A Model for Estimating Cargo Ship Costs BTCESHIP

Occasional Paper

In many of its analyses involving shipping, the Bureau of Transport Economics has been required to estimate costs associated with owning and operating vessels of various types. This Paper presents a model for estimating long-run average ship costs that was developed by the Bureau for this purpose. The model has been developed as a computer program (BTESHIP) to enable ship costs to be evaluated quickly and conveniently. However, to use the model effectively it is necessary to have an understanding of the principles involved in estimating ship costs. This Paper contains a discussion of the nature of ship costs and their estimation, as well as a user's manual which documents the structure and operation of the program.

Occasional Paper 83

A Model for Estimating Cargo Ship Costs

F.A. Spencer

AUSTRALIAN GOVERNMENT PUBLISHING SERVICE, CANBERRA 1987

ISSN 0157-7085
ISBN 0 644 06665 2

Printed in Australia by Union Offset Co. Pty Ltd, Canberra

FOREWORD

In many of its analyses involving shipping, the Bureau of Transport Economics has been required to estimate costs associated with owning and operating vessels of various types. This Paper presents a model for estimating long-run average ship costs that was developed by the Bureau for this purpose.

The model has been developed as a computer program (BTESHIP) to enable ship costs to be evaluated quickly and conveniently. However, to use the model effectively it is necessary to have an understanding of the principles involved in estimating ship costs. This Paper contains a discussion of the nature of ship costs and their estimation, as well as a user's manual which documents the structure and operation of the program. The Paper is accompanied by a floppy disc containing the program software and associated files. This material has been prepared in a format which is compatible with IBM PC microcomputers.

The ship costing model presented in this Paper was originally developed by Mr S. E. Wheatstone. Ms F. A. Spencer was responsible for producing the model and computer program in their current form and for preparing this Paper. The project was supervised by Mr G. P. Piko.

J. W. Moll
Assistant Director
Planning and Technology Branch

Bureau of Transport Economics
Canberra,
August 1987

SPECIAL NOTE

While every endeavour has been taken to ensure that the ship costing model and associated documentation are as accurate as possible the Bureau of Transport Economics (BTE) cannot assume responsibility for the effects of errors or oversights in the model or its implementation program (BTESHIP). The Bureau would appreciate being notified of any errors or omissions that users may discover.

The Bureau does not intend to provide ongoing support to users of the program BTESHIP and it is not envisaged that the Bureau will augment or update BTESHIP on any regular basis.

The BTESHIP computer program is contained on a floppy disc which accompanies this Paper. If this disc is not compatible with a user's computer system it may be possible to make the program available in another form. All enquires should be directed to:

The Publications Officer
Bureau of Transport Economics
GPO Box 501
CANBERRA ACT 2601

CONTENTS

TABLES

FIGURES

SUMMARY

The Bureau of Transport Economics has produced a model to assist in estimating long-run average costs associated with operating a cargo vessel with a specified load over a given journey between two ports. This model has been developed as a computer program (BTESHIP), to facilitate evaluation of effects of changes to vessel and voyage characteristics on costs.

Both bulk and non-bulk vessels can be costed. The model calculates the following vessel cost components:

- capital
- fuel
- crew
- repairs and maintenance
- insurance
- victuals and stores
- administration.

In addition, canal, port and stevedoring charges can be incorporated in the costing process if required.

The model is designed to calculate the costs incurred between the time vessel loading commences at port A and the time unloading ceases at port B. Although the model estimates the costs for a single-leg voyage, it is designed to allow the costs associated with a multi-leg voyage to be readily assessed by combining successive estimations.

Most cost components addressed by the model relate to items which are consumed during the voyage or services for which charges are levied by the service providers. Hence their cost can be estimated directly.

There are various ways of treating capital costs. An individual ship owner will have particular arrangements for financing vessels and these arrangements are negotiated commercially. The model makes no

attempt to represent individual financing arrangements in any way. Instead, the model estimates capital costs on the basis of an assumed opportunity cost of the capital investment in the vessel.

The capital costs associated with the ship are estimated using vessel newbuilding and resale prices. The net present value of the actual capital costs incurred throughout the analysis period is then annualised to produce a constant annual capital charge. The analysis period, which must be specified, might commonly be set equal to the remaining life of the vessel. This approach provides an estimate of the ship capital costs faced by ship owners and operators in their long-term decision making and in establishing the long-term profitability of a vessel. Other methods of calculating capital costs might be more appropriate for making short-term decisions about ship operations and the setting of freight rates.

A feature of the model is that it facilitates evaluation of the effects of varying certain vessel characteristics during the analysis period. In this way, it is possible to evaluate the effect on costs of altering the crew arrangements, upgrading the engine or installing other technological innovations during the analysis period.

The software representing the model has been developed using the FORTRAN language. It is available on the 5¼ inch floppy disc which accompanies this Paper. The disc contains the source code and executable code of BTESHIP, a set of skeleton input files, a set of input files containing test data and a file containing output from the test data. These files have been prepared in a format which is compatible with IBM PC operation.

CHAPTER 1 INTRODUCTION

Many projects undertaken by the Bureau of Transport Economics (BTE) require the calculation of ship costs. In addition, various government departments, port and marine authorities, importers, exporters, transport consultants, academics and, of course, ship operators are also engaged in the estimation of ship operating costs. Most of these transport related groups are interested in examining the effect of changes to the shipping system. They require a costing process to assist in the evaluation of various policy and planning issues.

Costing systems that are aimed at financial control and management are generally cumbersome and inappropriate for the analysis of policy and planning issues. Furthermore, some existing ship costing models require the maintenance of a substantial data base to provide input to the program (see for example, World Bank 1985). The Bureau therefore identified a need for a small, flexible, easy to use ship costing model which would allow cost trends related to changes in fleet and voyage characteristics to be assessed.

OUTLINE OF THE MODEL

The objective of this project was to produce a model for the estimation of long-run average ship costs, which could be installed on a microcomputer for ease and convenience of calculation.

The model described in this Paper requires the specification of:

- voyage, port and vessel characteristics
- cost data
- cargo carried.

All unit cost data, such as the price per tonne of fuel, are specified externally to the model in order that the model itself requires no updating when prices change. The vessel characteristics required by the model can be specified externally, or the model may be used to calculate them from basic data which is specified externally.

The model can be used to calculate vessel operating costs (capital, fuel, crew and so on), together with canal charges, port charges and stevedoring charges for both bulk and non-bulk vessels. The model calculates the long-run average costs for a single-leg voyage from port A to port B. However, it is structured so that the results for several legs can readily be summed to obtain the costs for a multi-leg voyage.

STRUCTURE OF THE PAPER

The following chapter discusses the nature of ship costs and describes the costing approach used in the model. The remainder of the Paper is a user's manual for the program (BTESHIP) representing the computer implementation of the model.

Chapter 3 contains an overview of the model. Chapter 4 of this Paper explains how to implement BTESHIP on a computer. The steps required to run the model are described and any language or machine dependencies identified. The nature of the input data is described in Chapter 5 with the input files illustrated in Appendices I, II and III. Chapter 6 describes how the results are output from the model. The user should make particular reference to Chapter 4 and Chapter 5. Appendix IV describes in detail the structure of BTESHIP. The operation of each subroutine is explained and Nassi-Shneidermann flowcharts (see Appendix V) are presented for the major routines. Appendix VI contains a dictionary of variables used in the program.

An IBM PC compatible floppy disc accompanies this Paper. The disc contains the source code, a compiled version of the program, a set of skeleton input files, input files containing test data and a file containing output from the test data files.

CHAPTER 2 ESTIMATION OF SHIP COSTS

This chapter discusses the nature of ship costs in general and provides an outline of the approach to ship costing used in the model. It then addresses each cost component in turn and discusses methods for estimating each component.

GENERAL APPROACH

In order to produce an estimate of ship costs, it is necessary to specify the vessel characteristics, voyage pattern and cargo loadings and to consider exactly which cost components are to be addressed. This section outlines the general approach used in the calculation of these costs.

Ship type

The model is constructed so that any type of cargo ship can be costed if the user specifies all the ship characteristics. Alternatively, the model has access to regression relations which can estimate gross registered tons (grt), net registered tons (nrt), length, beam, draught and maximum engine power as functions of deadweight. The regression relations have been derived from Lloyd's Register of Shipping (1984b) and are discussed in Chapter 5. Regression relations are available for the following ship types:

- container
- roll-on roll-off (ro-ro)
- general cargo
- container-bulk (con-bulk)
- bulk
- ore
- tanker.

Voyage pattern

In practice, vessels sail a variety of different voyage patterns. For example, a vessel may sail from port A to port B and back again, or it may sail a triangular voyage pattern where the vessel is loaded on two legs and sails in ballast on the third leg. Alternatively, vessels can sail regular 'round the world' routes, or other complex voyage patterns.

