AD-A111 092 EG AND G WASHINGTON ANALYTICAL SERVICES CENTER INC R--ETC F/G 13/2
A METHODOLOGY FOR STATISTICAL ANALYSIS OF PORT SYSTEM REQUIREME--ETC(U)
FEB 82 E S STICKELS, D A TAYLOR, R N THOMAS N00014-78-C-0834
UNCLASSIFIED EG/G-TR-D190-0002 NL

1 of 1
AD
A111092

END
DATE
FILMED
3-82
DTIC

# A METHODOLOGY FOR STATISTICAL ANALYSIS OF PORT SYSTEM REQUIREMENTS







EG&G

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
|---|---|---|
| 1. REPORT NUMBER TR-D190-0002 | 2. GOVT ACCESSION NO. AD-A111092 | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle) A Methodology for Statistical Analysis of Port System Requirements | | 5. TYPE OF REPORT & PERIOD COVERED analysis |
| | | 6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s) E. Scott Stickels; Donald A. Taylor; Robert N. L. Thomas; Kenneth C. Youngmann | | 8. CONTRACT OR GRANT NUMBER(s) N00014-78-C-0834 |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS EG&G WASHINGTON ANALYTICAL SERVICES CENTER, INC 2150 Fields Road, Rockville, MD 20850 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS |
| 11. CONTROLLING OFFICE NAME AND ADDRESS Assistant Commander for Research & Development Naval Facilities Engineering Command | | 12. REPORT DATE February 1982 |
| | | 13. NUMBER OF PAGES |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) | | 15. SECURITY CLASS. (of this report) UNCLASSIFIED |
| | | 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE |

16. DISTRIBUTION STATEMENT (of this Report)

Distribution of this document is unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Port Requirements
Port Analysis
Requirements Prediction for Port Systems

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This document describes the development of a methodology by which Port System Requirements can be predicted using Statistical and Probability Theory. The report is written to provide information of use to executives, managers, and technicians.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

# A METHODOLOGY FOR STATISTICAL ANALYSIS OF PORT SYSTEMS REQUIREMENTS

February, 1982

BY

E. Scott Stickels

Donald A. Taylor

Robert W. L. Thomas

Kenneth C. Youngmann

Space and Ocean Systems Group
EG&G Washington Analytical Services Center, Inc.
Rockville, Maryland

FOR

Naval Facilities Engineering Command
Alexandria, Virginia

## EXECUTIVE OVERVIEW

Many attributes of port use are random in nature and, as such, complicate the problems associated with port planning and design. This work recognizes this situation and describes a method by which statistical techniques can be used to analyze port resource requirements. The methodology derived is titled Port Systems Requirements Prediction Methodology. Its description is intended to provide the information required by the full range of potential users - from manager to technician. A sample application is described as a mechanism to display data file development and computer programs.

The premise of the technical approach is that one cannot look into the future for design information, but rather the statistical distribution of utility service requirements can be established. These distributions can then be used to size port systems so that a predetermined low probability of failing to meet a demand can be achieved.

However, the Port Systems Requirements Prediction Methodology is not restricted to a single analytical output. This report discusses its potential use as a means of communication for MILCON planning and as a vehicle for analyzing the output of port utility measurement projects. In short, the Port Systems Requirements Prediction Methodology is a powerful analytical tool and the challenge presented by it is for planners and designers to articulate problems and issues that can exploit its potential.

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd.)



LIST OF FIGURES

## LIST OF FIGURES



## LIST OF TABLES

## SECTION ONE
## INTRODUCTION

### 1.0 Background.

The Port System Project Program Plan established the objective of relating actual utility demand data to pier design criteria. There are two reasons for doing this. The first is to update the criteria used to size the utility systems on Navy piers. And secondly, it is intended to be able to predict pier system changes that will be requir by changing fleet demands. A prediction technique such as this would be a valuable tool for port master planners to use when evaluating various design options. The work described in this report produced a model that relates the demand for services at a selected port facility to the operating tempo of the ships assigned to that facility and individual ship's cold-iron requirements. The model includes computer simulations with enough iterations for statistically valid conclusions.

### 1.1 Objective.

The objective of this work is to develop a methodology for predicting port service requirements for a given port load.

### 1.2 Scope.

The methodology described in this report covers the concept formulation, the development of representative data files, computer programming, simulation and illustrations of potential interpretations of results.

### 1.3 Approach.

The approach to developing the Port System Requirements Prediction Methodology starts with the premise that the need for port services can be analyzed by calculating the utility demands of specified ship populations while recognizing the service demands of individual ship classes. This information is combined with representative ship movement data to form a port activity model that can be computer simulated. This in turn permits the probability distribution of utility demands for specified ship populations to be statistically estimated. It is this information then, the probability distribution of the utility demands of specified ship populations, that constitutes the primary output of the Port Systems requirement methodology. Formats for aggregating and interpreting output information are suggested as the final step in methodology formation.

## 1.4 Limitations.

The work described herein represents the development of a methodology only. The results are based on representative data and care must be exercised not to use the results of this study out of context. For use of the methodology beyond the demonstration described, the data files would require adjustment for the specific situation. In addition to having used representative data, the following simplifying assumptions have been made:

- The only utility analyzed was electric power, and each ship was assumed to be drawing its full design capacity for shore power in accordance with DM-25.
- No consideration was given to the time of day variations that would be expected for electric power demand.
- The number of ships at cold-iron in each ship class is assumed to be binomially distributed and independent of other classes.
- Resource demands per ship do not correlate with the number of ships present.

It should be noted that these assumptions are not a prerequisite to the correctness of the technical approach to the methodology development. They have been made to limit the scope of this work and to provide a reasonable example of its application. In fact, each limitation can be eliminated by the use of more precise information. Methodology products would then provide an increasingly accurate representation of waterfront activity.

1.5 Application.

The immediate application of this methodology is to establish the cummulative probability distribution for utility demand for homeport loads of varying size and ship class mixes. This would be useful for sizing utility system improvements as well as for estimating the time to initiate such projects. Another application would be to use the Port System Requirements Prediction Methodology to interpret the output of port utility sampling projects. In this way, the results of this study can serve the Port Systems Project by providing a focus for the various utility demand data experiments being planned.

## SECTION TWO

## METHODOLOGY CONCEPT

### 2.0 Objective

The objective of this section is to show how to use a statistical approach for port requirements planning and to introduce a method by which this may be done. This method is called the Port System Requirements Prediction Methodology.

### 2.1 Scope

This section discusses the broad qualities of the port planning problem, describes a methodology for analyzing typical waterfront problems using statistical techniques, and presents potential uses for the products generated by the Port Systems Requirements Prediction Methodology.

### 2.2 Discussion

Ship service requirements at a given port can be predicted accurately for only a few days or weeks. This is due primarily to the uncertainty in future fleet operating characteristics which directly impact the presence or absence of any given ship at the port at any specified future time. There are also uncertainties in the per ship demand and in the number and type of ships operating from a given port. The result is that service capacity decisions must be made with limited information regarding operational scenarios. It cannot be stated, for instance, that on a specific date in 1990 there will be 83 ships in San Diego Harbor. Hence, maximum resource requirements cannot be established by surveying a list of ships.

Under these circumstances a reasonable approach for port system analysis is to attempt to derive the probability distribution for resource demand rates for different homeporting plans. The capacity for a selected utility can then be represented as a preset low probability of failing to meet the demand during the design lifetime of the capital installation. This approach offers reasonable possibilities for validation by reviewing historical data and/or through planned observations over the early years of its application.

Figure 2-1 illustrates how information of this nature could be presented:

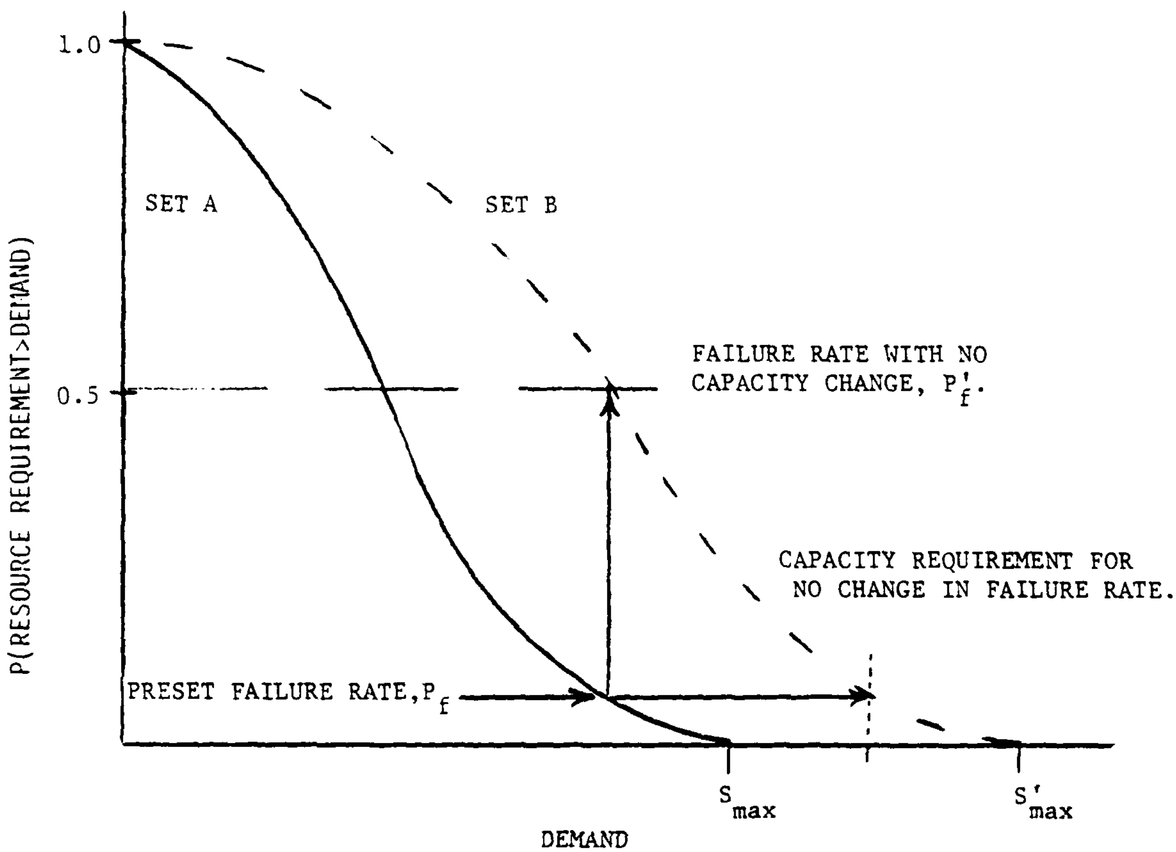



FIGURE 2-1 DESIRED FORMAT FOR METHODOLOGY OUTPUT.

The abscissa is the demand level for a given resource. The ordinate is the probability that the requirement of a specified group of ships for that resource will exceed a specified demand level during an interval of interest. The interval can be defined in many ways; it may be a randomly selected day in a month, part of a day, an entire year, or even the lifetime of the capital investment. Figure 2-1 depicts two graphs for the same interval. Each curve represents a different port load. One might be for the current homeport plan, and the other for some future port load. In this case, the preset "failure" probability $P_F$ is established relative to the present supply level, S. When the demand reaches the supply level S, the system will no longer function without special management measures such as rationing, berthing shifts, lighting off ships utility systems, etc.

The relationship between the curves of Figure 2-1 enables one to quickly evaluate alternative strategies for dealing with the resource requirement. For example, if there is no change in the supply capacity, then the probability of failure would rise to the value $P_F'$ in the case of the set of ships in the future. Alternatively, if it is required that the failure rate remain constant, then the supply would have to increase from S to $S'$. A larger increase in supply would result in a decreasing failure probability while either a zero or a small increase would result in a larger probability of failure. This information can be of immediate use in formulating priorities for acquisition of waterfront improvements.

## 2.3 Port System Requirements Prediction Methodology Objective

Developing information similar to that depicted by Figure 2-1 for various resources constitutes a new technique for analyzing port requirements and is the objective of the Port System Requirement Prediction Methodology. This technique if valuable from several points of view. For example, the degree to which a port control authority is forced to exercise special management procedures because of utility shortages can be quantitatively presented to Fleet decision makers. Alternatively, the impact of not updating pierside resources to accommodate planned ship alterations or new ship acquisitions can be quickly determined. Overall, the information available through this methodology is obtained at low cost and in a short timeframe once the methodology has been finalized. Other advantages in terms of project justification and acquisition strategies can be developed if this methodology is placed in the hands of knowledgeable port planners.

## 2.4 Methodology Application

The probability distribution of resource demand rates (i.e., the amount of the resources that would be consumed, if available) is identified above as information that could be effectively used for port requirements analysis. Graphs of the nature of Figure 2-1 are, then, the goal product of the Port Systems Requirement Methodology. Hence, the procedure for developing this information is of primary interest, and is in fact the conceptual basis of the Port System Requirements Methodology. Figure 2-2 is a model of how the goal product of Port System Requirements Methodology is generated. This figure shows that there are three phases of the Methodology. First is data acquisition and assembly. In the example used to illustrate the methodology 60Hz power was selected as the resource to be analyzed. Ship demand data were taken from DM-25. (These data could be made much more realistic by using actual measurement data from the ports of interest). Ship populations and cold iron probabilities were derived from OPNAV INST 3111.14U and NAVSEC Report 6139-72-2(1977), respectively.

