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IWR

INSTITUTE FOR WATER RESOURCES

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K. B. COOPER
Brigadier General, USA
Director

Planning for Coastal Ports on a Systems Basis: Preliminary Methodological Design

by
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Prepared for
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Institute for Water Resources

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Pennsylvania Transportation and Traffic Safety Center
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University Park, Pennsylvania 16802

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FOREWORD

A. Purpose

This research represents a first step in the development of procedures for planning and evaluating deep water port configurations on a systems basis. This effort is a search of the relevant literature and an evaluation of alternative evaluation strategies.

B. Findings

The report concludes with an evaluation system which integrates import and export commodity flows with modal split characteristics of the flows based upon inland travel and shipping modes. Impedance to the flows in the transport system would be identified and the relevant values assigned which would, in a feedback loop, affect the modal split of trade flows.

C. Assessment

This report presents a practical approach to systems analysis of the transport network which accommodates international trade flows. It is based largely on the extension of transportation modeling efforts in operation in the Corps of Engineers and at other places. This study was quite limited in scope and scale and therefore should be viewed as a base for additional work.

D. Status

This research represents the findings, conclusions and independent judgment of the team of researchers. It is therefore not to be construed to represent the view of the Corps of Engineers. Policy and procedural changes which may result from this research will be implemented by directives and guidelines provided by the Corps of Engineers through command channels.

ABSTRACT

A representative sample of the literature relating to the analysis of multiport deep draft transportation systems is reviewed, for the purpose of defining the major fields requiring investigation and identifying the methodologies which hold promise for use by the Corps of Engineers. Quantitative models for economic forecasting, shipping operations studies, and port planning and design are included in the survey, as well as several large-scale comprehensive transportation planning models. The literature survey is keyed to an abstract formulation of an integrated system of models for multiport planning, and the resulting package constitutes a set of preliminary specifications for development of such a model system. An annotated bibliography and a computerized bibliographic index are included in the report.

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FOREWORD

This study represents the necessary first step in what would appear to be a relatively long term effort devoted to the development of improved methods for planning and programming deep water port improvements on a systems basis. The orientation of the study was toward reviewing as much of the relevant literature as possible within the short time and limited resources (approximately 7 man-months) available for the study, although a small amount of relatively abstract theoretical work was needed in order to provide an overall framework for the literature survey. The rather modest scope of effort precluded full and detailed treatment of the many interesting questions raised, and simply did not permit review of all the significant references in the field of transportation science. Nevertheless we feel that an adequate base for future work has been provided, and that the bibliography prepared for this study can be easily augmented as specific modeling problems arise.

The work described herein was performed by the Pennsylvania Transportation and Traffic Safety Center (PTTSC), an interdisciplinary research unit of The Pennsylvania State University, for the U.S. Army Corps of Engineers, Institute for Water Resources, under contract number DACW31-71-C-0100. The contract period was from 4 June to 4 November, 1971. PTTSC personnel who participated in this study were the following:

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I. INTRODUCTION

The Center for Economic Studies, Institute for Water Resources (IWR), Corps of Engineers is conducting a study to develop the methodology for a systems approach to the evaluation of future deep draft navigation improvements. The first phase in this study is the preparation of a "state-of-the-art" report, depicting the present situation regarding methodology and available mathematical models, and including an annotated bibliography, a critique of existing models, and proposals for feasible approaches to later phases of the study.

IWR contracted with the Pennsylvania Transportation and Traffic Safety Center (PTTSC) of The Pennsylvania State University to conduct this phase I study, under contract number DACW31-71-C-0100. This document constitutes the Center's final report concerning the research carried out under the contract.

SCOPE OF WORK

The basic intent of the IWR study is to develop procedures for estimating the economic efficiency of particular plans for navigation systems and to derive information from such analyses concerning the cost-effectiveness of Corps investments. The analytical capabilities to be developed will aid in addressing such questions as:

1. the efficient use of inland and deep draft navigation facilities;

2. relationship of the inland waterways to major port development;
3. optimal budget allocation between maintenance and repair and new construction, and between locations;
4. how existing or proposed transportation systems could be altered by alternative schemes for consolidating, loading, and moving freight.

The PTTSC, in phase I of the study, assessed the methodologies which may be applicable to analyzing the economic efficiency of navigation improvements as elements of the Nation's transportation system.

The investigators recognized that other related studies are underway both within the Corps of Engineers and elsewhere. IWR is conducting other studies in the field of transportation. A task force in the Office of the Chief of Engineers (OCE) considered the question of systems analysis as it may be applied to inland transport, and recommended continuation of its work in a transportation analysis branch to be established in OCE. Further, the Department of Transportation (DOT) is currently conducting a national transportation needs study. In view of this related work, and in order that the present study might make a maximum contribution to the overall efforts described above, the primary orientation of this study was toward the analysis of multiport deep draft harbor facilities.

The term "multiport" in the preceding sentence indicates the type of systems viewpoint which was adopted for the study. The Corps of Engineers is being continually petitioned by local interest groups for harbor and channel improvements, which often require substantial investments. A proper evaluation of such proposals requires a consideration of a particular project's impact upon the complementary and competing transport facilities provided by other ports serving the region. That is, the contribution of a particular project to the total deep draft transportation needs of a geographical area is the relevant topic to be investigated. Hence the overall IWR study is directed toward developing the analytical tools needed for such investigations.

It should be noted that the investigators also anticipate that some of the models and techniques disclosed by this research may be applicable to inland waterway transport and to other transportation modes. Such obvious transfer possibilities should not be neglected in reviewing the study results. In summary, the scope of work of this study was distinct from but complementary to other ongoing efforts in the general area of transportation systems analysis.

STUDY OBJECTIVES

Within the scope outlined above, the specific objectives of this study were the following:

1. to review the published literature, and as far as practical the unpublished, relating to the analysis of multiport deep draft transportation systems;
2. to define the major fields requiring investigation and to identify the methodologies which hold promise as analytical

tools, keeping in mind the needs of the Corps.

RESEARCH APPROACH

Research Tasks

The study objectives were achieved through the accomplishment of the following tasks:

1. Problem definition;
2. Identification of possible solution strategies;
3. Literature survey;
4. Preliminary methodological design.

The following paragraphs set forth the manner in which each of these tasks was performed.

Task 1: Problem Definition

In order to provide a set of guidelines for conducting the literature survey called for in the first objective, it was first necessary to define exactly what the systems analysis methodology is intended to accomplish. In particular, the system of concern had to be clearly delimited. In the context of navigation, the word "system" might have some or all of the following definitions:

a. the set of physical, economic, and institutional factors which interact to determine the supply and demand characteristics of a particular navigation project;

b. a set of interconnected navigation facilities, including channels, ports and harbors, and terminal facilities;

c. the set of transportation facilities serving a defined market area.

Other key elements requiring some definitional work included the planning horizon, the level of detail of the analysis, and the types of questions to be put to the methodology. Task 1 was devoted to clarifying and formalizing these and related concepts.

To accomplish task 1, project personnel held a series of discussions for the purpose of formulating an initial problem definition. Subsequently a meeting was held with IWR and other interested Corps representatives to review and agree upon this definition, and to obtain Corps inputs into task 2. The results of task 1 are reflected in the scope of work defined previously, and in the system conceptualization advanced in Chapter II.

Task 2: Identification of Possible Solution Strategies

Task 1 produced a statement of the problems, and the constraints upon solving them. Given these specifications, the job of task 2 was to delineate the procedures which might be used in obtaining solutions. In its broadest sense, this task was intended to set up the general framework of a system of analytical models to be used in attacking the problems defined in task 1. Such a framework was needed to indicate the function and output of each model, as well as the relationships between models.

Task 2 was accomplished through a synthesis of the general transportation planning expertise of project personnel and the inputs provided by Corps representatives at the meeting discussed under task 1. The resulting general methodological formulation is the subject of Chapter II of this report.

Task 3: Literature Survey

Upon completion of tasks 1 and 2, it was possible to intelligently survey the existing body of literature regarding both the individual models and similar model systems. Applicable studies were found in the following areas, among others:

business and military logistics

civil engineering

economics

geography

operations research

transportation planning

water resources

Primary sources for the literature survey were the University libraries and the specialized collection maintained by the Transportation and Traffic Safety Center. In addition, two information retrieval systems which maintain abstracts and resumes of completed and current research projects were utilized. These were the Maritime Research Information Service, which is administered by the Highway Research Board, and NTISearch, which was recently instituted by the National Technical Information Service of the U.S. Department of Commerce. The latter system contains abstracts of technical reports produced from Government-funded research and development projects released since 1964.

The literature in the area of transportation systems analysis and planning is voluminous, and it was not possible to survey all of it within the scope of this study. However, many of the earlier studies in the field developed basic knowledge and techniques which are well known to transportation planners and researchers, thus precluding the need to extensively survey that body of material. Further, most of the research performed to date has been oriented toward passenger transportation, while the present study is concerned primarily with commodity movements. Hence the scope of the literature survey was restricted to studies of freight transportation. Since a significant body of material was found in this area, models constructed for passenger transportation analyses were included only to a limited extent. Several applicable models devised for non-transport phenomena, particularly in the field of economic forecasting, were also reviewed.

It became obvious rather early in the literature search that a large number of pertinent references would be found. Hence, in order to facilitate retrieval, review, and processing of the references, a computerized bibliography was created, using the KWIC/360 bibliographic information system devised by the IBM Corporation [1].[1] The complete project bibliography is contained in Appendix B.

Following compilation of the bibliography, the most relevant documents were obtained for further study. Reviews and abstracts of these publications are contained in Appendix A. These reviews formed the basis for assessing the array of techniques currently available for a multiport analysis methodology. This state-of-the-art review is the subject of Chapters III and IV.

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[1]Numerals in brackets refer to corresponding items in the list of references.

Task 4: Preliminary Methodological Design

The purpose of this task was to update and refine the framework proposed in task 2, based upon the information yielded from task 3. The literature search revealed methodological approaches which were not considered previously, and showed that some of the models and model interrelations may have been inappropriately structured. Further, task 3 delineated the relative state of advancement of alternative model formulations. Thus, task 4 was needed to synthesize the study results into a tentatively recommended methodological design, which is given in Chapter V. Recommendations pursuant to implementing the methodology are also given in Chapter V.

II. A MODEL SYSTEM FOR MULTIPORT ANALYSES

At the conclusion of task 1 of this study, the problem facing the Corps of Engineers was defined as "the development of a methodology to analyze a multiport, deep draft transportation system." Task 2 called for the identification of possible solution strategies. Accordingly, a preliminary formulation of a model system for multiport analyses was devised, and is presented in this chapter.

STRATEGY FOR MULTIPORT ANALYSES

Before formulating the specific models required for the analysis, it is helpful to first construct a formal statement of the overall strategy to be employed. Figure 1 illustrates one possible form of such a statement. Other diagrams of the processes involved in multiport analyses could be drawn, but all would contain essentially the same general set of procedures and interrelationships.

Preliminary Steps

The several boxes at the top of the diagram indicate the steps which must be completed prior to the exercising of the system of analytical models. (Note: this does not preclude the possibility that some of these initial steps may themselves be mathematical models.)

1. System Definition

As a starting point, the particular ports to be included in the analysis must be specified. Next, the commodities moving through

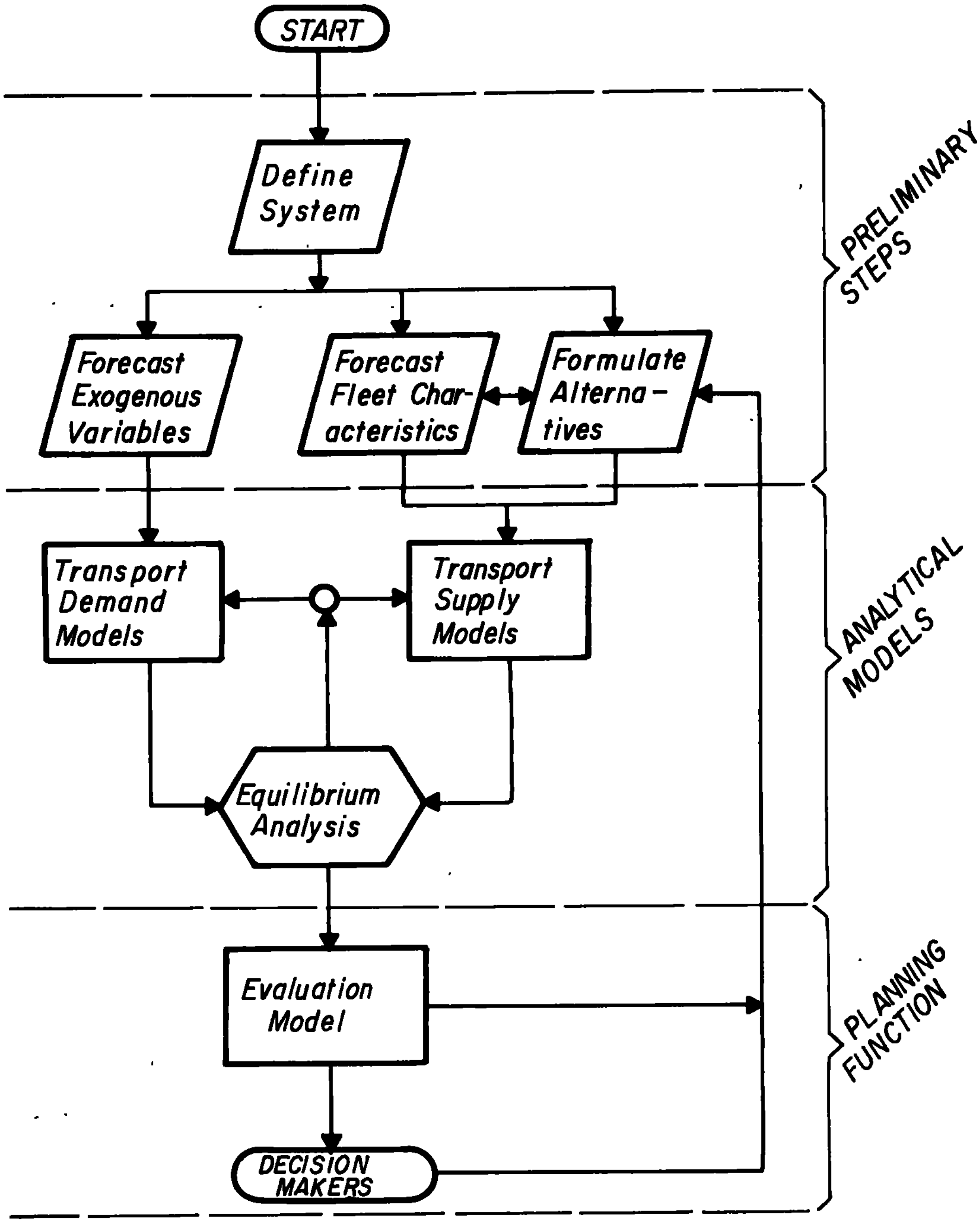

FIGURE 1. STRATEGY FOR MULTIPORT ANALYSES.

these ports must be identified. It will probably be sufficient to include only the set of commodities which account for, say 90% of the total import/export activity at the ports, e.g., petroleum, coal, grain, iron and steel products, and general cargo. Given the commodities and ports, the following may then be determined:

(a) The actual inland origins and destinations of the commodity shipments;

(b) The foreign terminal areas of the shipments.

The inland origins and destinations, referred to as "nodes" throughout this report, will collectively define the boundary of the hinterland region of the multiport system. This region may be different for each commodity, but rather than working with numerous boundaries, it will probably be advantageous to select the envelope boundary as the hinterland demarcation line. Certain nodes will then simply not enter into the analysis for some commodities.

Only a limited number of foreign terminals (say, four or five) need be defined. Each such terminal will thus represent the port complex serving a broad geographical area.

Figure 2 depicts schematically the multiport transportation network defined via the above considerations. Note that each node is connected to each port by an inland travel link, and each port to each foreign terminal by an overseas travel link. Obviously, the ports may also be nodes, in which case two network entities are defined at one location (i.e., the lines connecting the ports in the figure actually connect a node at a port city to a competing port).

In the formulations presented below, it is assumed that the system has been defined to consist of I nodes, J ports, and M foreign

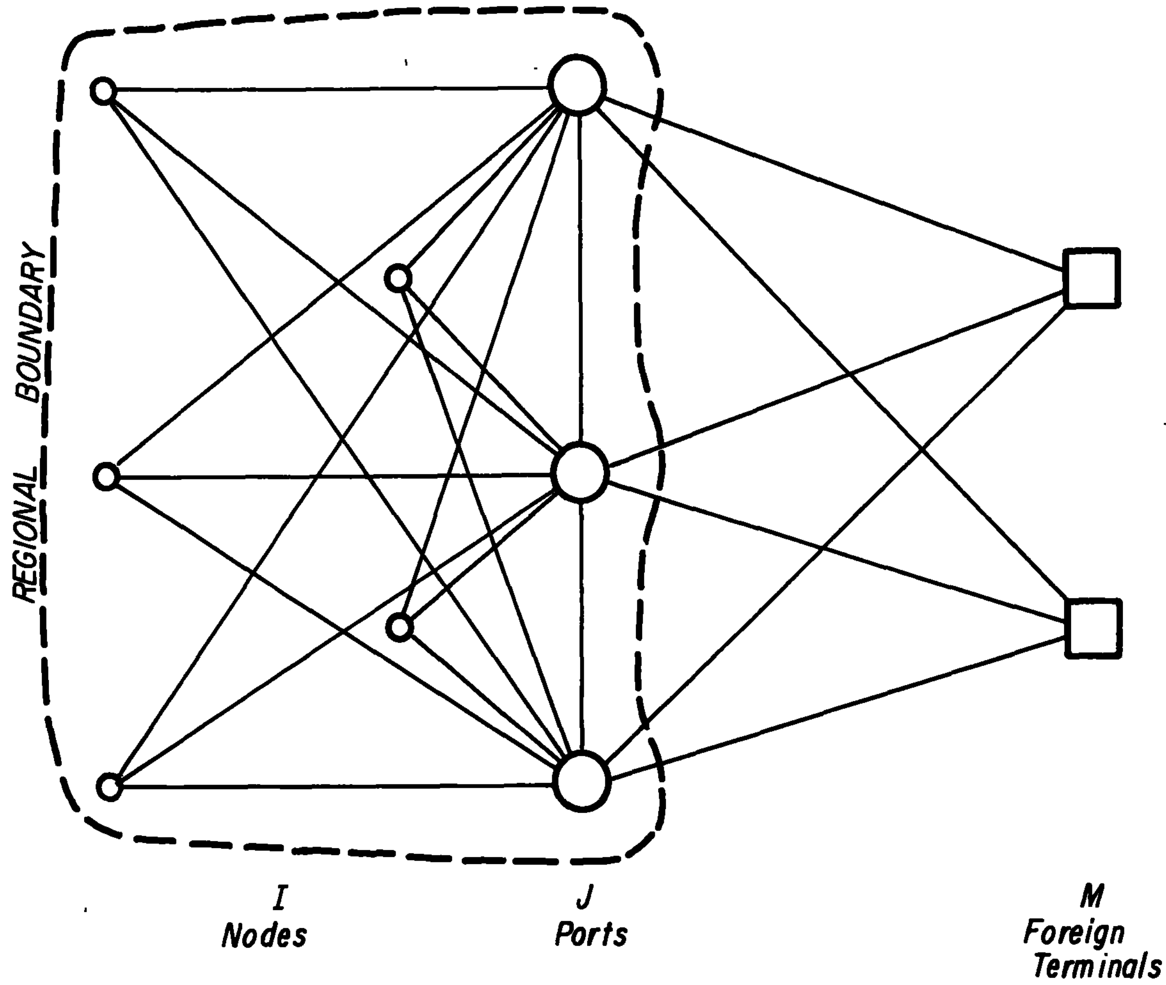

FIGURE 2. MULTIPORT TRANSPORTATION NETWORK.

terminals.[1] Corresponding lower case letters are used to refer to specific system elements.

2. Forecasts

Forecasts (or, for an existing conditions analysis, surveys) of the several classes of variables which enter into the analysis must be prepared. The characteristics of the transport fleet which will utilize the port system must be known or estimated. Quite possibly, forecasts of inland transportation characteristics might also be required, depending upon the specific form of the analytical model system. Also, several exogenous (i.e., non-transportation) variables will usually enter into the determination of transportation demand. These might include such things as GNP, industrial and agricultural production, population, employment, personal income, etc. The particular items needed depend upon the specific requirements of the analysis models.

The time frame for the analysis will have a great affect upon the selection of forecasting methods and upon the confidence which may be placed in the analytical results. Traditionally the Corps has used a relatively long study period, e.g., 50 years. This figure should be regarded as an upper limit for a multiport analysis. It may be more realistic to use a time period which corresponds more closely to the economic lives of the ships which will utilize the proposed harbor facilities.

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[1] In Figure 2, note that I = 8, J = 3, and M = 2.

This forecasting job is a large and important one, and should not be treated lightly. In many instances, forecasts of inland transportation and exogenous variables will be available from other agencies.

3. Alternatives

Finally, it is necessary to have available a set of alternatives to be analyzed. Several alternatives will undoubtedly already exist as the reasons for which the analysis is being undertaken in the first place, but these will usually not exhaust all the reasonably attractive projects. In addition, the "do nothing" alternative should always be included.

The usual set of alternatives considered by the Corps consist of channel deepening or widening. Other alternatives include such things as lightering and offshore terminals. Alternative locations for specified facilities (e.g., container handling equipment) might be analyzed within this methodological framework, as well as proposed investments (both public and private) to increase port efficiency.

One important class of alternatives generally overlooked involves the question of industrial location. It appears that many firms decide to locate near a particular port on the assumption that the requisite navigation facilities will be provided as needed. The existence of transport demand generated by these firms is then used as economic justification for channel improvements. A sounder analysis procedure would include as an alternative possible relocation of industrial activity.

Figure 1 shows an interaction between formulation of alternatives and forecasting transport fleet characteristics. Obviously the type of equipment utilizing a port depends largely upon the navigation facilities provided (e.g., channel depth affects the distribution of vessel sizes). Conversely, development of new vessels generates pressure for new facilities. These interactions must be taken into account in the preliminary stages of the analysis.

Analytical Models

The three boxes in the center of Figure 1 represent the analysis procedures which are normally employed for transport systems planning. Transport demand models are used to estimate the total transportation requirements which will be imposed upon the system. Transport supply models estimate the response and cost characteristics of the system in meeting this demand. Demand and supply must be brought together in an equilibrium analysis, as they jointly determine the level of transport costs. Succeeding sections of this chapter treat more thoroughly the demand, supply, and equilibrium models.

The Planning Function

The results of analyzing each alternative are ultimately input to an evaluation model. This may range from a simple unidimensional ranking scheme to something complex such as multiple ranking, mathematical programming, or decision theoretic techniques. The evaluation results may suggest some alternatives which were initially overlooked, hence the uppermost feedback loop shown in Figure 1.

Further, the data and results developed in the analysis may be used to help formulate additional alternatives. For example, the import/export flows (between nodes and foreign terminals) might be input to a model which selects optimal port locations.[2] These results could prove helpful in structuring a program of major port investments.

The final evaluation output is passed as a set of conclusions or recommendations to the decision making body. The decision makers may accept the analysis as complete, or perhaps ask for an analysis of some additional alternatives as shown by the lower feedback loop in the figure.

The remaining sections of this chapter are devoted to a formulation of the analysis models which one might use within the strategic context described above. For the most part an abstract mathematical representation is used, simply to indicate which important system variables are dependent upon which other variables.

TRANSPORT DEMAND MODELS

The transport demand models, shown in Figure 3, consist of an international trade model and a port distribution model. The former predicts the import/export activity at each node in the region, while the latter determines the distribution of this traffic among the system's ports.

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[2] Models developed for optimizing factory or warehouse locations may be applicable here.

