDA	0.006	0.555	0.325	0.029
	SCALE	0.176	0.744	0.781	0.250
61.0	-FCHARTS	6.2	56.6	38.3	6.5
389.0	-FNTMTEXT	60.5	311.1	332.6	146.5
0.0	-IMODATA	0.0	0.0	0.0	0.0
3.0	-NOSDATA	3.0	3.0	1.6	0.3
344.6	-OVRHDHRS	65.3	264.4	235.7	103.4
982.8	-PRODHOURS	172.5	689.5	824.1	259.5
1.0	-SHIPREPORT	0.2	0.7	0.8	1.0
0.0	-USACE	0.0	0.0	0.0	0.0
57.0	-USCGLL	13.6	6.7	57.0	9.8
163.0	-USCGLNTM	16.4	163.0	21.1	49.0
25.313	-WORKSTA	4.550	20.096	16.866	6.075
893.0	+CHARTFEAT	195.7	985.4	790.2	322.0
82.0	+LLFEAT	61.8	71.5	93.7	63.5

NTM22

Peers for Unit NTM22 efficiency 81.97% radial

NTM22	NTM12	NTM50

ACTUAL			
	LAMBDA	0.240	0.710
	SCALE	0.556	0.950
94.0	-FCHARTS	58.3	91.2
616.0	-FNTMTEXT	415.0	450.3
0.0	-IMODATA	0.0	0.0
0.0	-NOSDATA	0.0	0.0
333.6	-OVRHDHRS	204.7	258.0
979.2	-PRODHOURS	565.8	963.3
5.0	-SHIPREPORT	5.0	3.8
0.0	-USACE	0.0	0.0
88.0	-USCGLL	9.4	26.6
137.0	-USCGLNTM	68.3	18.0
25.650	-WORKSTA	15.000	25.650
989.0	+CHARTFEAT	717.2	1199.9
105.0	+LLFEAT	35.0	152.9

NTM24

Peers for Unit NTM24 efficiency 82.25% radial

Peers 1 to 4 out of 5 for target NTM24

NTM24		NTM17	NTM3	NTM4	NTM40
ACTUAL	LAMBDA	0.024	0.173	0.296	0.239
	SCALE	0.211	0.375	0.444	0.535
107.0	-FCHARTS	32.4	80.6	0.0	107.0
803.0	-FNTMTEXT	142.7	322.9	408.9	377.7
0.0	-IMODATA	0.0	0.0	0.0	0.0
4.0	-NOSDATA	4.0	0.4	4.0	1.6
675.4	-OVRHDHRS	62.2	336.1	486.0	157.8
561.0	-PRODHOURS	194.5	173.2	133.1	547.3
3.0	-SHIPREPORT	0.4	3.0	0.9	1.1

0.0 -USACE 0.0 0.0
0.0 0.0
176.0 -USCGLL 9.3 18.0
7.6 143.4
70.0 -USCGLNTM 21.7 35.2
46.2 40.7
27.000 -WORKSTA 5.684 9.872
12.000 14.445
734.0 +CHARTFEAT 330.5 339.4
293.3 775.2
77.0 +LLFEAT 30.7 22.5
58.2 47.1

Peer 5 out of 5 for target NTM24

NTM24		NTM50
ACTUAL	LAMBDA	0.124
	SCALE	0.553
107.0	-FCHARTS	53.1
803.0	-FNTMTEXT	262.2
0.0	-IMODATA	0.0
4.0	-NOSDATA	0.0
675.4	-OVRHDHRS	150.3
561.0	-PRODHOURS	561.0
3.0	-SHIPREPORT	2.2
0.0	-USACE	0.0
176.0	-USCGLL	15.5
70.0	-USCGLNTM	10.5
27.000	-WORKSTA	14.938
734.0	+CHARTFEAT	698.8
77.0	+LLFEAT	89.1

NTM25

Peers for Unit NTM25 efficiency 66.64% radial

Peers 1 to 4 out of 5 for target NTM25

NTM25 NTM16 NTM17
NTM40 NTM47
ACTUAL LAMBDA 0.523 0.061
0.070 0.087
SCALE 0.667 0.421
0.246 0.562

```
      126.0 -FCHARTS              74.7            64.8
49.3          42.7
      523.0 -FNTMTEXT            348.0           285.5
173.9         234.8
        0.0 -IMODATA               0.0             0.0
0.0           0.0
        8.0 -NOSDATA               8.0             8.0
0.7           2.2
      335.3 -OVRHDHRS            200.1           124.5
72.6         199.6
     1036.8 -PRODHOURS           703.2           389.1
251.9         520.3
        4.0 -SHIPREPORT            3.3             0.8
0.5           0.6
        0.0 -USACE                 0.0             0.0
0.0           0.0
       66.0 -USCGLL               44.0            18.5
66.0           5.1
      123.0 -USCGLNTM            111.3            43.4
18.7         123.0
     27.000 -WORKSTA            18.000          11.368
6.649        15.164
      934.0 +CHARTFEAT           971.3           661.1
356.8         743.6
       82.0 +LLFEAT              180.0            61.5
21.7          53.9
Peer      5 out of     5 for target NTM25
      NTM25                      NTM50
     ACTUAL         LAMBDA       0.258
                     SCALE       1.000
      126.0 -FCHARTS              96.0
      523.0 -FNTMTEXT            474.0
        0.0 -IMODATA               0.0
        8.0 -NOSDATA               0.0
      335.3 -OVRHDHRS            271.6
     1036.8 -PRODHOURS          1014.0
        4.0 -SHIPREPORT            4.0
        0.0 -USACE                 0.0
       66.0 -USCGLL               28.0
      123.0 -USCGLNTM             19.0
     27.000 -WORKSTA            27.000
      934.0 +CHARTFEAT          1263.0
```

82.0 +LLFEAT 161.0

NTM28

Peers for Unit NTM28 efficiency 93.10% radial

NTM28		NTM29	NTM6	NTM7
ACTUAL	LAMBDA	0.285	0.367	0.266
	SCALE	0.622	0.500	0.500
46.0	-FCHARTS	46.0	24.5	13.0
533.0	-FNTMTEXT	425.8	213.0	293.0
0.0	-IMODATA	0.0	0.0	0.0
1.0	-NOSDATA	0.0	1.0	0.5
313.2	-OVRHDHRS	201.4	150.9	206.8
984.6	-PRODHOURS	641.5	527.7	519.0
2.0	-SHIPREPORT	1.2	0.5	2.0
0.0	-USACE	0.0	0.0	0.0
97.0	-USCGLL	54.7	36.5	19.5
204.0	-USCGLNTM	91.4	13.5	98.0
27.000	-WORKSTA	16.784	10.800	12.150
918.0	+CHARTFEAT	593.6	506.0	644.0
73.0	+LLFEAT	71.5	60.0	127.0

NTM35

Peers for Unit NTM35 efficiency 68.34% radial

Peers 1 to 4 out of 6 for target NTM35

NTM35		NTM12	NTM26	NTM3	NTM40
ACTUAL	LAMBDA	0.207	0.025	0.028	0.057
	SCALE	0.667	0.200	0.386	0.134
98.0	-FCHARTS	70.0	11.4	83.0	26.9
739.0	-FNTMTEXT	498.0	127.4	332.5	94.8
0.0	-IMODATA	0.0	0.0	0.0	0.0
2.0	-NOSDATA	0.0	1.2	0.4	0.4
346.2	-OVRHDHRS	245.6	62.1	346.2	39.6
963.6	-PRODHOURS	678.9	195.3	178.4	137.4
6.0	-SHIPREPORT	6.0	1.6	3.1	0.3
0.0	-USACE	0.0	0.0	0.0	0.0
36.0	-USCGLL	11.3	36.0	18.5	36.0
145.0	-USCGLNTM	82.0	47.0	36.3	10.2
27.000	-WORKSTA	18.000	5.400	10.167	3.627
889.0	+CHARTFEAT	860.7	295.4	349.5	194.6
47.0	+LLFEAT	42.0	23.2	23.2	11.8

Peers 5 to 6 out of 6 for target NTM35

NTM35		NTM47	NTM50
ACTUAL	LAMBDA	0.413	0.270
	SCALE	0.500	0.950
98.0	-FCHARTS	38.0	91.2
739.0	-FNTMTEXT	209.0	450.4
0.0	-IMODATA	0.0	0.0
2.0	-NOSDATA	2.0	0.0

346.2	-OVRHDHRS	177.6	258.1
963.6	-PRODHOURS	463.2	963.6
6.0	-SHIPREPORT	0.5	3.8
0.0	-USACE	0.0	0.0
36.0	-USCGLL	4.5	26.6
145.0	-USCGLNTM	109.5	18.1
27.000	-WORKSTA	13.500	25.658
889.0	+CHARTFEAT	662.0	1200.2
47.0	+LLFEAT	48.0	153.0

NTM36

Peers for Unit NTM36 efficiency 94.49% radial

Peers 1 to 4 out of 5 for target NTM36

NTM36		NTM26	NTM30	NTM4	NTM52
ACTUAL	LAMBDA	0.238	0.478	0.070	0.180
	SCALE	0.351	0.987	0.462	0.600
20.0	-FCHARTS	20.0	0.0	0.0	16.2
581.0	-FNTMTEXT	223.5	393.8	424.8	462.6
0.0	-IMODATA	0.0	0.0	0.0	0.0
9.0	-NOSDATA	2.1	3.0	4.2	0.6
504.9	-OVRHDHRS	108.9	504.9	504.9	204.8
849.6	-PRODHOURS	342.6	746.7	138.2	574.2
6.0	-SHIPREPORT	2.8	3.9	0.9	6.0
23.0	-USACE	0.0	0.0	0.0	19.8
199.0	-USCGLL	63.2	120.4	7.8	15.6
143.0	-USCGLNTM	82.5	91.8	48.0	58.8

27.000 -WORKSTA 9.474 26.646
12.466 14.378
1109.0 +CHARTFEAT 518.2 936.6
304.7 816.0
65.0 +LLFEAT 40.7 111.5
60.5 84.6
Peer 5 out of 5 for target NTM36

NTM36		NTM7
ACTUAL	LAMBDA	0.059
	SCALE	0.730
20.0	-FCHARTS	19.0
581.0	-FNTMTEXT	427.5
0.0	-IMODATA	0.0
9.0	-NOSDATA	0.7
504.9	-OVRHDHRS	301.8
849.6	-PRODHOURS	757.3
6.0	-SHIPREPORT	2.9
23.0	-USACE	0.0
199.0	-USCGLL	28.5
143.0	-USCGLNTM	143.0
27.000	-WORKSTA	17.729
1109.0	+CHARTFEAT	939.7
65.0	+LLFEAT	185.3