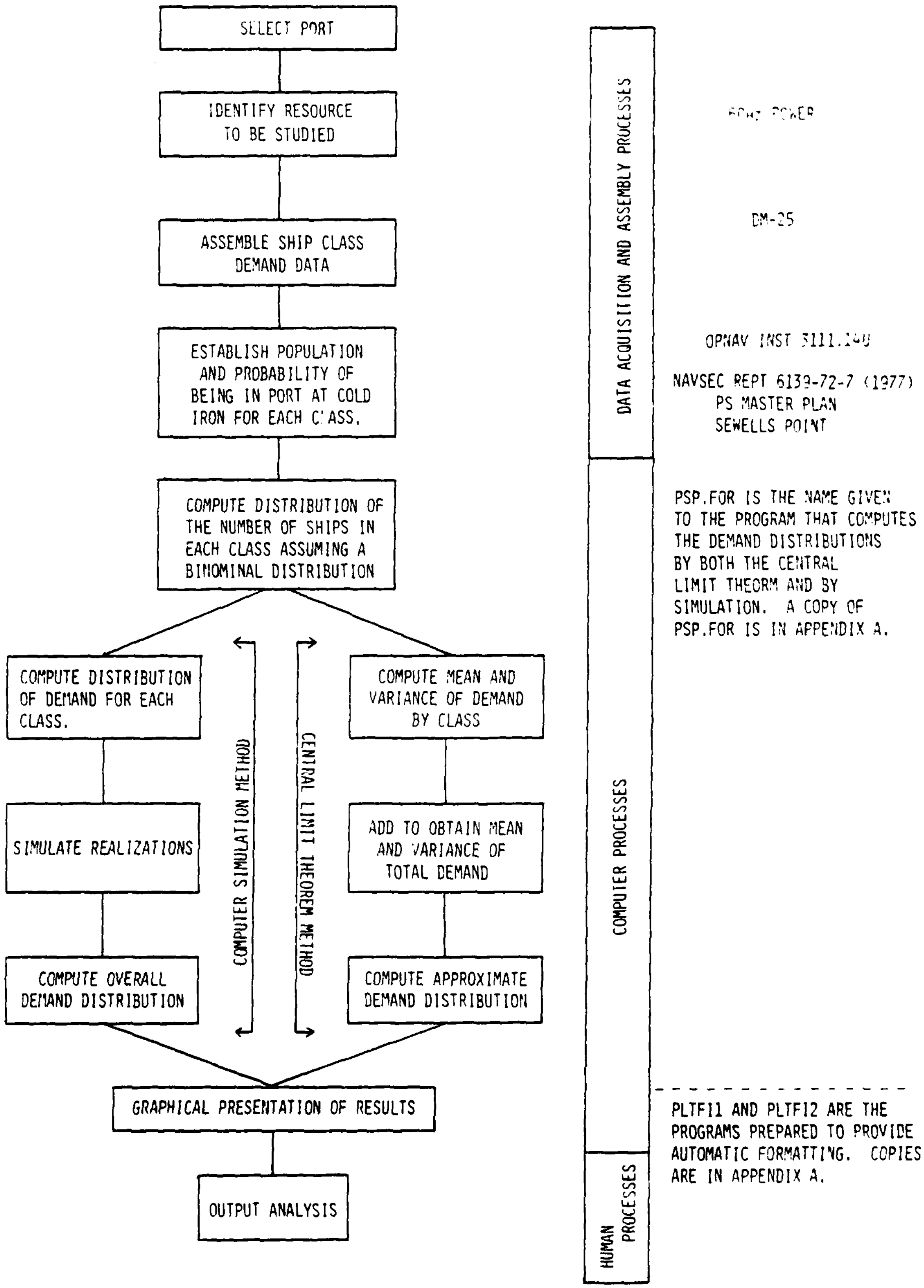



FIGURE 2-2. ACTIVITY FLOW IN PORT SYSTEMS REQUIREMENTS PREDICTION METHODOLOGY

Next, Naval Station, San Diego and Naval Operating Base, Norfolk were selected as the ports under study. The second phase consisted of the actual generation of the goal product, i.e., the demand distribution. Figure 2-2 shows that two techniques were used to develop this product, the computer simulation and the Central Limit Theorem methods. Computer programs were prepared during this study which performed the required calculations and permitted automatic graphical presentation of the results. The last phase of this methodology was output analysis. This, and the mathematical theory that forms the basis of computational work are described in the following sections of this report.

## SECTION THREE

## THEORETICAL BASIS

### 3.0 Objective.

The objective of this section is to describe the theoretical basis of the Port System Requirements Prediction Methodology.

### 3.1 Scope.

Three distinct elements form the theoretical basis of the Port System Requirements Prediction Methodology. These are:

a. An interpretation of port conditions that can be used as a framework for statistical analysis.

b. The derivation of the mathematical expressions used to generate the probability distribution for utility demand.

c. An explanation of the alternate means of acquiring the products of the Port System Requirements Prediction Methodology.

The first two elements are discussed in a single subsection titled "Theoretical Approach" and the latter element is discussed under the subsection titled "Product Development."

### 3.2 Theoretical Approach.

The distribution of total demand on a given service facility will depend on a number of port conditions. The most significant of these conditions are:

1. The ship population that may use the service facility.
2. The probability that a member of each individual ship class will actually be at cold iron, and

3. The probability distribution of the demand for each individual ship given that is at cold iron. In general terms, this may be a joint probability distribution for more than one ship if there is a cooperation of some type between ships.

The use of these conditions to determine the distribution of the total demand for a specific utility is described below.

First, let $P_k$ be the probability that a ship in the kth class is not at cold iron in the port or service facility of interest, and let $N_k$ be the total number of ships in class k that are assigned to the port under study during the period of interest. The cold iron probability, $P_k$, is simply $P_k = P_{1K} \cdot P_{2k}$ where

$P_{1k}$ = the probability that a ship in the kth class will be present at the port, and

$P_{2k}$ = the probability that a ship in port in the kth class will be at cold iron.

The next step is to estimate how the numbers of ships present are statistically distributed. As an initial step, we assume that there is no correlation between the presence of any one ship and any other ship. This will not be true if ships are traveling in company, but is a reasonable initial representation. In this event, the number of ships, $n_k$, actually present in the interval of interest will be binomially distributed. The related probability is:

$$P(n_k) = \binom{N_k}{n_k} P_K \quad (1 - P_k)^{N_k - n_k} \qquad (1)$$

where the first term on the right hand side is the number of combinations of $N_k$ articles that can be taken $n_k$ at a time, i.e.

$$\binom{N_k}{n_k} = \frac{N_k!}{n_k!\,(N_k - n_k)!} \qquad (2)$$

Figure 3.1 presents an example of a binominal distribution. The total population, $N_k$, has been set at 5 and the cold iron probability has been set to 0.5. The probability distribution obtained for these parameters is the familiar coin-toss distribution giving the probability of obtaining a given number of heads (or tails) when 5 coins are tossed. It should be noted that although, in the example given, the distribution is symmetric, this will not usually be the case.

The mean or average value of $n_k$ is denoted by E $(n_k)$ indicating "expected value". It is relatively easy to show that the mean has the following values:

$$E(n_k) = N_k P_k \qquad (3)$$

Additionally, we define the variance V $(n_k)$ of the distribution relating to the dispersion about the mean. It is, in fact, equal to the average of the squares of the deviations from the mean value. For the binominal distribution, the variance is given by:

$$V(n_k) = N_k P_k(1-P_k) \qquad (4)$$

In the example given above the expected value is 5 x 0.5 = 2.5 (ships) while the variance is 1.25 ships$^2$. The standard deviation of the number of ships present is defined as the square root of the variance i.e., $\sqrt{1.25}$ or 1.12.

The demand for resource, j, by a given ship will depend on its class, k. If $d_k$ is the value of this demand, it will be distributed over a range depending on the operations undertaken during servicing. Thus for a given interval of time there will be a matrix of probabilities $P_{ikj}$ giving the probability that

$N_k$ = Total population in ship class of interest

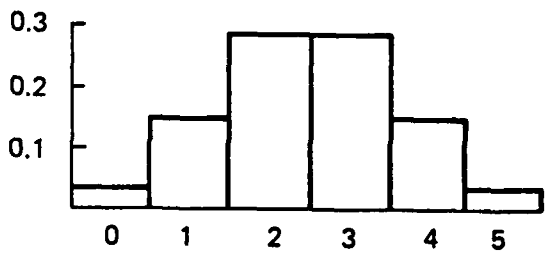
$p$ = Probability that class member is at cold iron

Probability that $n_k$ ships are present

$$P_k = p^{n_k}(1-p)^{N_k-n_k}\binom{N_k}{n_k}$$

$N_k = 5$

$p = 0.5$




$$P_k = \frac{p^{n_k}\,(1-p)^{N_k-n_k}N_k!}{n_k!\,(N_k-n_k)!}$$

Mean number of ships present $= N_k p$

Variance in number of ships present $= N_k p(1-p)$

FIGURE 3-1. Example of a Binomial Distribution

$d_{jk}$ will be in the range, $d_{jk(i-1)}$ to $d_{jk(i)}$, where $d_{jk(i)}$ is the ith marker for the given resource. *In testing our program, however, we have made the assumption that variability in the per ship demand is less important than the variability in the number of ships present and have taken the value of each* $d_{jk}$ *to be a constant.* This is equivalent to having a single infinitesimal range and setting $P_{1jk}$ to unity for all j and k. With this assumption, the mean or expected total demand for a given resource and its variance can be estimated as follows: If $D_j$ is the total demand for resource j, then its average value is given by

$$E(D_j) = \sum_k d_{jk}\, E(n_k) = \sum_k N_k P_k d_{jk} \tag{5}$$

and the variance is given by

$$V(D_j) = \sum_k d_{jk}\, V(n_k) = \sum_k d_{jk}\, N_k P_k\, (1-P_k) \tag{6}$$

It is equations (5) and (6) then, that are used to generate the goal product of the Port Systems Requirements Prediction Methodology.

## 3.3 Product Development

The calculation of the distribution of the total demand $D_j$ for resource j is quite complicated and is best performed by multiple complementary approaches. Fortunately, the three methods that have been developed always provide a mechanism for applying two techniques to every case considered. We shall now present the details of the three methods.

### Method 1 - Explicit Enumeration

This approach is suitable for "small" problems, i.e. when the number of ships and ship classes are small. The probability of obtaining a given distribution, $N_k$, of ships in class k is given by

$$P(n_1, n_2, \ldots n_m) = P(n_1)P(n_2)\ldots P(n_m) = \prod_{k=1}^{m} p(n_k) \tag{7}$$

In other words, the probability that we would obtain $n_1$ ships in class 1, $n_2$ ships in class 2, etc., is simply the product of the probabilities that the states be obtained independent of the other classes. If we believe that the numbers of members of any class do not depend on the numbers present in any other classes, but only on the total population in that class and the cold iron probabilities, then the use of the product with be valid with the individual probabilities given by equation (1).

The number of terms in equation (7) rises rapidly as the harbor size grows. If $N_k$ is the number of ships in class k, there are $(N_k+1)$ possibilities for this case. One is added to allow for the possibility of zero. The total number of terms is $\prod_{k=1}^{m} (N_k+1)$. As an example, if there were ten classes, each with ten ships, then the number of possible populations in the port would be $11^{10}$. Thus while this approach is useful for validating calculations on small problems, it is normally impracticable for realistic cases and has not been formally programmed.

Method 2 - Monte Carlo Simulation

Here, we introduce the concept of a "realization" of the conditions of operation of the port. If we are given the data describing the probability that the port will be in any given condition, then through the use of a random number generator we can perform a computer operation simulating that condition with a likelihood of occurrence equal to the real world probability. This is a realization of this condition. By generating many such realizations we can compute the statistics of usage of any resource surveyed.

For each class we establish a random number of ships at cold iron in accordance with a binomial distribution. Figure 3-2 illustrates how this is done. We generate a pseudorandom number, $\rho$, rectangularly distributed in [0,1] and then identify the number of ships present to the largest number, n, such that the probability of obtaining fewer than n numbers is less than $\rho$. For purposes of this work, a pseudorandom number is considered to be a number in the range [0,1] that is generated by a computer program and whose occurrence follows a rectangular distributon so as to possess the statistical quality of randomness. For Figure 3-2, the magnitudes of the probability increments are equal to the probabilities given in Figure 3-1 and in this specific example, the number selected by the procedure given is 2.

The generation of a realization of the entire system involves the determination of the number of ships present in each class. This requires that the operation described above be performed once for each class. Having determined the number of ships present in each class, we can then determine the total usage of resources for this realization.

The goal product is accomplished by generating a large number of realizations of the entire system (at least 100) and counting the number of times that the total demand for any given resource exceeds a specified value. An advantage of this approach is that complications such as a probability distribution of resource demands by individual ships can readily be accommodated in this part of the calculation.

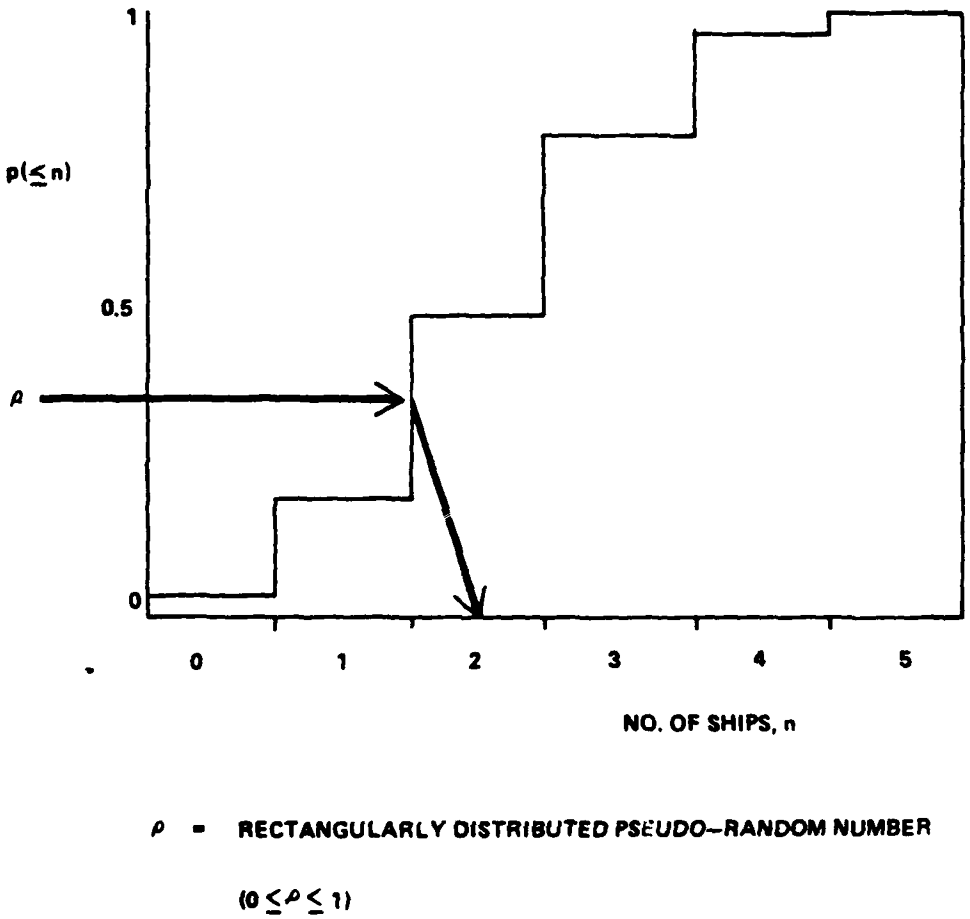



FIGURE 3-2. METHOD OF CALCULATING NUMBER OF SHIPS AT COLD IRON.