The model is designed to calculate the long-run average costs of a ship carrying a specified cargo load on a given voyage (port A to port B) over a specified analysis period. However, the time in port and the associated charges are treated so that separate applications of the model can be combined to yield a total long-run average cost for a multi-leg voyage without double counting port charges and other costs. Furthermore, the model can reflect the fact that some cargo may remain on board at one port for subsequent carriage to a further port.

The different cargo types capable of being carried by the above vessels types can have different cargo handling rates which affect the duration, and hence the cost, of a voyage. Wharfage and stevedoring charges also vary with the nature of the cargo. The model can accommodate both containerised and non-containerised cargo. The model accepts the specification of the appropriate handling rate for the cargo under consideration and the corresponding wharfage and stevedoring charges.

Cost components

The cost components associated with the vessel itself are:

- capital
- fuel
- crew
- repairs and maintenance
- insurance
- victuals and stores
- administration.

In addition there may also be a number of other costs associated with a particular voyage. These include:

- canal charges
- port charges
- stevedoring charges
- other charges.

The model is designed to accommodate these charges if required.

Costing approach

Some cost components considered in the model relate to items which are consumed during the voyage and hence their cost can be estimated directly. Fuel costs are an obvious example. The estimation of capital costs, however, is conceptually more complex. For example, the capital cost of a ship can be based on:

- construction cost
- charter rates
- newbuilding and resale prices.

The following paragraphs outline the principles adopted in treating capital costs in the model.

The capital cost of a vessel can be estimated by determining the cost that would actually be incurred to construct the vessel, and then amortising that cost over the expected life of the vessel. However, the capital cost faced by a ship owner or operator may differ considerably from the actual construction cost depending on the relative levels of supply and demand for shipbuilding at the time and the level of shipyard subsidies and so on. Charter rates can also be used as a basis for estimating ship capital costs, but this approach is more relevant to short-term decision making due to the fact that charter rates can fluctuate rapidly. Furthermore, little information is available on charter rates for non-bulk vessels.

The use of newbuilding and resale prices is the preferable method of estimating the ship capital costs actually faced by ship operators in their long-term decision making and in establishing the long-term profitability of a vessel. This is the approach adopted in the model. Newbuilding and resale values are available from shipping journals and other publications, although the resale prices for container vessels can be somewhat difficult to estimate as the second-hand market for these vessels is not very active (World Bank, 1985).

The capital cost of a vessel generally comprises a depreciation component and an interest component. The interest charges depend on the finance arrangements that have been made for the vessel and can vary significantly from case to case. An analysis which takes individual financing arrangements into account would be more appropriate to short-term decision making, as these arrangements can affect cash flows differently from year to year. The model was designed primarily to examine the long-term economic effects of alternative options for the shipping of cargo. In this context an approach based on an examination of the opportunity costs of capital invested in a vessel was adopted. Hence the model calculates the net present value of the actual capital costs incurred throughout the analysis period. This net present value is then annualised to produce a constant annual capital charge. The total annual capital charge derived in this way is constant over time. Again it must be stressed that this approach does not allow for any particular financial arrangements a given ship owner or operator may have in respect of a vessel. It simply provides one method by which long-term investment decisions may be assessed. Alternative treatments of capital can be taken into consideration extraneously to the model.

COST COMPONENTS

This section discusses methods of estimating each ship cost component considered in the model.

Capital

Ship capital
Capital expenditure in the shipping industry is generally very large, infrequent and provides benefits over an extended period of time. As a result, the model is used to calculate an annual capital charge using a specified analysis period, and a proportion of that annual charge is attributed to a particular voyage on the basis of the time taken for the voyage.

The vessel capital cost parameters considered in the model are:

- the resale value of the ship at the start of the analysis period;
- the salvage value for any ship replaced during the analysis period;
- the newbuilding price for any replacement vessel (which is identical in physical characteristics to the one being replaced) that may be purchased during the analysis period; and
- the resale value of the vessel in service at the end of the analysis period.

All relevant ship capital costs are discounted to determine their present value at the start of the analysis period (see Equation 2.1). This is done using a real discount rate which reflects the opportunity cost of the capital invested in the vessel. All capital costs are expressed in constant dollars. The resale value (in present value terms) of the vessel in service at the end of the analysis period is subtracted from the resale value of the ship at the start of the analysis period to determine the net present value of capital costs. If a ship is replaced during the analysis period, then the newbuilding price (in present value terms) for the replacement vessel is added to the net present value, and the salvage value (in present value terms) for the replaced vessel is subtracted from the net present value.

$$PV = \frac{V_n}{(1+i)^n} \qquad (2.1)$$

where PV is the present value of the value in year $n(V_n)$ and i is the annual discount rate.

This net present value is then converted into an equivalent annual capital charge using Equation 2.2.

$$A = \frac{PV*i*(1+i)^n}{(1+i)^n-1} \qquad (2.2)$$

where A is the annual capital charge over n years equivalent to a present value (PV) given an annual discount rate of i.

This process is illustrated diagrammatically in Figure 2.1. The appropriate proportion of the resulting annuity is then allocated to a voyage depending on the duration of the voyage.

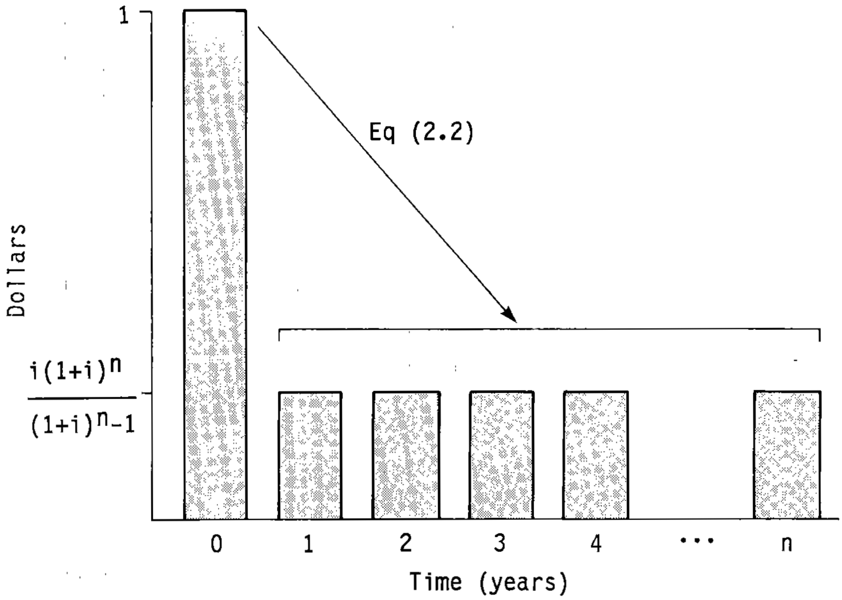
The model can be used to analyse the effect of a change in vessel characteristics at some point during the analysis period. If, for example, the ship will be fitted with new engines in year y, then there will be a one-off capital cost in year y associated with that change and resulting fuel savings thereafter.[1] Figure 2.2 illustrates the process involved. Essentially it involves the following steps:

- Equation 2.2 is used to calculate the present value in year y of future savings in fuel consumption.
- Capital cost in year y is subtracted.
- Equation 2.1 is used to calculate the present value in the base year.
- Equation 2.2 is then used to annualise these net savings throughout the analysis period and these are subtracted from the annual cost of fuel consumption based on the original (unmodified) vessel.

Other changes of this nature, affecting for example crew levels or repairs and maintenance, are treated similarly.