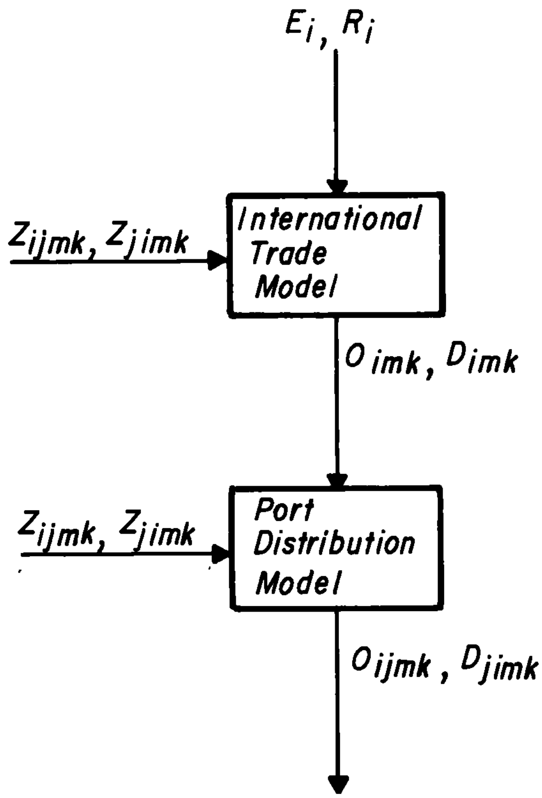

FIGURE 3. TRANSPORT DEMAND MODELS.

International Trade Model

The international trade model may be formulated as follows:

$$(1) \quad O_{imk} = f\ (E_i, R_i, Z_{ijmk}) \qquad i = 1, \ldots, I$$

$$D_{imk} = g\ (E_i, R_i, Z_{jimk}) \qquad j = 1, \ldots, J$$

$$k = 1, \ldots, K$$

where

O_{imk} = tonnage of commodity k exported from node i to terminal m

D_{imk} = tonnage of commodity k imported to node i from terminal m

E_i = vector of exogenous variables for node i

R_i = vector of regional variables for node i

Z_{ijmk} = impedance associated with exporting commodity k from node i through port j to terminal m

Z_{jimk} = impedance associated with importing commodity k to node i through port j from terminal m

K = total number of commodities.

Of course, a specific formulation of the model may require additional variables not presently included in equations 1, but the primary variables are those shown.

The E and R vectors input to the model are provided by prior steps in the analysis (see Figure 1), and are meant to include all variables which affect the import/export activity at a node. These might include such factors as population, industrial character, number of financial institutions, resource supplies, commercial enterprises, etc. Although not shown, the model might also require vectors E_m, giving the relevant characteristics of the foreign terminals. The exact variables included must be determined through experimentation.

The Z values are some measure of the cost of importing or exporting through a particular port, including the inland, transfer, and overseas portion of a shipment's journey. These values orginate elsewhere within the model system, although initial estimates must be supplied as a starting point. They are included to show that deep draft transport demand may well be dependent directly upon shipping costs.

Port Distribution Model

The port distribution model is formulated as follows:

$$(2) \quad O_{ijmk} = f\,(O_{imk}, Z_{ijmk}) \qquad i = 1, \ldots, I$$

$$D_{jimk} = g\,(D_{imk}, Z_{jimk}) \qquad j = 1, \ldots, J$$

$$k = 1, \ldots, K$$

$$m = 1, \ldots, M$$

where

O_{ijmk} = export tonnage of commodity k from node i shipped through port j

D_{jimk} = import tonnage of commodity k shipped to node i through port j

and the remaining variables are as defined for equations 1.

Note that the primary inputs to this model are the O_{imk} and D_{imk} values predicted by the international trade model. Not shown is the possibility that O_{ijmk} and D_{jimk} may be functions of the total import/export activity at port j (or some other attractiveness factor), but this can easily be added to the model if desired.

Again, as in the international trade model, the transport impedance measures Z_{ijmk} and Z_{jimk} are included as explanatory variables. Given rational behavior by shippers, it would appear that estimates of transport impedance provide the only logical basis for selecting one shipping route over another.

Alternate Formulation

It may prove more feasible to let the international trade model predict only the total tonnage of each commodity imported and exported at nodes and foreign terminals. The distribution model would then work with supplies and demands, rather than with international flows. The final output would be unchanged, but the revised mathematical formulation is as follows:

$$\text{(1a)} \quad O_{ik} = f_1(E_i, R_i, Z_{ijmk}) \qquad i = 1, \ldots, I$$

$$D_{ik} = g_1(E_i, R_i, Z_{jimk}) \qquad k = 1, \ldots, K$$

$$\text{(1b)} \quad O_{mk} = f_2(E_m, Z_{jimk}) \qquad m = 1, \ldots, M$$

$$D_{mk} = g_2(E_m, Z_{ijmk}) \qquad k = 1, \ldots, K$$

subject to

$$\text{(1c)} \quad \sum_i^I O_{ik} = \sum_m^M D_{mk} \qquad k = 1, \ldots, K$$

$$\sum_i^I D_{ik} = \sum_m^M O_{mk}$$

in which O_{ik} is the tonnage of commodity k exported from node i, etc. Equations 1c express the condition that total domestic exports must match total foreign receipts and vice-versa, i.e., a closed system is assumed. For an open system, equations 1c would be deleted, and foreign receipts would become a factor in the equation for domestic exports, etc.

The distribution model is then formulated as:

$$\text{(2a)} \quad O_{ijmk} = f(O_{ik}, D_{mk}, Z_{ijmk}) \qquad i = 1, \ldots, I$$

$$D_{jimk} = g(D_{ik}, O_{mk}, Z_{jimk}). \qquad j = 1, \ldots, J$$

$$m = 1, \ldots, M$$

$$k = 1, \ldots, K$$

TRANSPORT SUPPLY MODELS

Figure 4 illustrates the supply model segment of the multiport analysis model system. The purpose of the transport supply models is to predict the transportation impedance measures (Z-values) required as inputs to both the demand models and the evaluation process. This is accomplished by a port model and two travel models (inland and ocean). An interfacing step, the traffic allocation model, is also required.

Traffic Allocation Model

The output of the transport demand models is the commodity flow through each port in terms of tonnage. Port operations, however, are most conveniently modeled in terms of vessels. The task of the traffic allocation model is to convert the tonnage flow into vessel handling requirements.

The traffic allocation model may be represented mathematically as:

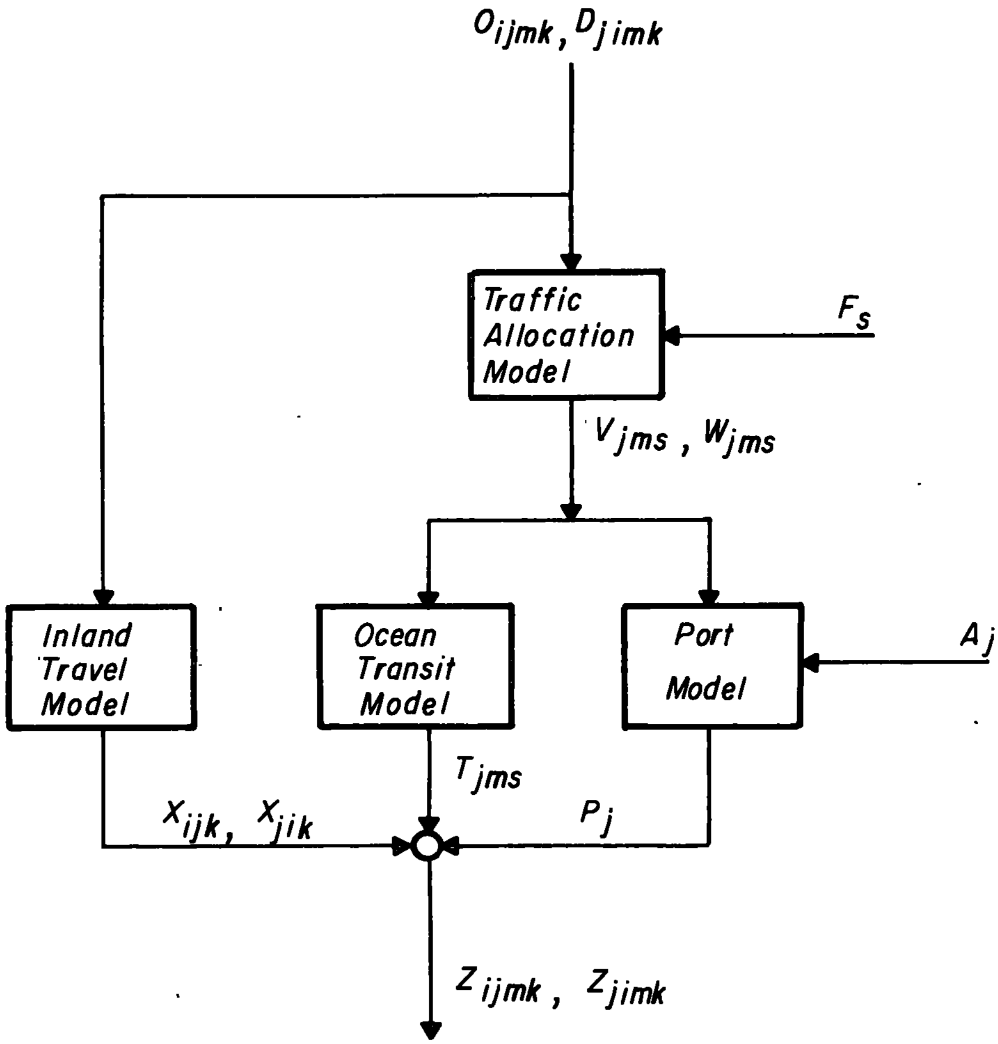

FIGURE 4. TRANSPORT SUPPLY MODELS.

(3) $V_{jms} = f\ (O_{ijmk},\ F_s)$ $\quad m = 1, \ldots, M$

$W_{jms} = g\ (D_{jimk},\ F_s)$ $\quad j = 1, \ldots, J$

$s = 1, \ldots, S$

where

V_{jms} = number of class s vessels departing from port j for terminal m

W_{jms} = number of class s vessels arriving at port j from terminal m

F_s = vector of fleet characteristics for class s vessels

S = total number of vessel classes

and O_{ijmk}, D_{jimk} are defined by equations 2.

In addition to simply making tonnage-to-vessel conversions, the traffic allocation model must be capable of handling situations such as (1) multiport vessel itineraries and (2) lightering and topping operations.

Port Model

The port model utilizes vessel demand and port characteristics to derive estimates of the transportation impedance at a port. In mathematical terms:

(4) $P_j = f\ (V_{jms},\ W_{jms},\ A_j)$ $\quad j = 1, \ldots, J$

where

P_j = impedance at port j

A_j = vector of characteristics of port j for the alternative under analysis

and V_{jms}, W_{jms} are derived from equations 3.

Quite possibly, this model and the traffic allocation model could be combined into a single model.

Ocean Transit Model

This model is included in order to derive measures of the transportation impedance accruing to the overseas portion of the trip. Mathematically,

$$(5) \quad T_{jms} = f\ (V_{jms}, W_{jms}, F_s) \qquad J = 1, \ldots, J$$

where

T_{jms} = ocean transit impedance for class s vessels passing through port j and terminal m and the remaining variables were defined previously.

Under conditions where no vessel availability constraints are considered, the F vectors are the primary explanatory variables, while variables V and W are used primarily as weighting factors. If, on the other hand, ship availability is taken into account, this model would have to be exercised in concert with the port model. The combined port and ocean transit models (and possibly the traffic allocation model also) would then be more appropriately termed a vessel scheduling model.

Inland Travel Model

To complete the set of impedance measures, the inland travel segment of a shipment's journey must also be considered. An inland travel model may be formulated as:

$$(6) \quad X_{ijk} = f\ (O_{ijmk}, D_{jimk}) \qquad i = 1, \ldots, I$$

$$X_{jik} = g\ (O_{ijmk}, D_{jimk}) \qquad j = 1, \ldots, J$$

$$k = 1, \ldots, K$$

where

X_{ijk} = inland impedance for commodity k shipped from node i to port j

X_{jik} = inland impedance for commodity k shipped from port j to node i

and other variables are as defined previously.

Initially, the inland travel model should be kept very simple. One might assume that the import/export tonnage traveling over inland transportation routes is such a small part of the total traffic on those routes that the inland impedances are essentially constant. Alternatively, simple impedance vs. flow functions might be derived in order to prevent drastic oscillations and lumpiness in the inland flow route predictions. Traffic and impedance estimates from other agencies will be very useful inputs to this model. Development of a comprehensive inland transportation model is clearly beyond the scope of a multiport analysis.

Combining Impedances

The impedance estimates produced by the three models described above must be combined to produce the required total impedance measures Z_{ijmk} and Z_{jimk}. This process may be represented as

(7) $Z_{ijmk} = f(X_{ijk}, T_{jms}, P_j)$ $\quad i = 1, \ldots, I \quad m = 1, \ldots, M$

$Z_{jimk} = f(X_{jik}, T_{jms}, P_j)$ $\quad j = 1, \ldots, J \quad k = 1, \ldots, K$

where all variables have been defined above.

EQUILIBRIUM ANALYSIS

The demand and supply models are combined into an iterative equilibrium analysis as illustrated in Figure 5. Initial estimates of transportation impedances are input to the demand models. The demand and supply models are then run in the sequence shown, resulting in the output of revised impedance measures. These revised impedances are input to the demand models, as indicated by the feedback loop in the figure, and the entire cycle is repeated. Iterations are continued until some preset impedance convergence criterion is satisfied. That is, iterations are stopped when

$$(8) \quad \left| \frac{Z_{(n)} - Z_{(n-1)}}{Z_{(n)}} \right| \leq E$$

where n is the iteration number and E is the error tolerance value.

This equilibrium concept may also be illustrated with the familiar demand and supply schedules of economic theory, as shown in Figure 6. One could run the demand models for a wide range of impedances and generate curve DD′, and the supply models could be run for a range of demands to generate curve SS′. The point of intersection of these curves then determines demand and supply Q*, and impedance Z*. The approach advanced in the preceding paragraph is akin to following path abcdefghij to arrive at a point reasonably close to (Q*, Z*). Unfortunately, the problem is not two dimensional. There are many different impedances and demands to consider, so the demand and supply curves are actually multidimensional surfaces, the intersection of which is most readily found by the iterative modeling technique described above.

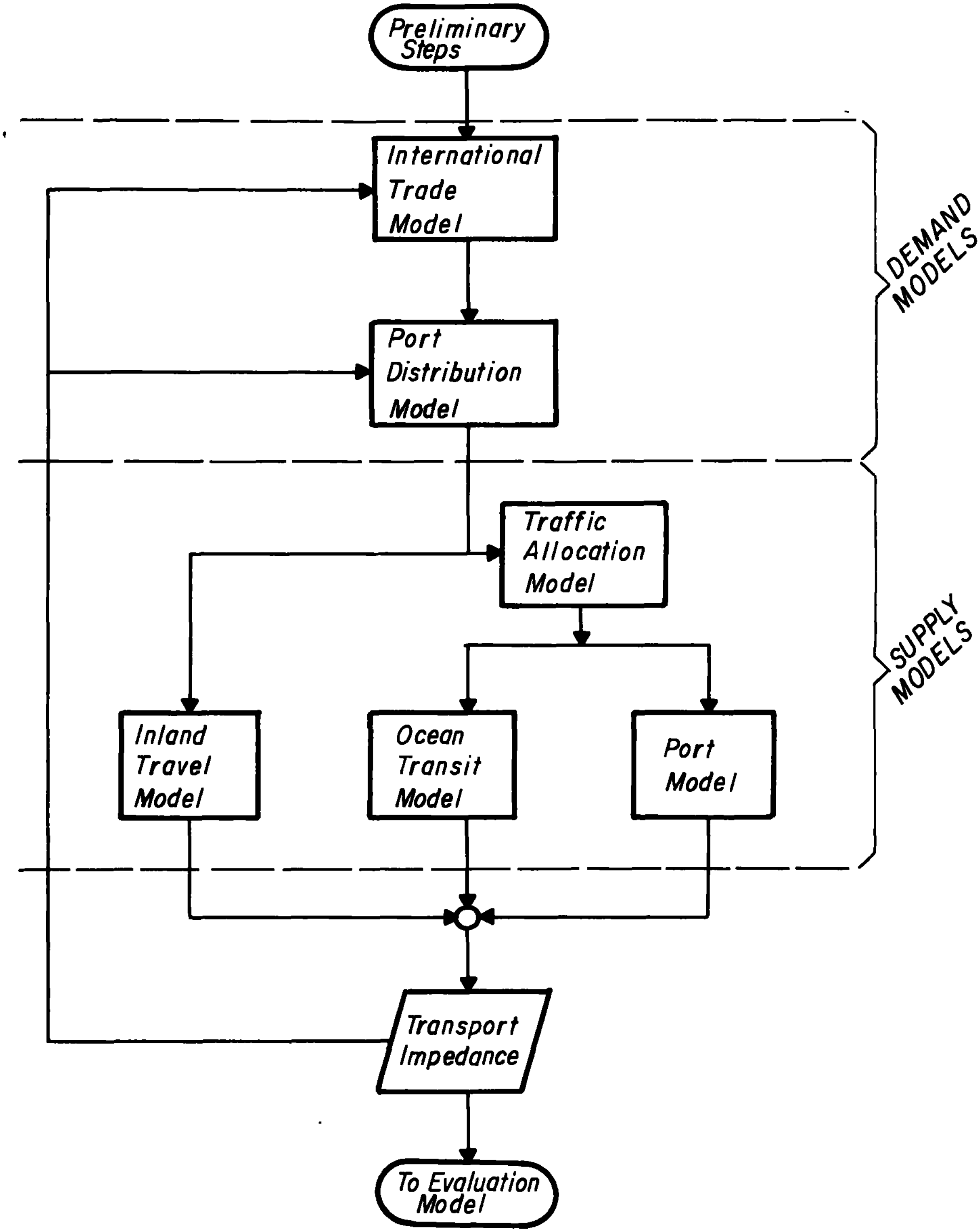

FIGURE 5. DEMAND—SUPPLY EQUILIBRIUM ANALYSIS.

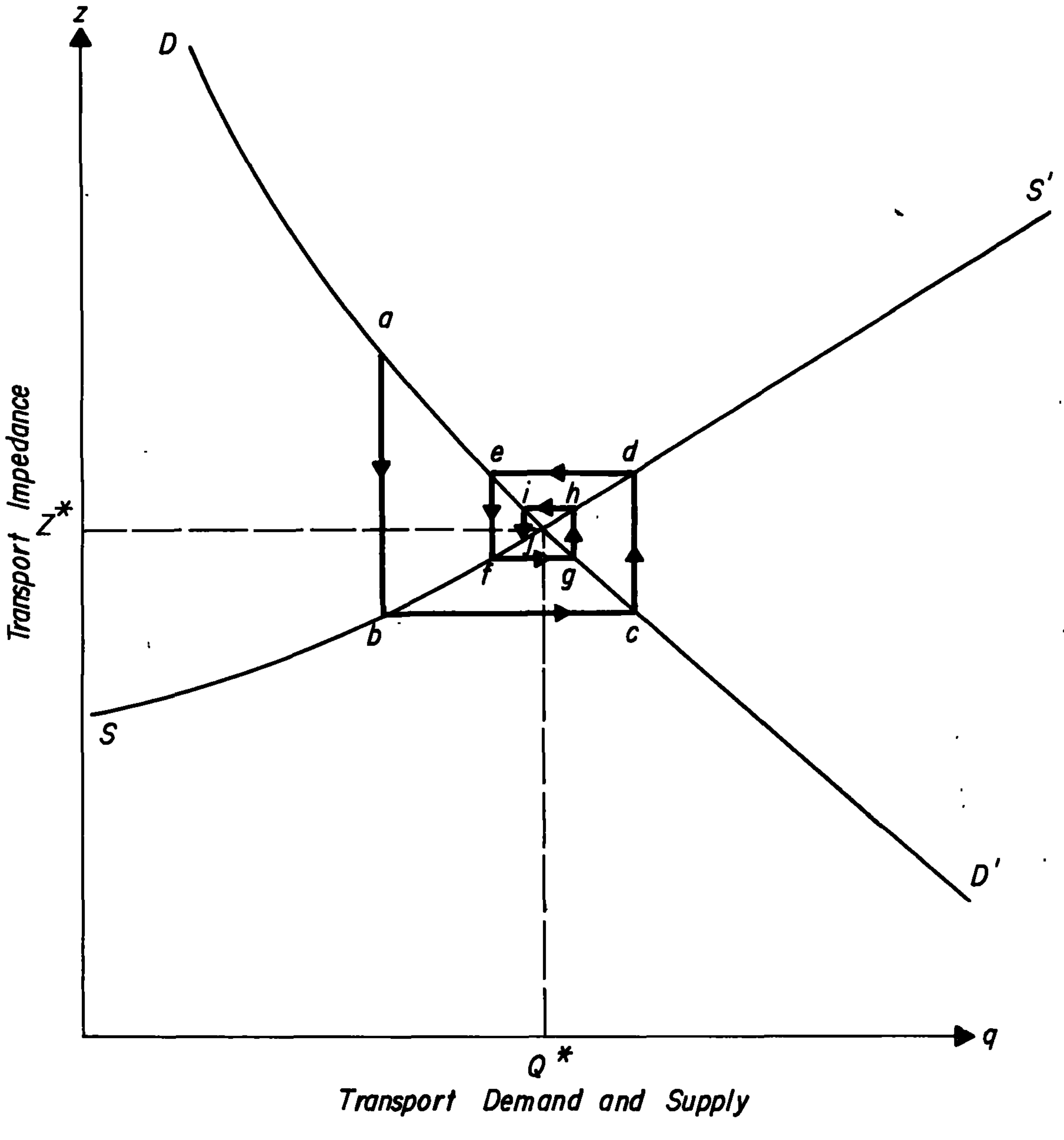

FIGURE 6. MARKET EQUILIBRIUM.

DISCUSSION

The model system for multiport analyses described above is presented as a rational basis upon which more detailed and specific model formulations may be built. It is to be expected, however, that further model development efforts may alter somewhat the overall analysis structure.

A reader familiar with transportation models in general will recognize many similarities between this model system and other large scale modeling efforts, including:

1. The Penn State Methodological Framework
2. Harvard Model
3. Northeast Corridor Transportation Project Model
4. Urban transportation planning models.

Many of the concepts are also similar to those proposed by the Board of Engineers for Rivers and Harbors in their multiport analysis prospectus. A review of these systems studies and their relationship to the present methodology is presented below in Chapter IV.

One problem not addressed in the model description is the modal split issue. Competition between air freight and ocean shipping may require introduction of a modal split element into either the traffic allocation model or the demand models.[3] Similarly, the inland travel model may have to consider modal split for some commodities.

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[3] Some recent research sponsored by IWR [2] suggests that discriminant analysis is a promising approach to this problem.

Another question heretofore avoided is that of coastwise shipping. In a completely general formulation, the possibility that each commodity could move from any inland node to any other node via deep draft transport would have to be considered. This would entail estimation of total internodal commodity flows, and then modal splitting between deep draft vs. inland modes. From a more practical viewpoint, however, it is unlikely that coastwise shipping involves very many nodes or all commodities. Thus separate estimates of coastwise commodity movements can be made and added to the model as another type of demand upon port facilities.

III. METHODOLOGICAL SURVEY

This Chapter presents a summary of the quantitative techniques disclosed in the literature survey (task 3) which appear to be useful for developing the various models delineated in Chapter II. The mathematical representation of Chapter II is eschewed in favor of a descriptive treatment; for precise mathematical formulations of the techniques discussed below the reader should refer to the source documents cited.

INTERNATIONAL TRADE MODEL

A model system for multiport analysis requires, as one of its elements, a model for projecting commodity flows. As this study is primarily concerned with deep water coastal ports, these projections essentially become predictions of imports and exports passing through the ports in the system. Since investment in port development is deemed long term - 50 years - the projections of imports and exports must also be of a long term nature. However, it is assumed that all forecasts will be continuously compared with actual growth as time progresses and adjustments made as required. The problem to be faced, then, is how to forecast commodity flows over the long term.

Forecasting Techniques

A literature survey on the subject of forecasting reveals that the greatest emphasis is placed on short term periods (quarterly to two years); long term forecasting is not promulgated in the literature. When one finds a reference to "long term" projections, the usual time period contemplated is 5 to 10 years.