NTM37
Peers for Unit NTM37 efficiency 80.93% radial
Peers 1 to 4 out of 6 for target NTM37
NTM37 NTM12 NTM17
NTM26 NTM47
ACTUAL LAMBDA 0.021 0.024
0.193 0.065
SCALE 0.714 0.105
0.322 0.461
189.0 -FCHARTS 74.9 16.2
18.4 35.1
533.0 -FNTMTEXT 533.0 71.4
205.3 192.8
0.0 -IMODATA 0.0 0.0
0.0 0.0

```
           2.0 -NOSDATA              0.0           2.0
1.9            1.8
         333.3 -OVRHDHRS           262.9          31.1
100.0          163.9
        1015.2 -PRODHOURS          726.6          97.3
314.6          427.2
          10.0 -SHIPREPORT           6.4           0.2
2.6            0.5
           0.0 -USACE                0.0           0.0
0.0            0.0
          58.0 -USCGLL              12.1           4.6
58.0            4.2
         101.0 -USCGLNTM            87.8          10.8
75.7          101.0
        27.000 -WORKSTA           19.265         2.842
8.700         12.452
        1081.0 +CHARTFEAT          921.2         165.3
475.9          610.6
          81.0 +LLFEAT              45.0          15.4
37.4           44.3
Peers     5 to     6 out of     6 for target NTM37
         NTM37                     NTM50          NTM7
        ACTUAL          LAMBDA     0.581         0.129
                         SCALE     1.000         0.515
         189.0 -FCHARTS             96.0          13.4
         533.0 -FNTMTEXT           474.0         302.0
           0.0 -IMODATA              0.0           0.0
           2.0 -NOSDATA              0.0           0.5
         333.3 -OVRHDHRS           271.6         213.1
        1015.2 -PRODHOURS         1014.0         534.9
          10.0 -SHIPREPORT           4.0           2.1
           0.0 -USACE                0.0           0.0
          58.0 -USCGLL              28.0          20.1
         101.0 -USCGLNTM            19.0         101.0
        27.000 -WORKSTA           27.000        12.522
        1081.0 +CHARTFEAT         1263.0         663.7
          81.0 +LLFEAT             161.0         130.9


    NTM38
Peers for Unit NTM38          efficiency   99.69% radial
```

NTM38

ACTUAL		NTM1	NTM10	NTM17	NTM50
	LAMBDA	0.051	0.061	0.671	0.017
	SCALE	0.577	0.737	0.689	0.721
204.0	-FCHARTS	43.3	56.8	106.2	69.2
539.0	-FNTMTEXT	354.2	539.0	467.4	341.6
0.0	-IMODATA	0.0	0.0	0.0	0.0
14.0	-NOSDATA	1.7	13.3	13.1	0.0
573.2	-OVRHDHRS	351.2	422.4	203.8	195.7
730.8	-PRODHOURS	449.0	648.1	636.9	730.8
6.0	-SHIPREPORT	2.9	3.7	1.4	2.9
0.0	-USACE	0.0	0.0	0.0	0.0
45.0	-USCGLL	45.0	21.4	30.3	20.2
71.0	-USCGLNTM	17.9	0.0	71.0	13.7
27.000	-WORKSTA	15.577	17.918	18.612	19.459
1196.0	+CHARTFEAT	624.2	838.4	1082.2	910.3
60.0	+LLFEAT	49.6	84.1	100.6	116.0

NTM39

Peers for Unit NTM39 efficiency 61.61% radial

NTM39

ACTUAL		NTM47	NTM5	NTM50
	LAMBDA	0.248	0.006	0.745

ACTUAL				
	SCALE	0.250	0.612	0.968
111.0	-FCHARTS	19.0	31.8	93.0
459.0	-FNTMTEXT	104.5	183.1	459.0
0.0	-IMODATA	0.0	0.0	0.0
1.0	-NOSDATA	1.0	0.6	0.0
365.6	-OVRHDHRS	88.8	243.8	263.0
1030.2	-PRODHOURS	231.6	581.5	981.9
5.0	-SHIPREPORT	0.3	1.2	3.9
0.0	-USACE	0.0	0.0	0.0
30.0	-USCGLL	2.2	30.0	27.1
148.0	-USCGLNTM	54.7	15.9	18.4
27.000	-WORKSTA	6.750	16.531	26.146
786.0	+CHARTFEAT	331.0	537.6	1223.0
74.0	+LLFEAT	24.0	42.2	155.9

NTM44

Peers for Unit NTM44 efficiency 89.19% radial

Peers 1 to 4 out of 7 for target NTM44

NTM44		NTM1	NTM17	NTM26	NTM3
ACTUAL	LAMBDA	0.121	0.213	0.005	0.100
	SCALE	0.564	0.316	0.244	0.375
132.0	-FCHARTS	42.3	48.6	13.9	80.6

```
      674.0 -FNTMTEXT            346.4          214.1
155.7       322.9
        0.0 -IMODATA               0.0            0.0
0.0         0.0
        6.0 -NOSDATA               1.7            6.0
1.5         0.4
      602.9 -OVRHDHRS            343.4           93.3
75.9       336.1
      774.0 -PRODHOURS           439.0          291.8
238.7       173.2
        3.0 -SHIPREPORT            2.8            0.6
2.0         3.0
        0.0 -USACE                 0.0            0.0
0.0         0.0
       44.0 -USCGLL               44.0           13.9
44.0        18.0
      108.0 -USCGLNTM             17.5           32.5
57.4        35.2
     27.000 -WORKSTA            15.231          8.526
6.600       9.872
     1082.0 +CHARTFEAT           610.4          495.8
361.0       339.4
      103.0 +LLFEAT               48.5           46.1
28.4        22.5
Peers    5 to    7 out of    7 for target NTM44
      NTM44                        NTM4         NTM40
NTM48
     ACTUAL        LAMBDA        0.044          0.025
0.494
                    SCALE        0.551          0.164
0.818
      132.0 -FCHARTS               0.0           32.8
104.7
      674.0 -FNTMTEXT            507.2          115.9
355.1
        0.0 -IMODATA               0.0            0.0
0.0
        6.0 -NOSDATA               5.0            0.5
1.6
      602.9 -OVRHDHRS            602.9           48.4
469.6
```

774.0	-PRODHOURS	165.1	168.0	650.5
3.0	-SHIPREPORT	1.1	0.3	1.6
0.0	-USACE	0.0	0.0	0.0
44.0	-USCGLL	9.4	44.0	19.6
108.0	-USCGLNTM	57.3	12.5	108.0
27.000	-WORKSTA	14.885	4.433	22.091
1082.0	+CHARTFEAT	363.9	237.9	967.1
103.0	+LLFEAT	72.2	14.4	105.5

NTM45

Peers for Unit NTM45 efficiency 68.90% radial

Peers 1 to 4 out of 8 for target NTM45

NTM45		NTM17	NTM26	NTM27	NTM33
ACTUAL	LAMBDA	0.183	0.004	0.284	0.111
	SCALE	0.421	0.375	0.391	0.471
110.0	-FCHARTS	64.8	21.4	48.5	16.5
567.0	-FNTMTEXT	285.5	238.9	245.1	161.4
0.0	-IMODATA	0.0	0.0	0.0	0.0
8.0	-NOSDATA	8.0	2.2	1.2	8.0
374.6	-OVRHDHRS	124.5	116.4	117.1	174.0
1000.8	-PRODHOURS	389.1	366.2	394.4	460.0
3.0	-SHIPREPORT	0.8	3.0	0.8	0.5

11.0	-USACE	0.0	0.0	7.4	0.0
92.0	-USCGLL	18.5	67.5	92.0	36.2
145.0	-USCGLNTM	43.4	88.1	77.9	43.8
27.000	-WORKSTA	11.368	10.125	10.570	12.134
992.0	+CHARTFEAT	661.1	553.9	573.5	521.9
200.0	+LLFEAT	61.5	43.5	212.2	164.7

Peers 5 to 8 out of 8 for target NTM45

NTM45		NTM42	NTM47	NTM52	NTM7
ACTUAL	LAMBDA	0.209	0.092	0.011	0.124
	SCALE	0.440	0.662	0.300	0.740
110.0	-FCHARTS	67.3	50.3	8.1	19.2
567.0	-FNTMTEXT	220.0	276.8	231.3	433.5
0.0	-IMODATA	0.0	0.0	0.0	0.0
8.0	-NOSDATA	2.6	2.6	0.3	0.7
374.6	-OVRHDHRS	158.9	235.2	102.4	306.0
1000.8	-PRODHOURS	438.0	613.4	287.1	767.9
3.0	-SHIPREPORT	2.2	0.7	3.0	3.0
11.0	-USACE	11.0	0.0	9.9	0.0
92.0	-USCGLL	4.0	6.0	7.8	28.9
145.0	-USCGLNTM	26.8	145.0	29.4	145.0
27.000	-WORKSTA	11.880	17.877	7.189	17.977

992.0	+CHARTFEAT	652.5	876.6	408.0	952.9
200.0	+LLFEAT	59.4	63.6	42.3	187.9

NTM49

Peers for Unit NTM49 efficiency 91.74% radial

Peers 1 to 4 out of 6 for target NTM49

NTM49		NTM12	NTM26	NTM40	NTM48
ACTUAL	LAMBDA	0.136	0.048	0.480	0.120
	SCALE	0.444	0.333	0.556	0.592
164.0	-FCHARTS	46.7	19.0	111.2	75.7
728.0	-FNTMTEXT	332.0	212.3	392.5	256.8
0.0	-IMODATA	0.0	0.0	0.0	0.0
2.0	-NOSDATA	0.0	2.0	1.7	1.2
339.6	-OVRHDHRS	163.7	103.5	164.0	339.6
994.8	-PRODHOURS	452.6	325.5	568.8	470.4
4.0	-SHIPREPORT	4.0	2.7	1.1	1.2
0.0	-USACE	0.0	0.0	0.0	0.0
149.0	-USCGLL	7.6	60.0	149.0	14.2
186.0	-USCGLNTM	54.7	78.3	42.3	78.1
27.000	-WORKSTA	12.000	9.000	15.011	15.977
1249.0	+CHARTFEAT	573.8	492.3	805.6	699.4
101.0	+LLFEAT	28.0	38.7	48.9	76.3

Peers 5 to 6 out of 6 for target NTM49

NTM49		NTM50	NTM7
ACTUAL	LAMBDA	0.187	0.032
	SCALE	0.981	0.821
164.0	-FCHARTS	94.2	21.3
728.0	-FNTMTEXT	465.0	481.2
0.0	-IMODATA	0.0	0.0
2.0	-NOSDATA	0.0	0.8
339.6	-OVRHDHRS	266.5	339.6
994.8	-PRODHOURS	994.8	852.3
4.0	-SHIPREPORT	3.9	3.3
0.0	-USACE	0.0	0.0
149.0	-USCGLL	27.5	32.0
186.0	-USCGLNTM	18.6	160.9
27.000	-WORKSTA	26.489	19.952
1249.0	+CHARTFEAT	1239.1	1057.6
101.0	+LLFEAT	158.0	208.6