---

1. Savings are assumed for discussion purposes. However, the model can accommodate extra rather than savings if required.



i = discount rate
n = number of years

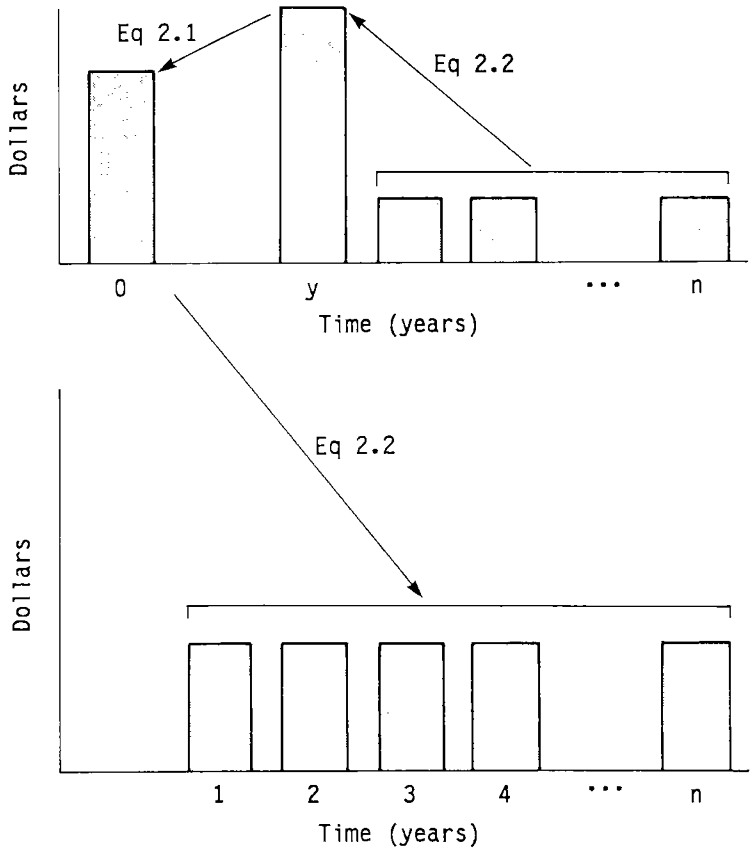
Note Figure not to scale

Figure 2.1 Relation between an annuity and its present value

Container capital

The model calculates the capital cost for containers using the same principles used to calculate ship capital cost. All capital inflows and outflows during the analysis period that relate to containers are discounted to the start of the period, a net present value determined and an equivalent annuity calculated.

The number of containers assumed to make up the container stock is dependent on the number of container slots in the vessel and the container slot ratio. The container slot ratio is the number of twenty-foot equivalent units (teus) owned by the shipping company for each teu capacity of the vessel. Container capital costs are calculated by assuming that an equal proportion of containers is replaced each year. Replacement of containers therefore results in a constant annual capital cost. If, for example, the life of a container is 12 years then the capital cost incurred in replacing one-twelfth of the container stock each year, less the salvage value of those containers scrapped each year, would equal the net annual cost of replacing containers.



Note Figure not to scale

Figure 2.2 The annual effect resulting from a change to the vessel in year y

In addition, the opportunity cost of the capital invested in the container stock must be taken into account. The value of the container stock at the end of the analysis period is equal to the value at the start of the period due to the assumption concerning continual replacement of containers. The value of the container stock at the end of the period is discounted to the start of the period (using Equation 2.1) and then subtracted from the initial value of the container stock. This net present value is then converted into an equivalent annuity (using Equation 2.2) and added to the net annual cost of replacing containers to obtain an estimate of the total annual capital charge associated with containers.

The value of the container stock is assumed to equal half the net replacement cost of the containers plus the total salvage value of the containers. This is consistent with containers being depreciated by a constant amount per year and an even age distribution among the containers.

Fuel

It is assumed in the model that the main engines consume fuel at a constant rate for the entire time the ship is at sea, in canals or under pilot. No main engine fuel is consumed while the ship is at berth.

Main engine fuel consumption can be specified in either tonnes per day at sea, or in grams per kilowatt hour. If the latter is specified the power requirement is derived from a relationship using the ship type, deadweight and ship speed for the voyage. This is based on BTE (1980) and regressions of data from Lloyd's Register of Shipping (1984b). In this case, the fuel consumption is adjusted for the proportion of installed (or maximum) engine power utilised.

The model allows the auxiliary engine fuel consumption to be specified in tonnes per day, grams per kilowatt hour, set to zero, or estimated by the model.

Crew

There are many components of crew costs, and these vary considerably with the crew nationality, flag of the ship, the owner's policy and sometimes the crew member's work classification. The more common components include: basic salary, leave, overtime, bonuses, superannuation, union payments, subsistence, relocation of crew, standby pay, training and medical expenses. There are also many different ways in which these components are calculated and paid. The costs of victuals and insurance for crew members are usually calculated separately.

The model estimates crew costs for a given voyage by multiplying the annual crew cost per berth by the number of berths on the vessel, and then taking an appropriate proportion of this annual cost based on the duration of the voyage. This general approach was also taken by Zerby, Conlon and Kaye-Kucharzewski (1981) and Gallagher and Meyrick

(1984). The World Bank (1985) takes a similar approach but addresses the costs for officers and for ratings separately.

Repairs and maintenance

This item includes both routine repairs and maintenance and an allowance for unexpected repairs and maintenance. Repairs and maintenance include costs for labour, parts and materials, tools and equipment. Where maintenance is carried out by the ship crew, the labour cost is usually included under crew costs. Also, some of the items necessary for maintenance work may be included under stores costs. Routine maintenance costs can vary with ship and cargo type, ship age, engine type and trading area. Unexpected repairs are difficult to cost due to their irregular nature. These costs will vary considerably depending on the nature of the repairs and the location of the ship at the time.

Given the difficulty in estimating repair and maintenance costs directly, a common approach involves estimating them indirectly using the capital cost of the vessel. For example, Zerby, Conlon and Kaye-Kucharzewski (1981) express repair costs as a percentage of the book value of the vessel; BTE (1982) expresses repairs as a percentage of annual capital cost, and the World Bank (1985) expresses repairs as a percentage of the vessel newbuilding cost. The model allows the specification of either a constant daily or annual cost for repairs and maintenance, or the specification of these costs as a fraction of the ship newbuilding price.

Insurance

Insurance costs include cover for loss and damage to the hull and machinery, protection and indemnity, war risks and in some cases, loss of earnings, crew insurance, strike insurance and liability for oil pollution. Hull and machinery insurance covers loss and damage as well as liability in the case of a collision. The underwriters will quote a rate based on the size, classification, route sailed and value of the ship. The owner's management record and market conditions also have a large impact on the quote. Costs vary with the size of excess included in the policy and the value insured.

Insurance costs are usually estimated indirectly. Zerby, Conlon and Kaye-Kucharzewski (1981) estimate insurance costs as a percentage of the book value of the vessel. BTE (1982) estimates insurance costs as a percentage of the ship's initial cost, while the World Bank (1985) calculates insurance costs as a percentage of the ship replacement cost. The model allows the specification of either a daily or annual insurance cost, or the specification of the annual insurance cost as a fraction of the ship replacement cost.

Victuals and stores

Victuals costs are the costs of feeding the crew and any guests on board while in port. These may include wives and children of the crew, company officials, pilots and port officials, agents, surveyors and other official visitors. In past years, costs varied considerably depending on the ports visited. However, nowadays large amounts of food are carried deep frozen on board the vessel, making it possible to purchase the required foods where they are cheapest.

Victuals costs can be paid as a daily allowance to the crew, to a victualling agent, or incurred as a direct cost where the ship operator provides all the victualling. Where the ship operator employs cooks or where a daily allowance is paid, care needs to be taken not to include the same components in both crew and victuals costs.

Stores costs cover a large number of items necessary for running the ship. They may be summarised in the following categories:

- marine stores: paints, ropes, wires, safety equipment, cargo equipment and fresh water;
- engine stores: chemicals, gases, electrical consumable items, greases, packing and tools;
- lubricating oils;
- stewards stores: cleaning materials, stationery, linen, cutlery and soft furnishings;
- recreational stores;
- clothing supplies;
- extra handling charges to move stores to the vessel; and
- canteen and bar supplies (Downard 1981).

Once again care must be taken not to double count costs, especially with respect to items required for repairs and maintenance.

The model uses the common approach of modelling victuals costs as a constant cost per crewing position per day, and stores costs as a constant annual cost.

Administration and management

Administration and management involve maintaining a base or central point from where the ship is managed. Tasks performed include ship support, record keeping, accounting and communications. Ship support involves planning, arranging and organising crew recruitment and training, changing of crews, repairs and maintenance operations, insurance requirements and ordering supplies. These costs depend on the extent to which administration services are subcontracted, the size and structure of the shipping company and items such as the location of the office.

Apportionment of administration costs amongst vessels in a fleet can be difficult since administration costs do not necessarily vary greatly with vessel size. It is also difficult to distinguish between ship management costs and corporate management costs. Often allocation of these types of overhead costs can only be done arbitrarily. The model simply allows administration costs to be specified in terms of either a constant daily cost or as a fraction of vessel operating costs excluding fuel. The model itself makes no attempt to allocate total administrative costs associated with (say) a fleet of ships to any particular ship or voyage.

Canal charges

Canal charges can consist of several items, including tolls, charges for line handlers, launch hire, minimum port charges, light dues and pilotage. The charges for the Panama and Suez canals are based mainly on net tonnages, and also on length and beam of the vessel. The net tonnages are measured in accordance with the instructions of the particular canal authority, and may differ significantly from the nrt. The canal charges also decrease significantly for vessels in ballast, and may fluctuate with currency changes.