Jacob Mincer of the National Bureau of Economic Research has compiled a text [3] on the subject of economic forecasting. However, the forecasts discussed are, in the majority, quarterly. The United Kingdom (U.K.) does forecast imports with a fair degree of accuracy, but only for a maximum time span of two years [4]. U.K. attempts to forecast exports [5] were not as successful, due to the many exogenous factors related to world demand. The Organization for Economic Cooperation and Development conducted a survey of forecasting methods used by its member countries [6]; once again the time span of most forecasts was one calendar or fiscal year.

Almon [7] constructed a forecasting model for the U.S. with a 7 year time span. However, exports as well as total labor force and capital replacement variables were assumed known in advance and, when empirically tested, significant errors were found.

Herman Kahn and his associates at the Hudson Institute have attempted to construct a framework from which to forecast the last third of this century and, within limitations, the first third of the next century. Their work [8] includes projections and conjectures of most characteristics of the U.S.A. and the rest of the world.

Scientific methods of forecasting are generally well developed. Basically there are three methods, as follows, ranked in the order of computational ease:

1. Trend Analysis;

2. Multiple Regression Analysis;

3. Model Building.

Trend analysis comprises two steps. First, a trend line is generated by analyzing historical data. Mathematical tools such as moving averages, exponential smoothing, and least squares methods are easily applied to historical data to generate a trend line which can take linear or other more sophisticated forms. Second, the trend line is extended to some given future time and the dependent variable is thus determined.

Multiple regression analysis is a statistical tool designed to yield a mathematical function which relates a dependent variable (e.g., imports) to one or more independent variables (e.g., GNP, Stockbuilding). The U.K. successfully used this method for forecasting imports [4]. Using historical data from the years 1955 to 1964, the following function was derived:

$$(9) \quad M - 0.19F = -136.3 + 0.51S + 1.938t + 0.279D$$

where,

M = Imports of goods and services;

F = Final Sales or Consumed Demand;

S = Stockbuilding

t = Time trend

D = Difference between National Expenditure and an estimate of GNP.

(Other functions were experimented with; the above is included only as an example of the method.)

When empirically tested, the method proved accurate to within approximately 1% over the short term of 1-2 years. However, as inputs, the future values of the independent variables need to be known with relative accuracy. When looking into the long term this presents serious problems.

Model building is the most sophisticated and complex method available. Models such as the 500 x 500 sector input-output model used by Professor Wassily Leontief of Harvard, the Brookings Institution model, and the model maintained by the Economic Forecasting Unit of the Wharton School of Finance and Commerce might be used [9]. However, all of these models are extremely complex and, as the forecasting time span is lengthened, their accuracy declines.

The models mentioned above are all macroscopic in nature. A second class of models are those which may be derived from microeconomic theory. A good review of the past research in this area, as well as some promising new approaches, may be found in a recent report to IWR by the Econometrics Center at Northwestern University [2]. Briefly, such models attempt to include the effects of spatial separation in determining the firm's supply schedule. The major difficulty in attempting to apply these models is that they all require market prices, marginal costs of production, and transport costs to be known. Also, the analysis is usually restricted to the output of a homogenous commodity by a single firm for sale in a well defined market, making the development of aggregate commodity flow totals an exceedingly laborious task.

Data Considerations

Collection of data presents another problem in making origin-destination tonnage projections. The data required are annual figures of commodity flows between given origins and destinations of the multiport system. These data should be stated in terms of commodity type--grain, petroleum, general cargo, etc. -- by weight and volume. Before 1959 there existed no data in any complete and collected form for routings from actual points of origin of an export to the ports of exit, thence by water transport to the foreign terminal. Likewise, no import data were available for consignments traveling from overseas ports of shipment to U.S. ports of unloading, and thence to interior points of ultimate destination. Various Bureau of the Census studies [10, 11, 12] have helped to partially alleviate this data gap. Tonnage statistics for import and export commodities at all U.S. ocean ports are published in annual reports of U.S. Waterborne Commerce [13].

Within the confines of the present study, the data problem can only be mentioned. A more thorough investigation is required in order to (a) determine what data are actually required, and (b) the availability of these data. It goes without saying that invalid or unreliable data will drastically affect any commodity flow forecasts, however derived.

Evaluation

The topic of economic forecasting is a complex and much debated one, and it was not possible within the limited scope of this study to resolve the key issues sufficiently to make any specific recommendations regarding forecasting techniques. In lieu of these, some general observations and guidelines are offered.

The single most important point to consider is that any forecast, regardless of the ingenuity of its methodological underpinnings, represents at best an educated guess about an uncertain future state of nature. Given this scenario, a wise course of action is to prepare several sets of forecasts under alternative assumptions. The sensitivity of the ultimate plan or decision to forecasting errors can then be examined and incorporated into the decision making process.

Secondly, it is not altogether clear that the Corps of Engineers should be burdened with the sole responsibility for making forecasts of international trade. The basic data going into such forecasts are likely already being collected by other agencies, and the forecast results will be useful for purposes other than multiport navigation analyses. Hence it would appear that an interdepartmental cooperative effort at the Federal level would be appropriate. This would also insure the compatibility of trade forecasts being used by different governmental agencies.

Finally, import/export forecasts for selected commodities and industries have probably already been prepared by various public and private interests (e.g., the U.S. Department of Agriculture's grain marketing analyses). The Corps should take full advantage of all such sources in developing an international trade model.

PORT DISTRIBUTION MODEL

As stated in Chapter II, the port distribution model determines the commodity flows into and out of each port, given the import/export activity at each node and foreign terminal. For most shipping studies appearing in the literature, this result is assumed to be known. However, two articles pertaining to this problem were uncovered.

Mickel and Rathbone [14] describe a network approach to a transportation system that is analagous to the network of Figure 2. The primary objective of the Mickle and Rathbone transportation system model is to help schedule the flow of a product through the network so as to minimize costs and meet a time deadline. Some of the constraints assumed in their model include limitations on port capacity and storage as well as certain delivery dates, shipping dates, and ship capacities. Rail is used as the transportation mode on land while ships are used at sea. No capacity constraints are assumed on any mode for any section of the network and the impedance or resistance of a given section of the graph is measured in dollars/ton and the transit time in days. Since the system is time dependent, dynamic programming is used for solving the problem.

"Discrete Programs for Moving Known Cargos from Origins to Destination on Time at Minimum Bargeline Fleet Cost" [15] is N. L. Schwartz's article on a specialized case of the Transportation Problem. Considered in this article are the actual mechanics of scheduling certain size or type barges and towboats for certain trips on certain branches of the network. The objective, as in the standard Transportation Problem, is to minimize the overall cost of moving the commodity from the origins to the destinations. The method also gives a complete schedule of where and when each barge and towboat should be at any given time during the scheduling period.

Most of the other references dealing with cargo routing are concerned with multiple port itineraries, and hence might be classified as fleet scheduling models. For the purposes of this study, such models are more closely associated with traffic allocation, and are described in a later section of this chapter.

Some techniques which have been successfully used for urban transportation planning also appear to be applicable here. In particular, the network minimum path model can be used to select the particular port through which a given shipment is likely to move. This procedure, which was first developed by Moore for routing messages through communication networks [16], is based upon the premise that each shipper will select that path through the network which will minimize total origin-destin (O-D) impedance.

If it is assumed that impedance varies with the volume of shipments using a particular port, as is the case in this study, the Moore algorithm must be combined with an equilibrium route choice principle, such as that proposed by Wardrop [17]. This principle states that if more than one route is used between a given O-D pair, then the impedances via each route must be equal and less than that of any unused route. That is, in equilibrium shipments between a given origin and destination will be apportioned among the available routes such that no shipper can reduce his O-D impedance by shifting to another route.

The combination of a minimum path procedure and a route selection and apportionment procedure is generically referred to as "traffic assignment." A large number of traffic assignment techniques have been developed, and are well documented in the literature [18, 19, 20, 21].

Alternative Formulation of Demand Models

In the alternative formulation of the transport demand models posed in Chapter II, the international trade model is called upon to predict only the import and export tonnage of each commodity at each node and foreign terminal, rather than the O-D pattern of commodity flows. The forecasting techniques reviewed in the previous section are equally applicable to this task, and require no revision. In this context, however, the port distribution model takes on the added duty of matching domestically produced exports to foreign receipts, and vice versa.

The articles by Mickle and Rathbone [14] and Schwartz [15] propose analysis methods which are even more appropriate for this revised model formulation than for the original one. Mathematical programming appears to be a viable method for solving the distribution problem. In particular, some version of the Standard Transportation Problem can probably be used to advantage here.

In addition, urban transportation planning again provides a wealth of techniques which are adaptable to this problem, which is referred to as the "trip distribution" problem. Trip distribution models normally assume that the number of trips between a given O-D pair is directly proportional to the trips produced at the origin and the trips attracted to the destination, and inversely proportional to the O-D impedance. The problem then reduces to one of estimating the proportionality factors. Several such procedures have been developed, including the gravity model, the interactance model, and the opportunity models, and are well documented in the literature [20, 21, 22].

Evaluation of Techniques

The selection of procedures for use in the port distribution model depends to a large extent upon which formulation of the transport demand models is adopted. Based on the review of techniques for the international trade model, it appears that the alternative demand model formulation is most appropriate. Economic forecasting has been performed with the greatest degree of success for imports and exports, rather than for international O-D flows. Thus the distribution portion of the demand models should be used for both O-D distribution and routing through ports.

Assuming adoption of the above recommendation, the choice of a distribution technique must be somewhat arbitrary at this point. The mathematical programming approach is firmly grounded upon operations research theory and is relatively easy to implement. It can, however, become quite complex and has unfortunate (from an analysis point of view) system wide optimization connotations. The trip distribution approach, while conceptually simple and devoid of optimization features, is beset with certain theoretical and parameter estimation problems. For the sake of simplicity, it is recommended that the distribution model be initially constructed as a linear programming transportation problem. Further model development, however, should give consideration to the trip distribution procedure.

Regardless of which distribution technique is chosen, a network minimum path algorithm will be an important part of the overall port distribution model. This is so because all distribution procedures require estimates of O-D impedance values, which can be derived from network analysis.

TRAFFIC ALLOCATION MODEL

The purpose of the traffic allocation model is the conversion of tonnage flows into vessel handling requirements. On the surface this doesn't appear to be a very difficult task. However much research has been done on this topic, primarily for the purpose of optimizing fleet scheduling for an individual shipping company. Many of the models developed for this purpose attempt to satisfy shipping demands at least cost within the constraints imposed by delivery dates and ship capacities. Shipping costs are dependent upon both ocean travel and port operations. While these models are broader in scope than the traffic allocation model proposed in Chapter II, they do constitute the existing body of knowledge and experience regarding analysis of shipping activities.

The paper by N. L. Schwartz referenced previously [15] considers a commodity flow problem where a commodity is available at several sources and is needed at several destinations. It sounds like a typical Transportation Problem except that the flow of the commodity is constrained by the availability and sizes of ships. The problem, then, is to schedule the ships available in an optimal way so that all the commodity demands are met.

Lawrence E. Briskin's article "Selecting Delivery Dates in the Tanker Scheduling Problem" [23] describes an algorithm for determining a program of delivery dates and volumes for multiport discharges. Dynamic programming is used in solving the algorithm and one size of tankers is assumed so as to simplify the problem.

Three linear programming models for ship scheduling are described by Appelgren [24]. The objective is to minimize transport costs while getting all cargoes to their destination on time. The major difference between this approach and the Transportation Problem is that a ship can carry more than one unit of cargo. The three linear programming models are similar in purpose but different in construction. A typical problem using Appelgren's method might have 40 ships, 50 cargoes, and a 60-day period with 4000 variables and 1000 constraints. The ships and cargo used in the model are differentiated by using a large number of parameters to describe them.

A paper by Olson, Sorenson, and Sullivan [25] deals with a problem of ship scheduling between the West Coast and Hawaii. The model formulated is a particular model devised for a particular situation. It does not fall into a neat category such as linear programming, network analysis, etc.

Another good article on the general area of scheduling and shipping is I. M. Datz's "Simulated Shipping" [26]. He covers the area well by mentioning two examples of simulated shipping and scheduling.

Although mostly qualitative in nature he does give many good ideas about what constraints must be considered in formulating models. His first example is the Matson Navigation Company (which is the West Coast-Hawaii shipping company mentioned in the previous article). The Matson Company model has been in use for the past five years and is providing management with valuable information which has resulted in real savings. The other model was developed by the Maritime Administrations' staff and Arthur D. Little, Inc. as a research project for the Federal Government. This model is much broader in scope and takes into account trade conditions in any part of the world. It is designed for long term use rather than short term. In the formulation of the model ships were considered as dynamic elements while ports are the passive elements. Ports are considered only as they affect the performance of ships. The ship's time is considered as a continum made up of five discrete time elements. This type of simulation is known as a critical event model. Natural delays caused by weather and port overcrowding are also considered within the model.

As is probably apparent by now, many of the fleet scheduling models just described are very similar. Besides the ones mentioned, there are many more available in different technical journals.

Evaluation of Models

The traffic allocation and ship scheduling problem has been the subject of a rather large amount of research, and the literature reveals a number of techniques available for its solution. It appears that the scheduling aspect of the problem should be given more attention than originally proposed in the multiport model system, particularly since so many solutions are available. Therefore the proposed triad of models -- traffic allocation, port, and ocean transit -- should be replaced by one large shipping model making use of the techniques discussed above. The port and ocean transit models will still be important submodels, but will have to be exercised in concert with scheduling constraints.

The simpler methods among the ones proposed in the literature should be adopted for initial model construction. If this approach proves to be infeasible, the port and ocean transit models can be broken out as separate models. The insights gained in attempting to structure the shipping model would then be useful in constructing the traffic allocation model as originally proposed.

PORT MODEL

The proposed port model utilizes vessel demand and port characteristics to derive estimates of the transportation impedance at a port. For all articles reviewed the ship arrival rate was described as a random process following the Poisson distribution. The basic strategy for determining the optimal size of a port was balancing the cost of maintaining a certain number of berths against the cost of maintaining ships while in harbor. A total cost equation would be defined and then attempts to minimize it by various methods would be made.

"Berth Planning by Evaluation of Congestion and Cost" by Stavros N. Nicolaou [27] contains a rigorous mathematical development of a

Poisson queuing model. Also included in the article are some port parameters defined explicitly by Nicolaou. Congestion and cost parameters may be used as impedances which can fit into the proposed port model. Other measures of impedance might include cargo handling rates and berth maintenance rates. All of these cost factors might be formulated into a single general impedance equation which can be adopted to each port analyzed. At any rate Nicolaou's article would provide a very good starting place for port model formulation.

Kohli [28] describes a very simple mathematical model of a port. Only the basic operations of a port are considered. The effect of ship turn around time and arrival rates on the movement of ships, the type of cargo handling facilities, the type of cargo storage facilities, and the rail and road movement of cargo are considered. These different facilities and their relative efficiencies in carrying out port operations may be used in formulating impedance equations for the port model.

Another article which may prove useful in formulating a port model is Carl H. Plumlee's "Optimum Size Seaport" [29]. A Poisson queuing model is used to describe the ship arrival rate. Other parameters used in describing a port include the total number of ships using the port in one year, the average number of ships present, the cost of a vacant berth per hour, and the cost of a waiting ship per hour. Data used in the article were derived from actual port operations in Central America and Ecuador. The article is primarily a mathematical modeling of a port based on the previously mentioned parameters.

Smith's article "A Functional Analysis of the Ocean Port" [30] describes port operations and planning in a nonquantitative but logical fashion. Many flow charts and tables are given which illustrate the complex interplay of factors which comprise a port. This article would be especially useful in the initial stages of planning a port model. It provides a very broad picture of everything that happens at a port and how seemingly unrelated activities are, in fact, related.

In summary, it can be seen that most authors have applied some aspects of queuing theory to the study of port operations. The port model should be built upon this base, and can also make use of results reported in the literature pertaining to generalized queuing models, which could not be included in this survey. If the resulting queue-theoretic model cannot be solved in closed form, it will probably be amenable to a simplified simulation treatment. A detailed and complex port simulation model is probably incompatible with the remainder of the multiport model system, particularly in view of its intended use as a long range planning tool. The simple queueing theory port model can be augmented with more complex processes as the need arises and as the analyst's understanding of multiport operations increases.

OCEAN TRANSIT MODEL

An ocean transit model is required for the model system in order to estimate shipping impedances accruing to the ocean voyage segment of a shipment's journey. Relatively few references to such models were found in the literature. Most of the more recent papers in the field of naval engineering are concerned with such topics as the effects of wave action and ship squat. Of course the fleet scheduling models reviewed above need information on port-to-port speeds or travel times, but most of these models treat such items as data.

An exception to this pattern is a study recently completed for the U.S. Department of Transportation by Planning Research Corporation [31]. Here transport cost and time are related to other shipping parameters. The model developed in the report also predicts other impedance values, including cargo waiting time, cargo handling and terminal costs, ocean transit times, and cargo insurance or claims costs. Hence this report can be useful for helping to structure the general shipping model recommended above, or else those parts of the model dealing with ocean transit can be extracted for use in a shipping model of different design.

INLAND TRAVEL MODEL

Literature pertaining to inland distribution of imports and exports was not reviewed in this study. Indeed, development of detailed inland travel models for the various modes clearly cannot be attempted within the scope of a multiport analysis. The recommendations of Chapter II hold firm, i.e., maximum reliance must be placed upon published data and upon inputs from other federal agencies. Average values for impedance should probably be used, with no attempt to relate impedance to cargo flows. Examples of possible sources for this information include the widely used work of Meyer, Peck, Stenason, and Zwick [32] and some recent research by DeSalvo and Case for IWR [2, Vol. 2].

CLOSURE

It is evident throughout this chapter that a great deal of research pertaining to the several elements of a multiport analysis has been completed, and a number of applicable mathematical models have been developed. In fact, it is the opinion of the authors that nearly all of the requisite analytical tools are already available, and need only be collected and integrated in order to produce a multiport model system with a surprising degree of sophistication.

It must be noted at this point that the literature survey was restricted primarily to the topic at hand, i.e., ports, shipping, and international trade. The more generalized and abstract areas of operations research, economics, etc. were not included. When a particular modeling problem is encountered, however, the source documents cited or other means at the analyst's disposal will probably be sufficient to uncover additional references in these fields.

Also, the literature search revealed that there are huge quantities of non-mathematical descriptive materials available covering virtually every conceivable aspect of ports. Although this information is not needed specifically in the multiport analysis, a broad general understanding of ports and how they operate could prove to be invaluable in keeping every aspect of the analysis in its proper perspective. For this reason, several of the better articles of a descriptive nature were reviewed. One of these sources, the Proceedings from the Fifth International Harbour Congress [33] contains an abundance of current research and development information on the topic of ports and harbors.

Finally, the reader will have noted that this chapter proposed several changes in the basic multiport model structure given in Chapter II. These proposals resulted from the relatively advanced state of certain modeling tasks disclosed by the literature search. These changes are incorporated into a recommended preliminary methodological design, which is presented in Chapter V. Prior to this, however, Chapter IV reviews some existing transportation systems analysis models, in order to determine if additional modifications of the basic model structure are desirable.

IV. EXISTING TRANSPORTATION PLANNING SYSTEMS

The methodology proposed in this report is really an adaptation of previous transportation planning model systems. The science of transportation planning has advanced in the past two decades to a point of general uniformity in its approach to the solution of various transport problems. The challenges of providing for urban passenger movements, which were first considered in the early 1950's, soon expanded into total transportation planning efforts including freight as well as passengers. As automated data processing capabilities expanded so did the complexity of the analyses and the geographical extent of the regions they considered. Methodologies now exist which consider entire countries as the geographic base and which can handle both freight and passenger flows.

This chapter attempts to describe a representative sample of the transportation planning models which have been proposed or implemented. The emphasis will of course be on freight movement rather than passenger transportation, even though some of the systems as outlined below consider both. The planning approaches included are the following:

1. PennDOT Model
2. Harvard Model
3. Northeast Corridor Model
4. SRI Model
5. Corps of Engineers Task Group Report
6. BERH Study

PENNDOT MODEL

This methodology was developed through a joint effort of The Pennsylvania State University and Carnegie-Mellon University in 1968 [21]. The project was to serve as a framework for transport planning for the entire Commonwealth of Pennsylvania and serves as a typical regional planning methodology upon which the discussions of this chapter may be based. Both passenger and freight transportation were considered.

The overall approach can be summarized as follows:

1. Identify relevant policy variables;
2. Identify effect variables;
3. Collect necessary data;
4. Develop forecasting model system;
5. Generate alternative transportation investment programs;
6. Estimate consequences of alternative programs;
7. Select best alternative.

The first step of the process forces the planner to answer the question: What should the transportation system accomplish for the users and operators? This means simply that planners should make a decision as to where to strike a balance between level of service and cost to society.

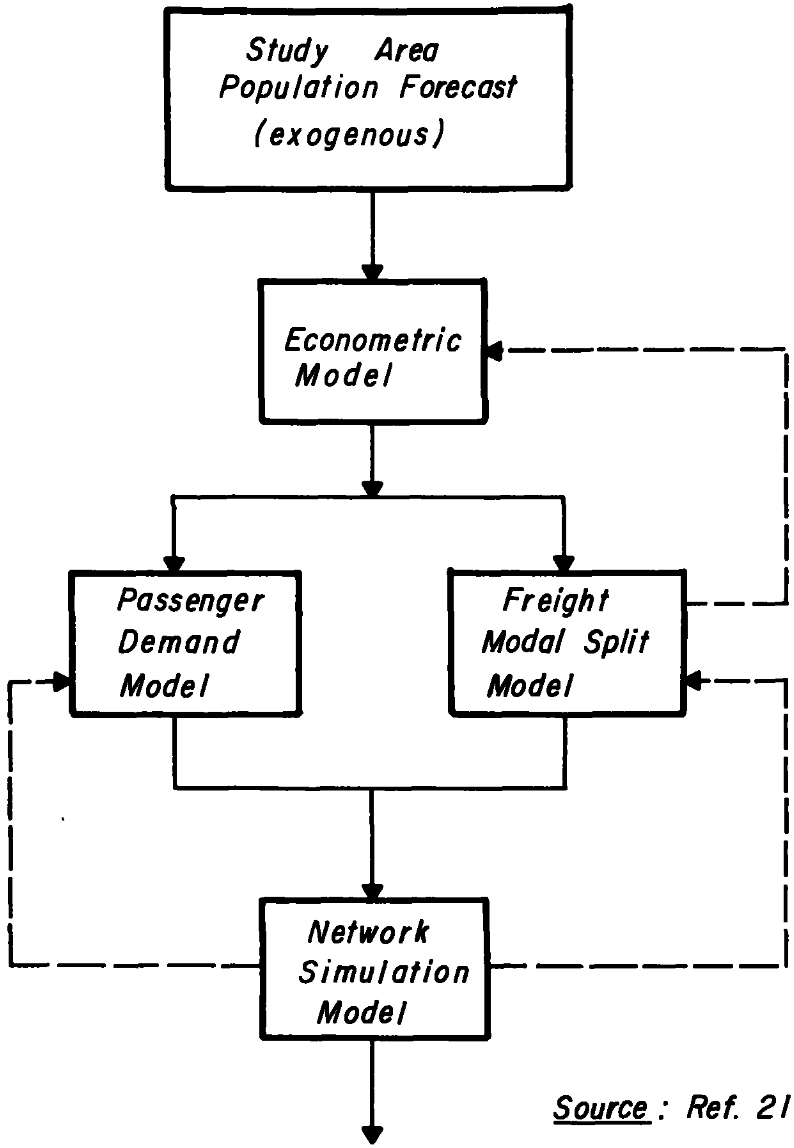
After the policy has been set, the necessary variables which will measure the degree to which a transportation system meets the policy standards must be selected. Step two of the above covers this process.

Data must be collected which will be used as inputs to the fourth stage of the PennDOT planning process, forecasting model development.