NTM51

Peers for Unit NTM51 efficiency 87.21% radial

NTM51		NTM17	NTM3	NTM48
ACTUAL	LAMBDA	0.151	0.179	0.475
	SCALE	0.211	0.500	0.755
158.0	-FCHARTS	32.4	107.5	96.6
463.0	-FNTMTEXT	142.7	430.5	327.5
0.0	-IMODATA	0.0	0.0	0.0
4.0	-NOSDATA	4.0	0.5	1.5
658.2	-OVRHDHRS	62.2	448.2	433.1
600.0	-PRODHOURS	194.5	231.0	600.0
4.0	-SHIPREPORT	0.4	4.0	1.5

```
        0.0 -USACE             0.0          0.0
0.0
       41.0 -USCGLL            9.3         24.0
18.1
      111.0 -USCGLNTM         21.7         47.0
99.6
     27.000 -WORKSTA         5.684       13.162
20.377
      838.0 +CHARTFEAT       330.5        452.5
892.1
       75.0 +LLFEAT           30.7         30.0
97.4


Give command ( or ? ) EX
```

Table D-4. Unit Target Values

```
Give the file name cnsdea.txt
Opening file cnsdea.txt for input
Data read with  13 variables and   52 units
Model at   10/MAR/1997 13:55:00
11 inputs    2 outputs 0 unused variables
  52 active units            0 unused units
   0 active constraints      0 unused constraints
Improvement model         RM radial
Radial objectives         OM outputs
Returns to scale          DB fixed
Target gains              RG Relative
Own unit as comparator    IX Included
Specified priorities      PU Uniform
Efficiency value          AE Related
```

NTM8

Targets for Unit NTM8 efficiency 89.09% radial

VARIABLE	ACTUAL	TARGET	TO GAIN	ACHIEVED
-FCHARTS	156.0	86.9	44.3%	55.7%
-FNTMTEXT	430.0	430.0	0.0%	100.0%
-IMODATA	0.0	0.0	0.0%	0.0%
-NOSDATA	8.0	7.7	3.8%	96.2%
-OVRHDHRS	292.2	292.2	0.0%	100.0%
-PRODHOURS	960.0	900.8	6.2%	93.8%
-SHIPREPORT	3.0	2.9	1.8%	98.2%
-USACE	0.0	0.0	0.0%	0.0%
-USCGLL	39.0	37.2	4.5%	95.5%
-USCGLNTM	206.0	170.9	17.0%	83.0%
-WORKSTA	27.000	24.344	9.8%	90.2%
+CHARTFEAT	1124.0	1261.7	12.2%	89.1%
+LLFEAT	140.0	175.4	25.3%	79.8%

NTM13

Targets for Unit NTM13 efficiency 84.18% radial

VARIABLE	ACTUAL	TARGET	TO GAIN	ACHIEVED

-FCHARTS	148.0	104.9	29.1%	70.9%
-FNTMTEXT	519.0	504.6	2.8%	97.2%
-IMODATA	0.0	0.0	0.0%	0.0%
-NOSDATA	2.0	2.0	0.0%	100.0%
-OVRHDHRS	420.8	350.0	16.8%	83.2%
-PRODHOURS	913.6	913.6	0.0%	100.0%
-SHIPREPORT	8.0	2.4	69.8%	30.2%
-USACE	0.0	0.0	0.0%	0.0%
-USCGLL	16.0	16.0	0.0%	100.0%
-USCGLNTM	66.0	66.0	0.0%	100.0%
-WORKSTA	25.988	25.988	0.0%	100.0%
+CHARTFEAT	990.0	1176.1	18.8%	84.2%
+LLFEAT	104.0	123.6	18.8%	84.2%

NTM14

Targets for Unit NTM14 efficiency 88.30% radial

VARIABLE	ACTUAL	TARGET	TO GAIN	ACHIEVED
-FCHARTS	152.0	102.1	32.8%	67.2%
-FNTMTEXT	600.0	520.2	13.3%	86.7%
-IMODATA	0.0	0.0	0.0%	0.0%
-NOSDATA	0.0	0.0	0.0%	0.0%
-OVRHDHRS	433.4	303.1	30.1%	69.9%
-PRODHOURS	976.6	968.7	0.8%	99.2%
-SHIPREPORT	3.0	3.0	0.0%	100.0%
-USACE	0.0	0.0	0.0%	0.0%
-USCGLL	154.0	14.7	90.5%	9.5%
-USCGLNTM	81.0	20.8	74.4%	25.6%
-WORKSTA	26.325	26.325	0.0%	100.0%
+CHARTFEAT	1023.0	1158.5	13.2%	88.3%
+LLFEAT	44.0	130.4	196.4%	33.7%

NTM15

Targets for Unit NTM15 efficiency 90.63% radial

VARIABLE	ACTUAL	TARGET	TO GAIN	ACHIEVED
-FCHARTS	79.0	79.0	0.0%	100.0%
-FNTMTEXT	663.0	596.2	10.1%	89.9%
-IMODATA	0.0	0.0	0.0%	0.0%
-NOSDATA	27.0	5.5	79.5%	20.5%

-OVRHDHRS	370.6	370.6	0.0%	100.0%
-PRODHOURS	1107.6	1107.6	0.0%	100.0%
-SHIPREPORT	9.0	3.1	65.2%	34.8%
-USACE	0.0	0.0	0.0%	0.0%
-USCGLL	113.0	50.9	55.0%	45.0%
-USCGLNTM	102.0	102.0	0.0%	100.0%
-WORKSTA	27.000	27.000	0.0%	100.0%
+CHARTFEAT	1252.0	1381.4	10.3%	90.6%
+LLFEAT	87.0	192.3	121.0%	45.2%

NTM21

Targets for Unit NTM21 efficiency 80.70% radial

VARIABLE	ACTUAL	TARGET	TO GAIN	ACHIEVED
-FCHARTS	61.0	59.0	3.3%	96.7%
-FNTMTEXT	389.0	389.0	0.0%	100.0%
-IMODATA	0.0	0.0	0.0%	0.0%
-NOSDATA	3.0	3.0	0.0%	100.0%
-OVRHDHRS	344.6	309.1	10.3%	89.7%
-PRODHOURS	982.8	892.1	9.2%	90.8%
-SHIPREPORT	1.0	1.0	0.0%	100.0%
-USACE	0.0	0.0	0.0%	0.0%
-USCGLL	57.0	30.3	46.9%	53.1%
-USCGLNTM	163.0	136.4	16.3%	83.7%
-WORKSTA	25.313	22.840	9.8%	90.2%
+CHARTFEAT	893.0	1106.5	23.9%	80.7%
+LLFEAT	82.0	101.6	23.9%	80.7%

NTM22

Targets for Unit NTM22 efficiency 81.97% radial

VARIABLE	ACTUAL	TARGET	TO GAIN	ACHIEVED
-FCHARTS	94.0	93.4	0.7%	99.3%
-FNTMTEXT	616.0	515.8	16.3%	83.7%
-IMODATA	0.0	0.0	0.0%	0.0%
-NOSDATA	0.0	0.0	0.0%	0.0%
-OVRHDHRS	333.6	281.3	15.7%	84.3%
-PRODHOURS	979.2	964.4	1.5%	98.5%
-SHIPREPORT	5.0	5.0	0.0%	100.0%
-USACE	0.0	0.0	0.0%	0.0%

-USCGLL	88.0	24.0	72.8%	27.2%
-USCGLNTM	137.0	43.0	68.6%	31.4%
-WORKSTA	25.650	25.650	0.0%	100.0%
+CHARTFEAT	989.0	1206.6	22.0%	82.0%
+LLFEAT	105.0	129.4	23.3%	81.1%

NTM24

Targets for Unit NTM24 efficiency 82.25% radial

VARIABLE	ACTUAL	TARGET	TO GAIN	ACHIEVED
-FCHARTS	107.0	100.6	5.9%	94.1%
-FNTMTEXT	803.0	664.9	17.2%	82.8%
-IMODATA	0.0	0.0	0.0%	0.0%
-NOSDATA	4.0	4.0	0.0%	100.0%
-OVRHDHRS	675.4	589.9	12.7%	87.3%
-PRODHOURS	561.0	561.0	0.0%	100.0%
-SHIPREPORT	3.0	3.0	0.0%	100.0%
-USACE	0.0	0.0	0.0%	0.0%
-USCGLL	176.0	81.9	53.4%	46.6%
-USCGLNTM	70.0	70.0	0.0%	100.0%
-WORKSTA	27.000	22.992	14.8%	85.2%
+CHARTFEAT	734.0	892.4	21.6%	82.2%
+LLFEAT	77.0	93.6	21.6%	82.2%

NTM25

Targets for Unit NTM25 efficiency 66.64% radial

VARIABLE	ACTUAL	TARGET	TO GAIN	ACHIEVED
-FCHARTS	126.0	113.5	9.9%	90.1%
-FNTMTEXT	523.0	523.0	0.0%	100.0%
-IMODATA	0.0	0.0	0.0%	0.0%
-NOSDATA	8.0	8.0	0.0%	100.0%
-OVRHDHRS	335.3	297.0	11.4%	88.6%
-PRODHOURS	1036.8	1022.9	1.3%	98.7%
-SHIPREPORT	4.0	4.0	0.0%	100.0%
-USACE	0.0	0.0	0.0%	0.0%
-USCGLL	66.0	64.1	2.9%	97.1%
-USCGLNTM	123.0	123.0	0.0%	100.0%
-WORKSTA	27.000	27.000	0.0%	100.0%
+CHARTFEAT	934.0	1401.7	50.1%	66.6%

+LLFEAT	82.0	206.4	151.7%	39.7%

NTM28

Targets for Unit NTM28 efficiency 93.10% radial

VARIABLE	ACTUAL	TARGET	TO GAIN	ACHIEVED
-FCHARTS	46.0	46.0	0.0%	100.0%
-FNTMTEXT	533.0	507.4	4.8%	95.2%
-IMODATA	0.0	0.0	0.0%	0.0%
-NOSDATA	1.0	1.0	0.0%	100.0%
-OVRHDHRS	313.2	313.1	0.0%	100.0%
-PRODHOURS	984.6	957.5	2.7%	97.3%
-SHIPREPORT	2.0	2.0	0.0%	100.0%
-USACE	0.0	0.0	0.0%	0.0%
-USCGLL	97.0	62.3	35.8%	64.2%
-USCGLNTM	204.0	103.9	49.1%	50.9%
-WORKSTA	27.000	22.085	18.2%	81.8%
+CHARTFEAT	918.0	986.0	7.4%	93.1%
+LLFEAT	73.0	144.3	97.7%	50.6%

NTM35

Targets for Unit NTM35 efficiency 68.34% radial

VARIABLE	ACTUAL	TARGET	TO GAIN	ACHIEVED
-FCHARTS	98.0	98.0	0.0%	100.0%
-FNTMTEXT	739.0	536.0	27.5%	72.5%
-IMODATA	0.0	0.0	0.0%	0.0%
-NOSDATA	2.0	2.0	0.0%	100.0%
-OVRHDHRS	346.2	346.2	0.0%	100.0%
-PRODHOURS	963.6	963.6	0.0%	100.0%
-SHIPREPORT	6.0	3.9	35.0%	65.0%
-USACE	0.0	0.0	0.0%	0.0%
-USCGLL	36.0	36.0	0.0%	100.0%
-USCGLNTM	145.0	133.9	7.7%	92.3%
-WORKSTA	27.000	27.000	0.0%	100.0%
+CHARTFEAT	889.0	1300.8	46.3%	68.3%
+LLFEAT	47.0	105.8	125.2%	44.4%