It must be remembered that the accuracy of the simulation result improves the number of realizations, N, is increased. In general, the standard error $\delta_p$, in any probability estimate, p, is given by $\sqrt{N^{-1}p(1-p)}$ so that, in order to halve the error, we must increase the number of simulations by a factor of 4. Initially, we used a value of N of 100, but this number can be increased as the input data becomes more accurate.

Method 3 - Central Limit Theorem

The total demand for any given resource often arises from many randomly behaving components that have the same probability density functions, and is computed as a sum of these components. The Central Limit Theorem states that, under these conditions, the sum is distributed in an asymptotically "Normal" or "Gaussian" fashion independent of the probability distributions of the individual components.

The normal distribution for any variable, x, with mean and variance E(x) and V(x), respectively, takes the form:

$$P(x) = \left(\sqrt{2\pi\, V(x)}\right)^{-1} \exp - \left\{ \frac{(x-E(x))^2}{2V(x)} \right\} \qquad (8)$$

and the integrals of this function or cumulative probabilities are computed in terms of "error functions," available in tabular fashion or computer routines. The practical application of this formula requires only that we substitute expressions (5) and (6) for the expectation and variance in (8) to compute the distribution of any resource demand, $D_j$. The cumulative distributions obtained in this way are generally smoother and will describe the distributions well in the median region. In the distribution wings, however, there may be serious errors in this approach and it is therefore only recommended for quick estimations.

## SECTION FOUR
## DATA ASSEMBLY

### 4.0 Objective.

The objective of this section is to present the data used in demonstrating the Port Systems Requirements Prediction Methodology.

### 4.1 Scope.

This section describes the data used to generate the Goal Product, sources of the data, incorporation into the computer program data files, and includes comments to clarify potentially obscure points.

### 4.2 Discussion.

Demonstration of the Port Systems Requirements Prediction Methodology necessitates the development of data files for ship populations, demands for resources, homeports, operating characteristics, etc. This information does not exist in a convenient form and must be assembled from a variety of sources. The accuracy of its selection and subsequent development bears directly on the correctness of the output of the Methodology.

The specific information required by the computer program, PSP as described in Appendia A, includes: a breakdown by class of ship homeport assignments, the percentage of time spent in port at cold iron, the type and amount of resources demanded, and estimates of future homeport assignments for 1985 and the period 1995-2000. Representative data from existing documents were used to describe these characteristics for 33 ship classes at two ports San Diego, CA, and Norfolk, VA. OPNAVINST 3111.14U was used to establish homeporting assignments. The number of ships in each class with homeports of either San Diego or Norfolk are listed in data files DA1 and DA2 in Table 4-1 - Summary of Data.

Estimates of the time spent in port at cold iron were derived using Table 4-2 - Ship Operational Modes, obtained from reference (b). The percentage of time spent in port and at cold iron was calculated by averaging the percent time in port for each period of time, the percent time at cold iron for each period of time, and multiplying. These data are listed in Table 4-1, column 2.

The distribution of resources was restricted to electrical demand. This information was obtained from DM-25 using KVA values for Ships Service (Hotel). For each ship class listed, a single value of KVA was selected to represent typical electrical demand for that class of ships. The electrical demands are listed in column three of Table 4-1 and were held constant for all scenarios under study. Estimates of the 1985 ship class populations were based on Table 4-3, extracted from reference (d), and involved scaling the 1981 ship class population figures up or down accordingly. This information is contained in data files DA3 and DA4.

The ship class populations in data files DA5 and DA6 are estimates for the period 1995-2000 and are based on reference (e). Actual figures from reference (e) were not used so that this report may remain unclassified.

For those ship classes homeported in San Diego or Norfolk where information on resource demands and/or percentage of time in port at cold iron was not available, an estimate was made based on ships of similar type. Five ship classes required this procedure for determining their percentage of time in port at cold iron. Seven classes required estimates of KVA demand.

| SHIP TYPE | PROBABILITY OF DEMAND | KVA | HOMEPORT | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 1981 | | 1985 | | 1995-2000 | |
| | | | SD | N | SD | N | SD | N |
| AD | .625 | 2200 | 3 | 3 | 3 | 3 | 2 | 2 |
| AFS | .381 | 1184 | 0 | 3 | 0 | 3 | 2 | 5 |
| AO | .500 | 800 | 0 | 3 | 4 | 7 | 0 | 3 |
| AOE | .314 | 1090 | 0 | 2 | 0 | 0 | 0 | 0 |
| AOR | .349 | 1012 | 0 | 2 | 0 | 2 | 0 | 2 |
| AR | .713 | 1714 | 2 | 1 | 2 | 1 | 2 | 1 |
| AS | .352 | 1250 SD<br>2500 N | 2 | 1 | 3 | 2 | 2 | 1 |
| ASR | .569 | 495 | 2 | 2 | 1 | 1 | 2 | 2 |
| ATF | .657 | 400[6] | 1 | 0 | 1 | 0 | 1 | 0 |
| CG | .516 | 2865 | 9 | 2 | 11 | 4 | 12 | 3 |
| CGN | .388 | 3293 | 3 | 5 | 3 | 5 | 4 | 6 |
| CV[2] | .347 | 6850 | 3 | 3 | 3 | 3 | 6 | 6 |
| CVN[2] | .344 | 11500 | 0 | 2 | 0 | 2 | 0 | 2 |
| CVT[2] | .515 | 935 | 0 | 0 | 1 | 1 | 0 | 0 |
| DD | .562 | 1100 | 9 | 10 | 12 | 13 | 5 | 5 |
| DDG | .570 | 1400 | 9 | 9 | 13 | 13 | 5 | 5 |
| FF | .576 | 1355 | 12 | 9 | 15 | 12 | 24 | 18 |
| FFG | .599 | 1012 | 3 | 1 | 8 | 6 | 6 | 3 |
| LCC | .584 | 311 | 1 | 1 | 1 | 1 | 1 | 1 |
| LKA | .563 | 1246 | 3 | 2 | 3 | 2 | 3 | 2 |
| LPA | .566 | 3000[6] | 0 | 1 | 0 | 1 | 0 | 1 |
| LPD | .516 | 1636 | 6 | 7 | 7 | 8 | 6 | 7 |
| LPH | .493 | 4000 | 3 | 4 | 3 | 4 | 3 | 4 |
| LSD | .576 | 3000[6] | 7 | 0 | 7 | 0 | 7 | 0 |
| LST | .547 | 3000[6] | 8 | 0 | 8 | 0 | 8 | 0 |
| MSO | .644 | 3000[6] | 2 | 0 | 2 | 0 | 2 | 0 |
| SS[4] | .701 | 75 | 3 | 0 | 3 | 0 | 3 | 0 |
| SSN[5] | .694 | 1000 | 12 | 13 | 22 | 23 | 12 | 13 |
| AGFF | .65[1] | 467 | 0 | 1 | 0 | 1 | 0 | 1 |
| AGDS | .65[1] | 467[6] | 1 | 0 | 1 | 0 | 1 | 0 |
| AGF | .65[1] | 467 | 0 | 1 | 0 | 0 | 0 | 1 |
| LHA | .55[1] | 3740 | 2 | 1 | 3 | 2 | 2 | 1 |
| PHM | .65[1] | 100[6] | 1 | 0 | 1 | 0 | 1 | 0 |
| TOTAL: 33 | | | 107 | 89 | 141 | 120 | 122 | 95 |
| DATA FILE: | | | DA1 | DA2 | DA3 | DA4 | DA5 | DA6 |

1 Probability of demand estimated due to lack of available data.

2 Aircraft carriers were considered as two groups - nuclear, and non-nuclear. The training carrier CUT was considered separately.

3 Electrical demand figures are for ships' service (hotel) only. They do not include the additional power required for industrial work load operations aboard ship when in for repairs or overhaul.

4 Includes SS, AGSS, SST, and LPSS classes.

5 SSN and SSBN classes grouped together.

6 Resource demand estimates based on ships of similar type.

TABLE 4-1. SUMMARY OF DATA

| Ship Type | Percent Time in Port | | Percent Time Cold Iron | |
|---|---|---|---|---|
| | 7/72-6/73 | 4/75-3/76 | 7/72-6/73 | 4/75-3/76 |
| AD | 93.0 | 94.2 | 66.8 | 66.8 |
| AE | 64.0 | 75.2 | 53.8 | 53.6 |
| AF | 61.9 | 64.0 | 57.6 | 70.6 |
| AFS | 61.8 | 72.8 | 51.6 | 61.6 |
| AG | 67.3 | 78.6 | 90.8 | 88.5 |
| AO | 65.5 | 78.2 | 67.7 | 71.4 |
| AOE | 62.6 | 67.5 | 45.5 | 51.0 |
| AOG | 76.7 | 96.9 | 63.3 | 98.7 |
| AOR | 52.8 | 74.0 | 41.5 | 68.5 |
| AR | 91.6 | 89.3 | 83.9 | 73.8 |
| ARS | 75.9 | 77.1 | 50.3 | 59.3 |
| AS | 94.4 | 96.5 | 41.7 | 32.1 |
| ASR | 78.4 | 77.8 | 66.9 | 78.8 |
| ATF | 78.8 | 77.8 | 83.1 | 84.8 |
| ATS | 82.7 | 78.6 | 69.8 | 66.0 |
| CG | 79.5 | 71.6 | 71.0 | 65.6 |
| CGN | 37.9 | 80.5 | 50.2 | 80.9 |
| CV | 57.4 | 64.5 | 54.7 | 59.0 |
| CVN | 38.9 | 69.1 | 45.8 | 81.5 |
| CVT | 77.0 | 73.9 | 65.4 | 71.1 |
| DD | 67.0 | 81.3 | 71.9 | 79.7 |
| DDG | 65.1 | 82.4 | 74.5 | 80.2 |
| FF | 69.2 | 73.5 | 80.7 | 80.8 |
| FFG | 66.0 | 77.7 | 77.6 | 89.0 |
| LCC | 74.2 | 77.7 | 64.5 | 89.2 |
| LKA | 75.7 | 75.5 | 75.6 | 73.3 |
| LPA | 69.8 | 85.5 | 61.8 | 83.0 |
| LPD | 72.0 | 79.9 | 66.2 | 69.8 |
| LPH | 68.3 | 78.1 | 65.2 | 69.4 |
| LSD | 74.6 | 80.6 | 73.7 | 74.7 |
| LST | 74.7 | 79.5 | 67.3 | 74.6 |
| MSO | 78.2 | 88.9 | 74.9 | 79.2 |
| PG | 79.7 | 87.4 | 83.0 | 76.9 |
| SS | 75.5 | 78.7 | 95.3 | 86.6 |
| SSN | 71.8 | 71.6 | 96.5 | 97.0 |
| SSBN | 50.8 | 48.1 | 93.8 | 89.7 |

TABLE 4-2. SHIP OPERATIONAL MODES

| TYPE | FY-77 | FY-85 | INCREASE | DECREASE |
|---|---|---|---|---|
| AD | 3 | 3 | - | - |
| AE | 1 | 0 | - | 1 |
| AFS | 3 | 3 | - | - |
| AGF | 1 | 0 | - | 1 |
| AGFF | 1 | 1 | - | - |
| AO | 4 | 8 | 4 | - |
| AOE | 2 | 0 | - | 2 |
| AOR | 2 | 2 | - | - |
| AR | 1 | 1 | - | - |
| AS | 1 | 2 | 1 | - |
| ASR | 2 | 1 | - | 1 |
| CG | 3 | 5 | 2 | - |
| CGN | 4 | 4 | - | - |
| CV | 3 | 3 | - | - |
| CVN | 2 | 2 | - | - |
| CVV | 0 | 1 | 1 | - |
| DD | 8 | 11 | 3 | - |
| DDG | 9 | 13 | 4 | - |
| FF | 9 | 12 | 3 | - |
| FFG | 1 | 6 | 5 | - |
| LCC | 1 | 1 | - | - |
| LHA | 1 | 2 | 1 | - |
| LKA | 2 | 2 | - | - |
| LPS (NR) | 1 | 1 | - | - |
| LPD | 6 | 7 | 1 | - |
| LPH | 4 | 4 | - | - |
| SSN | 12 | 22 | 10 | - |
| TOTAL | 87 | 117 | 35 | 5 |

TABLE 4-3. HOMEPORTED SHIPS

# SECTION FIVE

# APPLICATION

## 5.0 Objective.

This section describes the application of the Port Systems Requirement Prediction Methodology to the analysis of a specific utility requirement problem. It emphasizes the procedures necessary to acquire a goal product using the theory contained in Section Three and the data assembled in Section Four. The reader is reminded that this sample problem is only intended to demonstrate the Port Systems Requirements Prediction Methodology. Actual application of the Methodology requires refinement of the input data.