The forecasting model system is the heart of the planning process and accordingly will be given more than just passing notice. PennDOT's plan is shown graphically in Figure 7. For the purposes of this report the passenger demand model in the flow diagram can be ignored.

The system is initiated by inputting population forecasts which are prepared outside the model framework. These represent estimations of the population within the study area and its periphery for the horizon or planning year.

The Econometric Model is a method for forecasting future socio-economic activity for the projected population. It is interesting to note that a major assumption within the model is that industrial activity is sensitive primarily to freight transport service and that passenger transportation has little or no effect. The core of the Econometric Model is a Leontief input-output model which has been slightly modified. The modification was performed on the production function used in the analysis which the authors felt greatly increased the degree of price and transportation sensitivity. It is beyond the scope of this chapter to present a detailed account of input-output theory. The output of such an exercise in an estimation of all commodity flows between freight zones as well as a forecast of the levels of economic and demographic activity.



Source: Ref. 21, p. 212.

FIGURE 7. PennDOT FORECASTING MODEL SYSTEM.

Once commodity flows between areas have been established for the horizon year, the task remains to allocate that freight to the various modes. The PennDOT model proposes that modal choice is a function of the following variables:

1. Mode reliability (R_k);
2. Cost of shipment relative to the cheapest cost (C_k);
3. Transit time of the mode relative to fastest mode (T_k);
4. Frequency of service of the mode relative to the fastest service (F_k).

These variables would be the independent variables of a regression equation to predict the percentage of the tons of the commodity to be moved by the kth mode.

Mathematically the modal split is accomplished as shown below.

$$(10) \quad P_k(X_{igjh}) = \alpha_o \, R_k^{\alpha_1} \, C_k^{\alpha_2} \, T_k^{\alpha_3} \, F_k^{\alpha_4}$$

where:

X_{igjh} = tons of commodity i shipped from node g to industry j in node h;

$P_k(X_{igjh})$ = percentage of the tons of X_{igjh} shipped by mode k;

$\alpha_{o,1,2,3,4}$ = coefficients determined by regression analysis;

and

R_k, C_k, T_k, F_k are explained above.

The next step in the PennDOT model is to assign the freight flows (also passenger volumes) to the transportation network. The purpose of this is to load the network to determine capacity overloads or areas of projected high density. Ideally from a freight point of view the network would consist of highways, rail, air and waterways along with the appropriate interfaces. The PennDOT study, however, considers only the highway network for freight flow for a variety of reasons. The primary cause was that not enough is known about the systematic operation of the other modes. The Bureau of Public Roads Traffic assignment model is used as the basis for the network simulator.

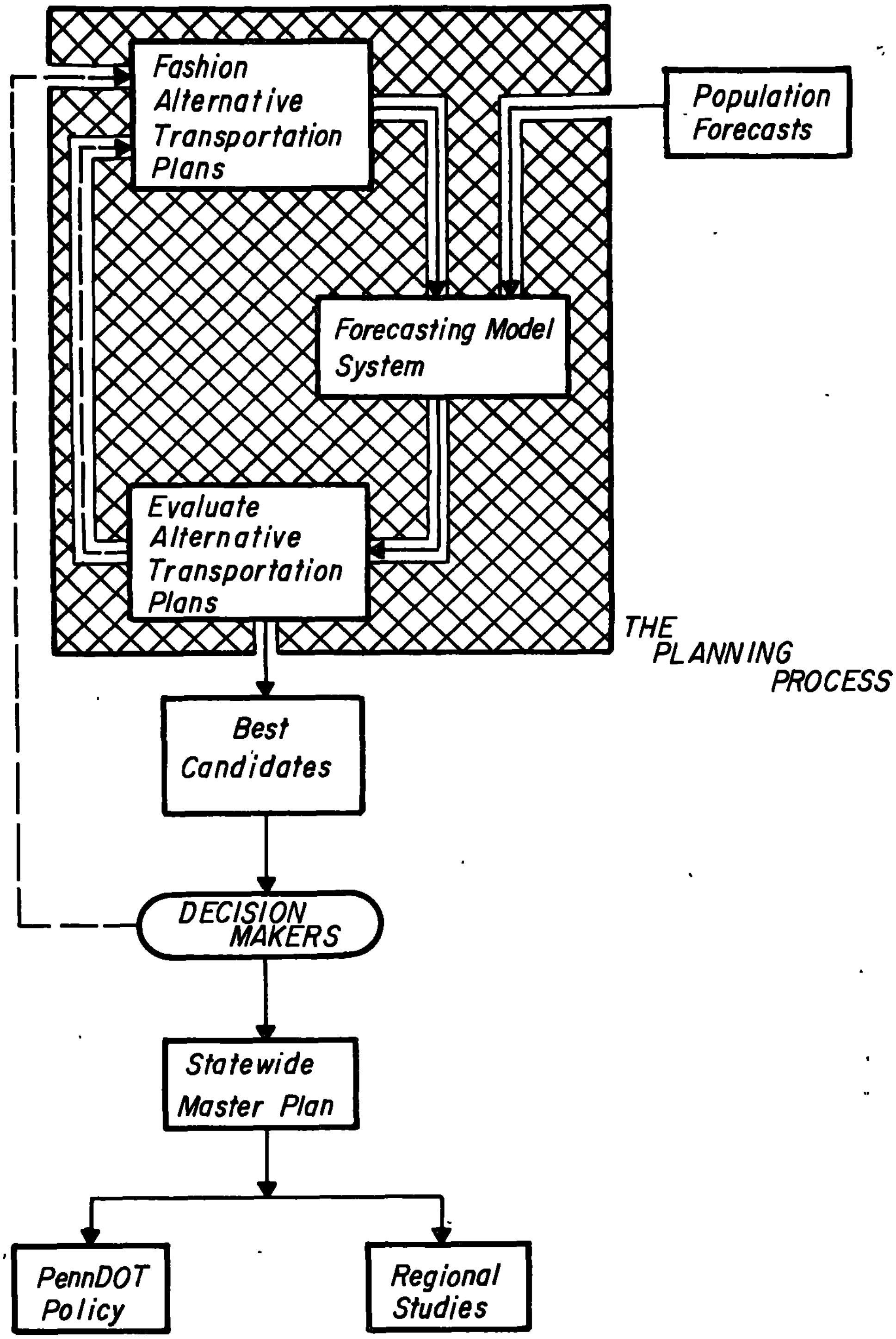
It is important to note that the PennDOT methodology includes feedback loops from the Network Simulation Model to the Freight Modal Split Model and finally to the Econometric Model. The idea is to run these models as a package thereby permitting a certain amount of interaction between all three.

Figure 8 summarizes the PennDOT approach. The methodology is technically complete but unfortunately has never been applied.

HARVARD MODEL

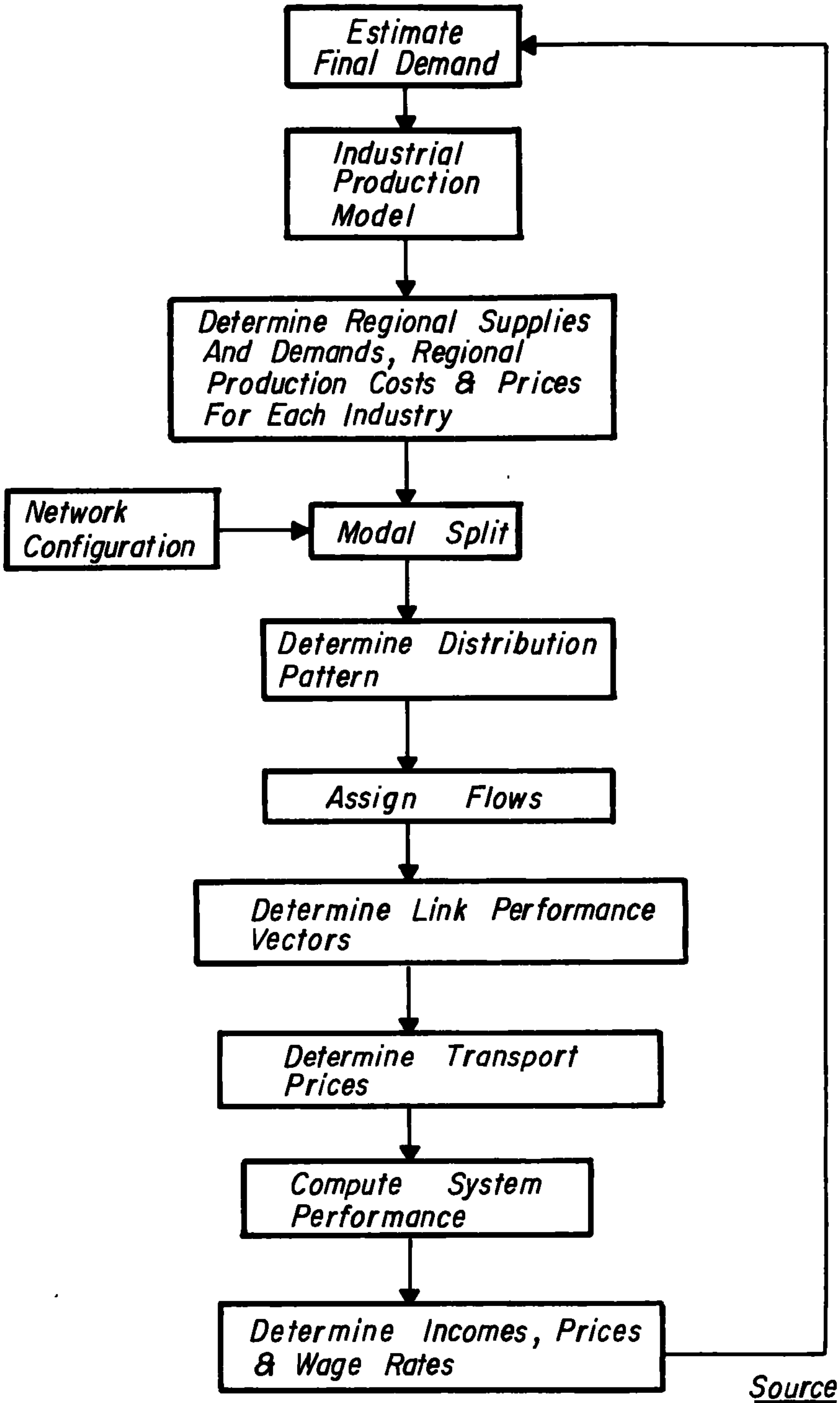
The Harvard Model was a transportation planning tool developed at the Brookings Institution for a particular application in Columbia [34]. The methodology is a very general one and could be adapted for use elsewhere.

The basic plan is schematically illustrated in Figure 9. Initial input into the forecasting model is a future economic activity pattern similar to the previous PennDOT methodology. The Macroeconomic Model requires data on future personal, government, and export consumption and supply of products as well as fixed regional in-



Source: Ref. 21, p. 218.

FIGURE 8. THE INTEGRATED STATEWIDE TRANSPORTATION PLANNING PROCESS.



Source: Ref. 34, Vol. 2.

FIGURE 9. SCHEMATIC DIAGRAM OF THE HARVARD MODEL.

vestments in order to generate total final demands for commodities. These demands are translated into industrial production by use of an input-output model. The unique feature here is the sensitivity that the system has built in to evaluate the effects of import policies and government purchases.

Modal split is accomplished by considering five factors:

1. Waiting time;
2. Travel time;
3. Travel time variability;
4. Probability of loss or damage;
5. Transportation charge.

These factors are converted to costs for a given link in the network by applying estimated dollar rates for each commodity. A path over the network is then fixed by computing a minimum cost flow. The model predicts the flow of a commodity over different modes through a general network. It should be noted that the network actually consists of subnetworks for each mode. Therefore modal interchange can be considered.

Distribution in the Harvard model is accomplished for freight flows in two ways. A linear programming technique is used when the commodity groups are split into very fine divisions. A gravity type model is preferred, however, when the commodity groups are only grossly divided. Assignment is done on the basis of the minimum cost paths that were fixed in the modal split section.

Experience using the model in Columbia suggests that it does model a transportation system adequately. The rather extensive data requirements make it an expensive undertaking, however.

NEC MODEL

The Northeast Corridor Transportation Project developed a large scale model system for predicting transportation demand and supply between large urban sections on the east coast of the United States [35]. The models emphasized passenger flows to the virtual exclusion of freight flows, and used concepts similar to the previous two methodologies. The interested reader may wish to review this study more carefully but further consideration of its contents here would not materially add to the ideas already discussed above.

SRI PLAN

A study which more closely parallels the needs of a methodology for port planning was performed by Stanford Research Institute in 1969 [36]. The SRI report is a plan for port analysis and is not a summary of actual work which has been performed. The study is very general in nature.

SRI recommends a seven phase plan for harbor development. The project was undertaken specifically to consider west coast activity but the author recommends that with minor modification, the plan can be used for all port systems. The seven phases are restated below.

1. Delineation of objectives;
2. Analysis of the economy served by the port complex;

3. Projection of cargo flows;
4. Estimation of demand for harbor facilities;
5. Estimation of additional capacity requirements;
6. Assessment of harbor development alternatives;
7. Guidelines and public policy.

Phase one, objective statements, is common to any transportation planning project. It involves setting down the goals which the long term project must attempt to satisfy. It is recommended that these objectives be arrived at by considering the goals of all parties connected with the port system including users, operators, and governments.

The geographical area which uses the port system must be clearly defined in Phase Two. Projections of regional imports and exports would be done by using an input-output approach. The method recommended is the Hochwald-Striner-Sonenblum Model [37]. The regions which are determined would be based on geographic boundaries and would not be different for different commodities.

Phase three of the method results in a detailed set of commodity flow matrices. The author suggests that two approaches should be pursued simultaneously. The first is to further refine the input-output analysis results of Phase two. The second is to base projections on historical trends of freight flow.

Estimating the demand on the harbor facilities, given the set of commodity flows, is the objective of Phase four. This phase is one of the most difficult yet is not very well explained in this report. Factors which must be considered include analysis of future trends in containerization, vessel size and type, defense requirements, air cargo, and environmental issues. These factors modify the demand upon a given harbor and this demand must be matched to the harbor capacity. The factors influencing overall capacity are noted as maximum draft, container capacity, specific bulk commodity capacity, and non-containerized general cargo capacity. Considering these as primary constraints and including others such as labor and technology considerations, the planner must prepare future capacity lists for each harbor.

Phase five of the proposed SRI Plan compares the current harbor facilities to the projected capacities required in Phase four. This step involves a simple inventory of existing capacities which are compared to all alternative future capacities resulting in a list of capacity shortages.

Assessing the alternatives by synthesizing all previous information is the task of Phase six. It is suggested that a linear programming model which will select optimal configurations of harbor capacities should be constructed to accomplish this phase. The optimization should be performed in two stages:

1. Select optimal configuration for each channel depth;
2. Select optimal channel depth.

This approach means that a large scale model of harbor operations must be constructed considering all capacity constraints, existing and future facilities, and new investment costs.

The concept of optimization is currently rather foreign to the science of transportation planners. Most experts feel that the problem is so complex and involves so many variables that inclusion of all of them into the analysis is impossible. Without complete control of all major factors optimization procedures are not valid, so past emphasis has been on a search and choice procedure.

The final phase of the plan to set the stage for the required harbor improvements. The public policy must be included into the harbor analysis by incorporating social and political judgments.

COE TASK FORCE REPORT

The U.S. Army, Corps of Engineers, commissioned a task force in 1970 to study the problem of systems analysis for the inland waterways. Their report gives a survey of existing modeling systems applicable to their problem which could be used either in a planning or operations study as well as recommendations for future work [38].

The most important point of the report is contained in their definition of systems analysis as it applies to the inland waterways. The term itself, systems analysis (or operations research), has often been cloaked in an air of mystery leading many people to regard the idea with awe and reverence. In point of fact, systems analysis is just a means of quantifying factors which indicate operational efficiency of a system so that decision makers may evaluate their operations with greater objectivity. This notion is certainly not beyond the grasp of any scientifically oriented person.

The current thrust of systems analysis is toward another mysterious tool, modeling. Modeling, as pointed out in the Task Force

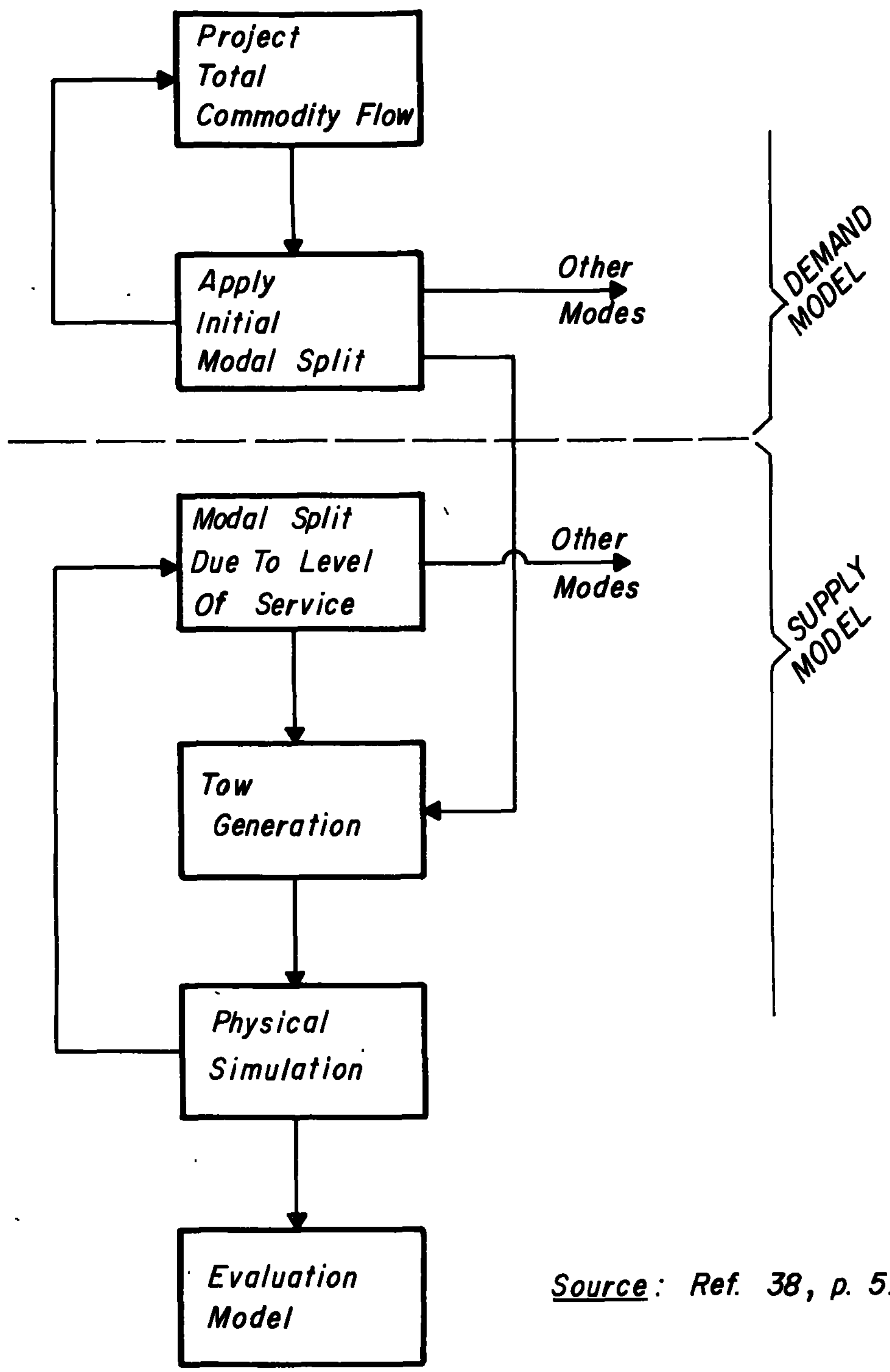
Report, is nothing more than a numerical representation of some real-life operation or phenomenon. Because many operations, such as movements of goods, are very complex, the models of them are broken into various subsystems which can be individually modeled. When taken as a whole, they represent the entire system operation.

Whenever the system performance is subject to random fluctuations or the computations involved are very complicated it becomes convenient for the analyst to make use of the electronic computer. Therefore the term systems analysis currently conjures up visions of whirring computers magically spewing forth answers to very complex problems. Really systems analysis involves just an intelligent breakdown of a complex phenomenon into units small enough to analyze, coupled with the introduction of probabilistic considerations.

A second important observation in this report is the fact that systems analysis may be applied to three types of problems experienced in the inland waterway environment. These are:

1. Long range planning for major construction;
2. Short range planning for operational alternatives;
3. Structural and non-structural design evaluation.

The basic flow of the procedure recommended by the Task Force is shown as Figure 10. The reader should realize by now that all the methodologies thus far are very similar in nature and the Task Force recommendation is no exception. The unique feature of this method comes in the consideration of the modal split task. The split is divided into two parts: the first due to industry location and available transportation considerations and the second due to levels of



Source: Ref. 38, p. 5.

FIGURE 10. COE SYSTEMS ANALYSIS DESIGN.

service experienced on the waterway.

This enables the method to be used for short range planning by assuming all input above the dashed line to be given and independent of system operation. The long range planning use of the model group assumes, however, that interaction across this line does occur and must be considered. This concept of dual use for both short and long range planning is a novel and useful idea.

BERH REGIONAL HARBOR ANALYSIS

The Board of Engineers for Rivers and Harbors within the Corps was charged with the investigation of the question of regional harbor development and improvements [39]. This project, like the SRI Study, considers specifically the problem of regional planning for port development.

The report is very basic in nature and covers no individual step in the proposed method with any great detail. The seven steps advocated by BERH are listed below.

1. Delineate the region to be studied
2. Estimate future commodities
3. Estimate vessel trends
4. Set up an analysis method
5. Consider phasing of improvements
6. Estimate the costs involved
7. Evaluate the alternatives

Several interesting points are raised in the discussion of step one. First, the region can vary according to the commodity considered and whether the commodity is imported or exported. Second, competition between different modes for distributing the goods to and from different ports must be investigated. Finally, the territory may expand or contract due to changes in commodity demand or transport or production technology.

The commodities which BERH considers are limited to bulk commodities only. The logic for this is that these bulk goods are the ones carried by superships and it is the presence and volume of large ships that are the primary factors in justifying harbor improvements. Containerized vessels are mentioned nowhere in this section. The future flows of bulk commodities should be estimated based on the following factors:

1. Consumption;
2. Manufacturing processes;
3. Natural resource availability;
4. Alternative sources for the commodity;
5. Technological advances;
6. Government policy;
7. Competitive commodities.

No method for projecting demand based on these factors is presented or suggested.

Estimates of future vessel sizes and numbers would be made using historical trends and judgments of their anticipated characteristics. These world-wide projections would be scaled down to the region of interest.

The method of analysis proposed is basically that the interactions between ports, given that certain changes are made at particular ports, are considered. The entire region would be considered in making an investment decision that would ideally maximize national efficiency. All possible improvement combinations could be considered and rated on a common benefit scale.

The planner should consider the phase investment advantages and disadvantages along with the total long term benefit. Step five would address this timing factor. The improvements must be considered on an incremental basis.

Step six amounts to a comparison of the costs and benefits of an alternative. The point is stressed that all advantages must be quantified for comparison purposes.

The final step in the planning process involves considering all possible port improvement possibilities. This means that offshore facilities, and lightering, in addition to channel dredging must be evaluated. The alternatives available differ with different commodities and are also sensitive to technological change.

DISCUSSION

As pointed out in the beginning of this chapter, the multiport analysis methodology proposed in this report does not differ significantly from presently existing or suggested large scale transport system models. The basic problem addressed in all such efforts is estimation of transportation demand and supply, and equilibrium analysis. The present methodology merely tailors previously developed transportation science principles to meet the needs of multiport planning.

The reader may have noted that, for most of the model systems described, transport supply phenomena are relatively well understood and are amenable to straight forward analysis, while transport demand continues to defy simplified analytical treatment. This is probably the case because transport supply deals with physically measurable technological relationships, whereas human decision making behavior is the ultimate determinant of demand.