The model avoids the complexity with which canal charges are actually calculated by simply requiring a single charge to be specified for each passage of a canal. An option exists within the model to exclude canal charges.

Port charges

Port charges are levied by State governments, national governments, various public port authorities and privately owned ports. Government charges can relate to navigational aids, lights and funds established to combat oil spills and other pollution caused by ships. Port authorities are generally responsible for maintaining channels, berths and wharf facilities and administration of the port including ship movements, provision of pilots and other services. Private ports are generally involved in the transport of industrial or mining products.

There is a large number of port authorities in Australia, each with different charging structures. The structure of port charges in overseas areas also varies greatly.

The charges fall into two categories: charges on the vessel and charges on the cargo. The first category includes tonnage charges, pilotage, tug hire, berthing, harbour and light dues, and incidental charges such as fresh water, electricity and garbage disposal. Charges on the cargo are generally termed 'wharfage' and based on the amount of cargo that is loaded and unloaded at the port. The charges generally differ for each cargo type.

The model allows for the specification of port charges in various ways. These are detailed in Chapter 5.

Stevedoring charges

Stevedoring charges are the charges levied for loading or unloading cargo from the vessel. The charges can vary with the nature of the cargo and the available facilities.

The model allows for stevedoring charges to be specified individually for dry containers, refrigerated containers (reefers), empty containers and non-containerised cargo as well as for fuel and stores.

CHAPTER 3 OVERVIEW

This chapter contains a brief overview of the ship costing model as it is implemented in the computer program BTESHIP. The main features of the program are also discussed.

BTESHIP calculates the long-run average costs for a voyage by a cargo vessel from port A to port B. The costs are calculated using an analysis period specified by the user. The resulting costs are output in total dollars for the voyage and, where appropriate, in dollars per unit of cargo carried.

BTESHIP calculates only costs relating to the voyage from port A to port B. This does not include costs associated with entering port A, or unloading cargo in port A. These costs are considered as part of the costs for the previous single-leg voyage. Similarly, in port B, costs associated with the subsequent single-leg voyage are not included.

Options exist within the program to allow the user to add canal charges, port charges and/or stevedoring charges to the vessel costs if this is desired. However, it is expected that users will often wish to run the program to estimate vessel costs only. This is because these costs are generally the area of prime concern and because information on port and stevedoring charges can be difficult to obtain. This is especially the case for ports in other countries.

If canal charges are included, they are input as a single charge covering each time a canal is traversed.

If port charges are included for a single-leg voyage from port A to port B, then the program will add the following items to the vessel operating costs:

- charges on the vessel at port A, (for example, tonnage);
- charges on the cargo at port A, (for example, wharfage);
- charges to exit port A, (for example, tug and launch charges);

- charges to enter port B
- charges on the cargo at port B
- charges on the vessel at port B

Each run of BTESHIP is designed to calculate the cost of moving cargo from one port to the next port. However, cargo ships often visit more than one port in each trade area, and may travel between several trade areas, resulting in cargo being carried to its destination port via other ports. BTESHIP is designed to allow the individual legs of a multi-leg voyage to be costed separately and then summed without double counting any costs.

If the option to include stevedoring charges is used, then charges relating to the amount of cargo loaded at port A and unloaded at port B are included. Stevedoring charges are therefore additive where a multi-leg voyage is being costed.

Testing of the sensitivity of ship operating costs to factors such as vessel size, crewing level or fuel consumption is facilitated by the fact that as many as four vessels of the same type but of different characteristics can be costed in one run of BTESHIP. Table 3.1 lists the vessel parameters which can be varied among the four vessels capable of being analysed within a single run of BTESHIP. The input files are structured to reflect this feature.

Finally, BTESHIP enables the user to vary certain vessel characteristics during the analysis period. The characteristics which may be varied are:

- ship capital cost
- fuel consumption rate
- crewing level
- repairs and maintenance cost.

This facility is useful for examining situations such as upgrading the engine, altering the crewing arrangements or installing other technological innovations. The point in time at which the change occurs must be specified. The user can vary the timing of the change to examine the costs of performing the changes earlier or later in the analysis period.

TABLE 3.1 PARAMETERS WHICH CAN BE VARIED WITH A SINGLE RUN OF BTESHIP

Category	*Notes*
Ship size and dimensions	Deadweight Container capacity Other cargo capacity Gross registered tonnage Net registered tonnage Length Beam Draught
Ship power	Maximum engine power
Crewing level	..
Vessel speed	..
Fuel consumption	Main engines: all input options Auxiliary engines: all input options
Ship capital cost	..
Unit costs	Insurance: annual or daily input option Repairs and maintenance: annual or daily Administration: daily cost
Cargo loadings	Voyage loading option only
Cargo handling rates	..

.. Not applicable.

CHAPTER 4 COMPUTER IMPLEMENTATION OF THE MODEL

This chapter describes the facilities required to use BTESHIP and the processes involved in operating the program.

COMPUTING REQUIREMENTS

BTESHIP is written in ANSI 1977 standard FORTRAN. McCracken (1984) is a useful guide to the FORTRAN language.

BTESHIP was developed on the Bureau's Concurrent Computer (CC) 3230 minicomputer and also implemented on an IBM PC. The program has almost 2800 lines of source code, 320 distinct variable names, and 44 routines. The executable code produced by the MICROSOFT FORTRAN Optimizing Compiler on the IBM PC takes up almost 100 kilobytes of memory.

The program's source code, executable code, input files (test data and application skeletons) and a file containing output from the test data are stored on the 5¼ inch floppy disc enclosed with this Paper. The skeletons are files into which the user inserts the required input data at indicated positions. The test data relates to four container ships of varying sizes. The user should make particular reference to these files, as they provide examples of the format in which the data should be entered, and are useful in learning how to run the program. The name, description and size of each file is shown in Table 4.1. Specifications for compatible use of this disc are:

- access to MS DOS 2.0 or PC DOS 2.0 or later versions of these operating systems;
- random access memory of at least 256 kilobyte; and
- at least one disc drive that can read a 360 kilobyte floppy disc.

TABLE 4.1 FILES STORED ON THE FLOPPY DISC ENCLOSED WITH THIS PAPER

File name	*Description*	*Size (bytes)*
BTESHIP.FOR	Program source code	101 123
BTESHIP.EXE	Program executable code	97 434
BTESHIP.SV1	Skeleton for input file 1	7 763
BTESHIP.SC1	Skeleton for input file 2	10 183
BTESHIP.SL1	Skeleton for input file 3, voyage loading option	4 196
BTESHIP.SL2	Skeleton for input file 3, percentage loading option	3 003
BTESHIP.SL3	Skeleton for input file 3, yearly loading option	3 685
BTESHIP.SE4	Input file 4	2 399
BTESHIP.SS5	Input file 5	1 298
BTESHIP.DV1	Test data for input file 1	7 763
BTESHIP.DC1	Test data for input file 2	10 183
BTESHIP.DL2	Test data for input file 3	3 003
TEST.OUT	Output from test data	22 687
..	Free space	81 920

.. Not applicable.

When the user can not make use of the disc provided, alternative arrangements may be made for obtaining the source code and other files (see the Special Note at the beginning of this Paper). The user will require use of a FORTRAN compiler when either:

- modifications are made to the source code, or
- access to an executable code compatible with the user's computing facilities is not available.

An editor or word processor will also be necessary to input the data required for running BTESHIP. Most computers are equipped with at least an elementary editor. If a word processor is used, the altered input files must be returned in ASCII format. The user will need a reasonable knowledge of editing or word processing procedures, especially with regard to entering data without changing the existing text. The user will need to know how to execute a program. The program takes around one minute to run on an IPM PC.

The output can be displayed on a terminal screen, or printed. The output file will be a maximum of 80 characters wide and may extend over several pages, as described in Chapter 6.

PROGRAM OPERATION

There are four basic steps in the operation of BTESHIP:

- program preparation
- preparation of the input files
- program execution
- examination of the output files.

The distribution disc must be copied before program operation, and stored in a safe place. Do not use the distribution disc for any program operations, so that you will always have at least one backup copy of all the provided files.

Program preparation

If the executable code provided on the floppy disc is compatible with the user's computing facilities, and if no changes have been made to the source code, then no program preparation is required. Otherwise the user will need to prepare a new version of the executable code. On the BTE's CC 3230 and IBM PC computers this involves compilation to produce an object code, and then linking. This procedure may vary depending on the FORTRAN compiler and the job control language employed by the computer being used.