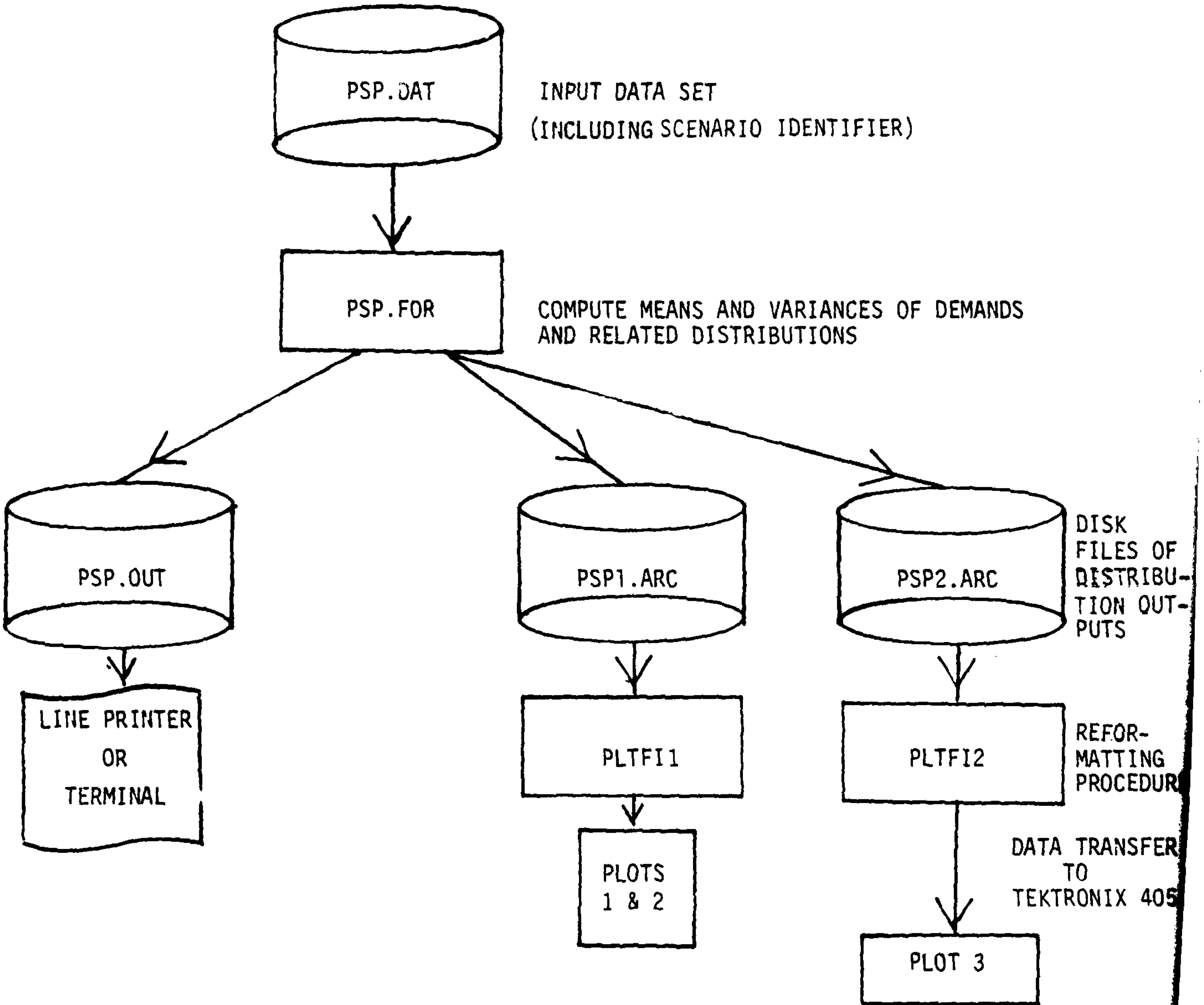
## 5.1 Scope.

This section provides detailed information concerning the computer procedures that are necessary to implement the Methodology. Typical Methodology products are presented with a discussion of the information that can be derived from them. Finally, recommendations are made for data refinements that would be desirable for further application of the Methodology.

## 5.2 Data and Logic Flow Structure.

A schematic diagram of the data flow for the PSP program system is presented in Figure 5-1. The input data set is prepared on disk and fed to the program PSP which computes the means and variances of the demands and the related probability distributions. The outputs of the computations are distributed to three disk files:

1) PSP.OUT, which is an image of the hardcopy output of the program and may be directed either to a line printer or any computer terminal.




| PLOT NO. | TYPE |
|---|---|
| 1 | CUMULATIVE PROBABILITY VS (LINEAR) RESOURCE AMOUNT |
| 2 | CUMULATIVE PROBABILITY VS (LOG) RESOURCE AMOUNT |
| 3 | MEAN AND STANDARD DEVIATION OF RESOURCE USE BY SHIP CLASS |

FIGURE 5-1 Schematic Diagram of PSP Code Data Flow

2) PSP1.ARC, which is an archive file to which is added an extract from the PSP.OUT data containing just the probability distributions necessary to produce the outputs of the type of Figures 5-5 and 5-6. The data in the PSP1.ARC file is reformatted into plotter compatible format using the program, PLTFI1.

3) PSP2.ARC, which is another archive file to which we add an extract of the PSP.OUT data containing the mean and variance results. These data are used to produce a plot of the type of Figure 5-7. The data in the PSP2.ARC file are reformatted for the plotter using the program, PLTFI2.

Figure 5-2 presents the logic flow or sequence of operations for the program PSP1. The first step is to read the input data. This may be accessed from a disk file when constructed off-line, or, in another version of the program, it may be entered directly at the keyboard as requested in conversational mode with the computer. The first calculation is to obtain the probability distribution of equation (1) for the number of ships present in each class. The next computational step is to estimate the mean numbers of ships present in each class as given in equation (3) and the associated variances given in equation (4). These are used to compute the means and variances of the resource demands as specified in equations (5) and (6).

The means and variances of the resource demands are fed to a subroutine which computes the distribution of total demands based on the assumption of the validity of the Central Limit Theorem, i.e., that the total demands have a Gaussian distribution. These distributions are printed at this time. Finally, the simulation is exercised to generate the desired number of realizations of the numbers of ships present in each class and assess the total resource demands for all the realizations generated. The output of this part of the computation is given as a percentile table for the total demand for each resource.

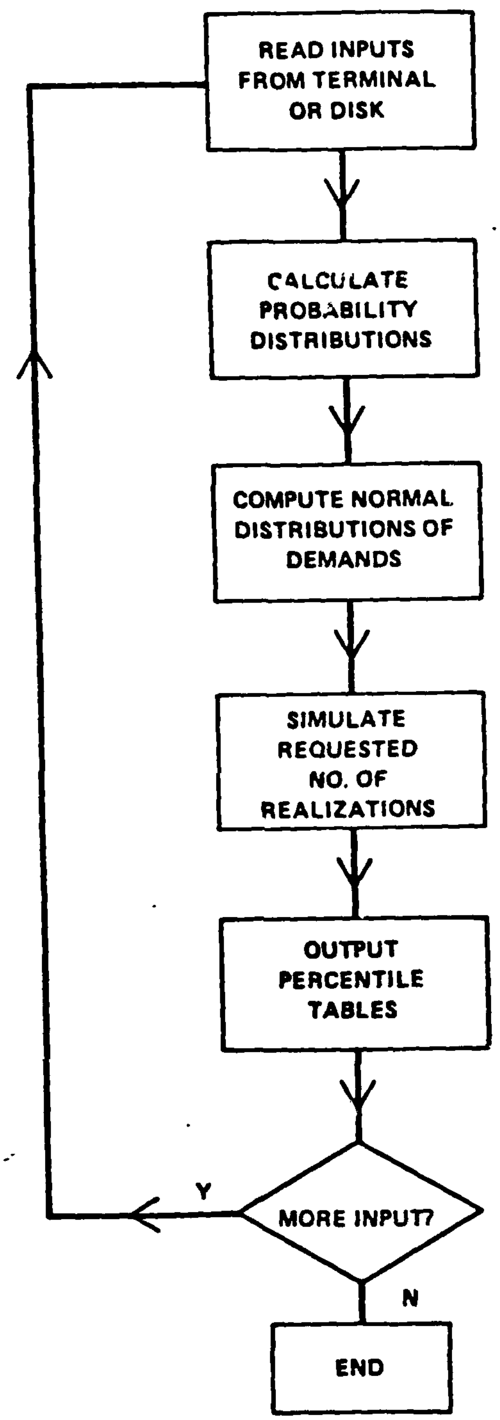



FIGURE 5-2  Logic Flow Diagram for Program PSP

If more inputs are indicated either through terminal interaction or through the disk data set, then the program returns to the data reading step. Otherwise, execution is terminated at this point.

5.3 Data Entry.

Figure 5-3 presents the prompts given to the user when entering a specific example of a data set. In this instance the program was reading data from a disk file so that the user entries do not appear on the page.

```
ENTER NO. OF SHIP CLASSES AND NO. OF RESOURCES (2I3)
ENTER SCENARIO DESCRIPTION IN 72 CHARACTERS OR LESS
ENTER 3 RESOURCE NAMES (NA4)
ENTER CLASS NAME, PROB. OF DEMAND AND RESOURCE DEMANDS (A4, NF7.3)
   1
   2
   .
   .
   .
  32
  33
  ENTER SHIP CLASS POPULATIONS (24I3)
  ENTER NO. OF SIMULATIONS, NO. DEPT, AND INITIAL R.N. (3I6)
```

FIGURE 5-3 User Prompts for Data Entry

An initial record specifies a six character user identification code. The next line of data gives the number of ship classes and number of resources in the format (2I3). This means that two right justified three-digit integers must be specified. The second line contains up to 72 characters of a scenario description, e.g., the name of the port and a time period or date. The names of the resources must then be specified, each having up to four characters (alphabetic and/or numerical). This completes the header record set.

The main body of the input data is the resource demand matrix giving the demand for each resource by a ship in each class. The data for each ship class is given in a single line. The first four characters give the ship class designation. These are followed by the expected demands for the resources specified, each demand being allowed seven characters including the decimal point.

Two closing records specify the ship class populations and the simulation control parameters. The number of ships that may be present in each class are given in the first record, each being specified as a right-justified three-digit integer. These are normally the numbers of ships in the various classes that are homeported at the site. The last record specifies the number of simulations to be performed (zero indicates no simulation desired), the number of (largest) demands to be retained for developing percentile tables for each resource, and the initial random number which can be any odd integer. Each of the numbers in the last record is given as a right-justified six-digit integer.

The computer returns a page presenting a formatted description of the input as illustrated in Figure 5-4. This may be reviewed by the user for correcting errors and filed for record keeping purposes.

## 5.4 Practical System Operation.

This PSP model is best executed in time-sharing mode using a computer terminal. It was developed on the ADP network and runs on a DEC 10 computer. The graphics output routines are written for a Tectronix 4051 computer/plotter. While there are some elements of the PSP program that are system specific, it is readily modified to work on any computer. The graphics routines will always

NORFOLK, 1995-2000

NUMBER OF CLASSES= 33 NUMBER OF RESOURCES= 3

NUMBER OF REALIZATIONS REQUESTED= 100

NUMBER KEPT= 100

INITIAL RANDOM NUMBER= 490873

RESOURCE DEMAND MATRIX IS AS FOLLOWS:

| | KVA | KWDC | NO. | PROB | |
|---|---|---|---|---|---|
| AD | 2200.000 | 0.000 | 1.000 | 0.625 | 2 |
| AFS | 1184.000 | 0.000 | 1.000 | 0.381 | 5 |
| AO | 800.000 | 0.000 | 1.000 | 0.500 | 3 |
| AOE | 1090.000 | 0.000 | 1.000 | 0.314 | 0 |
| AOR | 1012.000 | 0.000 | 1.000 | 0.349 | 2 |
| AR | 1714.000 | 0.000 | 1.000 | 0.713 | 1 |
| AS | 2500.000 | 0.000 | 1.000 | 0.352 | 1 |
| ASR | 495.000 | 0.000 | 1.000 | 0.569 | 2 |
| ATF | 400.000 | 0.000 | 1.000 | 0.657 | 0 |
| CG | 2865.000 | 0.000 | 1.000 | 0.516 | 3 |
| CGN | 3293.000 | 0.000 | 1.000 | 0.388 | 6 |
| CV | 6850.000 | 0.000 | 1.000 | 0.347 | 6 |
| CVN | 11500.000 | 0.000 | 1.000 | 0.344 | 2 |
| CVT | 935.000 | 0.000 | 1.000 | 0.515 | 0 |
| DD | 1100.000 | 0.000 | 1.000 | 0.562 | 5 |
| DDG | 1400.000 | 0.000 | 1.000 | 0.570 | 5 |
| FF | 1355.000 | 0.000 | 1.000 | 0.576 | 18 |
| FFG | 1012.000 | 0.000 | 1.000 | 0.599 | 3 |
| LCC | 311.000 | 576.000 | 1.000 | 0.584 | 1 |
| LKA | 1246.000 | 0.000 | 1.000 | 0.563 | 2 |
| LPA | 3000.000 | 0.000 | 1.000 | 0.566 | 1 |
| LPD | 1636.000 | 0.000 | 1.000 | 0.516 | 7 |
| LPH | 4000.000 | 0.000 | 1.000 | 0.493 | 4 |
| LSD | 3000.000 | 0.000 | 1.000 | 0.576 | 0 |
| LST | 3000.000 | 0.000 | 1.000 | 0.547 | 0 |
| MSO | 3000.000 | 0.000 | 1.000 | 0.644 | 0 |
| SS | 75.000 | 165.000 | 1.000 | 0.701 | 0 |
| SSN | 1000.000 | 0.000 | 1.000 | 0.694 | 13 |
| AGFF | 467.000 | 0.000 | 1.000 | 0.650 | 1 |
| AGDS | 467.000 | 0.000 | 1.000 | 0.650 | 0 |
| AGF | 467.000 | 0.000 | 1.000 | 0.650 | 1 |
| LHA | 3740.000 | 0.000 | 1.000 | 0.550 | 1 |
| PHM | 100.000 | 0.000 | 1.000 | 0.650 | 0 |

FIGURE 5-4 Sample Formatted Page Returned for Operator Review

require a Tektronix system, however, as new programs would have to be generated to work on another system.

When operating with a real time input version, the user merely responds to terminal requests for input once the six character run identifier has been given. For construction of the disk data file, any system text editor can be used.