In view of the demand-supply dichotomy noted above, it is not surprising to discover that the major point of departure of the multiport analysis system from previously designed planning methodologies is in the area of demand forecasting. The PennDOT model, the Harvard model, and the SRI prospectus all make use of input-output analysis for forecasting transportation demand. For multimodal networks covering large geographic areas, this tool may well be appropriate. In fact, the Harvard model used this approach for solving actual problems with a seemingly large degree of success. The multiport network of this study, however, does not consider flows of all commodities via all transportation modes. Hence the structural economic relationships required for applying input-output analysis appear to be absent in the multiport situation, and use of this tool cannot be unequivocally recommended.

In summary, the review of existing transportation planning systems carried out in this chapter does not indicate the need for any changes in the basic structure of the multiport analysis methodology. Implementation of the multiport models, however, should be facilitated by the experience base accumulated in the use of large scale transportation models.

V. CONCLUSIONS AND RECOMMENDATIONS

Chapters III and IV of this report have surveyed some mathematical models and transportation planning techniques which appear to be applicable to the analysis of multiport deep draft transportation systems. Certain suggestions concerning revisions of the analytical structure formulated in Chapter II were also given. This chapter presents a recommended methodological design for multiport analyses based upon these findings, and also provides suggestions relevant to implementation of the model system.

RECOMMENDED METHODOLOGICAL DESIGN

The recommendations given in this section regarding a methodology for multiport analyses should be regarded as short run in nature. That is, the model system as formulated below is susceptible to immediate implementation, utilizing a number of techniques made available through previous research efforts. A number of other possible analysis procedures were reviewed in this study, but the authors consider those to be more suitable for a long run investigatory program by the Corps of Engineers.

Figure 11 shows a diagramatic representation of the recommended multiport model system. Comparing this with Figure 5 in Chapter II above, several revisions of the preliminary model design can be noted. First, several of the constituant models have been renamed to more

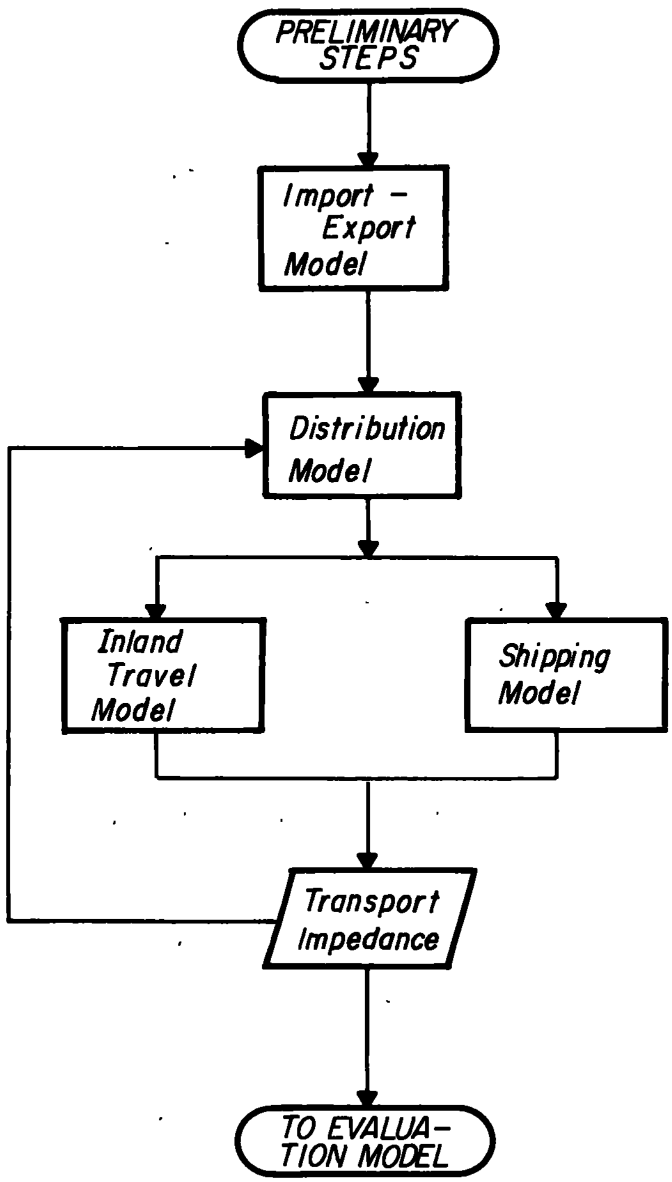


FIGURE 11. RECOMMENDED MODEL SYSTEM.

accurately portray their intended functions. Second, the three former transport supply models dealing with ocean transit have been combined into a single shipping model. Third, forecasts of import and export activity have been divorced from explicit consideration of transport impedance.

The following paragraphs take up each model in turn, summarizing the procedural recommendations given in Chapter III. In addition, the models are reformulated in abstract functional notation, in order that the important variables and relationships may be precisely stated. At this point the reader may wish to review the multiport network schematic presented in Figure 2, and recall that the system has been defined to consist of I nodes, J ports, M foreign terminals, K commodities, and S vessel classes.

Import-Export Model

The import-export model is basically an economic forecasting model, and predicts the total tonnage of each commodity imported and exported at each node and foreign terminal. A closed system should be used in preparing these forecasts, i.e., imports and exports destined for locations other than the nodes included in the network should not be included, etc. Although long range forecasts are required, they should be updated regularly to remain attuned to changing world trade conditions.

The import-export model[1] may be represented mathematically by the following set of equations:

$$(11) \quad O_{ik} = f\,(E_{ik}) \qquad i=1, \ldots, I+M$$

$$D_{ik} = g\,(E_{ik}) \qquad k=1, \ldots, K$$

$$(12) \quad \sum_{1}^{I} O_{ik} = \sum_{I+1}^{I+M} D_{ik} \qquad k=1, \ldots, K$$

$$\sum_{I+1}^{I+M} O_{ik} = \sum_{1}^{I} D_{ik}$$

in which

O_{ik} = tons of commodity k exported from node or foreign terminal i;

D_{ik} = tons of commodity k imported to node or foreign terminal i;

E_{ik} = vector of explanatory variables for commodity k at node or terminal i.

Equations 12 specify the conditions for a closed system.

Distribution Model

The task of the distribution model is to determine which domestic exports become which foreign receipts, and vice versa. In addi-

[1]The recently released Transoceanic Cargo Study [40], which was received just as this report was being completed, is recommended reading in conjunction with this report. It contains actual international trade forecasts and presents a rather complete discussion of forecasting techniques, as well as some economic forecasting models not considered in Chapter III.

tion, these commodity origin-destination (O-D) flows must be allocated to specific ports. Transport impedance values will be important determinants of both O-D and port allocations and should be calculated by means of a network minimum path algorithm. This routine will also generate the required port routings. The O-D flow problem should be solved as a linear programming Transportation Problem.

This model may be formulated in functional notation as follows:

$$(13)\quad O_{ijmk} = f\,(O_{ik}, D_{mk}, Z_{ijmk}) \qquad i = 1, \ldots, I$$

$$D_{jimk} = g\,(D_{ik}, O_{mk}, Z_{jimk}) \qquad j = 1, \ldots, J$$

$$m = 1, \ldots, M$$

$$k = 1, \ldots, K$$

where

O_{ijmk} = tons of commodity k flowing from node i to foreign terminal m through port j;

D_{jimk} = tons of commodity k flowing to node i from foreign terminal m through port j;

Z_{ijmk} = transport impedance for shipping commodity k on route i-j-m;

Z_{jimk} = transport impedance for shipping commodity k on route m-j-i.

The transport impedance values originate elsewhere within the model system, as shown in Figure 11. Since these impedances are functions of route cargo volumes, the model system must be used in an iterative fashion, until some convergence criterion such as that of equation 8 is satisfied. The possibility of multiple routings between given origins and destinations can be accommodated by at least two means:

1. the import and export tonnage can be "loaded" onto the network in several increments;
2. all tonnage can be loaded on each iteration, and route flows averaged after the final iteration.

Shipping Model

The shipping model estimates ship transit impedance as a function of cargo volume, fleet characteristics, and network properties. Important submodels will include a port model, an ocean transit model, and a scheduling algorithm. Several shipping models have been reported in the literature, and can be adapted to meet the needs of the multiport analysis methodology.

Mathematically, the shipping model may be represented as follows:

(14) $$T_{jmk} = f\,(O_{ijmk}, U_j, F, C_{jk}, C_{mk}, A_j, A_m, d_{jm})$$

$$T_{mjk} = g\,(D_{jimk}, U_j, F, C_{jk}, C_{mk}, A_j, A_m, d_{jm})$$

$$j = 1, \ldots, J \qquad m = 1, \ldots, M \qquad k = 1, \ldots, K$$

in which

T_{jmk} = shipping impedance for commodity k exported through port j to foreign terminal m;

T_{mjk} = shipping impedance for commodity k imported through port j from foreign terminal m;

U_j = coast-wise shipping demands at port j;

F = vector of fleet characteristics;

C_{jk}, C_{mk} = scheduling constraints for commodity k at port j and terminal m, respectively;

A_j, A_m = vectors of port characteristics for domestic and foreign ports, respectively;

d_{jm} = distance between port j and foreign terminal m.

The scheduling algorithm included within the shipping model will most likely make use of ocean transit and port impedance values. These, in turn, may depend upon the scheduling results. Hence there may be a need to provide an iteration mechanism for achieving sub-model equilibrium.

Inland Travel Model

The inland travel model is needed to predict the transport impedances accruing to the inland segments of commodity O-D shipments. These impedances should be treated as constants, and should be obtained from external sources. For the sake of completeness, the inland travel model is expressed as follows:

$$(15) \quad X_{ijk} = f\,(d_{ij}, B_k) \qquad i = 1, \ldots, I$$
$$X_{jik} = g\,(d_{ij}, B_k) \qquad j = 1, \ldots, J$$
$$k = 1, \ldots, K$$

where

X_{ijk}, X_{jik} = inland impedance for shipping commodity k between node i and port j;

d_{ij} = distance between node i and port j;

B_k = vector of network characteristics for inland distribution of commodity k.

Transportation Impedance

Finally, some means is needed within the model system to combine the inland and shipping impedances into estimates of the total transport impedances needed by the distribution model. This process may be represented as follows:

$$(16) \quad Z_{ijmk} = f\,(X_{ijk}, T_{jmk}) \qquad i = 1, \ldots, I$$

$$Z_{jimk} = g\,(X_{jik}, T_{mjk}) \qquad j = 1, \ldots, J$$

$$m = 1, \ldots, M$$

$$k = 1, \ldots, K$$

where all terms have been defined previously.

IMPLEMENTATION AND RESEARCH RECOMMENDATIONS

The primary requirement for implementing the recommended multiport analysis methodology is the acquisition of an adequate data base. The oft repeated maxim that modeling results are only as good as the data upon which they are posited hardly needs repeating. Thus the Corps of Engineers should undertake a study to (a) ascertain the type, extent, and level of detail of the data input needs of the multiport model system, and (b) survey existing data sources to determine if these data requirements are or can be met. This data survey may well show that the methodological design is too ambitious in terms of data, or that it fails to take advantage of some readily available data. Hence the third part of a data survey should include review of the methodology in light of data availabilities, and revision of the design if required.

A second recommendation stems from the short term considerations embodied in the methodological design. The reader may recall that Chapters III and IV pointed out the existence of some advanced analytical techniques, particularly regarding estimation of transport demand, which would probably be quite difficult to implement immediately. This short run consideration should not preclude further investigation of such methods. The potential benefits from developing demand models grounded in economic theory, for example, are probably far greater than those which have been realized from the use of relatively sophisticated transport supply models.

A final recommendation concerns the overall concept of planning for multiport development. Figure 1 above presented a diagram of the entire multiport planning process. Most of the remainder of this report was devoted to the analytical models imbedded within the planning process. Yet these models cannot be utilized successfully without the rest of the apparatus depicted in Figure 1. Thus the Corps should, in parallel with further model investigations, institute a program of developing procedures for the following:

1. defining the elements of a multiport system;
2. formulating the alternatives;
3. technological forecasting;
4. evaluating alternatives.

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APPENDIX A

REVIEWS AND ABSTRACTS OF SELECTED ARTICLES

This appendix contains reviews and/or abstracts of the papers and reports which served as the basis for much of the material in Chapter III. In most cases the abstracts were prepared by the document's author, and were copied directly from the publication. The reviews were written by Center staff, and are oriented toward evaluating the contribution which a paper might make to the development of a multiport model system.

The following two abbreviations appear in the bibliographic citation for some of the articles:

U.S.G.R. and D.R. - U.S. Government Research and Development Report;

NTIS - available from the National Technical Information Service, Springfield, Virginia 22151.

"Systems Analysis for Port Planning"

H. Agerschou and J. Korsgaard

Dock and Harbour Authority, vol. 49, no. 581, March 1969, pp. 411-415

KEYWORDS: Transportation Model; Port; Transport; Planning

ABSTRACT: Application of queuing analysis for port planning and analytical solutions to queuing problems; assuming Poisson distribution for number of arrivals per time unit as being valid for locations with reasonably high number of arrivals per year, existing and/or predicted service time distribution is determined; approach is based on assumption of either long stretch of wharf with fairly high number of average size berths where waiting ship will always fit into first available berth, or smaller number of berths which will all accommodate any ship which calls; program was written in General Purpose Systems Simulator II language according to IBM Manual B20-6346-1. 17 refs. (Engr. Index)

"Simulation of the Operations of a Fleet"

Y. Almogy, C. Levin, and Z. Drezner

Israel Journal of Technology (Israel), vol. 6, no. 5, Nov.-Dec. 1968, pp. 283-287

KEYWORDS: Fleet; Transportation Model; Scheduling; Simulation Model

ABSTRACT: An attempt is made to simulate, on a digital computer, the operations of a fleet. The simulation comprises two major parts; (a) the schedule generator, which assigns schedules to the fleet elements by considering cargo generations at the different ports and determining the most profitable route for a particular ship within the limits of the policy constraints; (b) the voyage generator, which moves each ship along the route assigned to it by the schedule generator, loads and discharges cargoes, and generates revenues, expenses and time according to their respective known probability distributions. The output consists of (a) "voyage logs" listing the "actual" port calls and their duration, the cargoes loaded and discharged, etc., and comparing them with the estimates of the schedule generator, and (b) periodical reports of cargo movements, revenues and expenses; and, for new ship construction--calculations of present worth or internal rate of return. Although the simulation is extended for the use of a specific shipping company, its flexibility permits a variety of operational policies to be accommodated, and its port-network capacity suffices for any actual large-scale operation. It is written for the Philco 212 unit of the Computer Centre of the Israel Ministry of Defense. (Author; reviewed)

"A Column Generation Algorithm for a Ship Scheduling Problem"

Leif H. Appelgren

Transportation Science, vol. 3, no. 1, February 1969, pp. 53-68

KEYWORDS: Fleet; Scheduling; Transportation Model

ABSTRACT: This paper describes an algorithm for a ship scheduling problem, obtained from a Swedish shipowning company. The algorithm uses the Dantzig-Wolfe decomposition method for linear programming. The subprograms are simple network flow problems that are solved by dynamic programming. The master program in the decomposition algorithm is an LP problem with only zero-one elements in the matrix and the right-hand side. Integer solutions are not guaranteed, but generation and solution of a large number of problems indicates that the frequency of fractional solutions is as small as 1-2 per cent. Problems with about 40 ships and 50 cargoes are solved in about 2.5 minutes on an IBM 7090. In order to resolve the fractional cases, integer programming experiments have been made. The results will be reported in a forthcoming paper. (Author)

REVIEW: An algorithm is described for use in scheduling cargoes on a given fleet of ships between a set of origins and destinations. The object is to minimize transport costs while getting all cargoes to their destinations on time. The major difference between this problem and the Transportation Problem is that a ship can carry more than one unit of cargo. For this reason the Transportation Problem cannot be used at all for solving this problem.

Three linear programming models which are described in general may be used. Model 1 is a multicommodity flow model in which the objective function is an expression for total revenue which must be maximized. The three basic sets of constraints include flow constraints, ship constraints, and cargo constraints. A typical problem might have 40 ships, 50 cargoes, a 60-day period with 4000 variables and 1000 constraints.

Model 2 is similar to Model 1 except that many of the flow constraints are eliminated using convexity constraints.

Model 3 is formed by the decomposition of Model 1 through the Dantzig-Wolfe method of decomposition. The end result is a master program with cargo constraints and an individual subprogram for each ship with its own constraints.

The cargoes used in the model are measured by such factors as size, type, earliest loading date, latest loading data, loading port, discharging port, time for loading and discharging, voyage costs, and revenue for optional cargoes. Ships are measured by size, permitted types of cargo, initial open position, initial open date, speed, fuel consumption, and position costs.

The algorithm is probably most useful on a computer. Included within the article are appendices on integer solutions of the algorithms, input data for the generation of random problems (includes tables of input data), and a simulated problem and its solution.

"Criteria for Social Investment"

Kenneth J. Arrow

Water Resources Research (U.S.), vol. 1, no. 1, April 1965, pp. 1-8

KEYWORDS: Planning

ABSTRACT: This is an elementary exposition of choice criteria for social investment which draws on water resources for illustrative examples. After discussing the two causes for discounting future benefits, time preference and opportunity cost, the inappropriate nature of many social investments is explained. A description of problems in the measurement of benefits includes: divergence between social and private benefits, shadow pricing, economies of scale and consumers surplus, and production and consumption benefits. The choice of a discount rate for the commensuration of benefits and the measurement of costs are discussed.

Matthew J. Sobel (U.S.)

"Vybor optimal'nogo kompleksa tekhnicheskikh sredstv dostavki gruzov" (Selection of an Optimal Complex of Technical Means of Supply of Goods) (in Russian)

B. A. Atlas and S. S. Gdalevich

Ekonomika i matem. metody. (USSR) vol. 2, no. 3, 1966, pp. 394-405

KEYWORDS: Scheduling; Transport

ABSTRACT: The following problem is considered: given a certain number of points between which water transportation is possible, it is required to select a complex of technical means of supply of goods (types of ships and methods of mechanization of loading-unloading) so as to guarantee given volumes of transport with minimal total incurred costs. Utilizing certain properties of actual transportation processes, the authors construct for solution of the posed problem an algorithm which employs dynamic programming methods. A numerical example is given.

Yu. Finkel'shteyn (USSR)

"Ob Odnom Priblizhennom Metode Resheniya Zadach po Rasstanovke Flota" (An Approximation Method for Solution of Problems on the Disposition of a Fleet) (in Russian)

V. P. Bakhrakh

Primenenie Matematiki v Ekonomike (U.S.S.R.), no. 1, 1963, pp. 133-146

KEYWORDS: Fleet; Transportation Model; Transport

ABSTRACT: An approximate algorithm is given for solving the generalized transportation problem using the example of the optimal distribution of vessels of the Far Eastern steamship line.

(A. Sobolev)

"Pooling Cross Section and Time Series Data in the Estimation of a Dynamic Model: The Demand for Natural Gas"

Pietro Balestra and Marc Nerlove

Econometrica, Vol. 34, No. 3, July 1966, pp. 585-612.

KEYWORDS: Forecast; Forecast Technique

ABSTRACT: In this paper, we consider two basic aspects of demand analysis, with application to the demand for natural gas in the residential and commerical market. The more fundamental one consists in the formulation of a demand function for commodities--such as natural gas--whose consumption is technologically related to the stock of appliances. We believe that in such markets, the behavior of the consumer can be described best in terms of a dynamic mechanism.

Related to this is the more specific problem of estimating the parameters of the demand function, when the demand model is cast in dynamic terms and when observations are drawn from a time series of cross sections.

Accordingly, this paper is centered around these two major themes, although, as the title suggests, the emphasis is placed on the second one. In Section 1, we present the theoretical formulation of the dynamic model for gas. In section 2, the results of the estimation of the gas model by ordinary least squares methods are presented. These results, together with more fundamental theoretical considerations, suggest a different approach. The essence of this approach, which is not restricted to the gas model, is discussed in Section 3, while two alternative procedures for estimating the coefficients of the dynamic model in the light of this new approach are proposed in Section 4. It is subsequently shown that the application of these procedures to the gas data produces results that are reasonable on the basis of a priori theoretical considerations. (Author)

U.S.A. and Its Economic Future

Arnold B. Barach (Twentieth Century Fund, Inc.)

The Macmillan Company, New York, 1964

KEYWORDS: Forecast

REVIEW: This very general text outlines such U.S. trends as employment, population, agriculture, consumption, housing, clothing, recreation, travel, government, income, and education during the period from the early 1900's to 1962. Bar charts are extensively used and the relevant facts are presented in simply written style. An excellent annotated Appendix offers a statistical summary of all major facts.

Projections are made to 1975 - the methods of predictions are not given. Discussions of societies' future in terms of attitudes, environment, and the U.S.'s place in the world are also presented in general terms.

"An Algorithm for the Minimum Number of Transport Units to Maintain a Fixed Schedule"

T. E. Bartlett (Management Sciences Research Group, Purdue University)

Naval Logistics Research Quarterly, vol. 4, no. 2, June 1957, pp. 139-149

KEYWORDS: Fleet; Scheduling; Transport

ABSTRACT: This paper is the first in a series on various aspects of transportation systems planning and control. Although the concrete focus of these studies currently is rail transportation, results also applicable to other modes of transportation will be presented in covering generality wherever possible. Thus, we shall develop in this paper a method for evaluating the minimum number of "transport units" required to maintain a fixed schedule.

The analysis culminates in an algorithm which employs only data usually found in schedules, e.g., arrival and departure times of the various runs at the various termini during the typical time period. It develops the minimum number of transport units required in terms of certain convenient quantities related to: (1) the times associated with minimal total layover of transport units between arrivals and departures, (2) the times associated with runs between terminals, (3) the length of the typical time period.

The proof that this algorithm is valid embodies additionally a theorem of more general interest on finite ordered sequences of numbers. (Author)

"An Inventory Theoretic Model of Freight Transport Demand"

W. J. Baumol and H. D. Vinod

Management Science, Vol. 16, No. 7, March, 1970, pp. 413-421

KEYWORDS: Transport; Transportation Model

ABSTRACT: The model in this paper is intended to explain the choice of transport made by shippers, as well as their total demand for transportation services. The optimal choice of mode is shown to involve a trade-off among freight rates, speed, dependability (variance in speed) and en-route lossage. It is shown that faster, more dependable service simply reduces the shipper's or receiver's inventories, including his safety stock and his inventory in transit. Hence inventory theory makes possible a direct comparison of the four attributes on which mode selection is based and leads to a model of rational choice in transport demand. The resulting model is suitable for statistical estimation given adequate data. (Author)

"Several of the Forecasting Techniques in Use Today"

Richard Berger (Commercial Research Engineer, General Aniline & Film Corp., New York City)

Commercial and Financial Chronicle, Vol. 189, May 1959, pp. 2210-2211

KEYWORDS: Forecast; Forecast Technique

ABSTRACT: For businessmen and analysts, Dr. Berger defines forecasting, explains why or how it may be used and its construction. The chemical firm's statistician discusses the pros and cons of non-numerical and numerical methods. With regard to the former, he evaluates the methods of consensus of executive opinion, sales manager's estimates, historical analogy, composite by industry experts and sampling of group opinions, and, regarding the latter, the methods involving trends, cycles and correlations. The author concludes by offering criteria to judge which of the several methods to use. (Commercial and Financial Chronicle)

"A Model For Maritime Transportation Systems"

Paul B. Billing and J. E. Walsh (System Development Corp., Santa Monica, Calif., SP105300001, April 26, 1963)

U.S.G.R. and D.R., April 1963, 19 p., available NTIS, Doc. No. AD-407 320

KEYWORDS: Fleet; Scheduling; Transport

ABSTRACT: A model for maritime transportation systems is presented. Procedures are outlined for quantifying and interrelating the many factors that are involved in a worldwide maritime operation over a given period of time. In broad terms, the simulation model consists of the inputs to the over-all maritime system, a method of determining the operation of the system on the basis of these inputs, and the outputs that result from this operation. Some of the inputs and system interrelations are controlled by the nation whose maritime operation is being considered for improvement. An evaluation criterion is used for representing the over-all desirability of the system outputs from the viewpoint of this nation. Then, on a parametric analysis basis, a study can be made with respect to the choice of inputs and interrelations (of those controlled) that are most desirable for this nation. Methods are outlined for deciding on inputs that are not controlled and for efficiently performing the simulations. (Author)

"Forecasting Imports: A Re-examination"

I. G. Black, J. E. Kidgell, and G. F. Ray

National Institute Economic Review, November 1967, pp. 52-57

KEYWORDS: Forecast; Import Forecast

REVIEW: This article discusses the empirical testing of import forecasting equations developed by Godley and Shepherd in 1965. The testing was carried out with Britain's national income accounting data from 1965 to 1967.