Some compilers may have additional procedures to follow when compiling programs as large as BTESHIP. The manual for MICROSOFT FORTRAN Version 3 contains a chapter on this subject. To compile BTESHIP using MICROSOFT FORTRAN Version 3 on the IBM PC, it was necessary to split the program into five parts, compile each part separately and then link the parts together. This procedure was not necessary when the MICROSOFT FORTRAN Optimising Compiler was used. Every endeavour has been taken to ensure that BTESHIP is written in standard FORTRAN. However, there may be minor differences in other implementations of FORTRAN that will require changes to BTESHIP before it will compile successfully.

Input file preparation

Preparation of the input files involves entering data into the skeleton input files using an editor. Chapter 5 describes these files and the required data in detail. It is often convenient to print copies of the skeleton input files and use them as a proforma for preparing the input to BTESHIP. A copy of the three skeleton input files is contained in Appendix I, data for input file 4 in Appendix II, and a copy of input file 5 in Appendix III. Each of the skeleton files must be copied before entering the required data. In this way a blank copy of the input files will always be retained and so a totally new set of data may easily be entered at a later time. This process also provides a backup version of the input files. Data in input file 4 may also need to be updated.

The input items necessary to prevent zero divide calculation errors are:

- ship type, deadweight, expected life, speed, length of the analysis period, number of ship working days per year, sea distance, discount rate and exchange rates;
- container life if containerised cargo is carried;
- if port charges are included in the input, the number of port calls in each country during the time period covered by each national light due payment; and
- the number of times that the current voyage is made per year if the yearly loading input is chosen.

As all the input data are retained in the skeleton input files, it is a simple matter to perform additional runs of the program. To examine the sensitivity of the results to a particular parameter, the user only needs to alter that parameter in the input files rather than re-enter all input data before executing the program again.

Program execution

To run the executable code on the disc provided with this Paper, simply enter the name of the executable file: BTESHIP. The program will then ask for names for the input and output files. The file name entered for the output file should refer to a file that does not yet exist on the disc being used. File names entered for the input files must refer to files which already exist and contain data. Figure 4.1 shows the resulting monitor screen when BTESHIP is run with the provided test data, and the output is sent to a file called BTESHIP.OUT.

To execute the program on the BTE's CC 3230, the following operations are performed:

- load the executable code

- allocate a record length for the output file
- assign logical unit 0 to the keyboard and screen
- start the program
- enter a name for each input or output file as prompted.

Once again, the precise commands used will depend on the job control language employed by the computer being used. The program has several logical units for input and output. Table 4.2 describes the files which are assigned to each logical unit during program execution. BTESHIP typically takes less than a minute to execute.

Some common errors that may occur in the program execution are:

- in reading the input files when:
  - lines have been inserted into, or deleted from, the body of an input file
  - data of an incorrect type have been entered (for example, a letter where a digit is required); and
- in program calculations when:
  - a necessary input item has not been entered, resulting in a 'zero divide' calculation error
  - invalid changes have been made to the program.

To check whether lines have been inserted or deleted, compare the size of the input files with the size of the corresponding skeleton files. A list of the input items necessary to prevent zero divide errors is given in the previous section on input file preparation.

```
PLEASE ENTER NAMES FOR THE FOLLWING FILES:
OUTPUT FILE > BTESHIP.OUT
INPUT FILE 1 > BTESHIP.DV1
INPUT FILE 2 > BTESHIP.DC1
INPUT FILE 3 > BTESHIP.DL2

DEFAULT NAME FOR INPUT FILE 4 IS BTESHIP.SE4
DO YOU WANT TO ALTER THIS? (Y/N) > N

DEFAULT NAME FOR INPUT FILE 5 IS BTESHIP.SS5
DO YOU WANT TO ALTER THIS? (Y/N) > N
```

Figure 4.1 Running BTESHIP with provided test data.

Output

To examine the output, the output file may be printed or displayed on the screen depending on the computer's facilities and the user's requirements. The output file produced by BTESHIP contains a '1' in the first column where a page feed is required. Elsewhere, this first column is left blank. The user may wish to alter these characters to the particular page feed character acceptable to the printer being used. Chapter 6 fully describes the output files.

TABLE 4.2 LOGICAL UNIT ASSIGNMENTS

Logical unit	*File type*	*File number*	*Description*
0	Input/ouput	..	Keyboard/screen
1	Input	1	Voyage, port and vessel characteristics
2	Input	2	Cost data
3	Input	3	Cargo details
4	Input	4	Coefficients for equations
5	Input	5	Headings for output tables
6	Output	1	All output

.. Not applicable.

CHAPTER 5 INPUTS

The aim of this chapter is to provide information on the methods of entering data for running BTESHIP. It begins with a description of the design objectives for the data input files and the resulting file formats. It then discusses each item contained in the input files. Discussion of the input items includes definitions, possible data sources, default options and the impact of particular items on the program. The user should also examine Appendix I, which provides guidance on how to use the conventions employed within the data input files. The test data file set contained on the floppy disc which accompanies this Paper is a very useful guide for confirming the manner in which data should be entered.

DESIGN OF THE INPUT FILES

Skeleton input files are used to provide a clear indication of where each data item should be positioned. Skeleton files are files that do not include any input data, but do include a short description of each input, together with marks indicating the position and form of each data item to be entered. It is often convenient to print copies of the skeleton input files and use them as a proforma for preparing the input to BTESHIP.

The use of computer files to store the input data means that it is a simple matter to perform multiple runs of the model. For example, the user may desire to alter just one item of input and then rerun the program. With BTESHIP this can be accomplished by simply altering the relevant data item in the input file, rather than having to re-enter all the data. Furthermore, the use of input files allows the user to hold, say, the vessel and voyage characteristics on a computer file and to vary the loading details as required. In this way, it is possible to build up a permanent library of input files depicting various vessels and/or routes. These procedures not only reduce the time required to input data but also allow the program to execute more quickly than it would if it was arranged on, say, an interactive basis.

There are three primary data input files and two additional input files containing data used in the program. The three primary data files comprise: input file 1 containing voyage, port and vessel characteristics; input file 2 containing costing data and input file 3 containing data on the cargo carried.

There is one skeleton file for input file 1, and one for input file 2. These first two input files contain most of the input data. However, the input for each cargo loading option is fairly lengthy, and so there are three alternative skeleton files for input file 3: one for each cargo loading option. The structures of the skeleton input files 1, 2 and 3 are shown in Appendix I.

The following three sections discuss input files 1, 2 and 3. The discussion explains the main points which should be noted when preparing the input files and references some primary information sources from which input parameter values can be obtained.

The user would normally only have to complete input files 1 to 3. The two other input files comprise: input file 4 containing coefficients for equations used within the model and input file 5 containing table headings which BTESHIP uses when printing out results. Appendix II contains data for input file 4, and Appendix III contains a copy of input file 5. Input files 4 and 5 are discussed in later sections.

INPUT FILE 1: VOYAGE, PORT AND VESSEL CHARACTERISTICS

Input file 1 contains seven main groups of associated data items. These groups cover data relating to:

- run description
- vessel description
- crewing level
- vessel speed
- fuel consumption
- voyage, port and other parameters
- parameter value changes within the analysis period.

The program is structured to allow four vessels of the same ship type, but of varying vessel characteristics, to be costed in a single execution. Input file 1 therefore allows up to four values of deadweight, physical dimensions, crewing level, fuel consumption and so on to be entered. If fewer than four ships are being costed, then the data must be entered in the leftmost of the four spaces in the skeleton input file. Data must be entered for each ship being costed, wherever this is possible, irrespective of whether the data are the same for each ship. The ships must always be referred to in the same order within the data file for one run.

Run description

The run description inputs are labelled within the skeleton files as 'general description', 'origin' and 'destination'. Their purpose is to aid the user in documenting and identifying the outputs for each run of the program. This is best achieved by entering unique run descriptions for each run. However, it is not essential that such descriptions are entered. The run descriptions are simply text which is printed at the top of each page of the output.

Vessel description

Vessel description includes ship type, cargo capacity, deadweight correction value,[1] storage requirements for water, stores, crew and their effects, ship life, age, length, beam, draught, maximum engine power, gross registered tonnage and net registered tonnage. Certain vessel characteristics can be used to calculate various charges levied against the ship (for example, certain port charges, tug charges, light dues and so on). Most of this information can be obtained from Lloyd's *Register of Ships* or other shipping literature.

Ship type
Ship type can be input as one of the following:

- container
- ro-ro
- general cargo
- con-bulk
- bulk
- ore
- tanker.

Ship type is used in the program for determining values for various ship characteristics if these values have not been entered by the user. These ship characteristics include ship length, beam, draught, maximum engine power, gross registered tonnage, net registered

---

1. The deadweight correction value is used to estimate the cargo weight capacity of the vessel by reducing the deadweight to account for fuel, water, stores and other such items.

tonnage, auxiliary engine fuel consumption, and required engine power (which affects main engine fuel costs if the main engine fuel consumption is input in grams per kilowatt hour).