## 5.5 Methodology Output.

Section 2 introduced the goal product of the Port Systems Requirements Prediction Methodology, i.e., a curve depicting the probability of exceeding the demand for a selected utility for a given port condition and discussed its utilization. The computer programs contained in Appendix A provide this product as an automatically graphed output. Examples of these goal products are given in Figures 5-5, 5-6, and 5-7. These curves present unique ways in which the primary output of the Port System Requirements Prediction Methodology may be used. These techniques are described as follows:

Figure 5-5. Three sets of data are represented here. They are the ships homeported in San Diego in 1981, the ships that would be in San Diego in 1985 if the fleet were to expand in size comparable to that depicted in Sewell's Point Master Plan (1985), and a 1995 - 2000 fleet determined by assuming that the projections of reference (e) are realistic. Applying the technique of Section 2, it can be seen that a twenty percent probability of the demand for electricity exceeding the supply would grow to 70% and 90% for the 1995 and 1985 Scenarios, respectively, if there is no increase in supply. Alternatively, to maintain the probability of failing to meet demand, the supply must be increased 16-24000 KVA. This type of analysis can be used to determine the impact of changes to current homeport assignments, base closures, or to determine the adequacy of utility supply for alternative concepts of future fleets. Other applications exist at the pier level. For example, utility

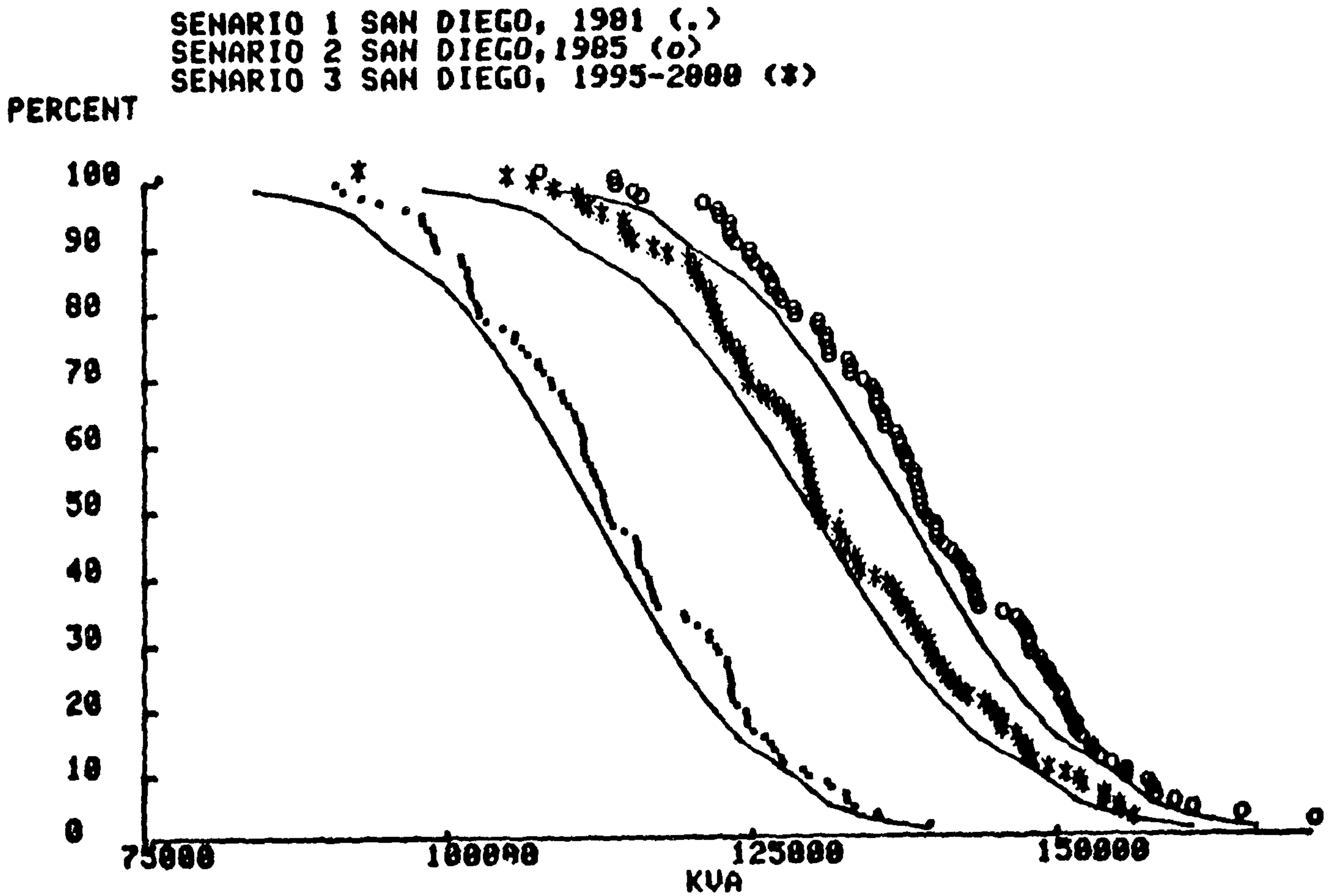



FIGURE 5-5 Probability of Exceeding a Specified Demand for Three Alternate Homeporting Plans

adequacy for a specific pier loading could be established and compared to alternative pier loading plans.

Figure 5-6. The output depicted in Figure 5-6 is formatted the same as Figure 5-5. However, the manner in which the initial conditions are established makes this a unique output. Here the per ship current demand is incremented by a predetermined amount and the resultant increase in failure probability can be observed. Using this technique, a port planner could determine when improvements to ships, installed in accordance with the Fleet Modernization Program, would aggregate to the point of affecting a particular pier. However, certain data files would have to be constructed before this could be achieved. This would be expensive on a Navy-wide basis, but it could be very effective at selected ports where the use of selected facilities could be statistically characterized.

Both Figures 5-5 and 5-6 result from applying the Central Limit Theorem (solid line) and the Simulator (points) for the different scenarios under study.

Figure 5-7. Figure 5-7 presents a bar chart indicating the mean and standard deviation of the usage of the given resource determined by the population and deployment cycle of the different ship classes. This chart enables one to identify the critical classes for consumption of the given resource. In this regard, and referring to the use of Figure 5-6, this chart could provide the initial guidance for determining the key classes of ships that one should include in a review of the Fleet Modernization Program as a prerequisite for studying selected piers.

## 5.6 Conclusions and Recommendations.

All that has been written in this report up to here has been directed at establishing an algorithm, or methodology, by which statistical techniques might be used for port analysis. A set of data has been operated upon by the programs developed for the PSRPM and the automatic generation of output has been demonstrated. The shortcomings of the process are those that were built in by the initial data used. However, the important fact to note is that the methodology worked and

SCENARIO 1 SAN DIEGO, 1981 NAVSTA 32ND ST. (.)
SCENARIO 2 SAN DIEGO, 1981 NAVSTA 32ND ST. 5% KVA INCREASE (o)
SCENARIO 3 SAN DIEGO, 1981 NAVSTA 32ND ST. 10% KVA INCREASE (*)

SOLID LINE REPRESENTS THE CENTRAL LIMIT THEOREM

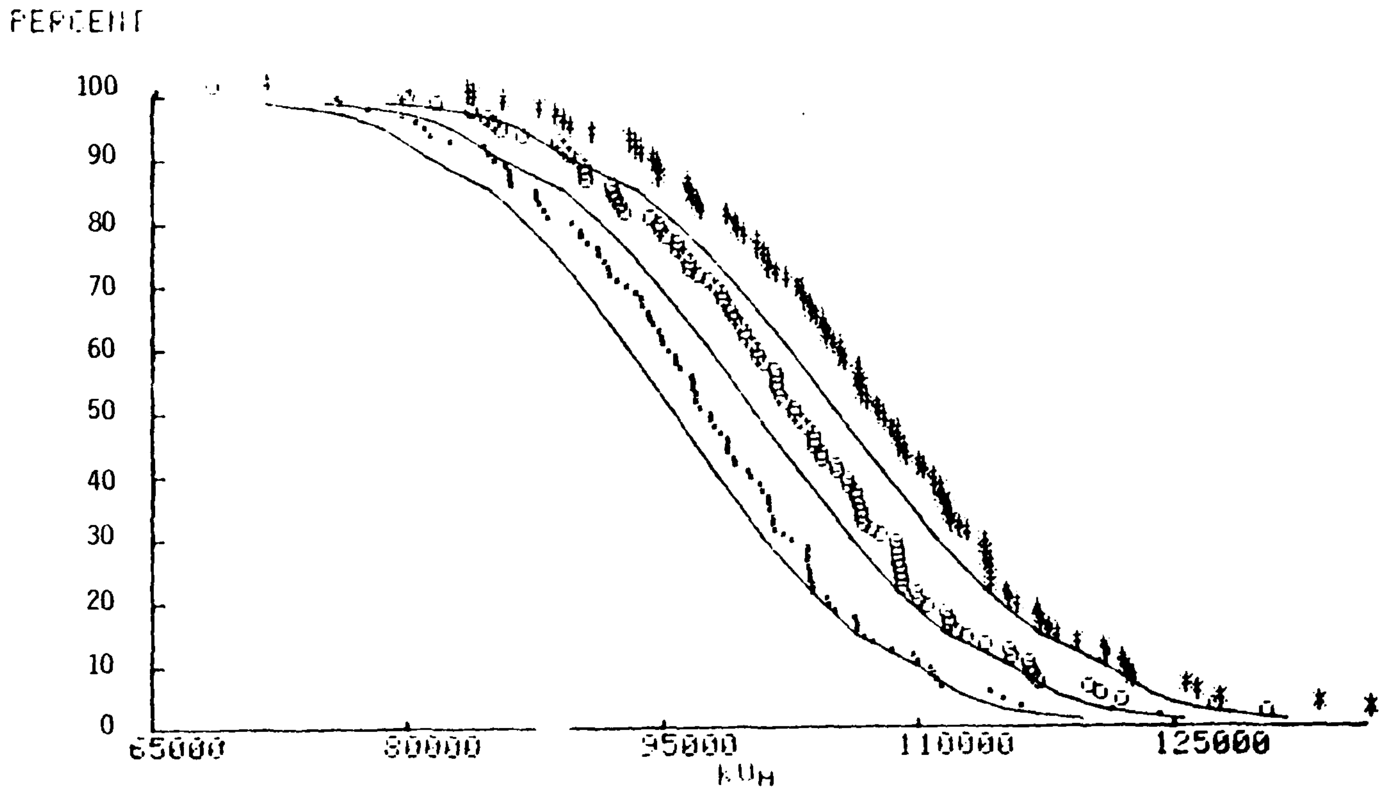



FIGURE 5-6 PROBABILITY OF EXCEEDING SPECIFIED DEMAND FOR KVA.

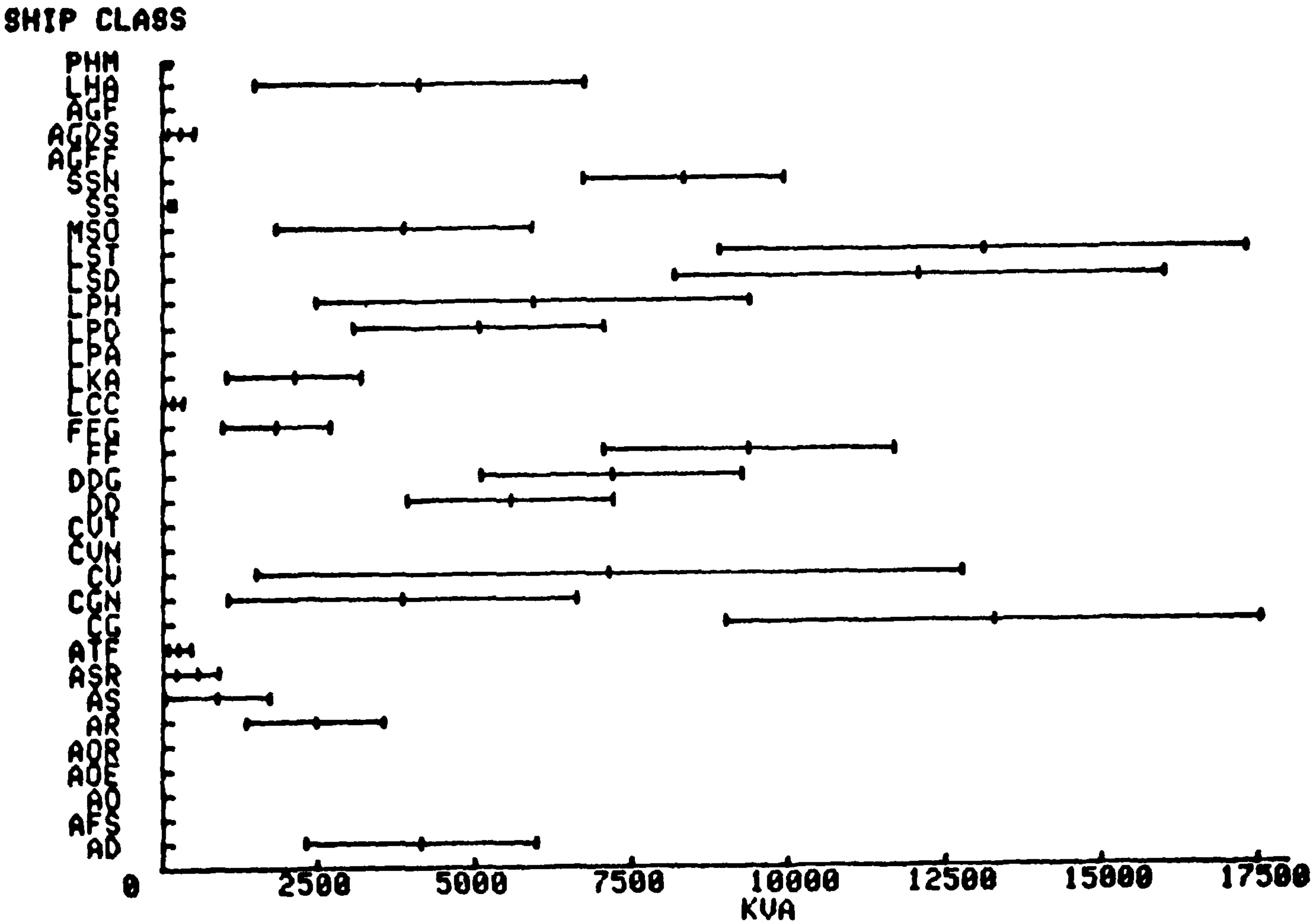



FIGURE 5-7 MEAN and STANDARD DEVIATION of demand for Electrical Power.

since it did, a significantly powerful and documented tool is now available to port planners and designers. The challenge is to learn to use the tool and to describe problems that can use its approach. In this sense, some initial recommendations concerning data bases to establish and possible near term studies to pursue for validating or refining the Port Systems Requirements Prediction Methodology can be made. These are:

a. Data Bases

(1) An immediate refinement to the Methodology can be made by using ship class electrical demand data that is based on actual measurements.

(2) Deployment cycle and turnaround/workup schedule information can be used to establish the amount of time a ship is operating out of its home port. This will be used to establish the total demand for a utility that will be made by selected ship groupings.

(3) Various conceptions of total fleet composition can be developed based on alternative strategies of fleet development. For example,

A Type I Fleet could be a projection of current types and levels to some maximum,

A Type II Fleet could be characterized by a concentration of capital ships, i.e., CVAs, CGs, Aegis ship, etc.,

A Type III Fleet could be characterized by high concentration of small combatants, and

A Type IV Fleet could be the best estimate of a 1990 Navy.

These fleets could then be used in selected problems and would serve as a basis for comparing port concepts.

b. Near Term Studies

An immediate objective of near term work with the Port Methodology is its validation and/or refinement. This could be achieved by using electrical measurement data to establish per ship demand and then using this data file to predict demand relationships at the pier level. The output of such a study could be used to assess the impact of selected MILCON Projects and/or to serve as a basis of an acquisition strategy. Finally, as familiarity with the process is gained, procedures could be developed for presenting NAVFAC and Fleet planners with an analytical review of existing and planned facilities.