NTM36

Targets for Unit NTM36 efficiency 94.49% radial

VARIABLE	ACTUAL	TARGET	TO GAIN	ACHIEVED
-FCHARTS	20.0	20.0	0.0%	100.0%
-FNTMTEXT	581.0	581.0	0.0%	100.0%
-IMODATA	0.0	0.0	0.0%	0.0%
-NOSDATA	9.0	3.7	58.5%	41.5%
-OVRHDHRS	504.9	481.4	4.6%	95.4%
-PRODHOURS	849.6	849.6	0.0%	100.0%
-SHIPREPORT	6.0	6.0	0.0%	100.0%
-USACE	23.0	6.0	74.1%	25.9%
-USCGLL	199.0	109.4	45.0%	55.0%
-USCGLNTM	143.0	137.1	4.1%	95.9%
-WORKSTA	27.000	27.000	0.0%	100.0%
+CHARTFEAT	1109.0	1173.7	5.8%	94.5%
+LLFEAT	65.0	131.4	102.1%	49.5%

NTM37

Targets for Unit NTM37 efficiency 80.93% radial

VARIABLE	ACTUAL	TARGET	TO GAIN	ACHIEVED
-FCHARTS	189.0	80.9	57.2%	42.8%
-FNTMTEXT	533.0	533.0	0.0%	100.0%
-IMODATA	0.0	0.0	0.0%	0.0%
-NOSDATA	2.0	2.0	0.0%	100.0%
-OVRHDHRS	333.3	309.0	7.3%	92.7%
-PRODHOURS	1015.2	1015.2	0.0%	100.0%
-SHIPREPORT	10.0	4.7	53.2%	46.8%
-USACE	0.0	0.0	0.0%	0.0%
-USCGLL	58.0	58.0	0.0%	100.0%
-USCGLNTM	101.0	101.0	0.0%	100.0%
-WORKSTA	27.000	27.000	0.0%	100.0%
+CHARTFEAT	1081.0	1335.7	23.6%	80.9%
+LLFEAT	81.0	159.8	97.3%	50.7%

NTM38

Targets for Unit NTM38 efficiency 99.69% radial

VARIABLE	ACTUAL	TARGET	TO GAIN	ACHIEVED
-FCHARTS	204.0	113.5	44.4%	55.6%

-FNTMTEXT	539.0	539.0	0.0%	100.0%
-IMODATA	0.0	0.0	0.0%	0.0%
-NOSDATA	14.0	14.0	0.0%	100.0%
-OVRHDHRS	573.2	269.0	53.1%	46.9%
-PRODHOURS	730.8	730.8	0.0%	100.0%
-SHIPREPORT	6.0	2.0	67.1%	32.9%
-USACE	0.0	0.0	0.0%	0.0%
-USCGLL	45.0	35.7	20.6%	79.4%
-USCGLNTM	71.0	71.0	0.0%	100.0%
-WORKSTA	27.000	21.441	20.6%	79.4%
+CHARTFEAT	1196.0	1199.7	0.3%	99.7%
+LLFEAT	60.0	112.1	86.8%	53.5%

NTM39

Targets for Unit NTM39 efficiency 61.61% radial

VARIABLE	ACTUAL	TARGET	TO GAIN	ACHIEVED
-FCHARTS	111.0	90.8	18.2%	81.8%
-FNTMTEXT	459.0	459.0	0.0%	100.0%
-IMODATA	0.0	0.0	0.0%	0.0%
-NOSDATA	1.0	1.0	0.0%	100.0%
-OVRHDHRS	365.6	293.2	19.8%	80.2%
-PRODHOURS	1030.2	991.8	3.7%	96.3%
-SHIPREPORT	5.0	3.2	35.2%	64.8%
-USACE	0.0	0.0	0.0%	0.0%
-USCGLL	30.0	23.4	22.0%	78.0%
-USCGLNTM	148.0	68.7	53.6%	46.4%
-WORKSTA	27.000	27.000	0.0%	100.0%
+CHARTFEAT	786.0	1275.8	62.3%	61.6%
+LLFEAT	74.0	144.3	95.0%	51.3%

NTM44

Targets for Unit NTM44 efficiency 89.19% radial

VARIABLE	ACTUAL	TARGET	TO GAIN	ACHIEVED
-FCHARTS	132.0	132.0	0.0%	100.0%
-FNTMTEXT	674.0	580.7	13.8%	86.2%
-IMODATA	0.0	0.0	0.0%	0.0%
-NOSDATA	6.0	6.0	0.0%	100.0%
-OVRHDHRS	602.9	567.0	6.0%	94.0%

-PRODHOURS	774.0	774.0	0.0%	100.0%
-SHIPREPORT	3.0	3.0	0.0%	100.0%
-USACE	0.0	0.0	0.0%	0.0%
-USCGLL	44.0	43.8	0.4%	99.6%
-USCGLNTM	108.0	108.0	0.0%	100.0%
-WORKSTA	27.000	27.000	0.0%	100.0%
+CHARTFEAT	1082.0	1213.1	12.1%	89.2%
+LLFEAT	103.0	119.8	16.3%	86.0%

NTM45

Targets for Unit NTM45 efficiency 68.90% radial

VARIABLE	ACTUAL	TARGET	TO GAIN	ACHIEVED
-FCHARTS	110.0	110.0	0.0%	100.0%
-FNTMTEXT	567.0	566.9	0.0%	100.0%
-IMODATA	0.0	0.0	0.0%	0.0%
-NOSDATA	8.0	8.0	0.0%	100.0%
-OVRHDHRS	374.6	344.7	8.0%	92.0%
-PRODHOURS	1000.8	1000.6	0.0%	100.0%
-SHIPREPORT	3.0	2.8	5.8%	94.2%
-USACE	11.0	11.0	0.0%	100.0%
-USCGLL	92.0	92.0	0.0%	100.0%
-USCGLNTM	145.0	145.0	0.0%	100.0%
-WORKSTA	27.000	26.994	0.0%	100.0%
+CHARTFEAT	992.0	1439.3	45.1%	68.9%
+LLFEAT	200.0	290.2	45.1%	68.9%

NTM49

Targets for Unit NTM49 efficiency 91.74% radial

VARIABLE	ACTUAL	TARGET	TO GAIN	ACHIEVED
-FCHARTS	164.0	147.2	10.2%	89.8%
-FNTMTEXT	728.0	630.7	13.4%	86.6%
-IMODATA	0.0	0.0	0.0%	0.0%
-NOSDATA	2.0	2.0	0.0%	100.0%
-OVRHDHRS	339.6	339.6	0.0%	100.0%
-PRODHOURS	994.8	994.8	0.0%	100.0%
-SHIPREPORT	4.0	3.7	7.9%	92.1%
-USACE	0.0	0.0	0.0%	0.0%
-USCGLL	149.0	149.0	0.0%	100.0%

-USCGLNTM	186.0	90.2	51.5%	48.5%
-WORKSTA	27.000	27.000	0.0%	100.0%
+CHARTFEAT	1249.0	1361.5	9.0%	91.7%
+LLFEAT	101.0	110.1	9.0%	91.7%

NTM51

Targets for Unit NTM51 efficiency 87.21% radial

VARIABLE	ACTUAL	TARGET	TO GAIN	ACHIEVED
-FCHARTS	158.0	122.6	22.4%	77.6%
-FNTMTEXT	463.0	463.0	0.0%	100.0%
-IMODATA	0.0	0.0	0.0%	0.0%
-NOSDATA	4.0	4.0	0.0%	100.0%
-OVRHDHRS	658.2	478.0	27.4%	72.6%
-PRODHOURS	600.0	600.0	0.0%	100.0%
-SHIPREPORT	4.0	2.7	32.8%	67.2%
-USACE	0.0	0.0	0.0%	0.0%
-USCGLL	41.0	26.7	35.0%	65.0%
-USCGLNTM	111.0	95.1	14.3%	85.7%
-WORKSTA	27.000	21.623	19.9%	80.1%
+CHARTFEAT	838.0	960.9	14.7%	87.2%
+LLFEAT	75.0	94.1	25.4%	79.7%

Give command (or ?) EX

Table D-5. Virtual Inputs and Outputs

```
Give the file name cnsdea.txt
Opening file cnsdea.txt for input
Data read with  13 variables and   52 units
Model at   10/MAR/1997 15:00:02
11 inputs    2 outputs 0 unused variables
  52 active units              0 unused units
   0 active constraints        0 unused constraints
Improvement model            RM radial
Radial objectives            OM outputs
Returns to scale             DB fixed
Target gains                 RG Relative
Own unit as comparator       IX Included
Specified priorities         PU Uniform
Efficiency value             AE Related
```

```
    NTM1
Virtual IOs for Unit NTM1           efficiency  100.00% radial
 VARIABLE    VIRTUAL IOs IO WEIGHTS
-FCHARTS          10.23%    0.00136
-FNTMTEXT          1.77%    0.00003
-IMODATA           0.00%    0.01772
-NOSDATA           1.77%    0.00591
-OVRHDHRS          1.77%    0.00003
-PRODHOURS        73.02%    0.00094
-SHIPREPORT        1.77%    0.00354
-USACE             0.00%    0.01772
-USCGLL            1.77%    0.00023
-USCGLNTM          6.11%    0.00197
-WORKSTA           1.77%    0.00066
+CHARTFEAT        98.23%    0.00091
+LLFEAT            1.77%    0.00021
```

```
    NTM2
Virtual IOs for Unit NTM2           efficiency  100.00% radial
 VARIABLE    VIRTUAL IOs IO WEIGHTS
```

-FCHARTS	3.60%	0.00057
-FNTMTEXT	3.60%	0.00012
-IMODATA	0.00%	0.03598
-NOSDATA	3.60%	0.00600
-OVRHDHRS	3.60%	0.00004
-PRODHOURS	40.92%	0.00076
-SHIPREPORT	0.00%	0.03598
-USACE	0.00%	0.03598
-USCGLL	37.49%	0.00605
-USCGLNTM	3.60%	0.00023
-WORKSTA	3.60%	0.00133
+CHARTFEAT	3.60%	0.00008
+LLFEAT	96.40%	0.01785

NTM3

Virtual IOs for Unit NTM3 efficiency 100.00% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	5.25%	0.00024
-FNTMTEXT	5.25%	0.00006
-IMODATA	0.00%	0.05246
-NOSDATA	5.25%	0.05246
-OVRHDHRS	5.25%	0.00006
-PRODHOURS	58.03%	0.00126
-SHIPREPORT	5.25%	0.00656
-USACE	0.00%	0.05246
-USCGLL	5.25%	0.00109
-USCGLNTM	5.25%	0.00056
-WORKSTA	5.25%	0.00199
+CHARTFEAT	94.75%	0.00105
+LLFEAT	5.25%	0.00087

NTM4

Virtual IOs for Unit NTM4 efficiency 100.00% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	0.00%	0.12500
-FNTMTEXT	12.50%	0.00014
-IMODATA	0.00%	0.12500
-NOSDATA	12.50%	0.01389