BTESHIP will cost ship types other than those listed above if the user inputs all the necessary vessel characteristics, including the actual daily fuel consumption.

Cargo capacity and related parameters
Input file 1 requires the user to enter ship deadweight, teu capacity and other cargo capacity. These values are available from Lloyd's Register of Shipping. The teu capacity is the total container carrying capacity, including reefers. The other cargo capacity is the grain or bale capacity which is defined as the capacity of cargo spaces, excluding spaces allocated to containers, expressed in cubic metres. Lloyd's *Register of Ships* records the cargo carrying capacity of tankers in litres, so for this vessel type the user needs to convert the capacity in litres to cubic metres and enter the figure against other cargo capacity.

The user must enter the deadweight and cargo capacity for each ship being costed. Deadweight is used throughout the program to estimate ship characteristics that are not entered by the user, for example, ship dimensions, tonnage and power requirements.

The cargo capacity of the ship by weight equals the deadweight minus the storage requirements for items such as fuel, water and stores. The user can either enter a deadweight correction value or allow the program to estimate the cargo weight capacity.

If the correction value is used, cargo capacity (in tonnes) is estimated using the following relationship:

cargo capacity = deadweight (1 - correction value)

Otherwise, the program will calculate the cargo weight capacity as the deadweight less an allowance for fuel. The storage requirement by weight for other items is very small.

Ship life and age
Ship life is the time from commissioning of the ship until it is scrapped. The age of the ship at the start of the analysis period is used in conjunction with ship life to determine when ships are replaced within the analysis period, and also to determine the age of the ship at the end of the analysis period. Ship life and age affect the ship capital cost.

Crew

The crewing level input by the user is the number of berths on the ship. It therefore excludes any crew members on shore leave. A crewing level must be input for each ship being costed. The crewing level affects the cost of victuals. Crewing levels vary considerably from ship to ship depending on their size, age and shipping company agreements.

Vessel speed

Vessel speed at sea can be input in two primary ways:[2]

- in knots
- in number of days for the voyage.

Speed entered as knots refers to the average speed of the vessel at sea, not including time in canals or pilotage. When speed is input as a number of days for the voyage, ship speed in knots is calculated using time in port (which depends on time spent stevedoring), the sea distance and bad weather factor (described later under voyage and port parameters).

Ship speed may be used in calculating the required power for the voyage, and hence fuel consumption. It is also used to calculate time at sea and so affects most of the at-sea costs.

Fuel consumption

The main engine fuel consumption rate can be entered in two ways: the actual consumption in tonnes per day or fuel consumption in grams per kilowatt hour when the vessel is travelling at design speed. Stubbs (1983) estimated that diesel vessels and steam turbine vessels consume 201 and 268 grams per kilowatt hour respectively. BTESHIP assumes main engine fuel consumption in port to be zero.

The auxiliary engine fuel consumption rate can be entered in four ways as follows:

- included in the figure for the main engines, in which case no further information is required;
- entered in tonnes per day;
- entered in grams per kilowatt hour; or
- estimated within the program (see the section on input file 4).

---

2. An option to calculate ship speed from the Froude number is also available but it is not expected that this would generally be used.

Lloyd's *Register of Ships* contains fuel consumption rates for some ships. Other sources of information include Motor Ship, similar magazines or engine manufacturers.

Voyage, port and other parameters

The user is required to input information relating to canal usage, sea distance, bad weather factor, pilotage times, hours spent not stevedoring in port and other parameters.

Canal usage

The program allows up to three canals to be traversed during the voyage being analysed. If one or two canals are traversed on the voyage, then the letters describing the appropriate canals must be placed in the leftmost positions of the appropriate fields in input file 1. For example, if just the Suez canal is traversed during the voyage, enter an 'S' in the leftmost field and leave the others blank. Time spent traversing each canal should be placed beneath the corresponding canal identifier.

Lloyd's Voyage Record can be used to determine which canals are used on a particular voyage. Advice from various shipping companies suggests that 8 and 20 hours for the Panama and Suez Canals respectively are reasonable travel durations for these canals. However, the real time will also depend on the time spent waiting. Economic and Social Commission for Asia and the Pacific (1979) recommends that one day should be allowed for a canal transit including waiting time. Any waiting time should be included in 'time at port spent not stevedoring', as this gives a more realistic calculation of fuel costs. Time spent in canals is included in time at sea, and hence affects most of the at sea costs.

Analysis period

The analysis period is the number of years over which capital costs are annualised, and over which the effects of any changes in vessel characteristics can be distributed. It may be convenient to set the analysis period equal to the remaining life of the ship. This may vary with the type of analysis being conducted.

Ship working days per year

The number of ship working days per year takes into account the average number of days spent in dry docks for maintenance. Due to technological improvements, the number of ship working days per year for a new or well kept vessel has increased in recent years from around 350 days to 359 days. However, Economic and Social Commission of Asia and the Pacific (1979) suggests that old vessels can lose a month per year due to breakdowns and repair and maintenance.

Pilotage times
Pilotage time is the time to travel between the port entrance and the wharf or vice versa. In the input file, this is described as the time to exit port A, and the time to enter port B. Pilotage distances for Australian ports can be found in Federal Department of Transport (1984).

Hours not stevedoring
The number of hours spent not stevedoring in port includes docking, industrial stoppages and any other time in port apart from that spent stevedoring. Data for Australian ports can be found in Federal Department of Transport (1984). Only the time in each port which is attributable to the single-leg voyage being costed should be entered.

Sea distance and bad weather factor
The sea distance between two ports can be obtained from Caney and Reynolds (1981). Routes can be determined by analysis of ship movements from *Lloyd's Voyage Record,* or by consulting shipping companies. The distance entered should not include pilotage distances or canal lengths.

A bad weather factor can be input to take into account both deviations in the route travelled, due to wind directions, currents or channels, and also loss of time due to bad weather. Time at sea for the voyage is obtained by dividing the distance by the bad weather factor and the speed. Experience in the shipping industry suggests that bad weather adds some 10-15 per cent to time at sea (Economic and Social Commission for Asia and the Pacific 1979), hence a bad weather factor of 0.85 was used when testing the program.

Container parameters
The average life of a container, in years, is used to calculate container capital costs. The weight of an empty container is used in calculating maximum allowable cargo loads, and in converting loading rates from tonnes per hour to teus per hour. The container slot ratio is the number of containers owned by the shipping company for each teu of the ship's capacity.

For a ro-ro vessel, only a proportion of the total container capacity may actually be occupied by containers. The rest of the space will be occupied by non-containerised cargo. The number of containers owned by the shipping line for each teu of the ship's capacity (that is, the container slot ratio) is therefore likely to be lower for a ro-ro vessel than for a container vessel.

Information on these items can be obtained from *Containerisation*

International or from various shipping companies. Economic and Social Commission for Asia and the Pacific (1979) suggested that the shipping industry assumes there are 2.5 containers for each slot on the vessel. Other sources suggest this ratio varies from 1.5 to 3 among different shipping lines. BTE (1986) utilised an average expected container life of 12 years. Finally, the approximate weight of an empty container is 2.5 tonnes.

Parameter value changes during the analysis period

BTESHIP has been structured to enable several vessel parameters to be varied during the analysis period. This capability is particularly useful for examining the difference in cost between modifying a vessel early in the analysis period and delaying the modification until later in the period.

The user can specify whether or not any change affects both the existing and any replacement ship introduced during the analysis period. The time of introduction of the change in terms of number of years from the start of the period is also specified.

Various items of information can be specified to allow the effect of changes in major components of ship costs to be examined.[3] In brief, these items are:

- fractional decrease in fuel consumption;
- fractional increase in cost of construction of a similar ship at the time of change (which can affect insurance and administration costs);
- capital cost of specific change to vessel. This can be specified directly and/or as a cost per kilowatt capacity of the ship's engine before modification (a form used primarily for changes to the ship's engines);
- increase in ship repair and maintenance cost after change; and
- reduction in crewing level.

If the option relating to the effect of change in vessel parameters is left blank then the program will assume that the vessel parameters are constant throughout the analysis period. Information on new ship technology can be obtained from various shipping journals.

---

3. Changes can be entered as positive or negative values to reflect the appropriate direction of the change. The list shown here refers to the positive values; for example, an increase in fuel consumption would be entered as a negative value.

INPUT FILE 2: COST DATA

Within input file 2 there are eight main groups of associated data items:

- discount rate, exchange rates and output specifications
- ship capital cost, insurance, maintenance and administration
- container capital cost, maintenance and cleaning costs
- crew, victuals and stores costs
- fuel prices
- canal charges
- port-related charges
- stevedoring charges.