Additional studies certainly can be developed, but at this stage of the development of the Port Systems Requirements Prediction Methodology, it would be premature to describe them. Rather, the development and execution of a meaningful initial study using measured data should be the primary objective. In this regard, any on-going or near-term utility measurement project could be used for this purpose.

## REFERENCES


A - OPNAV Instruction 3111.14U, Subj: Homeports and permanent duty stations, establishment, disestablishment, and modification of activities of the Operating Forces of the Navy.

B - Naval Ship Engineering Center, Report No. 6139-72-2 (1977).

C - NAVFAC DM-25, Waterfront Operational Facilities Design Manual, Dept. of the Navy, October 1971.

D - Master Plan, Volume 1, Sewells Point Area, Navy Complex, Norfolk, Virignia

E - TM No. M63-77-13 "Estimated U. S. Naval Fleet Characteristics and Homeport Assignments through the Year 2000 (U)", PRESEARCH, Inc.; Nov 1977. Naval Civil Engineering Laboratory, Naval Construction Battalion Center, Port Hueneme, California 93043.

## APPENDIX A

## PSP COMPUTER PROCESSING DOCUMENTATION

### PROGRAMS

PSP - PSP.FOR is the main processing program which computes the central limit theorem estimate and the Monte Carlo Simulations of port system demand for specified port resources and predicting scenarios. On each run of PSP.FOR (i.e. each specified scenario) two sets of data are written to an archive storage file. The first set of data output is the port system demand profile which contains both the central limit theorem and the simulation projections. This archive file is named PSP1.ARC and resides on the system hard disc. The second set of data output is the ship class demand profile which contains the computed mean and standard deviation of resource demand for each ship class. This archive file is named PSP2.ARC and also resides on the system hard disc. Both PSP1.ARC and PSP2.ARC are sequential files using operator defined five letter scenario codes to identify each scenario input to PSP.FOR.

```
C     THIS PROGRAM SIMULATES PORT SERVICE DEMAND OVER A NUMBER OF TIME
C     PERIODS AND DETERMINES THE PROBABILITY DISTRIBUTION OF THE DEMAND
C     FOR A NUMBER OF RESOURCES.
C     READ THE INPUT
      OPEN(UNIT=5,ACCESS='SEQIN',FILE='PSP.DAT',DEVICE='DSK')
      OPEN(UNIT=8,ACCESS='APPEND',FILE='PSP2.ARC',DEVICE='DSK')
      OPEN(UNIT=6,ACCESS='SEQOUT',FILE='PSP.OUT',DEVICE='DSK')
    1 CALL DESCR
C     COMPUTE MEANS AND VARIANCES OF CLASS DEMANDS
      CALL STATS
C     COMPUTE THE CUMULATIVE PROBABILITY DISTRIBUTIONS
      CALL INIT
C     PERFORM SIMULATION
      CALL SIMUL
C     OUTPUT THE RESULTS
      CALL OUTPUT
      CLOSE(UNIT=7,ACCESS='APPEND',FILE='PSP.ARC',DEVICE='DSK')
       CLOSE(UNIT=6,ACCESS='SEQOUT',FILE='PSP.OUT',DEVICE='DSK')
       CLOSE(UNIT=8,ACCESS='APPEND',FILE='PSP2.ARC',DEVICE='DSK')
      END
      SUBROUTINE DESCR
C     THIS ROUTINE INPUTS THE REQUIRED DATA
C      THE INPUT PARAMETERS ARE AS FOLLOW:
C        NCLASS  = NUMBER OF SHIP CLASSES SERVICED BY FACILITY
C                = 0 TO STOP
C                = NEGATIVE IF ONLY THE SHIP POPULATION CHANGES FROM
C                  PREVIOUS CASE RUN
C        NRS     = NUMBER OF RESOURCES OF INTEREST
C        IDUMP   = 1 FOR A DUMP OF THE INPUT (0 OTHERWISE)
C        NAMER(I)= NAME OF ITH RESOUCE
C        NAMEC(I)= NAME OF ITH SHIP CLASS
C        PR(I)   = PROBABILITY THAT MEMBER OF ITH CLASS REQUIRES SERVICE
C        R(J,I)  = AMOUNT OF JTH RESOURCE REQUIRED BY ITH SHIP CLASS
C        NSHIP(I)= TOTAL RELEVANT POPULATION IN ITH SHIP CLASS
C        NPER    = NUMBER OF REALIZATIONS TO BE GENERATED
C        NKE     = NUMBER OF HIGH DEMANDS OF EACH RESOUCE TO BE RETAINED
C        IXX     = INITIAL RANDOM NUMBER (=0 FOR STANDARD R.N. SET)
C                MCODE  = 6 CHARACTER ID. CODE
      DIMENSION MCODE(6)
      COMMON/DATA/NCLASS,NRS,NPER,NKE,IX,NAMER(20),NSHIP(50),PR(50),
     1NAMEC(50),R(20,50),IDUMP,MSG(18)
      OPEN(UNIT=7,ACCESS='APPEND',FILE='PSP.ARC',DEVICE='DSK')
      IX=4973127
      NCL=NCLASS
      READ(5,105,END=5) MCODE
  105 FORMAT(6A1)
      WRITE(7,105) MCODE
      WRITE(8,105) MCODE
      READ(5,100)NCLASS,NRS,IDUMP
      IF(NCLASS.EQ.0)GO TO 5
      READ(5,89)MSG
```

```
      WRITE(7,89) MSG
      WRITE(8,89) MSG
      IF(NCLASS.LT.0)GO TO 3
      WRITE(7,106) NCLASS,NRS
      WRITE(8,106) NCLASS,NRS
  106 FORMAT(I3,3X,I3)
      READ(5,101)(NAMER(I),I=1,NRS)
      WRITE(7,999) (NAMER(I),I=1,NRS)
      WRITE(8,999) (NAMER(I),I=1,NRS)
  999 FORMAT(3(A4,3X))
      DO 2 I=1,NCLASS
    2 READ(5,102)NAMEC(I),PR(I),(R(J,I),J=1,NRS)
      GO TO 4
    3 NCLASS=NCL
    4 CONTINUE
      READ(5,100)(NSHIP(I),I=1,NCLASS)
      READ(5,103)NPER,NKE,IXX
      WRITE(7,107) NPER,NKE
  107 FORMAT(I6,3X,I6)
      IF(IXX.NE.0)IX=IXX
      GO TO 6
    5 CLOSE(UNIT=5,ACCESS='SEQIN',FILE='PSP.DAT',DEVICE='DSK')
      CLOSE(UNIT=7,ACCESS='APPEND',FILE='PSP.ARC',DEVICE='DSK')
      STOP
   88 FORMAT(' ENTER SENARIO DESCRIPTION IN 72 CHARACTERS OR LESS')
   89 FORMAT(18A4)
   90 FORMAT(///'0ENTER NO. OF SHIP CLASSES AND NO. OF RESOURCES(2I3)')
   91 FORMAT(' ENTER',I4,' RESOURCE NAMES (NA4)')
   92 FORMAT(' ENTER CLASS NAME, PROB. OF DEMAND AND RESOURCE DEMANDS(A4
     1,NF7.3)')
   93 FORMAT(' ',I3)
   94 FORMAT(' ENTER SHIP CLASS POPULATIONS(24I3)')
   95 FORMAT(' ENTER NO. OF SIMULATIONS,NO. KEPT,AND INITIAL R.N.(3I6)')
  100 FORMAT(24I3)
  101 FORMAT(20A4)
  102 FORMAT(A4,10F7.3)
  103 FORMAT(3I6)
    6 RETURN
      END
      SUBROUTINE INIT
C     THIS ROUTINE INITIALIZES THE CUMULATIVE DISTRIBUTION FUNCTION
C     COMPUTED ON THE BASIS OF THE BINOMIAL DISTRIBUTION.
      COMMON/COMP/PROB(1000),NST(51)
      COMMON/AMERIT/BIG(20,100),IPOS(20,100),NKEPT,REQ(20)
      COMMON/DATA/NCLASS,NRS,NPER,NKE,IX,NAMER(20),NSHIP(50),PR(50),
     1NAMEC(50),R(20,50),IDUMP,MSG(18)
      NST(1)=0
      DO 1 I=1,NCLASS
      NN=NSHIP(I)
      FN=NN
      NN1=NN+1
      NST(I+1)=NST(I)+NN1
      P=PR(I)
      Q=1.-P
      PQ=P/Q
      K=NST(I)+1
      PP=Q**FN
      PROB(K)=PP
      IF(NN.EQ.0)GO TO 1
      DO 1 J=1,NN
```