-OVRHDHRS	12.50%	0.00011
-PRODHOURS	12.50%	0.00042
-SHIPREPORT	12.50%	0.06250
-USACE	0.00%	0.12500
-USCGLL	12.50%	0.00735
-USCGLNTM	12.50%	0.00120
-WORKSTA	12.50%	0.00463
+CHARTFEAT	12.50%	0.00019
+LLFEAT	87.50%	0.00668

NTM5

Virtual IOs for Unit NTM5 efficiency 100.00% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	29.62%	0.00570
-FNTMTEXT	41.16%	0.00138
-IMODATA	0.00%	0.03904
-NOSDATA	3.90%	0.03904
-OVRHDHRS	3.90%	0.00010
-PRODHOURS	3.90%	0.00004
-SHIPREPORT	5.79%	0.02896
-USACE	0.00%	0.03904
-USCGLL	3.90%	0.00080
-USCGLNTM	3.90%	0.00150
-WORKSTA	3.90%	0.00145
+CHARTFEAT	96.10%	0.00109
+LLFEAT	3.90%	0.00057

NTM6

Virtual IOs for Unit NTM6 efficiency 100.00% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	11.09%	0.00226
-FNTMTEXT	11.09%	0.00026
-IMODATA	0.00%	0.11086
-NOSDATA	11.09%	0.05543
-OVRHDHRS	11.09%	0.00037
-PRODHOURS	11.09%	0.00011
-SHIPREPORT	11.31%	0.11312
-USACE	0.00%	0.11086

-USCGLL	11.09%	0.00152
-USCGLNTM	11.09%	0.00411
-WORKSTA	11.09%	0.00513
+CHARTFEAT	88.91%	0.00088
+LLFEAT	11.09%	0.00092

NTM7

Virtual IOs for Unit NTM7 efficiency 100.00% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	11.11%	0.00427
-FNTMTEXT	11.11%	0.00019
-IMODATA	0.00%	0.11111
-NOSDATA	11.11%	0.11111
-OVRHDHRS	11.11%	0.00027
-PRODHOURS	11.11%	0.00011
-SHIPREPORT	11.11%	0.02778
-USACE	0.00%	0.11111
-USCGLL	11.11%	0.00285
-USCGLNTM	11.11%	0.00057
-WORKSTA	11.11%	0.00457
+CHARTFEAT	88.89%	0.00069
+LLFEAT	11.11%	0.00044

NTM8

Virtual IOs for Unit NTM8 efficiency 89.09% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	0.00%	0.00000
-FNTMTEXT	76.67%	0.00178
-IMODATA	0.00%	0.00000
-NOSDATA	0.00%	0.00000
-OVRHDHRS	35.58%	0.00122
-PRODHOURS	0.00%	0.00000
-SHIPREPORT	0.00%	0.00000
-USACE	0.00%	0.00000
-USCGLL	0.00%	0.00000
-USCGLNTM	0.00%	0.00000
-WORKSTA	0.00%	0.00000
+CHARTFEAT	100.00%	0.00089

+LLFEAT	0.00%	0.00000

NTM9

Virtual IOs for Unit NTM9 efficiency 100.00% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	33.68%	0.01981
-FNTMTEXT	5.51%	0.00007
-IMODATA	0.00%	0.05510
-NOSDATA	5.51%	0.01378
-OVRHDHRS	5.51%	0.00013
-PRODHOURS	5.51%	0.00005
-SHIPREPORT	5.51%	0.01102
-USACE	5.51%	0.00204
-USCGLL	9.94%	0.00331
-USCGLNTM	17.81%	0.00158
-WORKSTA	5.51%	0.00204
+CHARTFEAT	94.49%	0.00077
+LLFEAT	5.51%	0.00089

NTM10

Virtual IOs for Unit NTM10 efficiency 100.00% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	12.50%	0.00162
-FNTMTEXT	12.50%	0.00017
-IMODATA	0.00%	0.12500
-NOSDATA	12.50%	0.00694
-OVRHDHRS	12.50%	0.00022
-PRODHOURS	12.50%	0.00014
-SHIPREPORT	12.50%	0.02500
-USACE	0.00%	0.12500
-USCGLL	12.50%	0.00431
-USCGLNTM	0.00%	0.12500
-WORKSTA	12.50%	0.00514
+CHARTFEAT	87.50%	0.00077
+LLFEAT	12.50%	0.00110

NTM11

Virtual IOs for Unit NTM11 efficiency 100.00% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	0.00%	0.00000
-FNTMTEXT	0.00%	0.00000
-IMODATA	0.00%	0.00000
-NOSDATA	0.00%	0.00000
-OVRHDHRS	6.70%	0.00021
-PRODHOURS	76.05%	0.00071
-SHIPREPORT	0.00%	0.00000
-USACE	0.00%	0.00000
-USCGLL	17.25%	0.00595
-USCGLNTM	0.00%	0.00000
-WORKSTA	0.00%	0.00000
+CHARTFEAT	39.02%	0.00034
+LLFEAT	60.98%	0.00244

NTM12

Virtual IOs for Unit NTM12 efficiency 100.00% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	2.19%	0.00021
-FNTMTEXT	2.19%	0.00003
-IMODATA	0.00%	0.02193
-NOSDATA	0.00%	0.02193
-OVRHDHRS	2.19%	0.00006
-PRODHOURS	2.19%	0.00002
-SHIPREPORT	2.19%	0.00244
-USACE	0.00%	0.02193
-USCGLL	9.18%	0.00540
-USCGLNTM	2.19%	0.00018
-WORKSTA	77.66%	0.02876
+CHARTFEAT	97.81%	0.00076
+LLFEAT	2.19%	0.00035

NTM13

Virtual IOs for Unit NTM13 efficiency 84.18% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	0.00%	0.00000

-FNTMTEXT	0.00%	0.00000
-IMODATA	0.00%	0.00000
-NOSDATA	1.42%	0.00709
-OVRHDHRS	0.00%	0.00000
-PRODHOURS	72.64%	0.00080
-SHIPREPORT	0.00%	0.00000
-USACE	0.00%	0.00000
-USCGLL	11.62%	0.00726
-USCGLNTM	3.90%	0.00059
-WORKSTA	29.22%	0.01124
+CHARTFEAT	82.14%	0.00083
+LLFEAT	17.86%	0.00172

NTM14

Virtual IOs for Unit NTM14 efficiency 88.30% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	0.00%	0.00000
-FNTMTEXT	0.00%	0.00000
-IMODATA	0.00%	0.00000
-NOSDATA	0.00%	0.00000
-OVRHDHRS	0.00%	0.00000
-PRODHOURS	0.00%	0.00000
-SHIPREPORT	23.75%	0.07918
-USACE	0.00%	0.00000
-USCGLL	0.00%	0.00000
-USCGLNTM	0.00%	0.00000
-WORKSTA	89.49%	0.03400
+CHARTFEAT	100.00%	0.00098
+LLFEAT	0.00%	0.00000

NTM15

Virtual IOs for Unit NTM15 efficiency 90.63% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	20.57%	0.00260
-FNTMTEXT	0.00%	0.00000
-IMODATA	0.00%	0.00000
-NOSDATA	0.00%	0.00000
-OVRHDHRS	5.95%	0.00016

-PRODHOURS	20.44%	0.00018
-SHIPREPORT	0.00%	0.00000
-USACE	0.00%	0.00000
-USCGLL	0.00%	0.00000
-USCGLNTM	12.99%	0.00127
-WORKSTA	50.39%	0.01866
+CHARTFEAT	100.00%	0.00080
+LLFEAT	0.00%	0.00000

NTM16

Virtual IOs for Unit NTM16 efficiency 100.00% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	6.85%	0.00061
-FNTMTEXT	6.85%	0.00013
-IMODATA	0.00%	0.06853
-NOSDATA	6.85%	0.00571
-OVRHDHRS	45.18%	0.00150
-PRODHOURS	6.85%	0.00006
-SHIPREPORT	6.85%	0.01371
-USACE	0.00%	0.06853
-USCGLL	6.85%	0.00104
-USCGLNTM	6.85%	0.00041
-WORKSTA	6.85%	0.00254
+CHARTFEAT	58.95%	0.00040
+LLFEAT	41.05%	0.00152

NTM17

Virtual IOs for Unit NTM17 efficiency 100.00% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	10.40%	0.00068
-FNTMTEXT	10.40%	0.00015
-IMODATA	0.00%	0.10399
-NOSDATA	10.40%	0.00547
-OVRHDHRS	12.77%	0.00043
-PRODHOURS	10.40%	0.00011
-SHIPREPORT	13.80%	0.06900
-USACE	0.00%	0.10399
-USCGLL	10.40%	0.00236

-USCGLNTM	11.04%	0.00107
-WORKSTA	10.40%	0.00385
+CHARTFEAT	89.60%	0.00057
+LLFEAT	10.40%	0.00071

NTM18

Virtual IOs for Unit NTM18 efficiency 100.00% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	3.30%	0.00026
-FNTMTEXT	70.32%	0.00186
-IMODATA	0.00%	0.03298
-NOSDATA	3.30%	0.03298
-OVRHDHRS	3.30%	0.00009
-PRODHOURS	3.30%	0.00004
-SHIPREPORT	3.30%	0.00330
-USACE	3.30%	0.00087
-USCGLL	3.30%	0.00025
-USCGLNTM	3.30%	0.00022
-WORKSTA	3.30%	0.00129
+CHARTFEAT	85.03%	0.00069
+LLFEAT	14.97%	0.00092

NTM19

Virtual IOs for Unit NTM19 efficiency 100.00% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	25.52%	0.01501
-FNTMTEXT	0.80%	0.00001
-IMODATA	0.00%	0.00803
-NOSDATA	24.01%	0.08004
-OVRHDHRS	0.80%	0.00002
-PRODHOURS	0.80%	0.00001
-SHIPREPORT	0.80%	0.00067
-USACE	0.00%	0.00803
-USCGLL	19.12%	0.00398
-USCGLNTM	27.33%	0.00547
-WORKSTA	0.80%	0.00032
+CHARTFEAT	99.20%	0.00132
+LLFEAT	0.80%	0.00011

NTM20

Virtual IOs for Unit NTM20 efficiency 100.00% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	12.50%	0.00128
-FNTMTEXT	12.50%	0.00017
-IMODATA	0.00%	0.12500
-NOSDATA	12.50%	0.04167
-OVRHDHRS	12.50%	0.00021
-PRODHOURS	12.50%	0.00016
-SHIPREPORT	12.50%	0.03125
-USACE	0.00%	0.12500
-USCGLL	12.50%	0.00240
-USCGLNTM	0.00%	0.12500
-WORKSTA	12.50%	0.00487
+CHARTFEAT	87.50%	0.00095
+LLFEAT	12.50%	0.00179

NTM21

Virtual IOs for Unit NTM21 efficiency 80.70% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	0.00%	0.00000
-FNTMTEXT	84.68%	0.00218
-IMODATA	0.00%	0.00000
-NOSDATA	23.46%	0.07819
-OVRHDHRS	0.00%	0.00000
-PRODHOURS	0.00%	0.00000
-SHIPREPORT	15.77%	0.15774
-USACE	0.00%	0.00000
-USCGLL	0.00%	0.00000
-USCGLNTM	0.00%	0.00000
-WORKSTA	0.00%	0.00000
+CHARTFEAT	67.23%	0.00075
+LLFEAT	32.77%	0.00400