The imposing of coefficients for a more probable marginal propensity to import was ruled out as the resulting error was significant--the equations with freely determined coefficients were more accurate. (An import surcharge was in effect in Britain from October 1964 until the end of November 1966. Therefore another variable had to be added to the equation to take this into account.)

The authors experimented with disaggregated import forecasts and concluded that little, if any, improvement on aggregate forecasts results. However, the alternate approach serves as a useful check.

"Econometricians: How They Predict the Economic Future"

George A. W. Boehm

Management Review, vol. 56, September 1967, pp. 22-26

KEYWORDS: Forecast; Forecast Technique

REVIEW: This very general article defines econometrics and then in layman's terms mentions econometric models in practical use today.

These models may be used for forecasting and thus should be recorded as sources of research. Three important models of interest are:

a) 300 variables in 300 equations maintained at the Brookings Institution in Washington.

b) 80 equation model of the "Economic Forecasting Unit" of the Wharton School of Finance and Commerce, University of Pennsylvania presided over by Professor Lawrence R. Klein.

c) Input-output model (500 by 500 used by Professor Wassily Leontief of Harvard.

"Container Interchange and Pooling Arrangements"

Booz, Allen and Hamilton, Inc., New York

U.S.G.R. and D.R., June 1970, 223 p., available NTIS, Doc. No. PB-192 611

KEYWORDS: Transport

ABSTRACT: The purpose of the study was to identify current technical and commercial methods of interchange and pooling. Comprehensive analyses were made of selected methods. Feasible container interchange and pooling alternatives were evaluated in circumstances involving intra-and intermodal equipment operated domestically and internationally. A relationship between pooling and interchange was established. Conclusions were developed about existing impediments to interchanging and pooling intermodal containers used in international service, and the requirements to improved international intermodal interchange and pooling were identified. Existing and developing requirements of shippers and carriers were concurrently assessed for intermodal containers in export/import trade through 1973, to show the growing importance of international interchange. (Author)

"Economic Survey and Master Plan for Port Development the Port of Detroit"

Booz, Allen and Hamilton, Inc., Chicago. Ill.

U.S.G.R. and D.R., May 1963, 59 p., available NTIS, Doc. No. PB-170 166

KEYWORDS: Port; Planning

ABSTRACT: This report is divided into five major sections. The first section deals with the present and probable future volume of overseas cargo and the facilities required for handling it at the for-hire terminals. This cargo represents about 3% of Detroit's total waterborne commerce. The second section deals with the domestic and Canadian cargo handled by the for-hire terminals. This cargo is about 2% of total waterborne commerce through the port. The third section deals with the handling of domestic and Canadian cargo which flows over owner-used private docks. This cargo, which is largely bulk, accounts for the other 95% of waterborne commerce through the port, which in 1961 totaled 25 million tons. The fourth section discusses opportunities for development of water-oriented industries within the limits of the Wayne County waterfront. The fifth section deals with administrative and promotional factors related to the growth of the port.

"Difference Equations in Forecasting Formulas"

J. L. Brenner, D. A. D'esopo, and A. G. Fowler

Management Science, vol. 15, no. 3, November 1968, pp. 141-159

KEYWORDS: Forecast; Forecast Technique

ABSTRACT: The deviation of actual sales (or other time-dependent statistics) from a model of sales will give rise to forecasting errors that are enhanced, damped out, or shifted in phase, depending on the particular formulas that are used for forecasting. Following R. G. Brown, P. Winters, and Theil, Nerlove, and Wage, we start from a general set of forecasting formulas, but make fewer assumptions than those authors about deviations from the model, and obtain a more extensive collection of results. In particular, we show how to treat errors not serially uncorrelated, and how to investigate forecasting formulas of order higher than second. (Author)

"Selecting Delivery Dates in the Tanker Scheduling Problem"

Lawrence E. Briskin

Management Science (U.S.), vol. 12, no. 6, Feb. 1966, pp. B-224--B-235

KEYWORDS: Scheduling; Fleets

ABSTRACT: When scheduling tankers it is necessary to determine delivery dates. If multi-port discharges are permitted it is also necessary to determine proper volumes to be discharged at each port on a given voyage. This paper uses dynamic programming to determine a schedule of delivery dates and volumes for multi-port discharges. It is conjectured that the optimal strategy is to rank the ports by demand. When making a voyage, tanker capacity is then allocated to the respective ports in such a fashion that the port with the lowest demand receives the maximum possible load subject to not violating constraints. This rule has the effect of delivering loads with the maximum time value. The procedures may be used in conjunction with the Dantzig-Fulkerson routing schema. (Author)

REVIEW: An algorithm using dynamic programming is described in detail for the determination of a program of delivery dates and volumes for multi-port discharges. For simplification, one size of tankers is assumed. The main objective is to minimize the total cost which is equal to the sum of the costs of the voyages made during the individual periods. The algorithm is solved using a set of tableaus or tables. A step-by-step method is described in detail which doesn't seem too difficult if one can follow subscript notation and simple directions. As in any type of algorithm, the most difficult part is obtaining accurate input data. Due to the nature of this article and of the algorithm, the reader must understand not only the theory but also the mechanics in order to use the method in solving an actual problem.

"Comments on a Paper by A. Novaes and E. Frankel, 'A Queuing Model for Unitized Cargo Generation'"

J. F. Brown

Operations Research (U.S.), vol. 15, no. 3, May-June 1967, pp. 572-575

KEYWORDS: Export; Transport

ABSTRACT: Some discrepancies in an earlier paper describing a bulk service queuing situation with customer balking or reneging are pointed out, and a solution to the balking situation is suggested resulting in a set of differential-difference equations which may be solved recursively. This reformulation makes the model more valid and introduces a method for developing the state-time probabilities of the system. (Referee)

"A Study of the Port of Savannah, Georgia"

Chatham County-Savannah Metropolitan Planning Commission, Savannah, Ga.

U.S.G.R. an D.R., April 1970, 76 p., available NTIS, Doc. No. PB-196 668

KEYWORDS: Planning; Port

ABSTRACT: Shipping statistics are presented for Savannah and other major southeastern seaports. These statistics are meant to show whether total cargo tonnage shipped through Savannah is increasing as rapidly as tonnage shipped through other southeastern ports. Specific recommendations are made for improving the competitive position of the Port. (Author)

"Isthmian Canal Demand Forecast. An Economic Analysis of Potential Tonnage Traffic"

Walter J. Chilman (Department of Transportation, Washington, D.C.)

U.S.G.R. and D.R., 1969, 82 p., available NTIS, Doc. No. PB-185 015

KEYWORDS: Forecast

ABSTRACT: This paper presents the results of an economic analysis that develops an estimate of tonnage demand for commercial traffic through an isthmian passage in the Panama area. The study examines the historical relationship between time series growth of commercial tonnage in the Panama Canal traffic to several combinations of independent variables to establish an acceptable correlation for a mathematical equation that serves as a forecasting device. Total commercial traffic is expected to develop to about 338 to 409 million long tons by the year 2000 reflecting a downward shift in annual growth to about half that of the post-war experience. (Author)

"Development of Computers as Aid to Harbor Management," (Developpment des calculatrices electroniques comme auxiliaires de direction portuaire)

J. F. Corellou (Y. Bossard et P. Michael, Paris, France)

Fifth International Harbour Congress, June 2-8 1968, Antwerp, Belgium; Kon Vlaam Ing, Papers 1968, Section 1968, Section 8-COR, 13 p.

KEYWORDS: Port

ABSTRACT: Author analyses nature of problems to be taken care of and treats measures and methods to be used in order to make management effective. In French. (Engr. Index)

"A Two-Stage Forecasting Model: Exponential Smoothing and Multiple Regression"

Dwight B. Crane and James R. Crotty

Management Science, vol. 13, no. 8, April 1967, pp. B501-B507

KEYWORDS: Forecast; Forecast Technique

ABSTRACT: This paper presents a forecasting technique which attempts to combine the advantage of both time series analysis and multiple regression. In this two stage technique, an exponentially smoothed moving average model is used to forecast values of the dependent variables and/or selected independent variables as desired. These forecasts, along with data for other (lagged) independent variables, are then used as inputs to a multiple regression program. The objectives are selected sequentially by the regression model so that each equation is based only upon data which would have been available at the time of the forecast, and the coefficients of the equation are updated as new information become available. The final section of the paper describes a successful application of the two-stage model to a demand deposit (banking) forecasting problem. (Author)

"Simulated Shipping"

I. M. Datz

Datamation (U.S.), February 1966, pp. 61-63

KEYWORDS: Simulation Model; Transport; Transportation Model

ABSTRACT: A brief description of a mathematical simulation of ship operations developed by A. D. Little, Inc. and U. S. Maritime Administration. The objectives of the simulation lie in the following areas: 1) evaluation of subsidies, 2) evaluation of vessel replacement programs, 3) trade route reviews, 4) effects of competition and government cargo offerings, 5) evaluation of advanced systems, 6) mobilization planning. In the model, ship activities are broken up into basic components (e.g., at sea, enter port, etc.), each of which is described by a subprogram. The sequence of simulated operations includes stochastic effects. The simulation implies an input of a desired schedule and a cargo generation. The model will allow for a large number of ports, ships and cargo types. Decision rules are not described. Because of the detailed structure of the model, running times are quite long for a large system. No details of the applicabiltiy of the results are given and no measure of the achievement of the objectives is reported. Ernest Koenigsberg (U.S.)

REVIEW: This three page article presents qualitatively two examples of actual shipping models. The first is of Matson Navigation Company in San Francisco. For the past five years Matson has been using a simulation model which has aided management. Factors such as total cargo mix, ship scheduling, fleet composition, and labor practices were considered. Stochastic variability in cargo offerings, stevedoring costs, duration of port stays, and interport travel times were also taken into account. The model was concerned with West Coast-Hawaii trade only.

The other simulation model was developed as a joint effort by the Maritime Administration's staff and Arthur D. Little, Inc. Their model takes a much broader approach and considers trade conditions in any part of the world. It is mainly for long term rather than short term planning. Such things as vessel replacement programs, alternate trade routes, government control of cargo, and the seasonal variation in trade offerings were incorporated into the model. Natural delays caused by bad weather and crowded ports were also included. The number of ports considered within a problem greatly affected the capacity of the simulation. Other important limiting factors included the number of ships, ship space types, cargo classes, shipping lines, and ship fleets. A problem of maximum capacity might include 30 ports, 40 ships, 6 ship space types, 10 cargo classes, and 2 shipping lines. A problem of this magnitude, when simulated on an IBM 7090, might require between 3 1/2 and 5 1/2 hours per year of simulated time.

"Use of Computers for Port Administration"

(No author given)

Dock & Harbour Authority, vol. 44, no. 521, March 1964, pp. 366-8

KEYWORDS: Port

ABSTRACT: Use of electronic computers to solve port administration problems is illustrated by 2 applications; one example in Great Britian, employs computer mainly to carry out accountancy functions and statistical analysis; other example in United States, uses computer for operational purposes to control shipments and warehousing, and to obtain maximum utilization of port facilities, berths, docks, cranes, railways, and land transport. (Engr. Index)

"A Branch-bound Algorithm for Plant Location"

M. A. Efroymson and T. L. Ray (Esso Research and Engineering Company, Florham Park, New Jersey)

Operations Research (U.S.), Vol. 14, May-June 1966, pp. 361-368

KEYWORDS: Transport; Transportation Model

ABSTRACT: This paper discussed an integer-programming method for solving a special class of discrete programming problems called plant location. The basic contribution is that the problem is formulated as an integer program in such a way that the associated continuous problem can be efficiently optimized. A branch-bound algorithm is then used to solve the problem. The method discussed in the article has been successfully used to solve 'practical' location problems with upwards of fifty plants. (Authors)

"Missile Environment Shipping Simulation"

Martha Evans, Richard Margason, and John Neblett. (Army Transportation Research Command, Fort Eustis, Va. Interim Report No. 2, TCREC TR 61-126, October, 1961.)

U.S.G.R. and D.R., October 1961, 64 p., available NTIS, Doc. No. AD-272 411

KEYWORDS: Transport; Transportation Model; Port

ABSTRACT: A discussion is presented concerning a computer simulation of water terminal operations in a limited warfare situation for the time period 1965-1970. The missile environment shipping simulation is based on the fundamental techniques and rules of computer war games. The two sides in this simulation are Red, who attacks shipping activities, and Blue, who is attempting to supply a field-army-size operation in a beachhead situation. The results of the games are determined by the cargo mix, amount of cargo, and distribution of cargo delivered to the beach. Economic factors based on the number of damaged or destroyed Blue ships, amount of damaged or destroyed Blue cargo, number of Red sorties, and number of Red surveillance craft destroyed are also considered in the analysis of the results. The games simulated are determined by a factorial experiment using a fractional design to select the cases. This leads to multiple regression equations that will predict the results.
The goal of this effort is to simulate approximately 1,500 years of water terminal operations. This experience will be used to develop new water terminal concepts and/or future equipment requirements.
(Author)

"Application of Transportation Theory to Scheduling a Military Tanker Fleet"

Merrill M. Flood (Columbia University)

Operations Research, vol. 2, no. 3, May 1954, pp. 150-162

KEYWORDS: Transport; Scheduling; Fleet

ABSTRACT: A complete set of voyages for the tankers of the military fleet was computed so as to minimize the expected total distance to be traveled by the ships in ballast during the year ending 30 June 1950, based on deliveries according to the advance requirement estimates of the Armed Services Petroleum Purchasing Agency. The optimum route-schedule so computed required about 5 percent less mileage in ballast than would a schedule consisting entirely of simple round trips. No comparisons have been made with actual operations to determine the extent of conformity between the computed schedule and the actual sailings. The object of the analysis was to test the analytical approach of Koopmans on a fleet operation, as a first step in further development and application of such methods. The route-schedules obtained in this manner might well be compared with actual practice and the theory modified as necessary to allow for important factors not given proper attention in this first approximation. The author's interest in the problem was aroused by papers on transportation theory presented by Koopmans and Dantzig at a conference on linear programming in Chicago during June 1949, under the auspices of The Cowles Commission for Research in Economics of The University of Chicago. Frank L. Hitchcock, L. Kantorovitch, and Tjalling C. Koopmans have contributed independent formations of this same theory, and each has offered a computational scheme. Professor Koopmans, in his Introduction to the Chicago Conference Proceedings, has discussed the interrelation of the conference papers--including the bearing of some of these on the Hitchcock distribution problem. The present author has previously offered a computation scheme for treating the problem, including the troublesome degenerate cases. An extreme

degenerate case is that known as the "personnel assignment problem," as treated by Votaw and Orden and von Neumann. However, Orden has offered a simple and effective way to reduce the degenerate cases to nondegenerate ones easily manageable by Dantzig's simplex method; consequently the shipping example treated in the present paper is typical computationally for the general Hitchcock distribution problem. (Author)

"Forecasting Imports"

W. A. H. Godley and J. R. Shepherd

National Institute Economic Review, vol. 33, August 1965, pp. 35-42

KEYWORDS: Forecast; Forecast Technique; Import Forecast

REVIEW: This article discusses the development of equations for forecasting imports to Britain. The aggregate approach is described rather than the disaggregative approach to forecasting. That is, an attempt is made to find a relationship between the total volume of imports and various national expenditures (a commodity by commodity breakdown is not forecasted). The equations were developed for forecasting over a short period of 1-2 years.

Basically the method of formulation was to apply multiple regression analysis to historical data collected between 1955 and mid 1964. Experiments were conducted with several independent variables in order to find an adequate explanation, with the least cumbersome mathematical relationship, of the total movement of imports. Some of the independent variables investigated are as follows:

a) Final Sales - a measure of demand;
b) Stockpiling;
c) Time Trend;
d) Discrepancy between national expenditure figures and national income or output figures;
e) Capacity Utilization;
f) Unemployment.

Using final sales, stockpiling, and a time trend, a regression analysis was conducted yielding an equation which explained the volume of imports with an average error of slightly greater than 1%. This analysis was done using official figures which were determined by the National Expenditure approach to National Income Accounting. The fourth independent variable (d) was determined by formulating compromise figures using both the Expenditure approach and the Income approach to National Income Accounting. The resulting regression analysis reduced the average error to slightly less than 1%.

Experiments with the other independent variables listed did not produce any significant explanation. The disaggregation of demand (final sales) to provide further independent variables was also done on a limited basis. The resulting regression analysis proved that movements of import can be explained quite well without making any separate allowance for differing import content of the various sections of final demand.

The independent variable "stockpiling" was sub-divided into two major categories and a regression analysis run. The results indicated that such a breakdown is not required in order to obtain an aggregative picture of imports.

In summary, the past movements of the volume of imports can be explained by a relationship with total final sales, stockpiling, and of course, a time trend.

(The authors felt that the coefficients determined by regression analysis were out of line with the marginal propensities to import developed in Britain input-output table. Therefore they imposed certain coefficients which they thought were more probable. A later article by Black, Kidgell and Ray disproves this theorem.)

"Towards an Economic Appraisal of Port Investments"

R. O. Goss

Journal of Transport Economics and Policy, vol. 1, no. 3, September 1967, pp. 249-272

KEYWORDS: Economic Analysis; Port

ABSTRACT: There is widespread agreement that port facilities in many countries need improvement, partly to serve increased volumes of trade and partly because it appears that substantial economics in the cost of sea transport can only be achieved by improvements in seaports. The object of this paper is to discuss methods by which such proposals may be appraised. The discussion is, however, confined to proposals to improve the point of contact between ship and port, rather than the warehousing, processing and other activities which also take place in or near ports. (Author)

REVIEW: This paper considers port investments mainly from the economic viewpoint and at the micro scale, that is, one port at a time. This paper is mostly qualitative in nature but does quote various statistics to give some idea of the quantities being considered. There is, however, an appendix which presents the basic idea of the paper in mathematical form. The author stresses the idea that port investments are inevitable and that the basic questions are where, when, and how. He then goes on to describe various economic methods which may be used to answer some of these questions. Some of these include the social cost-benefit approach, the net present value approach, and the discounted cash flow approach. A section is presented on port planning and its relationship to national planning. The author does feel that within any country there should be a national port planning commission which coordinates the activities of the individual port authorities. One of the primary functions of this central port authority would be the optimum allocation of funds for port improvement and expansion.

Only through an impartial central authority could funds be distributed so as to maximize the overall national return on investment.

"Choice of Ships for the Routes of Foreign Transports by Linear Programming Methods" (in Russian)

E. Gromovoi and V. Suhotkii

Morskoi Flot (USSR). 1962, no. 9, pp. 15-17

KEYWORDS: Fleet; Scheduling; Transport

ABSTRACT: The problem mentioned in the title is reduced to a linear programming problem. A small example is introduced and solved by the index method. Reviewer's note: In the transformation of the expression for f (page 15) a gross algebraic error occurs

$$\left(\sum_{i,j} a_{ij} b_{ij} = \sum_{i,j} aij \sum_{i,j} b_{ij} ??\right)$$

A. Korbut

"Minimum-Time Ship Routing by Calculus of Variations Methods"

Harry D. Hamilton (Naval Postgraduate School, Monterey, Calif., Master's Thesis, 1961)

U.S.G.R. and D.R., 1961, 17 p., available NTIS, Doc. No. AD-262 324

KEYWORDS: Scheduling; Fleet; Transportation Model; Transport

ABSTRACT: The minimum-time route is determined by calculus of variations, rather than the conventional manual technique. The method consists of solving the associated Euler equation by numerical integration on the Control Data Corporation model 1604 digital computer. In case 1 the ship's speed is assumed to be primarily a function of position; and in case 2 the ship's speed is taken to be a function of its direction as well as position. Case 2 is recommended for operational adaptation. (Author)

"Great Lakes Port and Shipping Systems Research Report For: Office of Ports and Intermodal Systems U.S. Maritime Administration. Part I"

Melvin A. Hanson, Jehiel Novick, William A. Rabiega, and Roger H. Yaeger (Southern Illinois University, Carbondale, Transportation Inst.)

U.S.G.R. and D.R., Oct. 1969, 64 p., available NTIS, Doc. No. PB-188 791

KEYWORDS: Port

ABSTRACT: The Great Lakes ports and shipping systems study has four goals: To ascertain the effect of the St. Lawrence seaway upon traffic of U.S. Great Lakes ports; to highlight trends in the shipping system, pinpointing those ports which are favored by these trends, to recommend some generalized means whereby recognized problems may be met and favorable developments augmented; and to provide a complete reference source for those interested in United States Great Lakes ports. It is presented in two parts. The document contains part 1 which is the analytical section of the research. The first three areas, or goals, are covered therein. (Author)

"Great Lakes Port and Shipping Systems Research Report For: Office of Ports and Intermodal Systems U.S. Maritime Administration. Part II"

Melvin A. Hanson, Jehiel Novick, William A. Rabiega, and Roger H. Yaeger (Southern Illinois University, Carbondale. Transportation Inst.)

U.S.G.R. and D.R., Oct. 1969, 258 p., available NTIS, Doc. No. PB-188 937

KEYWORDS: Port

ABSTRACT: The report is a companion volume to three United States seaports publications. It contains data of value to commerce and shipping interests. This data consists of rates, services, and charges; labor contracts, rules, benefits, wage rates and related data; foreign and domestic trade; port development and port-related technical studies and research programs; and policy and legal actions taken by the Federal Government affecting the port industry. (Author)

"Computerized Scheduling of Sea-going Tankers"

H. O. Hartley, and M. D. McKay (Texas A & M University, College Station, Inst. of Statistics)

U.S.G.R. and D.R., April 1971, 25 p., available NTIS, Doc. No. AD-724 804

KEYWORDS: Transport; Scheduling

ABSTRACT: The paper represents a condensed summary of the mathematical aspects of a project which was carried out with the active cooperation of Defense Supply Agency Headquarters (DSAH), Defense Fuel Supply Center (DFSC), Military Sea Transportation Service (MSTS), Office of Naval Research (ONR). It must not be regarded as a complete statement of the logistic ramifications of the operational problem of the scheduling of tankers, but rather as a somewhat idealized version of the real life situation. The authors should state however that the computer program they have developed and which is briefly sketched in section 6 takes account of all operational aspects although certain modifications are still in progress. Mathematical formulations of the problem are given. One is a reduction to non-convex integer programming problem. The other (utilizing operational restrictions for the feasible tanker routes) reduces the problem to linear integer programming which is solved by a decomposition algorithm. (Author)

"Are Gravity and Interactance Models a Valid Technique for Planning Regional Transport Facilities?"