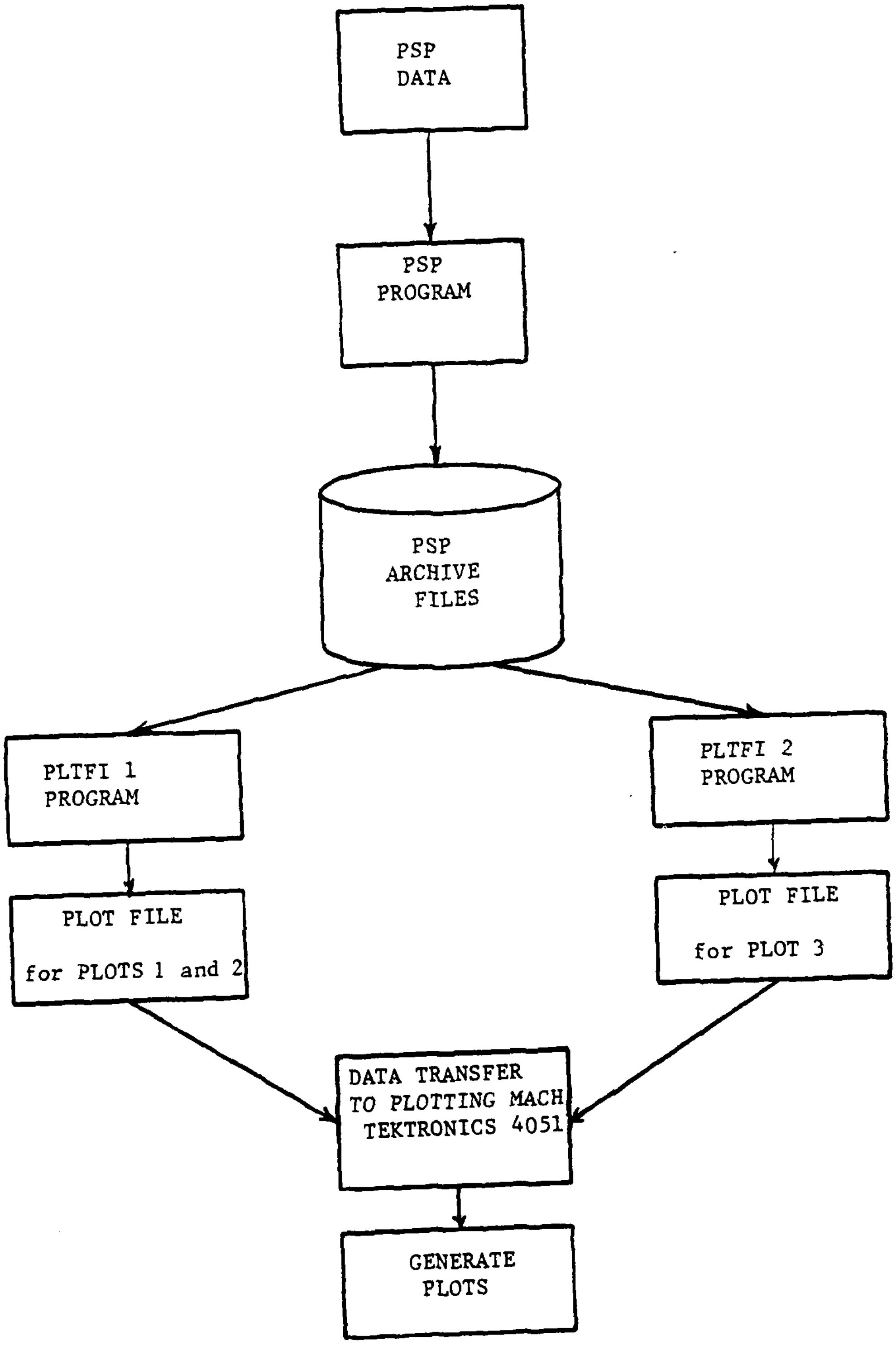
```
      K=K+1
      PP=PP*PQ*FLOAT(NN1-J)/FLOAT(J)
      PROB(K)=PROB(K-1)+PP
    1 CONTINUE
      NKEPT=0
      RETURN
      END
      SUBROUTINE SIMUL
C     THIS ROUTINE SIMULATES PORT SERVICE DEMAND FOR A SET OF SPECIFIED
C     RESOUCES.
      COMMON/COMP/PROB(1000),NST(51)
      COMMON/AMERIT/BIG(20,100),IPOS(20,100),NKEPT,REQ(20)
      COMMON/DATA/NCLASS,NRS,NPER,NKE,IX,NAMER(20),NSHIP(50),PR(50),
     1NAMEC(50),R(20,50),IDUMP,MSG(18)
      WRITE(6,100) (NAMER(I1),I1=1,NRS)
      DO 1 I=1,NPER
      DO 2 L=1,NRS
    2 REQ(L)=0.
      DO 3 J=1,NCLASS
      CALL RANDU(IX,IY,XX)
      IX=IY
      NN=NST(J)
      NM=NSHIP(J)
      DO 4 K=1,NM
      IF(XX.LT.PROB(K+NN))GO TO 5
    4 CONTINUE
    5 FN=FLOAT(K-1)
      DO 6 L=1,NRS
    6 REQ(L)=REQ(L)+FN*R(L,J)
    3 CONTINUE
      WRITE(6,101) I,(REQ(L),L=1,NRS)
      ILOC=I
    1 CALL PLACE(ILOC)
  100 FORMAT(///' SIMULATED REALIZATIONS OF RESOURCE DEMANDS'/
     1' ',5X,6(3X,A4,2X))
  101 FORMAT(' ',I4,8F9.1)
      RETURN
      END
      SUBROUTINE OUTPUT
C     THIS ROUTINE OUTPUTS THE LARGEST DEMANDS AND THEIR GENERATION NO
      COMMON/COMP/PROB(1000),NST(51)
      COMMON/AMERIT/BIG(20,100),IPOS(20,100) NKEPT,REQ(20)
      COMMON/DATA/NCLASS,NRS,NPER,NKE,IX,NAMER(20),NSHIP(50),PR(50),
     1NAMEC(50),R(20,50),IDUMP,MSG(18)
      WRITE(6,100) NKE,(NAMER(I),I=1,NRS)
      DO 2 J=1,NRS
        WRITE(7,102) (BIG(J,I), I=1,NKE)
    2 CONTINUE
      DO 3 I=1,NKE
      WRITE(6,101) I,(BIG(J,I),IPOS(J,I),J=1,NRS)
    3 CONTINUE
  102 FORMAT(20(2X,E11.4))
  100 FORMAT('THE LARGEST',I4,' DEMANDS FOR EACH RESOURCE WERE AS FO
     1LLOW'/' ',6(10X,A4))
  101 FORMAT(' ',I3,5(F9.1,I4))
      RETURN
      END
      SUBROUTINE PLACE(ILOC)
C     THIS ROUTINE CHECKS TO SEE IF ANY OF THE COMPUTED RESOURCE DEM
C     IN THE ILOCTH REALIZATION LIE IN THE HIGHEST GROUP
```

```
      COMMON/COMP/PROB(1000),NST(51)
      COMMON/AMERIT/BIG(20,100),IPOS(20,100),NKEPT,REQ(20)
      COMMON/DATA/NCLASS,NRS,NPER,NKE,IX,NAMER(20),NSHIP(50),PR(50),
     1NAMEC(50),R(20,50),IDUMP,MSG(18)
      IF(NKEPT.GT.NKE)NKEPT=NKE
      NK=NKEPT
      NK2=NK+2
      NK3=NK+3
      NKEPT=NKEPT+1
      DO 12 I=1,NRS
      J=1
      IF(NKEPT.EQ.1)GO TO 2
      IF(NKEPT.GT.NKE.AND.REQ(I).LT.BIG(I,NK))GO TO 12
      DO 3 J=1,NK
      IF(REQ(I).LE.BIG(I,NKEPT-J))GO TO 4
    3 CONTINUE
    4 IF(J.EQ.1)GO TO 2
C     MOVE UP (J-1) VALUES AND POSITION INDICATORS
      DO 5 K=2,J
      IF(NK3-K.GT.NKE)GO TO 5
      BIG(I,NK3-K)=BIG(I,NK2-K)
      IPOS(I,NK3-K)=IPOS(I,NK2-K)
    5 CONTINUE
C     INSERT NEW VALUES
    2 BIG(I,NK2-J)=REQ(I)
      IPOS(I,NK2-J)=ILOC
   12 CONTINUE
      RETURN
      END
      SUBROUTINE DUMP
C     THIS ROUTINE DUMPS THE INPUT DATA
      COMMON/DATA/NCLASS,NRS,NPER,NKE,IX,NAMER(20),NSHIP(50),PR(50),
     1NAMEC(50),R(20,50),IDUMP,MSG(18)
      DATA LAB/'PROB'/
      WRITE(6,99) MSG
      WRITE(6,100)NCLASS,NRS,NPER,NKE,IX,(NAMER(I),I=1,NRS),LAB
      DO 1 I=1,NCLASS
      WRITE(6,101) NAMEC(I),(R(J,I),J=1,NRS),PR(I)
    1 WRITE(6,102) NSHIP(I)
   99 FORMAT(18A4)
  100 FORMAT('NUMBER OF CLASSES=',I4,6X,'NUMBER OF RESOURCES=',
     1I4/'NUMBER OF REALIZATIONS REQUESTED=',I5/'NUMBER KEPT='
     2,I4/'INITIAL RANDOM NUMBER=',I10/
     3' RESOURCE DEMAND MATRIX IS AS FOLLOWS:'/' ',3X,6(6X,A4))
  101 FORMAT(A4,5F10.3)
  102 FORMAT(65X,I5)
      RETURN
      END
      SUBROUTINE STATS
C     THIS SUBROUTINE COMPUTES MEANS AND VARIANCES OF RESOURCE
C     REQUIREMENTS OF THE CLASSES AND COMPUTES THE PERCENTILES
C     OF THE TOTAL RESOURCE USE BY THE CENTRAL LIMIT THEOREM.
      COMMON/DATA/NCLASS,NRS,NPER,NKE,IX,NAMER(20),NSHIP(50),PR(50),
     1NAMEC(50),R(20,50),IDUMP,MSG(18)
      DIMENSION OUT(20,2),SUM(20),VAR(20),PERC(23),PMULT(23)
      DATA PERC/99.,98.,97.,96.,95.,90.,85.,80.,75.,70.,60.,50.,
     140.,30.,25.,20.,15.,10.,5.,4.,3.,2.,1./
      DATA PMULT/-2.327,-2.054,-1.881,-1.751,-1.645,-1.382,-1.037,
     1-0.842,-0.674,-0.524,-0.253,0.0,0.253,0.524,0.674,0.842,1.037,
     21.382,1.645,1.751,1.881,2.054,2.327/
```

```
      DATA NPERC/23/
      WRITE(6,99) MSG
      WRITE(6,100) (NAMER(J),J=1,NRS)
      DO 1 J=1,NRS
      SUM(J)=0.
    1 VAR(J)=0.
      DO 3 I=1,NCLASS
      AN=FLOAT(NSHIP(I))*PR(I)
      FN=AN*(1.-PR(I))
      DO 2 J=1,NRS
      OUT(J,1)=R(J,I)*AN
      V=R(J,I)**2*FN
      OUT(J,2)=SQRT(V)
      SUM(J)=SUM(J)+OUT(J,1)
    2 VAR(J)=VAR(J)+V
      WRITE(6,101) NAMEC(I),(OUT(J,1),J=1,NRS)
      WRITE(6,102) (OUT(J,2),J=1,NRS)
      WRITE(8,109) (OUT(J,1),OUT(J,2),J=1,NRS)
  109 FORMAT(6(2X,F10.3))
    3 CONTINUE
      DO 4 J=1,NRS
    4 VAR(J)=SQRT(VAR(J))
   99 FORMAT(//' ',18A4//' MEANS AND STANDARD DEVIATIONS OF RESOURCE DEMA
     1NDS')
  100 FORMAT(' ',4X,6(10X,A4))
  101 FORMAT(' ',A4,6(4X,F10.3))
  102 FORMAT(' ',2X,6('  ',F10.3))
  103 FORMAT('0ALL',6(4X,F10.3))
  105 FORMAT(' ',F6.1,4X,6(F10.3,4X))
      DO 5 I=1,NPERC
      DO 6 J=1,NRS
    6 OUT(J,1)=SUM(J)+PMULT(I)*VAR(J)
      WRITE(7,96) (OUT(J,1),J=1,NRS)
    5 CONTINUE
   96 FORMAT(20(2X,E11.4))
      RETURN
      END
```

PLTFI1 - PLTFI1.FOR is the program which generates plot files for plot types 1 and 2. PLTFI1.FOR prompts the operator for the scenarios and resources which are to be plotted, using the five character scenario code previously defined. PLTFI1.FOR then searches the archive file PSP1.ARC for the resource and scenarios requested. When the data to be plotted is found, it is written to a file, whose name is specified by the operator, in a plottable ASCII format.

Note: When generating plot type 4 the first scenario entered is assumed to be the reference scenario.




FLOW DIAGRAM FOR PSP PLOT GENERATION PROCEDURE

```
C     THIS PROGRAM GENERATES PLOT FILES F
C
C
      INTEGER RESP,CODE,NCODE,OUTFIL,NAM
      DIMENSION NNAME(20),MSG(20),OUT
   10 TYPE 20
   20 FORMAT(' RESOURCE TO BE PLOTTED (4 C
      READ (5,30,ERR=10) NAME
   30 FORMAT(A4)
   40 TYPE 50
   50 FORMAT(' HOW MANY SENARIOS TO BE PL
      READ(5,60,ERR=40) NPLOT
   60 FORMAT(I1)
      DO 100 I=1,NPLOT
   70   TYPE 80,I
   80   FORMAT(' TYPE 6 CHARACTER CODE FOR',I2,'TH SENERARIO')
        READ(5,90,ERR=70) CODE(I)
   90   FORMAT(A6)
  100 CONTINUE
  110 TYPE 120
  120 FORMAT(' TYPE THE NAME OF THE PLOT FILE TO BE GENERATED')
      READ(5,90,ERR=110) OUTFIL
      OPEN(UNIT=3,ACCESS='SEQIN',FILE='PSP.APC',DEVICE='DSK')
      OPEN(UNIT=4,ACCESS='SEQOUT',FILE=OUTFIL,DEVICE='DSK')
      WRITE(4,30) NAME
      WRITE(4,60) NPLOT
      IPLOT=1
  130 READ(3,90,END=9990) NCODE
      IF (CODE(IPLOT).EQ.NCODE) GOTO 140
      GOTO 130
  140 READ(3,150) MSG
  150 FORMAT(20A4)
      READ(3,160) X,NRS
  160 FORMAT(I3,4X,I2)
      READ(3,170) (NNAME(I),I=1,NRS)
  170 FORMAT(20(A4,3X))
      INDEX=0
      DO 180 J=1,NRS
        IF(NAME.EQ.NNAME(J)) INDEX=J
  180 CONTINUE
      IF (INDEX.EQ.0) GOTO 9990
      READ(3,185) NPER,NKEPT
  185 FORMAT(I6,3X,I6)
      WRITE(4,185)NPER,NKEPT
      WRITE(4,150) MSG
      DO 190 J=1,23
        READ(3,200) (CLT(L,J),L=1,3)
  190 CONTINUE
  200 FORMAT(20(2X,E11.4))
      WRITE(4,210) (CLT(INDEX,J),J=1,23)
  210 FORMAT(23(2X,E11.4))
      DO 220 J=1,3
        READ(3,200) (SIMUL(J,L),L=1,NKEPT)
  220 CONTINUE
      WRITE(4,230) (SIMUL(INDEX,L),L=1,NKEPT)
  230 FORMAT(100(2X,E11.4))
  240 IPLOT=IPLOT+1
      REWIND 3
      IF (IPLOT.LE.NPLOT) GOTO 130
```

```
  250 CLOSE(UNIT=3,DIS [illegible]
      WRITE(1,260)
  260 FORMAT('END')
      CLOSE(UNIT=4,DIS [illegible]
      STOP
 9000 TYPE 999,CODE(1) [illegible]
  999 FORMAT(' ERROR! - [illegible] NOT HAVE THIS EXAMPLE [illegible]
  900 TYPE 910
  910 FORMAT(' DO YOU WISH [illegible] (Y/N)')
      READ(5,905,ERR=900) [illegible]
  905 FORMAT(A1)
      IF (RESP.EQ.'Y') [illegible]
      GOTO 250
 9999 TYPE 800,I [illegible]
  800 FORMAT(' ERROR! - SENARIO NUMBER ',I2,' NOT FOUND IN [illegible]
      GOTO 900
      END
```