NTM22

Virtual IOs for Unit NTM22 efficiency 81.97% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	0.00%	0.00000
-FNTMTEXT	0.00%	0.00000
-IMODATA	0.00%	0.00000
-NOSDATA	0.00%	0.00000
-OVRHDHRS	0.00%	0.00000
-PRODHOURS	0.00%	0.00000
-SHIPREPORT	2.83%	0.00566
-USACE	0.00%	0.00000
-USCGLL	0.00%	0.00000
-USCGLNTM	0.00%	0.00000
-WORKSTA	119.17%	0.04646
+CHARTFEAT	100.00%	0.00101
+LLFEAT	0.00%	0.00000

NTM23

Virtual IOs for Unit NTM23 efficiency 100.00% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	14.29%	0.00124
-FNTMTEXT	14.29%	0.00024
-IMODATA	0.00%	0.14286
-NOSDATA	0.00%	0.14286
-OVRHDHRS	14.29%	0.00040
-PRODHOURS	14.29%	0.00015
-SHIPREPORT	14.29%	0.07143
-USACE	0.00%	0.14286
-USCGLL	0.00%	0.14286
-USCGLNTM	14.29%	0.00595
-WORKSTA	14.29%	0.00529
+CHARTFEAT	14.29%	0.00013
+LLFEAT	85.71%	0.00840

Give command (or ?) SV

NTM24

NTM24

Virtual IOs for Unit NTM24 efficiency 82.25% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	0.00%	0.00000

-FNTMTEXT	0.00%	0.00000
-IMODATA	0.00%	0.00000
-NOSDATA	7.35%	0.01836
-OVRHDHRS	0.00%	0.00000
-PRODHOURS	88.15%	0.00157
-SHIPREPORT	7.91%	0.02638
-USACE	0.00%	0.00000
-USCGLL	0.00%	0.00000
-USCGLNTM	18.18%	0.00260
-WORKSTA	0.00%	0.00000
+CHARTFEAT	92.60%	0.00126
+LLFEAT	7.40%	0.00096

NTM25

Virtual IOs for Unit NTM25 efficiency 66.64% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	0.00%	0.00000
-FNTMTEXT	36.22%	0.00069
-IMODATA	0.00%	0.00000
-NOSDATA	6.85%	0.00856
-OVRHDHRS	0.00%	0.00000
-PRODHOURS	0.00%	0.00000
-SHIPREPORT	2.49%	0.00622
-USACE	0.00%	0.00000
-USCGLL	0.00%	0.00000
-USCGLNTM	5.44%	0.00044
-WORKSTA	99.07%	0.03669
+CHARTFEAT	100.00%	0.00107
+LLFEAT	0.00%	0.00000

NTM26

Virtual IOs for Unit NTM26 efficiency 100.00% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	17.34%	0.00304
-FNTMTEXT	5.10%	0.00008
-IMODATA	0.00%	0.05104
-NOSDATA	5.10%	0.00851
-OVRHDHRS	46.94%	0.00151

-PRODHOURS	5.10%	0.00005
-SHIPREPORT	5.10%	0.00638
-USACE	0.00%	0.05104
-USCGLL	5.10%	0.00028
-USCGLNTM	5.10%	0.00022
-WORKSTA	5.10%	0.00189
+CHARTFEAT	94.90%	0.00064
+LLFEAT	5.10%	0.00044

NTM27

Virtual IOs for Unit NTM27 efficiency 100.00% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	10.00%	0.00081
-FNTMTEXT	10.00%	0.00016
-IMODATA	0.00%	0.10000
-NOSDATA	10.00%	0.03333
-OVRHDHRS	10.00%	0.00033
-PRODHOURS	10.00%	0.00010
-SHIPREPORT	10.00%	0.05000
-USACE	10.00%	0.00526
-USCGLL	10.00%	0.00043
-USCGLNTM	10.00%	0.00050
-WORKSTA	10.00%	0.00370
+CHARTFEAT	65.30%	0.00045
+LLFEAT	34.70%	0.00064

NTM28

Virtual IOs for Unit NTM28 efficiency 93.10% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	34.81%	0.00757
-FNTMTEXT	0.00%	0.00000
-IMODATA	0.00%	0.00000
-NOSDATA	24.57%	0.24572
-OVRHDHRS	0.00%	0.00000
-PRODHOURS	0.00%	0.00000
-SHIPREPORT	48.03%	0.24014
-USACE	0.00%	0.00000
-USCGLL	0.00%	0.00000

-USCGLNTM	0.00%	0.00000
-WORKSTA	0.00%	0.00000
+CHARTFEAT	100.00%	0.00109
+LLFEAT	0.00%	0.00000

NTM29

Virtual IOs for Unit NTM29 efficiency 100.00% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	6.93%	0.00094
-FNTMTEXT	6.93%	0.00010
-IMODATA	0.00%	0.06925
-NOSDATA	0.00%	0.06925
-OVRHDHRS	6.93%	0.00021
-PRODHOURS	6.93%	0.00007
-SHIPREPORT	51.52%	0.25761
-USACE	0.00%	0.06925
-USCGLL	6.93%	0.00079
-USCGLNTM	6.93%	0.00047
-WORKSTA	6.93%	0.00256
+CHARTFEAT	7.03%	0.00007
+LLFEAT	92.97%	0.00808

NTM30

Virtual IOs for Unit NTM30 efficiency 100.00% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	0.00%	0.12500
-FNTMTEXT	12.50%	0.00031
-IMODATA	0.00%	0.12500
-NOSDATA	12.50%	0.04167
-OVRHDHRS	12.50%	0.00024
-PRODHOURS	12.50%	0.00017
-SHIPREPORT	12.50%	0.03125
-USACE	0.00%	0.12500
-USCGLL	12.50%	0.00102
-USCGLNTM	12.50%	0.00134
-WORKSTA	12.50%	0.00463
+CHARTFEAT	87.50%	0.00092
+LLFEAT	12.50%	0.00111

NTM31

Virtual IOs for Unit NTM31 efficiency 100.00% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	0.78%	0.00004
-FNTMTEXT	0.78%	0.00001
-IMODATA	0.00%	0.00779
-NOSDATA	0.00%	0.00779
-OVRHDHRS	0.78%	0.00002
-PRODHOURS	94.55%	0.00097
-SHIPREPORT	0.78%	0.00156
-USACE	0.00%	0.00779
-USCGLL	0.78%	0.00004
-USCGLNTM	0.78%	0.00004
-WORKSTA	0.78%	0.00029
+CHARTFEAT	0.78%	0.00001
+LLFEAT	99.22%	0.00624

NTM32

Virtual IOs for Unit NTM32 efficiency 100.00% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	24.10%	0.00753
-FNTMTEXT	9.49%	0.00014
-IMODATA	0.00%	0.09487
-NOSDATA	9.49%	0.01355
-OVRHDHRS	9.49%	0.00026
-PRODHOURS	9.49%	0.00010
-SHIPREPORT	9.49%	0.02372
-USACE	0.00%	0.09487
-USCGLL	9.49%	0.00211
-USCGLNTM	9.49%	0.00862
-WORKSTA	9.49%	0.00351
+CHARTFEAT	90.51%	0.00092
+LLFEAT	9.49%	0.00137

NTM33

Virtual IOs for Unit NTM33 efficiency 100.00% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	11.11%	0.00317
-FNTMTEXT	11.11%	0.00032
-IMODATA	0.00%	0.11111
-NOSDATA	11.11%	0.00654
-OVRHDHRS	11.11%	0.00030
-PRODHOURS	11.11%	0.00011
-SHIPREPORT	11.11%	0.11111
-USACE	0.00%	0.11111
-USCGLL	11.11%	0.00144
-USCGLNTM	11.11%	0.00119
-WORKSTA	11.11%	0.00431
+CHARTFEAT	11.11%	0.00010
+LLFEAT	88.89%	0.00254

NTM34

Virtual IOs for Unit NTM34 efficiency 100.00% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	5.12%	0.00080
-FNTMTEXT	1.23%	0.00001
-IMODATA	0.00%	0.01234
-NOSDATA	4.75%	0.04755
-OVRHDHRS	1.23%	0.00003
-PRODHOURS	81.51%	0.00091
-SHIPREPORT	1.23%	0.00206
-USACE	0.00%	0.01234
-USCGLL	2.44%	0.00076
-USCGLNTM	1.23%	0.00005
-WORKSTA	1.23%	0.00046
+CHARTFEAT	98.77%	0.00081
+LLFEAT	1.23%	0.00016

NTM35

Virtual IOs for Unit NTM35 efficiency 68.34% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	0.36%	0.00004

-FNTMTEXT	0.00%	0.00000
-IMODATA	0.00%	0.00000
-NOSDATA	7.55%	0.03773
-OVRHDHRS	10.56%	0.00030
-PRODHOURS	111.31%	0.00116
-SHIPREPORT	0.00%	0.00000
-USACE	0.00%	0.00000
-USCGLL	1.12%	0.00031
-USCGLNTM	0.00%	0.00000
-WORKSTA	15.44%	0.00572
+CHARTFEAT	100.00%	0.00112
+LLFEAT	0.00%	0.00000

NTM36

Virtual IOs for Unit NTM36 efficiency 94.49% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	7.97%	0.00399
-FNTMTEXT	9.30%	0.00016
-IMODATA	0.00%	0.00000
-NOSDATA	0.00%	0.00000
-OVRHDHRS	0.00%	0.00000
-PRODHOURS	58.37%	0.00069
-SHIPREPORT	8.96%	0.01494
-USACE	0.00%	0.00000
-USCGLL	0.00%	0.00000
-USCGLNTM	0.00%	0.00000
-WORKSTA	21.23%	0.00786
+CHARTFEAT	100.00%	0.00090
+LLFEAT	0.00%	0.00000

NTM37

Virtual IOs for Unit NTM37 efficiency 80.93% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	0.00%	0.00000
-FNTMTEXT	0.37%	0.00001
-IMODATA	0.00%	0.00000
-NOSDATA	3.22%	0.01608
-OVRHDHRS	0.00%	0.00000

-PRODHOURS	57.76%	0.00057
-SHIPREPORT	0.00%	0.00000
-USACE	0.00%	0.00000
-USCGLL	2.56%	0.00044
-USCGLNTM	2.56%	0.00025
-WORKSTA	57.11%	0.02115
+CHARTFEAT	100.00%	0.00093
+LLFEAT	0.00%	0.00000

NTM38

Virtual IOs for Unit NTM38 efficiency 99.69% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	0.00%	0.00000
-FNTMTEXT	7.59%	0.00014
-IMODATA	0.00%	0.00000
-NOSDATA	3.29%	0.00235
-OVRHDHRS	0.00%	0.00000
-PRODHOURS	66.97%	0.00092
-SHIPREPORT	0.00%	0.00000
-USACE	0.00%	0.00000
-USCGLL	0.00%	0.00000
-USCGLNTM	22.47%	0.00316
-WORKSTA	0.00%	0.00000
+CHARTFEAT	100.00%	0.00084
+LLFEAT	0.00%	0.00000