I. G. Heggie

Operational Research Quarterly, (U.K.), vol. 20, no. 1, March 1969, pp. 93-110

KEYWORDS: Transport; Transportation Model

ABSTRACT: After briefly introducing the gravity and interactance models, the following article goes on to discuss the status of these models and asks: are the hypotheses reasonable; are the models logically consistent; and do the models fit the facts? The first two sections are of a theoretical nature although a number of practical examples are given to illustrate certain of the points made. The third section consists of a series of case studies covering UK port traffic; inter-urban traffic in Ghana; and urban road traffic in Oxford. Graphs are plotted to show the relationship between the various traffic model parameters. The general conclusions from the analysis is that gravity and interactance models do not provide a valid means of producing traffic forecasts in a regional environment. The concluding section is devoted to discussing other methods of traffic forecasting and suggesting the most promising areas for future research. (Author; refereed)

"Port of Future"

S. Johnson (Institution of Engineers and Shipbuilders in Scotland)
Transportation, vol. 111, part 3, 1967-68, pp. 129-156, part 4, pp. 157-162

KEYWORDS: Port

ABSTRACT: Factors which govern type, location and capacity of ports required in immediate future; these factors are primarily economic--changes in cargo and passenger traffic and costs of sea and land components of transport, also cost of competing systems such as air transport; technical factors are concerned, such as possibility of building and operating larger and more specialized ships, and new ways of cargo handling. (Engr. Index)

"An Efficient Branch and Bound Algorithm for the Warehouse Location Problem"

Basheer M. Khumawala

Unpublished Ph.D. dissertation, Krannert Graduate School of Industrial Administration, Purdue University, June 1970

KEYWORDS: Transport; Transportation Model

ABSTRACT: This paper introduces an efficient branch and bound algorithm for a special class of mixed integer programming problems called the warehouse location problem. A set of branching decision rules is proposed for selecting warehouses to be constrained open and closed from any node of the branch and bound tree. These rules are tested for their efficiency in reducing computation times and storage requirements to reach optimal solutions. An improved method of solving the linear programming problems at the nodes which substantially reduces the computations is also introduced in this paper. (Author)

"A Comparison of Short and Medium Range Statistical Forecasting Methods"

Robert M. Kirby (The Singer Company, New York)

Management Science, vol. 13, no. 4, December 1966, pp. B202-B210

KEYWORDS: Forecast; Forecast Technique

ABSTRACT: Exponential Smoothing, Moving Average, and Least Squares forecasting models were tested by simulating their operation on seven years of actual data for various sewing machine product groups. The relative accuracy of the forecasts varied according to the length of the period being forecasted and the characteristics of the data. Tests were also conducted on synthetic series designed to isolate the cyclical, trend and noise components. For the series tested, the Exponential Smoothing and Moving Average methods were about equal in overall performance for intermediate range forecasts (next six month's demand). For the short range (next month's demand), the Exponential Smooth gave slightly better over-all results. The difference in relative performance between the Exponential Smoothing and Moving Average methods for intermediate versus short range forecasts appears to be due to a subcomponent identified as "caused noise". (Author)

"Quantitative Models to Represent Port Operations"

U. K. Kohli

Opsearch (India), vol. 5, no. 2, June 1968, pp. 75-87

KEYWORDS: Port; Transportation Model; Transport

ABSTRACT: The basic operations at an ocean port are identified. A quantitative model using queuing theory is developed to determine the total turn-round time. N. K. Jaiswal (India)

REVIEW: This paper presents a very simple mathematical model of a port which takes into account only the basic operations. The formulas used are very simple and all variables used are defined very clearly. A queuing model is used for ship arrivals. Using different combinations of turn around times and arrival rates, varying port capacities are achieved. By picking certain combinations, the port capacity can be maximized. It is pointed out that the model developed is useful in developing information which can be used for making decisions. Among the possible decision areas are the movement of ships, type of cargo handling facilities, type of cargo storage facilities, the rail and road movements of cargo, and the effect of external factors.

"A Hueristic Program for Locating Warehouses"

Alfred A. Kuehn and Michael J. Hamburger (Carnegie Institute of Technology, Pittsburgh, Pennsylvania)

Management Science, Vol. 9, July 1963, pp. 643-666

KEYWORDS: Transport; Transportation Model

ABSTRACT: The linear programming algorithms available for optimizing the routing of shipments in multi-plant, multi-destination systems cannot, in the current state of knowledge, be applied directly to the more general problem of determining the number and location of regional warehouses in large-scale distribution networks.

This paper outlines a heuristic computer program for locating warehouses and compares it with recently published efforts at solving the problem either by means of simulation or as a variant of linear programming. The heuristic approach outlined in this paper appears to offer significant advantages in the solution of this class of problems in that it (1) provides considerable flexibility in the specification (modeling) of the problem to be solved, (2) can be used to study large-scale problems, that is, complexes with several hundred potential warehouse sites and several thousand shipment destinations, and (3) is economical of computer time. The results obtained in applying the program to small scale problems have been equal to or better than those provided by the alternative methods considered. (Authors)

"Vessel Allocation By Linear Programming"

J. Laderman, L. Gleiberman, and J. F. Egan (Operations Research Department, Service Bureau Corporation, New York, New York)

Naval Logistics Research Quarterly, vol. 13, no. 3, September 1966, pp. 315-320

KEYWORDS: Fleet; Scheduling; Transport; Transportation Model

ABSTRACT: This paper presents a linear programming model of a fleet of vessels which is required to transport quantities of cargo, such as coal, iron ore, limestone, and salt from certain producing ports to specific destination ports. This model has been implemented and is currently being used both for planning purposes and as an aid in scheduling the trips to be made by each vessel. (Authors)

"Overcoming the Limitation of General Economic Forecasts"

Oscar F. Litterer (Business Economist, Federal Reserve Bank of Minneapolis)

The Commercial and Financial Chronicle, Vol. 190, number 5868, July 1959, p. 423

KEYWORDS: Forecast

ABSTRACT: Limitations of the general type of forecasts, even when accurate, for credit men, individual firms, regional appraisals, etc., trying to predict future trends can be overcome, according to Dr. Litterer who explains how in his brief paper. The economist prefers a composite of forecasts to a single one, and avers that an explanation of the forces underlying a decline, for example, may be more important than the percentages.

"Port Management Problem Study"

Arthur D. Little, Inc., Cambridge, Mass.

U.S.G.R. and D.R., July 1969, 35 p., available NTIS, Doc. No. PB-185 468

KEYWORDS: Port

ABSTRACT: The purpose of the study was to: (1) identify key problem areas where the introduction of new management techniques could assist management in improving the efficiency of U.S. port operations; (2) develop research recommendations for the Maritime Administration that could assist in the industry's efforts to cope with changing managerial requirements; and (3) identify the information and data requirements that would enable port managers to make better decisions in both short and long-term port development and operations. During the course of the study a selection and survey of representative seaports on the Great Lakes, the Atlantic, the Pacific and Gulf coasts was made. (Author)

"Waterborne Feeder Subsystems for Unitized Cargo Transportation, Volume 1."

Arthur D. Little, Inc., Cambridge, Mass.

U.S.G.R. and D.R., March 1970, 88 p., available NTIS, Doc. No. PB-191 478

KEYWORDS: Transport

ABSTRACT: In view of the planned development of large unitized container ships that will serve only a few major 'express' ports, there is growing interest in the possibility of instituting waterborne feeder services (WFS) to and from subsidiary ports. A study was made to examine the desirability and feasibility of such services. Volume I is devoted to assessing the demand for WFS in sample trade environements, and to selecting vehicle specifications appropriate to these environments. (Author)

"Waterborne Feeder Subsystems for Unitized Cargo Transportation."
Volume 2 Appendices

Arthur D. Little, Inc., Cambridge, Mass.

U.S.G.R. and D.R., Dec. 1969, 213 p., available NTIS, Doc. No. PB-191 479

KEYWORDS: Transport

ABSTRACT: Volume II contains Appendices A through V and also a separate report entitled 'Characteristics of Waterborne Feeder Vessels for Unitized Cargo Transportation.'

"Forecasting Exports and Imports: Introduction"

R. L. Major

National Institute Economic Review, Volume 42, November 1967, pp. 32-34

KEYWORDS: Export Forecast; Import Forecast; Forecast

REVIEW: This article is simply an introduction to the following two readings:

a) "Forecasting British Exports of Manufactures to Industrial Countries," National Institute Economic Review, Volume 42, November 1967, pp. 35-51;

b) "Forecasting Imports - a Re-examination," National Institute Economic Review, Volume 42, November 1967, pp. 52-57.

A discussion of the accuracies of the forecasts - import and export - brings to light the problems involved in forecasting even in the short run. Comparisons between forecasted and actual figures for 1962-1967 are made. Forecasts for imports are fairly accurate in the short run given that government policies are unchanged. However, export forecasts are significantly inaccurate due to exogeneous factors such as the demand for goods and services in the many diversified countries of the world.

"Etude de la Capacite d'un Port Mineralier" (Study of the Capacity of an Ore Port)

Jacques Melese

Gestion (France), vol. 8, June 1965, pp. 342-350

KEYWORDS: Import; Transport; Transportation Model; Port

ABSTRACT: Ship arrivals, unloading equipments, works requirements are described. A parametric linear program optimizes the use of existing equipment, the daily requirements being used as a parameter. Ship arrivals are manually simulated by a stuttering--Poison distribution to study demurrage variations, equipment use and service to works. Claude Witkowski (France)

"Seaports and Waterways Master Plan"

Metropolitan Dade County Planning Dept., Miami, Florida.

U.S.G.R. and D.R., Dec. 1968, 69 p., available NTIS, Doc. No. PB-184 728

KEYWORDS: Port; Planning

ABSTRACT: The study is one of five master plan elements which have been prepared as part of a comprehensive transportation master plan. The element is part of the joint federal, state, and county sponsored Miami Urban Area Transportation Study. The master plan examines goals for seaport and waterway development to 1985 and concludes that: (1) Miami has the potential of becoming the foremost cruise passenger port in the nation: (2) Port and waterway activity must remain compatible with an unpolluted resort environment and a tourist economy; and (3) Port of Miami cargo activity should complement, not duplicate that at Port Everglades (Broward County). Alternative port sites are considered, including the possiblity of an industrial bulk cargo port in the southern portion of the county. The master plan recommends rehabilitation of the Miami River as an urban waterway through bulkheading, revised land uses on its banks, and a general clean-up effort. Because of uncertainty over the effect upon Biscayne Bay of a bulk cargo port development, dredging and channel construction, the master plan suggests a comprehensive hydrological - biological ecological study of the bay, with a working hydraulic model. (Author)

"Modeling and Simulation of a Logistical Transportation System"

M. H. Mickle and D. E. Rathbone (University of Pittsburgh)

Institute of Electrical and Electronics Engineers, Region Six Conference, May 20-22, 1968, paper 2-A-2, 8 p.

KEYWORDS: Simulation Model; Transport; Transportation Model

ABSTRACT: This paper presents the results of a study of an ammunition allocation problem. The ammunitions are shipped from various origins in the Continental United States (CONUS) through major ports of embarkation (POE's) to various ports of debarkation (POD's) throughout the world. The shipment components together form an integral unit and must leave the CONUS on one ship. The shipment has a required delivery date at the POD. Each POE has a limited storage capacity and a maximum and a minimum throughput constraint. The problem is to allocate the ammunition shipments on a day-to-day basis so as to minimize shipping costs and to meet shipping schedules. The solution must of course satisfy such constraints as port capacity and storage, delivery dates, shipping dates and ship capacities.

The above system was modeled and simulated digitally. The modeling allowed scheduling, routing, and storage throughout the system such as to allow an optimization of the process with respect to shipping costs or to move the ammunitions in minimum time. The simulation was constructed around the occurrence of events in the system. Time is a basic input, and the system is dynamic. At the present time, the simulation model is performing the following functions:

1. Simulation
2. Optimization
3. Notification
4. Bookkeeping

(Authors)

REVIEW: This article presents a good example of transportation system modeling and simulation. The network used consists of three different types of terminals. These are inland origins, Ports of Embarkation, and Ports of Debarkation. The major emphasis in this report is the scheduling of a particular product through the network so as to meet a time deadline and minimize transport costs. A considerable portion of the report is devoted to the logic and reasoning going into the formulation of the model. Some of the constraints assumed in their model include limitations on port capacity and storage as well as certain delivery dates, shipping dates, and ship capacities. The transportation mode between the inland origins and the Ports of Embarkation is rail while the mode between the Ports of Embarkation and the Ports of Debarkation is ships. No capacity constraints are assumed on any mode for any section of the network except the Ports of Embarkation and the impedance or resistance of a given section of the graph is measured in dollars/ton and the transit time in days.

The simulation languages considered included SIMSCRIPT and GPSS but Mickle and Rathbone wanted to be able to interact with the simulation while it was being run which was impossible with these languages. Therefore, they finally chose FORTRAN IV as the language for this project.

Perhaps the most important single variable this system uses is time. For that reason it can be considered a dynamic programming problem.

"Economic Forecasts and Expectations"

Jacob Mincer, (Editor; National Bureau of Economic Research)

Columbia University Press, New York, 1969

KEYWORDS: Forecast; Forecast Technique

REVIEW: This text is a compilation of papers written by specialists in the field of economic forecasting. Empirical tests of forecasting methods are disclosed; the majority dealing with short term and quarterly forecasts. Discussions of data accuracy and measurement of forecast error are included along with progmatic considerations of forecasting. A fair degree of mathematical and statistical expertise is assumed as the models are depicted in these terms.

An extensive reference list is included at the end of every chapter. Edited by Jacob Mincer of the National Bureau of Economic Research, the text is valid and reliable as a source of information on short term economic forecasting in the United States.

"Berth Planning by Evaluation of Congestion and Cost"

S. N. Nicolaou

American Society of Civil Engineers - Proceedings, vol. 93 (Journal of Waterways and Harbors Division), no. WW4, Nov. 1967, paper 5577, pp. 107-132

KEYWORDS: Economic Analysis; Planning

ABSTRACT: Studies of observed patterns of ship arrivals in general cargo ports for which all berths are operated by port authorities indicate satisfactory agreement with Poisson's distribution function; analytical inter-relations between berth occupancy, congestion, fixed costs of idle port facilities, and cost of waiting ships have been developed, and presented graphically; tables and graphs enable determination of number of berths in port by graphical methods. (Engr. Index)

REVIEW: This paper presents a method of using graphs and tables, which are included, to determine the optimum number of berths in a given port so as to minimize capital costs. The basic assumption is that a port must be planned so as to satisfy the needs of both the steamship companies and the operators of the port facilities. Of course, the ideal situation is to have all the berths occupied all of the time.

Several different port parameters are defined precisely and then used to determine port size. The main parameters are "percentage of congestion", "percentage of occupancy", and "degree of congestion". Rigorous mathematical development of a Poisson queuing model for ship arrivals is included along with a mathematical interpretation of the relationship of the several port parameters previously mentioned. Other sections of the article include the relationship of congestion and occupancy to the costs of maintaining the berths and the influence of cargo handling rates on the total port operational costs.

Two numerical examples are included in which step by step methods are outlined for the planning of a new port and the evaluation of an existing port. The parameters or factors used in planning a new port include the following:

1. total annual general cargo handled in port
2. total annual general cargo handled per berth
3. cost per day of operating a berth
4. cost per day of operating an idle ship

The parameters used in evaluating an existing port are similar.

Although sophisticated mathematics is used throughout the article, the graphs and tables can be used without an understanding of this mathematics. In fact, the primary reason for developing this graphical and empirical approach to port planning was to eliminate the long calculations or extensive computer time that would be needed otherwise.

"A Queuing Model for Unitized Cargo Generation"

A. Novaes and E. Frankel

Operations Research (U.S.), vol. 14, no. 1, January-February, 1966, pp. 100-132

KEYWORDS: Export; Transport

ABSTRACT: A good attempt at developing a model of cargo generation and vessel allocation for cargo which can be considered uniform (containers, roll-on-roll-off or unitized bulk). Several assumptions regarding cargo generation are made, e.g., cargo offered depends on schedule, frequency of service is independent of fleet composition; and cargo loss is not further included in the model except for reneging. The authors consider both constant and exponential service times for service of cargo analytically and bulk queues by simulation and direct calculations. Ernest Koenigsberg (U.S.)

"Analysis and Simulation of Segmented Cargo Ship Operation"

O'Hughes, F. Seibold and E. Frankel (MIT, Cambridge, Dept. of Naval Architecture and Marine Engineering, August 1964)

U.S.G.R. and D.R., August 1964, 249 p., available NTIS, Doc. No. PB-166 666

KEYWORDS: Transportation Model; Scheduling

ABSTRACT: The problem is first to evaluate the economic feasibility of articulated ships under simplified and idealized conditions and to compare its profitability with that of conventional ships; second, to examine how this performance is affected by the random or stochastic processes which were ignored in the simplified economic analysis. The economic aspect was treated first by constructing a model which would primarily consider economic factors (revenue, costs, rate of return, etc.), and which would simulate only very simple operating characteristics. This first model is actually a "steady-state" analysis. The operational aspect was then examined with the use of a second model which allowed time-varying and stochastic inputs so as to give a high degree of realism.

"Medium-Range Scheduling for a Freighter Fleet"

C. A. Olson, E. E. Sorenson, and W. J. Sullivan

Operations Research (U.S.), vol. 17, no. 4, July-Aug. 1969, pp. 565-582

KEYWORDS: Fleet; Scheduling

ABSTRACT: A model of Matson Navigation Company's freighter movements has been created to schedule voyages between the West Coast and Hawaii for periods of three months. The model describes the ships and port facilities; it regards the West Coast as consisting of three port areas. Ship timings are based on average values; no stochastic variables are used. Inputs to a run include cargo forecasts and initial positions of the ships in the fleet. Decisions of ship movements are made sequentially on the basis of calculated voyage profit and service requirements. Twelve cargo classes and six port pairs are considered, but of 72 possible combinations of cargoes and port pairs, only 29 actually occur. Programming is in GPSS-III for the IBM 7094. IBM 360/30 programs were written to facilitate entry of data and also to tabulate the output in several types of management reports for easier analysis of results. A three-month period, in one-hour increments, takes six months to run on the 7094. The model utilizes the computer to obtain schedules in the region of optimum profit, consistent with certain rules laid down by management. The model has been used in planning activities of the current fleet and in studying requirements for the future fleet. It offers the following advantages: computational accuracy in production of medium-range schedules; incorporation of profit criteria in many schedule decisions; speed of testing many alternatives; and consequently, more responsive and satisfactory fleet scheduling than could be done by normal manual methods. (Authors. Reprinted from Opns. Res.)

REVIEW: The scheduling of the freighter fleet of Matson Navigation Company between Hawaii and the West Coast of the United State is the problem tackled in this article. The method used is presented in a completely qualitative manner with not one equation. The explanations of the logic and reasoning going into formulating the system is very clear. All assumptions are stated, flow diagrams are drawn, and the specific computers and computer languages are named and the reasons why they were chosen are given. Although very descriptive in nature, this article would provide a good background of basic knowledge which could prove useful in the formulation of similar models for use in fleet scheduling.

Techniques of Economic Forecasting

Organization For Economic Cooperation and Development

Paris, 1965

KEYWORDS: Forecast; Forecast Technique

REVIEW: This paperback is an account of the methods of short-term economic forecasting used by the Governments of Canada, France, the Netherlands, Sweden, the United Kingdom, and the United States. The methods discussed outline forecasts of GNP and its components for 1 to 2 years. The mathematics of the methods are kept to a minimum and the general pragmatic characteristics of various independent variables are discussed.

An introduction and general overview is presented by C. W. McMahon, formerly of Magdalen College and presently at the Bank of England. The overview in itself presents sufficient information on the various methods used and their problems.

"Transoceanic Cargo Study: Volume II. Distribution Costs and Productivities of Transoceanic Transport Technologies"

Planning Research Corporation, Los, Angeles, California 90024

U.S. Department of Transportation, Assistant Secretary for Policy and International Affairs, Office of Systems Analysis and Information, Washington, D.C. 20590, March 1971.

KEYWORDS: Economic Analysis; Transport; Planning

ABSTRACT: This is the second of three volumes presenting the results of the Transoceanic Cargo Study. It presents the costs and productivities of the transoceanic transport technologies for the years 1970-1980. Included are the B-747F/L-500 type jumbo cargo aircraft for the air mode and representative configurations of Bulkers, Tankers, Container Ships, Break-Bulk Ships, and Barge Carriers for the ocean mode. Consideration is also given to the domestic and foreign inland modes and to peripheral costs such as documentation, inventory, pickup and delivery, and insurance.

For information regarding use and operation of the program, contact R. D. Murphy, Department of Transportation, Washington, D.C. (A/D 202-426-2090)

REVIEW: This volume reports the results of a Transoceanic Cargo Study prepared for the Department of Transportation. Although the air and inland modes are considered, the bulk of the volume deals with the ocean mode. Each of the three sections explain the formulation of equations relating the various parameters used in measuring different factors which affect the transport cost or transport time for the given mode. For the section on the ocean mode, a brief outline of the basic logic of the mathematical model developed is presented. The model is designed to output shipping cost and total transit time. Other outputs include cargo waiting time, cargo handling and terminal cost, "Transoceanic Cargo Study: Volume II. Distribution Costs and Productivities of Transoceanic Transport Technologies" - 2

ocean transit time, cargo insurance or claims cost, etc. Five different vessel types are considered within the model. The model is deterministic since average values of parameters are used rather than probability distributions. A basic constraint of the model is that it is general and can therefore be used only for normal or average operating environments. Another constraint is that the number of user supplied input parameters was kept low so as to increase ease of use. For each parameter used, an equation is presented which relates the parameter to other parameters. The equation is then plotted on full page graphs. By knowing values of certain parameters, values of other related parameters can simply be read off the graph. These values can then be used as input data for the mathematical model of the entire shipping system.

"Optimum Size Seaport"

Carl H. Plumlee

Proceedings of the American Society of Civil Engineers, Journal of the Waterways and Harbors Division, ASCE, vol. 92, no. WW3, August 1966

KEYWORDS: Port

ABSTRACT: How many berths should be provided in a seaport? The answer to that question depends on various points of view and on the magnitude and the character of shipping that will use the port facilities.

It is natural that operators of steamship lines look with favor on a port having sufficient berthing space to accommodate every ship promptly on arrival, thereby eliminating the costly waiting time that results when there are not enough berths for all ships present. The berths in such a port may be vacant much of the time. It is also natural to expect that the operators of port terminal facilities generally would not want to have ship berths standing idle. Somewhere between these opposing objectives, each port must reach a compromise--hopefully, one that will provide the number of berths which will achieve the most economical transfer of cargo between ships and shore, considering all elements of cost.

The quest to discover techniques that may simplify solution of the problem stated above has led the writer into three principal areas of study that are reported and examined herein. These are:

1. Investigation of the patterns of ship traffic at seaports;
2. Determination of a theoretical relationship, in a seaport, between the average number of ships present and the number of berths available that will minimize the

combined costs of idle facilities ashore and afloat; and

3. determination of a theoretical relationship between the usage of berths of a port and the number of berths that will minimize the combined costs of idle port facilities and of ships waiting for a berth.

The writer does not attempt to provide a panacea for the problems of the managers and the planners of seaports. However, for those key executives, criteria and techniques are suggested to facilitate the decision-making process. (Author)

REVIEW: This article presents a methodology for finding the optimum number of berths for a port so as to minimize the total costs. The total costs are the costs of maintaining the port plus the costs of maintaining a ship while in a berth or waiting for a berth. A Poisson queuing model is used to describe the ship arrival pattern. Data used throughout the article are based on data from actual ports in Central America and Ecuador. The parameters used are the total number of ships using the port in one year, the average number of ships present, the cost of a vacant berth per hour, and the cost of a waiting ship per hour. The article is very clearly written and although it contains some advanced mathematics, very little of the general idea of the article will be missed if the mathematics is skipped. Many graphs and tables are presented to increase understanding of the method used.

Proceedings of the Fifth International Harbour Congress

(no author given)

June 2-8, 1968 Koninklijke Vlaamse Ingenieursvereniging, Ingenieurshuis, Jan Van Rijswijcklaan 58, Antwerp 1, Belgium

KEYWORDS: Planning; Port; Scheduling; Transport

ABSTRACT: The 5th International Harbour Congress which took place in Antwerp in June, from 2 to 8, 1968, as had been the case with previous congresses, brought together again a great many harbour experts. No less than 600 attending people from the 5 continents, representing 50 countries and 84 harbours, respectively, joined in the activities of one or more of the eight technical-scientifical sections of the congress.