PLTFI2 - PLTFI2.FOR generates plottable files for plot type 3. PLTFI2 follows the same procedure as PLTFI1 except it retrieves data from the archive file PSP2.ARC which contains ship class demand profiles.

```
C THIS PROGRAM GENERATES PLOT FILES FROM THE ARCHIVE FILE PSP2.ARC

      INTEGER CODE,IOUT,NCODE,OUTFIL,NAME AND NNAME
      DIMENSION NNAME(30),MSG(20),OUT(6,33),CODE(9)
   10 TYPE 20
   20 FORMAT(' RESOURCE TO BE PLOTTED (4 CHAR, RIGHT JUSTIFIED)')
      READ(5,30,ERR=10) NAME
   30 FORMAT(A4)
   40 TYPE 50
   50 FORMAT(' HOW MANY SENARIOS TO BE PLOTTED?')
      READ(5,60,ERR=40) NPLOT
   60 FORMAT(I1)
      DO 100 I=1,NPLOT
   70   TYPE 80,I
   80   FORMAT(' TYPE 6 CHARACTER CODE FOR',I2,'TH SENERARIO')
        READ(5,90,ERR=70) CODE(I)
   90   FORMAT(A6)
  100 CONTINUE
  110 TYPE 120
  120 FORMAT(' TYPE THE NAME OF THE PLOT FILE TO BE GENERATED')
      READ(5,90,ERR=110) OUTFIL
      OPEN(UNIT=3,ACCESS='SEQIN',FILE='PSP2.ARC',DEVICE='DSK')
      OPEN(UNIT=4,ACCESS='SEQOUT',FILE=OUTFIL,DEVICE='DSK')
      WRITE(4,30) NAME
      WRITE(4,60) NPLOT
      IPLOT=1
  130 READ(3,90,END=9999) NCODE
      IF (CODE(IPLOT).EQ.NCODE) GOTO 140
      GOTO 130
  140 READ(3,150) MSG
  150 FORMAT(20A4)
      READ(3,160) X,NRS
  160 FORMAT(I3,4X,I2)
      READ(3,170) (NNAME(I),I=1,NRS)
  170 FORMAT(20(A4,3X))
      INDEX=0
      DO 180 J=1,NRS
        IF(NAME.EQ.NNAME(J)) INDEX=J
  180 CONTINUE
      IF (INDEX.EQ.0) GOTO 9990
      WRITE(4,150) MSG
      DO 190 I=1,33
        READ(3,200)(OUT(J,I),J=1,6)
  190 CONTINUE
  200 FORMAT(6(2X,F10.3))
      WRITE(4,210) (OUT(INDEX*2-1,I),I=1,33)
      WRITE(4,210) (OUT(2*INDEX,I),I=1,33)
  210 FORMAT(33(2X,F10.3))
  230 IPLOT=IPLOT+1
      REWIND 3
      IF (IPLOT.LE.NPLOT) GOTO 130
  250 CLOSE(UNIT=3,ACCESS='SEQIN',FILE='PSP2.ARC',DEVICE='DSK')
      WRITE(4,260)
  260 FORMAT('END')
      CLOSE(UNIT=4,ACCESS='SEQOUT',FILE=OUTFIL,DEVICE='DSK')
      STOP
 9990 TYPE 999,CODE(I)
  999 FORMAT(' ERROR! - ',A6,' DOES NOT HAVE THIS RESOURCE')
 9999 TYPE 910
```

```
 910 FORMAT(' DO YOU WISH TO CONTINUE? (Y/N) ')
     READ(5,905,ERR=900) RESP
 905 FORMAT(A1)
     IF (RESP.EQ.'Y') GOTO 240
     GOTO 250
 900 TYPE 300,I
 300 FORMAT(' ERROR - SCENARIO NUMBER ',I2,' NOT FOUND IN FSPECS.DAT')
     GOTO 900
     END
```

```
100 REM THIS PROGRAM PLOTS PSP DATA (PLOTS 1 AND 2)
110 REM GET DATA TO BE PLOTTED
120 GOSUB 830
130 REM CALCULATE MAX AND MIN
140 GOSUB 1040
150 REM SELECT AXIS AND TIC SETTINGS
160 GOSUB 1250
165 P=1
170 REM MAIN PROGRAM TO GENERATE PLOT #1
180 PAGE
190 VIEWPORT 15,125,15,93-5*C
200 WINDOW X1,M2,0,100
204 HOME
205 PRINT "               ";
206 PRINT "PROBABILITY OF EXCEEDING SPECIFIED DEMAND FOR ";N$
210 AXIS S1,10,X1,0
220 REM LABEL TICS
230 FOR I=0 TO 100 STEP 10
240 MOVE X1,I
250 PRINT "HHHH";I
260 NEXT I
270 FOR I=X1 TO M2 STEP S1
280 MOVE I,0
290 PRINT "JH";I
300 NEXT I
310 DIM Y(23)
320 FOR I=1 TO 23
330 READ Y(I)
340 NEXT I
350 DATA 99,98,97,96,95,90,85,80,75,70,60,50,40,30
```

```
,25,20,15,10,5,4,3,2,1
360 REM GENERATE PLOT NUMBER 1
370 FIND F
380 INPUT @33:X$
390 INPUT @33:X
400 FOR I=1 TO C
410 INPUT @33:X
420 INPUT @33:M$
425 C$=CHR(M(J))
430 HOME
450 FOR J=0 TO I
460 PRINT
470 NEXT J
480 M$=SEG(M$,2,LEN(M$))
490 PRINT "            SENARIO ";I;" ";M$;" (";C$;")"
500 FOR J=1 TO 2
510 INPUT @33:X
520 NEXT J
530 MOVE A(I,1),99
540 FOR J=1 TO 23
550 DRAW A(I,J),Y(J)
560 NEXT J
570 FOR J=N2(I)/N1(I)*100 TO 1 STEP -(100/N1(I))
580 MOVE B(I,J),J
600 PRINT C$
610 NEXT J
620 NEXT I
630 MOVE (X1+M2)/2,0
632 IF P=2 THEN 645
640 PRINT "JJHH";N$
642 GO TO 650
645 PRINT "JJHHHHHLOG OF ";N$
650 MOVE X1,110
660 PRINT "HHHHHHHPERCENT"
670 COPY
```

```
680 PAGE
685 IF P=1 THEN 690
686 STOP
690 PRINT "MAX","MIN"
695 PRINT LGT(M2),LGT(M1)
696 PRINT "INPUT AXIS CROSSING ";
697 INPUT X1
698 PRINT "INPUT X-AXIS SEPARATION ";
699 INPUT S1
700 M2=LGT(M2)
710 M1=LGT(M1)
720 P=2
730 FOR I=1 TO C
740 FOR J=1 TO 23
750 A(I,J)=LGT(A(I,J))
760 NEXT J
770 FOR J=1 TO 100
780 B(I,J)=LGT(B(I,J))
790 NEXT J
800 NEXT I
810 RESTORE
820 GO TO 170
830 REM SUBROUTINE TO GET DATA TO BE PLOTTED
840 PRINT "FILE ";
850 INPUT F
860 FIND F
870 DIM N$(8)
880 INPUT @33:N$
890 INPUT @33:C
900 DIM A(C,23),B(C,100),M$(72),N1(C),N2(C),A1(23),B1(100)
910 FOR I=1 TO C
920 INPUT @33:N1(I),N2(I)
930 INPUT @33:M$
940 INPUT @33:A1
950 FOR J=1 TO 23
```

```
960 A(I,J)=A1(J)
970 NEXT J
980 INPUT @33:B1
990 FOR J=1 TO 100
1000 B(I,J)=B1(J)
1010 NEXT J
1020 NEXT I
1030 RETURN
1040 REM SUBROUTINE TO CALCULATE MAX AND MIN OF PLOT DATA
1050 DIM A4(2*C),A5(2*C)
1060 FOR I=1 TO C
1070 FOR J=1 TO 23
1080 A1(J)=A(I,J)
1090 NEXT J
1100 CALL "MAX",A1,X,J5
1110 A5(I)=X
1120 CALL "MIN",A1,X,J5
1130 A4(I)=X
1140 FOR J=1 TO 100
1150 B1(J)=B(I,J)
1160 NEXT J
1170 CALL "MAX",B1,X,J5
1180 A5(I+C)=X
1190 CALL "MIN",B1,X,J5
1200 A4(I+C)=X
1210 NEXT I
1220 CALL "MAX",A5,M2,J5
1230 CALL "MIN",A4,M1,J5
1240 RETURN
1250 REM SUBROUTINE TO SELECT AXIS AND TIC SETTINGS
1260 PRINT "MAX","MIN"
1270 PRINT M2,M1
1280 PRINT "WHERE DO YOU WISH TO CROSS AXIS? ";
1290 INPUT X1
1300 PRINT "WHERE DO YOU WISH TO PLACE X-AXIS TICS? ";
```

```
100 REM  THIS PROGRAM GENERATES PLOT 3 FOR PSP DATA
110 REM**********************************************
120 DIM R$(4)
130 REM HOW MANY PLOTS
140 PRINT "FILE ";
150 INPUT F
160 FIND F
165 INPUT @33:R$
170 INPUT @33:N
180 PRINT "THIS FILE CONTAINS ";N;" PLOTS"
190 REM MAIN
200 DIM T$(80),M(33),S(33)
205 FOR I9=1 TO N
210 INPUT @33:T$
220 INPUT @33:M
230 INPUT @33:S
240 REM CALCULATE MAX AND MIN
250 GOSUB 1000
260 REM CHOOSE PLOT SCALE AND MAX
270 GOSUB 1500
275 PAGE
280 VIEWPORT 15,125,15,95
290 WINDOW 0,X1,0,33
300 AXIS S1,1
310 REM LABEL TICS
320 GOSUB 2000
330 FOR I=1 TO 33
340 MOVE M(I),I
350 RDRAW 0,0.2
360 RDRAW 0,-0.4
370 MOVE M(I),I
380 DRAW M(I)+S(I),I
390 RDRAW 0,0.2
400 RDRAW 0,-0.4
```

```
410 MOVE M(I),I
420 DRAW M(I)-S(I),I
430 RDRAW 0,0.2
440 RDRAW 0,-0.4
450 NEXT I
460 MOVE 0,0
500 REM LABEL PLOT
510 HOME
520 PRINT "SHIP CLASS";
530 PRINT "            MEAN AND STANDARD DEVIATION OF DEMAND FOR ";R$
540 FOR I=1 TO (80-LEN(T$))/2
550 PRINT " ";
560 NEXT I
570 PRINT T$
580 MOVE 0,0
590 PRINT "J"
600 FOR I=1 TO 40
610 PRINT " ";
620 NEXT I
630 PRINT R$
640 COPY
650 MOVE 0,0
660 FOR I=1 TO 33
670 DRAW M(I),I
680 NEXT I
690 COPY
700 PAGE
710 NEXT I9
720 PRINT "CONTINUE (Y/N) ";
730 INPUT Y$
740 IF Y$="Y" THEN 100
750 END
1000 REM SUBROUTINE TO CALCULATE MAX AND MIN
1010 CALL "MAX",M,M1,J1
1020 M9=M1+S(J1)
```

```
1030 RETURN
1500 REM SUBROUTINE TO SELECT SCALING
1510 PRINT "MAX IS ";M9
1520 PRINT "INPUT X1,S1: ";
1530 INPUT X1,S1
1540 RETURN
2000 REM SUBROUTINE TO LABEL TICS
2010 FOR I=0 TO X1 STEP S1
2020 MOVE I,0
2030 PRINT "JHH";I
2040 NEXT I
2060 MOVE 0,0.5
2070 PRINT "HHHHAD"
2080 MOVE 0,1.5
2090 PRINT "HHHHHAFS"
2100 MOVE 0,3-0.5
2110 PRINT "HHHHAO"
2120 MOVE 0,4-0.5
2130 PRINT "HHHHHAOE"
2140 MOVE 0,5-0.5
2150 PRINT "HHHHHAOR"
2160 MOVE 0,6-0.5
2170 PRINT "HHHHAR"
2180 MOVE 0,7-0.5
2190 PRINT "HHHHAS"
2200 MOVE 0,8-0.5
2210 PRINT "HHHHHASR"
2220 MOVE 0,9-0.5
2230 PRINT "HHHHHATF"
2240 MOVE 0,10-0.5
2250 PRINT "HHHHCG"
2260 MOVE 0,11-0.5
2270 PRINT "HHHHHCGN"
2280 MOVE 0,12-0.5
2290 PRINT "HHHHCV"
```

```
2300 MOVE 0,13-0.5
2310 PRINT "ɄɄɄɄɄCVN"
2320 MOVE 0,14-0.5
2330 PRINT "ɄɄɄɄɄCVT"
2340 MOVE 0,15-0.5
2350 PRINT "ɄɄɄɄDD"
2360 MOVE 0,16-0.5
2370 PRINT "ɄɄɄɄɄDDG"
2380 MOVE 0,17-0.5
2390 PRINT "ɄɄɄɄFF"
2400 MOVE 0,18-0.5
2410 PRINT "ɄɄɄɄɄFFG"
2420 MOVE 0,19-0.5
2430 PRINT "ɄɄɄɄɄLCC"
2440 MOVE 0,20-0.5
2450 PRINT "ɄɄɄɄɄLKA"
2460 MOVE 0,21-0.5
2470 PRINT "ɄɄɄɄɄLPA"
2480 MOVE 0,22-0.5
2490 PRINT "ɄɄɄɄɄLPD"
2500 MOVE 0,23-0.5
2510 PRINT "ɄɄɄɄɄLPH"
2520 MOVE 0,24-0.5
2530 PRINT "ɄɄɄɄɄLSD"
2540 MOVE 0,25-0.5
2550 PRINT "ɄɄɄɄɄLST"
2560 MOVE 0,26-0.5
2570 PRINT "ɄɄɄɄɄMSO"
2580 MOVE 0,27-0.5
2590 PRINT "ɄɄɄɄSS"
2600 MOVE 0,28-0.5
2610 PRINT "ɄɄɄɄɄSSN"
2620 MOVE 0,29-0.5
2630 PRINT "ɄɄɄɄɄɄAGFF"
2640 MOVE 0,30-0.5
```

```
2650 PRINT "AAAAAAAGDS"
2660 MOVE 0,31-0.5
2670 PRINT "AAAAAAGF"
2680 MOVE 0,32-0.5
2690 PRINT "AAAAALHA"
2700 MOVE 0,33-0.5
2710 PRINT "AAAAAPHM"
2720 RETURN
```

```
100 REM****** THIS PROGRAM GENERATES PLOT 4 OF PSP DATA *********
110 REM
120 REM**************************************************************
130 PRINT "FILE ";
140 INPUT F
150 FIND F
160 DIM R$(4)
170 INPUT @33:R$
180 INPUT @33:N
190 DIM A(N,100),B(100),M(2),N1(N),N2(N),P1(50),X(50)
200 REM READ DATA FROM TAPE
210 GOSUB 1000
220 REM SET UP PLOT
230 PAGE
240 GOSUB 2000
250 REM PLOT DATA
260 MOVE 0,0
270 REM  DRAW REFERENCE LINE
280 DRAW 2,2
290 REM DRAW COMPARISON CURVES
300 FOR C=2 TO N
310 REM CALCULATE MAX AND MIN DEMAND
320 DIM M(2*N)
330 FOR I1=1 TO N
340 M(I1)=A(I1,1)
350 M(I1+N)=A(I1,100)
360 NEXT I1
370 CALL "MAX",M,M2,J1
380 CALL "MIN",M,M1,I1
390 S=(M2-M1)/50
400 REM DETERMINE VECTOR P1
420 FOR K=1 TO 50
430 FOR L=1 TO 100
440 IF A(1,L)<M1+K*S THEN 460
```

```
450 NEXT L
455 L=L-1
460 P1(K)=LGT(101-L)
465 NEXT K
470 REM PLOT CURVES
480 FOR L=2 TO N
490 FOR K=1 TO 50
500 FOR J=1 TO 100
510 IF A(L,J)<M1+K*S THEN 530
520 NEXT J
525 J=J-1
530 X(K)=LGT(101-J)
540 NEXT K
550 MOVE X(1),P1(1)
555 PRINT L
560 FOR P=1 TO 50
570 DRAW X(P),P1(P)
580 NEXT P
590 NEXT L
600 COPY
610 END
1000 REM SUBROUTINE TO READ DATA FROM TAPE
1010 FOR I=1 TO N
1020 INPUT @33:N1(I),N2(I)
1030 INPUT @33:M$
1040 INPUT @33:Z
1050 INPUT @33:B
1060 FOR J=1 TO 100
1070 A(I,J)=B(J)
1080 NEXT J
1090 NEXT I
1100 RETURN
2000 REM SUBROUTINE TO SET UP PLOT
2010 VIEWPORT 15,125,15,93-5*N
2020 WINDOW 0,2,0,2
```

```
2030 AXIS 0.5,0.5
2040 FIND F
2050 HOME
2060 PRINT "PERCENT PROBABILITY OF EXCEEDING DEMAND FOR SENARIO 1 ";
2070 PRINT "vs. SENARIO 1 TO ";N
2090 INPUT @33:A$
2090 INPUT @33:Z
2100 FOR I=1 TO N
2110 INPUT @33:Z
2120 INPUT @33:M$
2130 M$=SEG(M$,2,LEN(M$))
2140 PRINT "           SENARIO ";I;" - ";M$
2150 INPUT @33:Z
2160 INPUT @33:Z
2170 NEXT I
2180 FOR I=0 TO 2 STEP 0.5
2190 MOVE I,0
2200 PRINT "JH";I
2210 MOVE 0,I
2220 PRINT "HHHH";I
2230 NEXT I
2240 MOVE 0.5,0
2250 PRINT "JJLOG PERCENT PROBABILITY"
2260 HOME
2270 FOR I=1 TO N+1
2280 PRINT
2290 NEXT I
2300 PRINT "LOG PERCENTIRESOURCE IS ";R$
2310 PRINT "PROBABILITY"
2320 RETURN
```

DA

FILM

3 –