NTM39

Virtual IOs for Unit NTM39 efficiency 61.61% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	0.00%	0.00000
-FNTMTEXT	145.18%	0.00316
-IMODATA	0.00%	0.00000
-NOSDATA	6.37%	0.06368
-OVRHDHRS	0.00%	0.00000
-PRODHOURS	0.00%	0.00000
-SHIPREPORT	0.00%	0.00000
-USACE	0.00%	0.00000
-USCGLL	0.00%	0.00000

-USCGLNTM	0.00%	0.00000
-WORKSTA	10.77%	0.00399
+CHARTFEAT	100.00%	0.00127
+LLFEAT	0.00%	0.00000

NTM40

Virtual IOs for Unit NTM40 efficiency 100.00% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	6.27%	0.00031
-FNTMTEXT	6.27%	0.00009
-IMODATA	0.00%	0.06272
-NOSDATA	6.27%	0.02091
-OVRHDHRS	12.09%	0.00041
-PRODHOURS	33.94%	0.00033
-SHIPREPORT	16.34%	0.08170
-USACE	0.00%	0.06272
-USCGLL	6.27%	0.00023
-USCGLNTM	6.27%	0.00083
-WORKSTA	6.27%	0.00232
+CHARTFEAT	93.73%	0.00065
+LLFEAT	6.27%	0.00071

NTM41

Virtual IOs for Unit NTM41 efficiency 100.00% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	0.00%	0.00000
-FNTMTEXT	94.56%	0.00411
-IMODATA	0.00%	0.00000
-NOSDATA	0.00%	0.00000
-OVRHDHRS	0.00%	0.00000
-PRODHOURS	0.00%	0.00000
-SHIPREPORT	0.00%	0.00000
-USACE	0.00%	0.00000
-USCGLL	5.43%	0.00147
-USCGLNTM	0.00%	0.00000
-WORKSTA	0.00%	0.00000
+CHARTFEAT	100.00%	0.00123
+LLFEAT	0.00%	0.00000

NTM42

Virtual IOs for Unit NTM42 efficiency 100.00% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	7.29%	0.00048
-FNTMTEXT	34.41%	0.00069
-IMODATA	0.00%	0.07288
-NOSDATA	7.29%	0.01215
-OVRHDHRS	7.29%	0.00020
-PRODHOURS	7.29%	0.00007
-SHIPREPORT	7.29%	0.01458
-USACE	7.29%	0.00292
-USCGLL	7.29%	0.00810
-USCGLNTM	7.29%	0.00119
-WORKSTA	7.29%	0.00270
+CHARTFEAT	92.71%	0.00063
+LLFEAT	7.29%	0.00054

NTM43

Virtual IOs for Unit NTM43 efficiency 100.00% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	12.50%	0.00063
-FNTMTEXT	12.50%	0.00020
-IMODATA	0.00%	0.12500
-NOSDATA	12.50%	0.03125
-OVRHDHRS	12.50%	0.00032
-PRODHOURS	12.50%	0.00013
-SHIPREPORT	0.00%	0.12500
-USACE	0.00%	0.12500
-USCGLL	12.50%	0.00171
-USCGLNTM	12.50%	0.00179
-WORKSTA	12.50%	0.00463
+CHARTFEAT	12.50%	0.00014
+LLFEAT	87.50%	0.01108

NTM44

Virtual IOs for Unit NTM44 efficiency 89.19% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	10.02%	0.00076
-FNTMTEXT	0.00%	0.00000
-IMODATA	0.00%	0.00000
-NOSDATA	8.37%	0.01394
-OVRHDHRS	0.00%	0.00000
-PRODHOURS	72.51%	0.00094
-SHIPREPORT	1.59%	0.00532
-USACE	0.00%	0.00000
-USCGLL	0.03%	0.00001
-USCGLNTM	7.13%	0.00066
-WORKSTA	12.46%	0.00462
+CHARTFEAT	100.00%	0.00092
+LLFEAT	0.00%	0.00000

NTM45

Virtual IOs for Unit NTM45 efficiency 68.90% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	18.64%	0.00169
-FNTMTEXT	30.02%	0.00053
-IMODATA	0.00%	0.00000
-NOSDATA	1.05%	0.00132
-OVRHDHRS	0.00%	0.00000
-PRODHOURS	50.93%	0.00051
-SHIPREPORT	0.00%	0.00000
-USACE	0.65%	0.00059
-USCGLL	1.74%	0.00019
-USCGLNTM	5.86%	0.00040
-WORKSTA	36.23%	0.01342
+CHARTFEAT	93.52%	0.00094
+LLFEAT	6.48%	0.00032

NTM46

Virtual IOs for Unit NTM46 efficiency 100.00% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	12.50%	0.00260

-FNTMTEXT	12.50%	0.00026
-IMODATA	0.00%	0.12500
-NOSDATA	12.50%	0.01042
-OVRHDHRS	12.50%	0.00034
-PRODHOURS	12.50%	0.00012
-SHIPREPORT	0.00%	0.12500
-USACE	0.00%	0.12500
-USCGLL	12.50%	0.00091
-USCGLNTM	12.50%	0.00093
-WORKSTA	12.50%	0.00463
+CHARTFEAT	12.50%	0.00013
+LLFEAT	87.50%	0.00893

NTM47

Virtual IOs for Unit NTM47 efficiency 100.00% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	11.11%	0.00146
-FNTMTEXT	11.11%	0.00027
-IMODATA	0.00%	0.11111
-NOSDATA	11.11%	0.02778
-OVRHDHRS	11.11%	0.00031
-PRODHOURS	11.11%	0.00012
-SHIPREPORT	11.11%	0.11111
-USACE	0.00%	0.11111
-USCGLL	11.11%	0.01235
-USCGLNTM	11.11%	0.00051
-WORKSTA	11.11%	0.00412
+CHARTFEAT	69.62%	0.00053
+LLFEAT	30.38%	0.00316

NTM48

Virtual IOs for Unit NTM48 efficiency 100.00% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	5.50%	0.00043
-FNTMTEXT	5.50%	0.00013
-IMODATA	0.00%	0.05502
-NOSDATA	5.50%	0.02751
-OVRHDHRS	5.50%	0.00010

-PRODHOURS	53.35%	0.00067
-SHIPREPORT	8.14%	0.04068
-USACE	0.00%	0.05502
-USCGLL	5.50%	0.00229
-USCGLNTM	5.50%	0.00042
-WORKSTA	5.50%	0.00204
+CHARTFEAT	83.75%	0.00071
+LLFEAT	16.25%	0.00126

NTM49

Virtual IOs for Unit NTM49 efficiency 91.74% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	0.00%	0.00000
-FNTMTEXT	0.00%	0.00000
-IMODATA	0.00%	0.00000
-NOSDATA	5.04%	0.02519
-OVRHDHRS	3.65%	0.00011
-PRODHOURS	68.02%	0.00068
-SHIPREPORT	0.00%	0.00000
-USACE	0.00%	0.00000
-USCGLL	3.39%	0.00023
-USCGLNTM	0.00%	0.00000
-WORKSTA	28.91%	0.01071
+CHARTFEAT	98.84%	0.00079
+LLFEAT	1.16%	0.00011

NTM50

Virtual IOs for Unit NTM50 efficiency 100.00% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	12.50%	0.00130
-FNTMTEXT	12.50%	0.00026
-IMODATA	0.00%	0.12500
-NOSDATA	0.00%	0.12500
-OVRHDHRS	12.50%	0.00046
-PRODHOURS	12.50%	0.00012
-SHIPREPORT	12.50%	0.03125
-USACE	0.00%	0.12500
-USCGLL	12.50%	0.00446

-USCGLNTM	12.50%	0.00658
-WORKSTA	12.50%	0.00463
+CHARTFEAT	12.50%	0.00010
+LLFEAT	87.50%	0.00543

NTM51

Virtual IOs for Unit NTM51 efficiency 87.21% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	0.00%	0.00000
-FNTMTEXT	19.91%	0.00043
-IMODATA	0.00%	0.00000
-NOSDATA	3.83%	0.00956
-OVRHDHRS	0.00%	0.00000
-PRODHOURS	90.92%	0.00152
-SHIPREPORT	0.00%	0.00000
-USACE	0.00%	0.00000
-USCGLL	0.00%	0.00000
-USCGLNTM	0.00%	0.00000
-WORKSTA	0.00%	0.00000
+CHARTFEAT	100.00%	0.00119
+LLFEAT	0.00%	0.00000

NTM52

Virtual IOs for Unit NTM52 efficiency 100.00% radial

VARIABLE	VIRTUAL IOs	IO WEIGHTS
-FCHARTS	12.68%	0.00470
-FNTMTEXT	9.32%	0.00012
-IMODATA	0.00%	0.09322
-NOSDATA	9.32%	0.09322
-OVRHDHRS	9.32%	0.00027
-PRODHOURS	9.32%	0.00010
-SHIPREPORT	9.32%	0.00932
-USACE	9.32%	0.00282
-USCGLL	9.32%	0.00359
-USCGLNTM	12.74%	0.00130
-WORKSTA	9.32%	0.00389
+CHARTFEAT	90.68%	0.00067
+LLFEAT	9.32%	0.00066

APPENDIX E
NSS LEARNING CURVE MODEL RESULTS

This appendix contains the results of the Learning Curve Model presented in Chapter 5. Table E-1 contains the model results for the equivalent of 63 employees and NTM workstations, Table E-2 contains the model for the equivalent of 46 employees and NTM workstations, and Table E-3 contains the model for the equivalent of 30 employees and NTM workstations.

The columns in tables represent:

NTM# - Notice to Mariners cycle number

CNS - The number of features processed on the CNS during one cycle

NSS .- The number of features processed on the NSS during the one cycle

Backlog - The cumulative number of features that are waiting in the queue to be processed.

Table E-1. Learning Curve Results for the Equivalent of 63 NTM Workstations.