Discount rate, exchange rates and output specifications

The model uses the discount rate for the discounting and annualising of capital costs and any other costs affected by a change in the vessel parameters during the analysis period. It must be entered as a decimal fraction.

Exchange rates are used to convert input unit costs to the appropriate currency. Input file 2 is structured to allow each cost item to be input in its most convenient currency. Hence, port charges can be input in their own currency and crew costs can be input in the currency in which they are paid. The program then uses the relevant exchange rates to convert all costs either to US$ or $A depending on the output currency option selected by the user. The user is also required to specify whether the summary output format or the extended output format is desired (see Chapter 6). Exchange rates can be obtained from the *Australian Financial Review,* Reserve Bank publications and a wide variety of other published material.

Ship capital cost, insurance, maintenance and administration

Ship capital cost

The user is required to select one of four input currency options for ship capital costs. These are the same four currency options that are provided for the input of various other cost items throughout input file 2.

The program is structured to annualise capital costs over an analysis period specified by the user. If, for example, the analysis period is set equal to the remaining life of the ship, then the following capital costs would need to be specified:

- resale value of the vessel at the start of the period
- scrap value.

However, the program can also account for the replacement of the existing vessel with a vessel of similar characteristics. In this case four cost items need to be specified:

- resale value of the existing vessel at the start of the period
- scrap value of the existing vessel
- newbuilding price of the replacement vessel
- resale value of the replacement vessel at the end of the analysis period.

Each of these four ship capital costs should relate to vessels of similar characteristics but differing ages. Capital costs should all be expressed in constant dollars. If more than one ship is being costed then the user is required to input separate capital costs for each ship. The data must be entered in the leftmost of the four spaces in the skeleton input file if fewer than four ships are being costed.

Shipping Statistics and Economics, *Lloyds Shipping Economist*, *Fairplay International Shipping Weekly* and similar magazines carry information on ship capital costs. *Shipping Statistics and Economics* (1985) expresses scrap prices in US$ per light displacement ton. Factors for converting deadweight tonnes to light displacement tons are contained in Table 5.1.

Capital costs can also affect the calculation of ship insurance, ship repair and maintenance and administration costs, depending on the input options chosen for these costs.

Insurance and maintenance costs
There are three ways of entering ship costs:

- as a fraction of ship replacement cost;
- as a cost per year; or
- as a cost per day the ship is in operation.

The program assumes the replacement cost equals the newbuilding price unless the user has specified a change in the ship construction cost since the beginning of the analysis period. In this case, the replacement cost from the time of the change equals the newbuilding price plus the change in construction cost.

TABLE 5.1 CONVERSION FROM DEADWEIGHT TONNES TO LIGHT DISPLACEMENT TONS

Ship deadweight ('000 tonnes)			*Conversion factor (ldt/dwt)*
0.01	-	5.00	0.45
5.01	-	10.00	0.39
10.01	-	15.00	0.35
15.01	-	20.00	0.33
20.01	-	30.00	0.30
30.01	-	40.00	0.28
40.01	-	50.00	0.26
50.01	-	75.00	0.23
75.01	-	100.00	0.21
100.01	-	150.00	0.19
150.01	-	200.00	0.16
200.01	-	250.00	0.14
250.01	-	500.00	0.11
500.01	-	1 000.00	0.05

Source The World Bank (1985).

The user may specify ship repair and maintenance costs:

- as a fraction of the ship's newbuilding price (in which case the user should check that a newbuilding price has been entered in input file 2);
- as a cost per year; or
- as a cost per day the ship is in operation.

Ship repair and maintenance costs should not include the cost of stores used for ship maintenance, as this should be included in the stores cost.

Both ship insurance and ship repair and maintenance costs are difficult to estimate. Downard (1981) lists the owner's good record as being important in obtaining reasonable insurance premiums, as well as the trading area, flag, classification and dimensions of the ship. The types and extent of insurance can also vary. The World Bank (1985) reports 'Repair and maintenance costs are difficult to determine since they will vary widely with size, age, and condition of a vessel and with the location in which repairs are performed.'

As a result, users may generally prefer to enter insurance as a fraction of replacement cost, and repairs and maintenance as a fraction of newbuilding cost.

Zerby, Conlon and Kaye-Kucharzewski (1981) estimate ship insurance costs to be 2.0 per cent of the ship's book value, and repairs and stores costs combined to be 2.5 per cent of the ship's book value. The World Bank (1985) estimates annual insurance costs, as a percentage of vessel replacement cost, to be 0.4 to 0.7 per cent for tankers, 0.6 to 1.0 per cent for dry bulk ships, 0.6 to 1.2 per cent for general cargo ships and 0.7 to 1.3 per cent for container vessels. It estimates annual repair and maintenance costs to be between 1.5 and 2.5 per cent of the vessel newbuilding cost. BTE (1982) estimates ship insurance costs to be 1.0 per cent of ship's initial capital cost, and follows Gilman et al. (1978) by estimating annual ship repair and maintenance costs to be 10.0 per cent of annual capital costs. However, this estimate of repair and maintenance costs assumed that a discount rate of about 12 per cent was used. If lower discount rates are used this approach can result in an under-estimate of repairs and maintenance costs.

Administration costs

The user may enter ship administration costs as a fraction of ship costs excluding fuel or as a cost per day the ship is in operation. Ship costs include: ship capital, container capital, ship repair and maintenance, container repair and maintenance, container cleaning, ship insurance, crew, stores, fuel and administration costs. When ship administration costs are entered as a fraction of ship costs excluding fuel, care must be taken that each of these other component costs is entered.

BTE (1982) reports that in 1978 '$300 per day was quoted by one operator as indicative (of administrative costs for one ship)' and further states that, on this basis, administration costs are between 1 and 5 per cent of operating costs without fuel. Gallagher and Meyrick (1984) estimate administration and overhead costs to be between $600 and $1200 per day, which represents 4.9 to 10.6 per cent of operating costs without fuel. Zerby, Conlon and Kaye-Kucharzewski (1981) assume an administration cost of $900 per day for each ship.

Container capital cost, maintenance and cleaning costs

The program allows the specification of current replacement costs and salvage values for dry and reefer containers, annual container maintenance costs and cleaning costs. Clearly, this information only needs to be entered if the ship is carrying containerised cargo.

Costs are for an International Standards Organisation (ISO) standard teu.

Possible sources for these data items are shipping companies, container manufacturers, container leasing firms, shipping consultants and magazines such as *Containerisation International, Fairplay International Shipping Weekly* and *Cargo Systems International.* Estimates of these costs at August 1986 were US$2000 for a new ISO standard dry container and US$12 000 for a new ISO standard integral reefer container (based on *Containerisation International,* 1986). Furthermore, BTE (1982) suggested that an insulated reefer (port hole type) was about half the cost of an integral reefer. Annual maintenance costs were estimated to be about $A400 per container in 1986, although this figure can vary markedly for dry and reefer containers and is dependant on various operating practices. The charge in 1986 to sweep, clean and remove labels from a container was about $A35, although steam cleaning of a reefer can cost up to $A200.

Crew, victuals and stores costs

Crew costs

To avoid the complexity associated with the various components and determinants of crew costs, the program requires only the specification of average annual crew cost per berth. In the case of crew members who are employed by the shipping company, this should be a cost which reflects the total annual cost per berth (including wages, leave, superannuation and allowances). If, on the other hand, the crew has only been hired for the voyage the specified data should include all costs associated with hiring a crew member. BTE (1986) used a value of $A85 000 per berth per year as an estimate for Australian conditions at January 1985. Crew costs vary considerably by nationality: India, Liberia, Korea, Singapore and the Philippines are at the lower end of the world scale (World Bank 1985).

Victuals and stores costs

The two inputs required are: victuals expenditure per person per day and annual ship stores expenditure. Victuals expenditure includes all catering costs except for items such as vacation meal allowances which are included in crew costs. Ship stores include paints, ropes, greases, oils, cleaning materials, clothing supplies and canteen supplies.

The World Bank (1985) estimated victuals expenditure to be US$9.50 per person per day, plus or minus 30 per cent depending on the crew nationality and flag of the ship. The World Bank also estimated annual stores costs to be 0.5 percent of the replacement cost of the vessel. BTE (1982) estimated victuals costs in Australia for one ship in mid-1978 to be $A2000 per year per crew member, and annual stores costs at the same time to be $A90 000.

Fuel prices

Fuel prices need to be entered for both the main and auxiliary engines in dollars per tonne. Main engines use fuels such as marine fuel oil or heavy fuel oil. For a diesel engine vessel, auxiliary power is generated using marine diesel oil. However, for a steam turbine vessel both main and auxiliary power are generated using marine fuel oil. Care must be taken that the data entered for fuel prices and fuel consumption rates refer to the same grade of oil.