As had been the case during the 4th Harbour Congress in 1965, the 5th also was complemented in an exciting way by the 2nd International Harbour Exhibition, which had been simultaneously prepared and proved quite interesting. In total 29 exhibitors took part, 12 of which were foreign harbours, 4 being Belgian harbours and 13 being firms. The exhibition was held in the same building as the congress, thus allowing the congress registrants to pay a series of visits to the stands. Said 2nd International Harbour Exhibition was opened with a certain solemnity on Sunday, June the 2nd, by Mr. L. Delwaide, duputy mayor for the Port of Antwerp, after an introductory speech by Mr. A. Meyfroot, president of the Exhibition. (Author)

REVIEW: The proceedings of the conference is published in a book of 185 pages which is categorized into such areas as geology and soil mechanics in harbor construction, hydraulic engineering in harbours and off-shore, port equipment for handling and transhipment of goods, etc. The organization of the conference was such that various selected people presented their own papers to all those interested. Some of the papers presented in the Port Management category, for example, included "How Should Port Authorities Operate?", "The Curtailing of the Turn-round of Ships in Ports," "Port Problems in Developing Countries," etc. A note is made at the beginning of the book that individual papers presented at the conference have been published and are available at the following address:

General Secretariat of the Koninklijke Vlaamse
Ingenieursvereniging
Ingenieurshuis
Jan Van Rijswijcklaan 58
Antwerp 1, Belgium

It should be noted that the proceedings are an overview of what was presented and do not contain any of the papers presented verbatim.

"Traffic Handling Delays in Ports"

T. Rallis (Technical University of Denmark, Copenhagen)

Fifth International Harbour Congress, June 2-8 1968, Antwerp, Belgium; Kon Vlaam Ing, Papers 1968, Section 3-RA, 6 p.

KEYWORDS: Port; Scheduling

ABSTRACT: On basis of telephone traffic theory and with aid of Erlangs rejection and waiting time formulas, probability of disturbance and delay in traffic handled in Port of Copenhagen has been calculated; geometrical conditions of harbor and handling of traffic in port are described; special reference is made to quays, warehouses and quayside roads in Free Port. 11 refs. (Engr. Index)

"The Integration of Port Functions: A Network Definition of Spatial Structure"

R. Robinson

Supplemental Papers - Ninth Annual Meeting, Transportation Research Forum, 1968, pp. 119-130

KEYWORDS: Port; Port Model; Transport

REVIEW: The author applies rudimentary graph theory to an analysis of ship movements among the complex of ports serving southern British Columbia. By this means the operational integration of the port system is demonstrated. This type of analysis could be useful in identifying the particular ports which should be included in a multiport system.

"Discrete Programs for Moving Known Cargos from Origins to Destinations on Time at Minimum Bargeline Fleet Cost"

N. L. Schwartz

Transportation Science (U.S.), vol. 2, no. 2, May 1968, pp. 134-145

KEYWORDS: Economic Analysis; Fleet; Scheduling

ABSTRACT: A bargeline which accepts various cargos for timely delivery between pairs of ports in its district must determine the routing and timing of movements of barges and towboats to execute the agreed freight movements at minimum fleet cost. A linear discrete programming model of this optimization problem is developed. The cargo movements to be made and the times needed for transit, loading, and unloading are assumed known. A solution of the model gives the numbers of barges and towboats of each size required to provide the service, with the consequent minimal cost. It also provides a complete schedule for the bargeline, specifying the location and status of the barges, boats, and freight at every time unit of the scheduling period. (Author)

REVIEW: This article outlines an algorithm which is essentially a specialized case of the Transportation Problem. The basic Transportation Problem is used when a least cost allocation of a given commodity is needed between several sources and several destinations. The total supply at each source is known as well as the total demand at each destination and the per unit cost of transportation between any two points. In the model of the article, the actual mechanics of scheduling certain size or type barges and towboats for certain trips on certain branches of the network is considered. The objective, of course, is to minimize the overall cost of moving the commodity from the origins to the destinations. The method presented also gives a complete schedule of where and when each barge and towboat should be at any given time during the scheduling period. All assumptions used in formulating the model are explained as well as the notation used in the equations. Special cases are considered in which all equipment needed is not available, and also the adaptation of the model to handle problems in which there are branches in the river system. Although the mathematics used is not too advanced the notation is somewhat confusing and the nesting of summations does get involved.

"Development of Computers as Aid to Port Management"

B. E. Sewell (Port of London Authority, England)

Fifth International Harbour Congress, June 2-8 1968, Antwerp, Belgium; Kon Vlaam Ing, Papers 1968, Section 8-SEW, 4 p.

KEYWORDS: Port

ABSTRACT: Paper describes present use of computers in assisting various levels of management in port industry with regard to routine accounting functions, commercial and marketing statistics, operational techniques and mathematical models, need to define clearly management's objectives leading to establishment of integrated management information system, is stressed. (Engr. Index)

"Industrial Engineering at the Port of New York Authority"

John R. Shelton (Chief, Operations Standards Division)

The Journal of Industrial Engineering, vol. 15, no. 5, Sept.-Oct. 1964, pp. 272-276

KEYWORDS: Port

ABSTRACT: The primary function of the industrial engineering division is to provide internal management consulting services to all line and staff units throughout an organization dedicated to public service in the field of transportation. Emphasis is on operational studies using the various techniques of traditional industrial engineering, operations research, mathematics, statistics, transportation economics, engineering administration and economics. Studies have been conducted to develop operations and maintenance cost estimates, to analyze construction plans, to evaluate manpower and maintenance requirements, to determine traffic flow patterns through high level aerial photography, and to study transportation facilities through simulation and waiting-line techniques. (Author)

"The Demand for Inland Waterway Transportation"

Eugene Silberberg (Purdue University, Lafayette, Indiana)

Water Resources Research, vol. 2, No. 1, First Quarter 1966, pp. 13-29

KEYWORDS: Forecast; Forecast Technique; Planning

ABSTRACT: A new type of forecasting model of great potential for predicting flows in complicated spatial transportation networks is illustrated through application to the forecasting of interregional coal flows by barge over the Mississippi River system. Changes in these flows are related to regional coal production and consumption levels and to the freight charges by barge and rail. The special feature of the model is the great saving on the data needed for its implementation made possible by assuming that transportation patterns will be efficient, i.e., least-cost, for given regional imports and exports. This assumption is incorporated by using the linear programming transportation method to generate individual flows from regional barge imports and exports forecasts by a system of statistically fitted equations. Various applications are illustrated. (Author)

REVIEW: This article is concerned with the construction and use of a forecasting model of the volume of traffic moved by barge over the principal routes of the Mississippi River System. The model relates changes in the barge transportation pattern to changes in various exogenous variables such as regional industrial activities and freight rates charged by the barge companies and their principal competitors, the railroads. The paper deals only with barge transportation of bituminous coal, but the model is not restricted to this commodity.

The approach used rests on a normative feature of the spatial equilibrium model, namely, that a system of regions in spatial equilibrium will minimize the total transportation cost of shipping the goods between the regions, giving the final export and import levels in each region. In other words, a competitive system will perform the transportation activity in an efficient or least cost manner. This efficient trade pattern is exactly what would be derived, assuming constant unit transportation costs, by solution of the linear programming transportation problem using regional export and import levels as the constraint constants.

"A Functional Analysis of the Ocean Port"

T. Arthur Smith (Operations Research, Inc., Silver Spring, Md.)

U.S.G.R. and D.R., August 1964, 59 p., available NTIS, Doc. No. AD-166 578

KEYWORDS: Port Operations; Port Planning; Ports; Port Management

ABSTRACT: The basic function of all ports is to provide facilities for the two-way exchange of traffic between inland and oceangoing transport. In this study the port is subjected to analysis and a port system defined in terms of port operations, i.e., harbor, terminal, and distribution functions; supported by specialized and general administration functions. Port development is analyzed and the relationships between planning, research, financing, property acquisition, facility construction, and information exchange are shown. The metropolitan transportation function is considered, major problems are discussed, and their impact on port development is indicated. (Author)

REVIEW: In this rather lengthy article of 50 pages the port is analyzed very thoroughly in a very objective but nonquantitative manner. Many different topics are considered such as the role of ports in the transportation system, the function of an ocean port, port operations, port administration functions, port development, and port planning. The financing of port facilities as well as property acquisition and facility construction are explained. Numerous flow charts and tables illustrate and clarify the ideas presented. A glossary of commonly used port terms is also included. This article would be most useful to someone just starting a study of any aspect of ports. It presents every conceivable aspect of the subject in a concise, yet clear manner without mathematical development.

"Algorithms for the Simple Plant-Location Problem with Some Side Conditions"

Kurt Spielberg (IBM Corporation, New York, N.Y.)

Operations Research (U.S.), Vol. 17, Jan. 1969, pp. 85-111.

KEYWORDS: Transportation Model; Transport

ABSTRACT: The algorithms of this paper belong to the direct-search or implicit-enumeration type. They compare to the recently proposed algorithm of Efroymson and Ray, as does the mixed integer algorithm proposed by C.E. Lemke and the author to that of Land and Doig. The general plan of procedure is expected to be equally valid for the capacitated plant-location problem and for transshipment problems with fixed charges, with some of the proposed devices more important for these difficult problems than for the simple plant location problem. Considerable computational experience has been accumulated and is discussed at some length. It suggests that additional work on the construction of 'adaptive' programs, matching algorithm to data structure, is desirable. (Author)

"Project Culdesac: Concepts for Cargo Handling at Primitive Ports."

Stanwick Corp., Washington, D.C.

U.S.G.R. and D.R., Jan. 1964, 186 p., available NTIS, Doc. No. PB-167 182

KEYWORDS: Port

ABSTRACT: Concepts for the transfer of limited quantities of general cargo at primitive ports are presented. These concepts were investigated with respect to economic and technical feasibility. Of the concepts studied, the simpliest (towing cargo from an off-shore ship packed in watertight containers) also resulted in the greatest cost advantage. Except for a few particular situations, the other techniques studied resulted in little or negative cost advantage. The cost advantage offered by the concept of towing the cargo to the pier via watertight containers resulted in cost advantages varying from $16/ton for 50 tons transferred to $6.86/ton for 500 tons transferred. The cost advantage of the towed watertight containers over conventional lightering amounts to $7.40/ton. All systems studied were considered practical except for the Fully Automatic Shuttle Transfer (FAST) which, because of operational factors, was considered marginal for commercial operations. (Author)

"Port Development and National Planning Strategy"

M. F. Tanner and A. F. Williams

Journal of Transport Economics and Policy, vol. 1, no. 3, September 1967, pp. 315-324

KEYWORDS: Planning; Port

REVIEW: Port planning and its relationship to national planning strategy is presented in this article. Portbury is a proposed international port to be located in England. Many of the potential social and economic effects of a new port are considered as well as effects on other ports. The article is entirely descriptive in nature and mentions many of the broad underlying factors which affect long term decisions.

"Texas Marine Resources: The Ports and Waterways View"

Texas Engineering Experiment Station, College Station, Industrial Economics Research Div.

U.S.G.R. and D.R., Aug. 1970, 19 p., available NTIS, Doc. No. PB-195 090

KEYWORDS: Transport; Port

ABSTRACT: The report represents a consensus statement of the participants at the workshop. The meeting represented the first time a major university program has attempted to assist port directors and planners in identifying common goals and recommendations for action by state government. Specific topics considered were: The current needs of Texas ports that can be served by the Sea Grant Program; The major problems hindering the development of Texas ports; and actions by federal, state, or local governments which would be helpful in stimulating the growth of Texas ports.

"U.S. Foreign Trade. Bunker Fuel"

U.S. Bureau of the Census, Washington, D.C.

U.S.G.R. and D.R., 1971, 12 issues, available NTIS, Doc. No. COM-71-50216

KEYWORDS: Export; Import

ABSTRACT: The report contains information on bunker oil and coal of domestic and foreign registry engaged in foreign trade and on Canadian vessels passing from one U.S. port to another in the trade of the Great Lakes. Data on total value and quantity are shown separately for American and foreign vessels with the quantity distributed by U.S. customs districts of lading. This information is not included in the U.S. export statistics. (Author)

"U.S. Foreign Trade. Export and Import Merchandise"

U.S. Bureau of the Census, Washington, D.C.

U.S.G.R. and D.R., 1971, 12 issues, available NTIS, Doc. No. COM-71-50212

KEYWORDS: Export; Import

ABSTRACT: The report shows value on U.S. exports, general imports, and merchandise trade balance, adjusted for seasonal and working-day variations; by months: January 1970 to date. Comparable data on exports, imports, and merchandise trade balance have been charted for January 1966 to date. Data are shown for exports including Department of Defense (DOD) Military Assistance program, Grant-Aid shipments, and Schedule B sections and selected divisions and general imports--Schedule A sections, unadjusted, by months: January 1970 to date. (Author)

"U.S. Foreign Trade. Exports: Commodity by Country"

U.S. Bureau of the Census, Washington, D.C.

U.S.G.R. and D.R., 1971, 12 issues, available NTIS, Doc. No. COM-71-50223

KEYWORDS: Export; Export Data

ABSTRACT: The report shows data on quantity and value of individual 7-digit Schedule B commodity by country of destination. Value is also shown in terms of 1,2, 3 and 4-digit Schedule B commodity groupings. Data valued less than $251 to all other countries are omitted from the commodity detail statistics. Shipments individually valued $251 - $1,999 to Canada and $251 - $499 to other countries are estimated by sampling. Data shown are for the current month and cumulative year-to-date. (Census abstract)

"U.S. Foreign Trade. Highlights of Exports and Imports"

U.S. Bureau of the Census, Washington, D.C.

U.S.G.R. and D.R., 1971, 12 issues, available NTIS, Doc. No. COM-71-50215

KEYWORDS: Export; Import

ABSTRACT: The report shows value on U.S. exports and general imports; merchandise trade balance, adjusted for seasonal and working-day variations; selected Schedules B (exports) and A (imports) sections and selected world areas, monthly January 1970-to-date. Comparable data on exports, imports, and merchandise trade balance has been charted for January 1966-to-date. Shown are charts on exports including Dept. of Defense (DOD) Military Assistance program Grant-Aid shipments showing selected Schedule B section (exports) and Schedule A sections (general imports) and selected world areas January 1965-December 1970. Total value of U.S. exports (domestic and foreign merchandise), and imports (general and for consumption) are shown from 1960 to date. Statistics for exports and imports, U.S. customs regions and districts, and method of transportation, world areas, country, and End-Use commodity category by world area. Statistics on calculated duty and dutiable value by world area and country are given for general imports and imports for consumption. Figures are given for the current month, the previous month, cumulative year-to-date, and comparisons with a year ago. (Author)

"U.S. Foreign Trade. Imports: Commodity by Country"
U.S. Bureau of the Census, Washington, D.C.

U.S.G.R. and D.R., 1971, 12 issues, available NTIS, Doc. No. COM-71-50222

KEYWORDS: Import; Import Data

ABSTRACT: The report presents data on quantity and value for U.S. imports, general and consumption, in terms of seven-digit Schedule A commodity by country of origin. Value totals are shown for 1, 2, 3, and 4-digit Schedule A groupings. These estimates do not include mail shipments of duty free merchandise valued under $251. Data shown are for the current month and cumulative year-to-date. (Census abstract)

"U.S. Foreign Trade. Waterborne Exports and General Imports"

U.S. Bureau of the Census, Washington, D.C.

U.S.G.R. and D.R., 1971, 12 issues, available NTIS, Doc. No. COM-71-50214

KEYWORDS: Export; Import; Export Data; Import Data

ABSTRACT: The report presents data on shipping weight and value of U.S. waterborne exports, outbound intransit merchandise and shipments of Department of Defense (DOD) controlled cargo and special category non-Department of Defense controlled cargo; U.S. general imports and inbound intransit merchandise moving on dry cargo and tanker vessels by customs district and port of lading/unlading. Data on shipping weight are shown for waterborne exports, general imports, and Department of Defense (DOD) controlled cargo and special category non-DOD controlled cargo by trade area, U.S. coastal district, type of service and U.S. flag. Detailed figures are for the current month summary; figures are given for previous months for comparative purposes. (Author)

"Policies, Standards, and Procedures in the Formulation, Evaluation, and Review of Plans for Use and Development of Water and Related Land Resources"

U.S. Senate

87th Congress, 2d Session, Senate Document No. 97 (U.S. Government Printing Office, Washington, D.C.), May 29, 1962, 13 pages, free

KEYWORDS: Planning

ABSTRACT: Policies regarding planning water resource projects, especially with regard to factors to be included in benefits and costs, were generated by the Departments of Army, Interior, Agriculture, and Health, Education, and Welfare. The document replaces the earlier Budget Bureau Circular A-47, and was approved by the President as guidance for future water and land resource studies. In verbal disclosure that approaches mathematical formulation, various kinds of tangible and intangible benefit criteria are listed and rules for their aggregation are suggested. For example, it is required that if b_i be an enumerable benefit, and c_j an enumerable cost for a given project, $\Sigma_i b_i > \Sigma_j c_j$; that each separable suboptimization give a net benefit; that net benefits are to be maximized; and that no program whose c_j' is less than one included in the "optimal" system be inconsistent with the "optimal" project. W. Edward Cushen (U.S.)

"All Weather Harbor Navigation Model"

William K. Vogeler (International Engineering Co., Arlington, Va.)

U.S.G.R. and D.R., Aug. 1970, 295 p., available NTIS, Doc. No. Ad-711 767

KEYWORDS: Port; Port Model

ABSTRACT: A computer simulation model containing harbor features, navigational data, weather information, and ship movement routines was developed. Operation of the model makes it possible to simulate the movement of ships in a realistic manner through harbor and other restricted water areas. Information yielded by the model includes collisions, near misses, groundings, and potential groundings for all vessels. A record of time spent in the harbor and the generation of a harbor utilization index for each vessel is also delivered by the model. Harbor status reports are automatically printed at regular intervals. This report contains the model philosophy, description, Fortran listing, flow chart, and operating instructions for model usage. (Author).

"Transportation Information: A Report to the Committee on Appropriations, U.S. House of Representatives, from the Secretary of Transportation"

John A. Volpe (Department of Transportation, Washington, D.C.)

U.S.G.R. and D.R., May 1969, 255 p., available NTIS, Doc. No. PB-184 974

KEYWORDS: Transport

ABSTRACT: This report presents an initial five-year program for meeting the critical transportation information needs of industry and government at national, state and local levels. The program provides for information on the flows of persons and goods, information on the activities (population and industry) that generate the flows, and information on the channels (transportation facilities and terminals) that carry the flows. This information would cover all modes of transportation - highway, rail, air, water and pipeline; and all geographic levels - urban, interurban (including regional-corridor), and international. Accident experience information is provided for under information on channels (transportation facilities and terminals), but transportation safety information is not treated comprehensively. The program presented in this report provides for use of existing transportation information programs to the greatest practicable extent. The program also provides a framework for consolidation and reallocation of transportation information functions both within and outside the Department. (Author)

"East European Service Industries: Translations No. 571"

Josko Vukov (Joint Publications Research Service, Washington, D.C.)

U.S.G.R. and D.R., Oct. 1967, 51 p., available NTIS, Doc. No. JPRS-43063

KEYWORDS: Forecast; Planning; Transport

ABSTRACT: Although the planned development of transportation through 1970 is based on the modernization of existing facilities as well as the construction of new transportation lines (or the completion of projects underway), it will again be too diffuse and less effective, because of the partially erroneous estimates of the volume to be handled by individual transportation routes and terminals and the insufficiency of funds. The estimates to date based on the overall economic progress of Yugoslavia and the foreign market indicate that transportation volume will be about 20 million tons in 1970. This is almost twice the 1963 volume. If this estimated volume is realized it will require not only increasing the capabilities of those port-transportation centers bearing the heaviest loads but also their modernization to speed up handling operations and their specialization to conform with the future level of foreign trade development. Thus it is of critical importance to establish not only the absolute volume, which can only be approximated, but also the points, or port complexes, which will handle the greatest loads of foreign trade and through freight business, so that they can be fully equipped.

"The Feasibility of a Global Airlift"

R. S. Weinberg and J. W. Higgins (Center for Naval Analyses, Arlington, Virginia; Naval Warfare Analysis Group)

U.S.G.R. and D.R., Sept. 1957, 25 p., available NTIS, Doc. No. Ad-719 899

KEYWORDS: Transport

ABSTRACT: The number of aircraft and amount of fuel needed to airlift U.S. imports and exports are determined in this study for both the full flow of U.S. overseas trade and for the more limited importation of only vital strategic materials. Because the airlifting of cargo and of the aircraft fuel needed to extend the range of the cargo aircraft is not yet feasible, the study considers an operation in which surface tankers haul the fuel for cargo aircraft to those overseas points where needed. Finally, the number of surface ships and the amount of fuel needed to sustain the same lift by sea is developed for comparison with the aircraft requirements. Surface transport of airlift fuel is shown to be almost as large a task as surface transport of the cargo involved, and modernization of the merchant fleet appears to be a much less costly way to reduce shipping protection requirements. (Author)

"Kokyo huto no Liner Berth Keikaku ni kansuru Kenkyu" (Study of the Liner-Berth Planning of a Public Wharf)

Kazuhiro Yoshikawa, Kazuo Kagawa and Keizo Koyama

Journal of the Society of Civil Engineering (Japan), vol. 51, no. 2, February 1966, pp. 76-78

KEYWORDS: Planning; Port; Transport

ABSTRACT: The number of cargo and of ships which arrive in port are estimated using both macroscopic and microscopic models. Then the optimum number of liner berths is calculated by Monte Carlo simulation. Computation shows larger berths to be desirable. Jiro Kondo (Japan)

APPENDIX B

BIBLIOGRAPHY

This bibliography consists of two parts: Part 1 - Keyword Index; Part 2 - Bibliographic Index.

Part 1 - Keyword Index

The keyword index provides a listing by keywords of all titles along with an alpha-numeric reference code. The keywords were imposed by the researchers and are as follows:

KEYWORD	MATERIAL REFERENCED
ECON-ANLY	Economic analysis of waterways, etc.;
EXP-DATA	Sources of data on exports;
EXP-FORECAST	Existing forecasts of exports and methods of forecasting exports;
EXPORT	All material related to exports;
FLEET	All material related to fleet operations;
FORE-TECH	Forecasting techniques and models;
FORECAST	All material related to forecasting;
IMP-DATA	Sources of data on imports;
IMP-FORECAST	Existing forecasts of imports and methods of forecasting imports;
IMPORT	All material related to imports;
PLANNING	All material related to waterways and transportation planning;
PORT	All material related to ports;

KEYWORD	MATERIAL REFERENCED
PORT-MODEL	Mathematical, heuristic, and other models of ports;
SCHEDULING	Scheduling and/or allocating of shipping units and modes;
SIM-MODEL	Simulation models;
TRANS-DATA	Sources of data on waterway shipping;
TRANS-MODEL	Transportation models such as the "Warehouse Location Model", "Gravity Model," etc.;
TRANSPORT	All material directly related to waterway transportation.

Once the reader has found a title of interest, he notes the reference code and proceeds to Part 2.

Part 2 - Bibliographic Index

The bibliographic index includes the authors name, title of the article or text, its source, and an alpha-numeric reference code. The listing is in alphabetic order of the author's names. Since the reference code is partly composed of the author's name, the listing is also in alphabetic order of the code. Therefore the reader can easily find the author and source of a title located in Part 1. For example, under the keyword FORECAST in Part 1, the title "COMBINATION OF FORECASTS" is found along with the reference code BAERJC 69COF. By looking down the left hand side of the pages in Part 2, that reference code is found along with the author and source. Part 2 is self-sufficient and may be used as a normal bibliography.

Of interest is the fact that the numeric portion of the reference code indicates the year of publication. If this portion of the code is not numeric but rather "MO", then the publication is monthly; if the source is an annual publication, this portion of the code is "AN". "MO" and "AN" are only used when specific editions are not referenced but rather the volume itself presents a source of material regardless of the data of publication (for example, U.S. Bureau of the Census publications).

PART 1

KEYWORD INDEX

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13. ABSTRACT

A representative sample of the literature relating to the analysis of multiport deep draft transportation systems is reviewed, for the purpose of defining the major fields requiring investigation and identifying the methodologies which hold promise for use by the Corps of Engineers. Quantitative models for economic forecasting, shipping operations studies, and port planning and design are included in the survey, as well as several large-scale comprehensive transportation planning models. The literature survey is keyed to an abstract formulation of an integrated system of models for multiport planning, and the resulting package constitutes a set of preliminary specifications for development of such a model system. An annotated bibliography and a computerized bibliographic index are included in the report.

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