PARALLEL OPERATIONS PRODUCTION RESULTS TOTALS					
NTM #	CNS	NSS	BACKLOG		
1	882	882	1134		
2	979	979	2172		
3	1060	1060	3128		
4	1127	1127	4017		
5	1183	1183	4851		
6	1229	1229	5638		
7	1268	1268	6386		
8	1300	1300	7102		
9	1327	1327	7791		
10	1349	1349	8458		
11	1350	1368	9106		
12	1350	1383	9740		
13	1350	1396	10360		
14	1350	1406	10969		
15	1350	1415	11570		
16	1350	1423	12164		
17	1350	1429	12751		
18	1350	1434	13333		
19	1350	1438	13911		
20	1350	1442	14485		
21	1350	1445	15057		
22	1350	1447	15626		
23	1350	1449	16192		
24	1350	1451	16758		
NSS STAND ALONE OPERATION PRODUCTION TOTALS					
NTM #		NSS	NSS BACKLOG		
25		2004	16769		
26		2006	16779		
27		2008	16787		
28		2009	16793		
29		2010	16799		
30		2011	16804		
31		2012	16807		
32		2013	16811		
33		2013	16813		
34		2014	16815		
35		2014	16817		
36		2014	16819		
37		2015	16820		
38		2015	16821		
39		2015	16822		
40		2015	16823		
41		2015	16823		
42		2015	16824		
43		2016	16824		
44		2016	16825		
45		2016	16825		
46		2016	16825		
47		2016	16825		
48		2016	16825		
49		2016	16826		
50		2016	16826		
51		2016	16826		
52		2016	16826		

Table E-2. Learning Curve Results for the Equivalent of 46 NTM Workstations

PARALLEL OPERATIONS PRODUCTION RESULTS TOTALS			
NTM #	CNS	NSS	NFL BACKLOG
1	647	647	1369
2	714	714	2671
3	771	771	3916
4	817	817	5115
5	856	856	6275
6	889	889	7402
7	915	915	8503
8	938	938	9581
9	956	956	10641
10	972	972	11685
11	985	985	12716
12	996	996	13736
13	1005	1005	14748
14	1012	1012	15752
15	1018	1018	16750
16	1023	1023	17742
17	1027	1027	18731
18	1031	1031	19716
19	1034	1034	20698
20	1036	1036	21677
21	1038	1038	22655
22	1040	1040	23631
23	1042	1042	24605
24	1043	1043	25578
NSS STAND ALONE OPERATION PRODUCTION TOTALS			
NTM #		NSS	NSS BACKLOG
25		1429	26165
26		1430	26751
27		1432	27335
28		1433	27918
29		1433	28501
30		1434	29083
31		1434	29665
32		1435	30246
33		1435	30827
34		1436	31407
35		1436	31987
36		1436	32567
37		1436	33147
38		1436	33726
39		1437	34306
40		1437	34885
41		1437	35465
42		1437	36044
43		1437	36623
44		1437	37202
45		1437	37781
46		1437	38360
47		1437	38939
48		1437	39518
49		1437	40097
50		1437	40676
51		1437	41255
52		1437	41834

Table E-2. Learning Curve Results for the Equivalent of 46 NTM Workstations (continued)

NTM #		NSS	NSS BACKLOG
53		1437	42413
54		1437	42992
55		1437	43571
56		1437	44150
57		1437	44729
58		1437	45308
59		1437	45887
60		1437	46466
61		1437	47044
62		1437	47623
63		1437	48202
64		1437	48781
65		1437	49360
66		1437	49939
67		1437	50518
68		1437	51097
69		1437	51676
70		1437	52255
71		1437	52833
72		1437	53412
73		1437	53991
74		1437	54570
75		1437	55149
76		1437	55728
77		1437	56307
78		1437	56886
79		1437	57465
80		1437	58043
81		1437	58622
82		1437	59201
83		1437	59780
84		1437	60359
85		1437	60938
86		1437	61517
87		1437	62096
88		1437	62675
89		1437	63253
90		1437	63832
91		1437	64411
92		1437	64990
93		1437	65569
94		1437	66148
95		1437	66727
96		1437	67306
97		1437	67885
98		1437	68463
99		1437	69042
100		1437	69621
101		1437	70200
102		1437	70779
103		1437	71358
104		1437	71937
105		1437	72516

Table E-2. Learning Curve Results for the Equivalent of 46 NTM Workstations (continued)

NTM #		NSS	NSS BACKLOG
106		1437	73095
107		1437	73673
108		1437	74252
109		1437	74831
110		1437	75410
111		1437	75989
112		1437	76568
113		1437	77147
114		1437	77726
115		1437	78305
116		1437	78883
117		1437	79462
118		1437	80041
119		1437	80620
120		1437	81199
121		1437	81778
122		1437	82357
123		1437	82936
124		1437	83515
125		1437	84093
126		1437	84672
127		1437	85251
128		1437	85830
129		1437	86409
130		1437	86988
131		1437	87567
132		1437	88146
133		1437	88725
134		1437	89303
135		1437	89882
136		1437	90461
137		1437	91040
138		1437	91619
139		1437	92198
140		1437	92777
141		1437	93356
142		1437	93935
143		1437	94513
144		1437	95092
145		1437	95671
146		1437	96250
147		1437	96829
148		1437	97408
149		1437	97987
150		1437	98566
151		1437	99145
152		1437	99723
153		1437	100302
154		1437	100881
155		1437	101460
156		1437	102039
157		1437	102618
158		1437	103197

Table E-2. Learning Curve Results for the Equivalent of 46 NTM Workstations (continued)

NTM #		NSS	NSS BACKLOG
159		1437	103776
160		1437	104355
161		1437	104934
162		1437	105512
163		1437	106091
164		1437	106670
165		1437	107249
166		1437	107828
167		1437	108407
168		1437	108986
169		1437	109565
170		1437	110144
171		1437	110722
172		1437	111301
173		1437	111880
174		1437	112459
175		1437	113038
176		1437	113617
177		1437	114196
178		1437	114775
179		1437	115354
180		1437	115932
181		1437	116511
182		1437	117090
183		1437	117669
184		1437	118248
185		1437	118827
186		1437	119406
187		1437	119985
188		1437	120564
189		1437	121142
190		1437	121721
191		1437	122300
192		1437	122879
193		1437	123458
194		1437	124037
195		1437	124616
196		1437	125195
197		1437	125774
198		1437	126352
199		1437	126931
200		1437	127510
201		1437	128089
202		1437	128668
203		1437	129247
204		1437	129826
205		1437	130405
206		1437	130984
207		1437	131562
208		1437	132141

Table E-3. Learning Curve Results for the Equivalent of 30 NTM Workstations

PARALLEL OPERATIONS PRODUCTION RESULTS TOTALS					
NTM #	CNS	NSS	BACKLOG		
1	407	407	1609		
2	450	450	3175		
3	485	485	4706		
4	515	515	6207		
5	539	539	7684		
6	560	560	9140		
7	577	577	10579		
8	591	591	12004		
9	603	603	13418		
10	612	612	14822		
11	620	620	16217		
12	627	627	17606		
13	633	633	18989		
14	637	637	20368		
15	641	641	21742		
16	645	645	23114		
17	647	647	24483		
18	650	650	25849		
19	651	651	27214		
20	653	653	28577		
21	654	654	29938		
22	655	655	31299		
23	656	656	32659		
24	657	657	34018		
NSS STAND ALONE OPERATION PRODUCTION TOTALS					
NTM #		NSS	BACKLOG		
25		900	35134		
26		901	36249		
27		901	37364		
28		902	38478		
29		903	39591		
30		903	40705		
31		903	41817		
32		904	42930		
33		904	44042		
34		904	45154		
35		904	46266		
36		904	47378		
37		904	48489		
38		904	49601		
39		905	50712		
40		905	51824		
41		905	52935		
42		905	54047		
43		905	55158		
44		905	56269		
45		905	57380		
46		905	58491		
47		905	59603		
48		905	60714		
49		905	61825		
50		905	62936		
51		905	64047		
52		905	65158		

Table E-3. Learning Curve Results for the Equivalent of 30 NTM Workstations (continued).

NTM #		NSS	BACKLOG
53		905	66270
54		905	67381
55		905	68492
56		905	69603
57		905	70714
58		905	71825
59		905	72936
60		905	74047
61		905	75158
62		905	76270
63		905	77381
64		905	78492
65		905	79603
66		905	80714
67		905	81825
68		905	82936
69		905	84047
70		905	85158
71		905	86269
72		905	87381
73		905	88492
74		905	89603
75		905	90714
76		905	91825
77		905	92936
78		905	94047
79		905	95158
80		905	96269
81		905	97381
82		905	98492
83		905	99603
84		905	100714
85		905	101825
86		905	102936
87		905	104047
88		905	105158
89		905	106269
90		905	107380
91		905	108492
92		905	109603
93		905	110714
94		905	111825
95		905	112936
96		905	114047
97		905	115158
98		905	116269
99		905	117380
100		905	118491
101		905	119603
102		905	120714
103		905	121825
104		905	122936
105		905	124047

Table E-3. Learning Curve Results for the Equivalent of 30 NTM Workstations (continued).

NTM #		NSS	BACKLOG
106		905	125158
107		905	126269
108		905	127380
109		905	128491
110		905	129602
111		905	130714
112		905	131825
113		905	132936
114		905	134047
115		905	135158
116		905	136269
117		905	137380
118		905	138491
119		905	139602
120		905	140713
121		905	141825
122		905	142936
123		905	144047
124		905	145158
125		905	146269
126		905	147380
127		905	148491
128		905	149602
129		905	150713
130		905	151824
131		905	152936
132		905	154047
133		905	155158
134		905	156269
135		905	157380
136		905	158491
137		905	159602
138		905	160713
139		905	161824
140		905	162935
141		905	164047
142		905	165158
143		905	166269
144		905	167380
145		905	168491
146		905	169602
147		905	170713
148		905	171824
149		905	172935
150		905	174046
151		905	175158
152		905	176269
153		905	177380
154		905	178491
155		905	179602
156		905	180713
157		905	181824
158		905	182935

Table E-3. Learning Curve Results for the Equivalent of 30 NTM Workstations (continued).

NTM #		NSS	BACKLOG
159		905	184046
160		905	185157
161		905	186269
162		905	187380
163		905	188491
164		905	189602
165		905	190713
166		905	191824
167		905	192935
168		905	194046
169		905	195157
170		905	196268
171		905	197380
172		905	198491
173		905	199602
174		905	200713
175		905	201824
176		905	202935
177		905	204046
178		905	205157
179		905	206268
180		905	207379
181		905	208491
182		905	209602
183		905	210713
184		905	211824
185		905	212935
186		905	214046
187		905	215157
188		905	216268
189		905	217379
190		905	218490
191		905	219602
192		905	220713
193		905	221824
194		905	222935
195		905	224046
196		905	225157
197		905	226268
198		905	227379
199		905	228490
200		905	229601
201		905	230713
202		905	231824
203		905	232935
204		905	234046
205		905	235157
206		905	236268
207		905	237379
208		905	238490

Warren Kenneth Vaneman

Warren Vaneman has been employed by the National Imagery and Mapping Agency (NIMA), and its predecessor: the Defense Mapping Agency (DMA), for seven of the last eleven years. Currently assigned as a Systems Engineer in the Process Improvement Office, Mr. Vaneman has held a variety of positions in the Marine Navigation Department.

In 1988 Mr. Vaneman activated his Naval Reserve Commission and served the next four years on active duty as a Surface Warfare Officer. While on active duty, he served as the Navigator of the USS BIDDLE (CG-34). Currently he is the Executive Officer of the Assault Craft Unit Four Naval Reserve Unit. A veteran of Desert Shield and Desert Storm, Mr. Vaneman has received a variety personal medals and awards.

Mr. Vaneman holds an Associates Degree in Science and Mathematics from Camden County College, Blackwood, New Jersey; a Bachelor of Science Degree in Meteorology and Oceanography from the State University of New York Maritime College, Bronx, New York; and a Master of Science Degree in Systems Engineering from Virginia Polytechnic Institute and State University. He also maintains a Federal Merchant Marine License as Master of vessels not greater than 1600 gross tons, and second mate of vessels of unlimited tonnage.

Warren lives in Manassas, Virginia, with his wife Robin.

Warren Kenneth Vaneman