Information on fuel prices is readily available in *Lloyd's Ship Manager, Daily Commercial News* and from companies such as Shell International Trading Company and British Petroleum Australia. Fuel prices have a large impact on total costs, and may have an impact on administration costs.

Canal charges

Canal charges are levied by the relevant canal authorities for each transit of a canal. The components of these charges and their method of calculation vary, depending on the canal traversed. The net tonnages used to calculate some charges are measured in accordance with the instructions of the particular canal authority, and may differ significantly from the nrt. For simplicity the program requires a single canal charge to be entered for each canal traversed. Data on canal charges can be obtained from canal authorities or shipping companies. Suez Canal charges at January 1985 were approximately US$17 000 plus US$2.3 per Suez Canal net ton. Tolls for the Panama Canal at the same time were US$1.83 per Panama Canal net ton for laden vessels, and US$1.46 per Panama Canal net ton for vessels in ballast. A line handling charge of between US$1240 and US$2390, depending on the length and beam of the vessel, was also levied.

Port-related charges

The user is only required to input this information if port charges are to be included in the calculation of vessel costs. Port charges are input under two basic categories: those partially attributable to the current single-leg voyage, and those totally attributable to the current single-leg voyage. Port charges vary considerably from port to port, in both magnitude and structure. Port and related charges can be obtained from relevant port authorities, State marine boards and towage companies.

Charges that are dependent on the time spent in port or the amount of cargo handled are totally attributable to the single-leg voyage being costed. Charges which relate to the size of the vessel and which are independent of the length of time spent in port are partly attributable to this leg, partly attributable to the previous leg in the case of port A and partly attributable to the next leg in the case of port B. Hence, the fraction of these charges, in each port, to be attributed to the current leg has to be specified in the input data. A value of 0.5 is assumed by the program if no other value is input by the user.

Partially attributable port charges
National light and pollution dues generally cover a number of months, during which time several port calls may be made in the country. Hence, the input data should include the number of port calls that are likely to be made in the relevant country during the period covered by the charge. This allows the appropriate portion of the charge to be attributed to this port call. The charge may then be input in dollars per nrt of the ship, or grt. If both origin and destination ports are in the same country, then the same data for national dues should be entered for each port. An entry must be made for the number of port calls if port charges are to be included, irrespective of whether any national light and pollution charges are entered.

Other partially attributable charges include tonnage, pilotage, mooring and State harbour and light dues (conservancy). Partially attributable charges may be entered in the following ways:

- dollars
- dollars per nrt
- dollars per grt
- dollars per metre of ship beam
- dollars per metre of ship length
- dollars per metre of ship draught.

If, for example, two charges are based on grt the user should sum the charges and enter the total. Once the partially attributable port charges are calculated, they are multiplied by the fraction attributable to the single-leg voyage being costed. Hence, partially attributable charges must be entered as the total charge from when the ship enters that port until it exits that port.

Totally attributable port charges
Port-related charges that are totally attributable to a specific port

call include tug and launch charges, wharfage, berth rent and ancillary services, that is, any charge which is time or cargo dependent. Charges can be entered under a number of categories, as indicated in Appendix I (including a wharfage charge for any fuel loaded in port A). If two charges are based on the same measure, the total charge should be input.

Both tug and launch charges can be entered in dollars per movement or dollars per ship ton. It is assumed that only one movement in each port is attributable to the current leg. The measure for tug and launch charges may be either nrt or grt. The tug charge will depend on the type of tug required, as well as port details and the time at which tugs are required. The number of tugs required depends on the type of tug utilised, the size and type of the vessel, weather and tidal conditions, any fittings on the vessel which increase manoeuverability and the ship master's preferences. Launches may be used to ferry shipboard lines from the vessel to the wharf during docking, or the reverse on departure. A launch may also be used to ferry the pilot to or from the vessel, and this should be included if it is not included in the pilotage charges.

Stevedoring charges

As BTESHIP costs a single-leg voyage, the program only considers loading charges in port A and unloading charges in port B. In each case the user is required to enter unit stevedoring charges for various sorts of cargo. These charges may be obtained from stevedoring companies, specialised terminal operators or shipping companies. The stevedoring charge to load fuel in Australia in early 1985 was approximately $7 per tonne (BTE 1986).

INPUT FILE 3: CARGO DETAILS

Input file 3 contains five groups of associated data:

- loading option
- maximum allowable loading
- cargo carried
- cargo handling rates
- cargo densitites.

Loading option

Information on the cargo carried can be entered in three ways:

- voyage loadings

- percentage loadings
- yearly loadings.

Separate input formats and skeleton files exist for each of these options as shown in Appendix I. BTESHIP determines the option chosen by reading the code after the words 'SHIP LOADING OPTION ='. This code must not be changed in the skeletons, or a run time error will occur.

Maximum allowable loading

If input loading options 1 or 3 are used, the user can enter a maximum allowable loading for the ship. The maximum amount of all cargo and containers (including empty containers) is entered as a percentage of the total cargo capacity of the ship. This input item can be used to ensure that the total loading on the ship does not exceed a certain level. This might reflect, for example, operating a ship in a period of depressed demand or operating a vessel on a route where draught restrictions mean the vessel cannot be fully loaded. A default value of 100 per cent is assumed if this item is left blank. It is not necessary to specify a maximum allowable loading if input option 2 is used because in that case the loading is already expressed as a percentage of the ship's capacity.

Cargo carried

The cargo carried by the vessel is input differently for each of the three loading options. The input requirements for these options are discussed below.

Voyage loadings
When the voyage loading option is used, details of the following are required:

- cargo remaining on board at port A
- cargo loaded at port A
- cargo unloaded at port B.

Details of the cargo carried are required for each ship specified in input file 1, and must be entered separately for each of the following categories where appropriate:

- non-empty dry containers
- empty dry containers
- non-empty reefer containers

- empty reefer containers
- non-containerised cargo.

When describing the cargo loaded at port A or unloaded at port B, it is also necessary to specify the number of non-empty containers and the amount of non-containerised cargo that is being transhipped. Transhipped cargo is cargo that is unloaded from one vessel for transfer to another vessel. This cargo can attract a lower stevedoring charge. It is assumed that transhipped containers are not empty.

Percentage loadings
If the percentage loading option is chosen, then it is assumed that the same percentages will apply to each of the four ships specified in input file 1. The total cargo load for the voyage is entered as a percentage of either the cargo weight or volume capacity of the ship. The weight capacity is calculated from the deadweight and an allowance for other items. The volume capacity is specified in input file 1.

The amount of non-containerised cargo is entered as a percentage of the total cargo by weight or volume, whichever is used to specify the total load.

The percentages of containers which are empty, reefers and transhipments respectively are entered. It is assumed that the same proportion of reefers will be empty as for all containers, and that the same proportion of transhipments will be reefers as for all containers. It is further assumed that no empty containers are transhipped. The percentage of non-containerised cargo which is transhipped in each port is also entered.

Yearly loadings
The yearly cargo load is assumed to be the same for all of the ships entered in input file 1. Details are required for the following:

- cargo loaded at port A
- cargo on board during the voyage
- cargo unloaded at port B.

Cargo loadings must be entered separately for each of the relevant cargo categories mentioned previously.

When describing the cargo loaded at port A or unloaded at port B, the number of non-empty dry and reefer containers and the amount of non-containerised cargo which is transhipped in each port is also required. It is assumed that no empty containers are transhipped. In order to calculate the load for a voyage, the number of voyages per year is also required. This will need to be estimated by the user, taking into account the total utilisation of the vessel over a year.

Cargo handling rates

Cargo handling rates must be entered in teus per 24-hour day for containers and thousands of tonnes per 24-hour day for non-containerised cargo. The actual rate will depend on the type of cargo being moved, the size of the vessel and the cargo handling facilities being used. Separate cargo handling rates can be input for each ship being costed.

Cargo densities

The average weight of cargo per container (in tonnes) is required to calculate total cargo weight. This weight should not include the weight of the container itself, which is contained in input file 1. The weight of non-containerised cargo per cubic metre is required to calculate the total cargo volume.

If these items are not entered, checks on whether the total cargo exceeds the vessel capacity are not performed. Also, if the percentage loading option is chosen the following must be entered:

- weight of cargo per container if containerised cargo is carried and the total load is specified as a percentage by weight; and
- weight of non-containerised cargo per cubic metre if non-containerised cargo is carried and the total load is specified as a percentage by volume.

INPUT FILE 4: COEFFICIENTS FOR EQUATIONS

Input file 4 contains the values of coefficients for equations used within the model, together with the values of a number of constants. The user would not normally have to alter these values. The relations covered by these coefficients are:

- ship characteristics as a function of ship deadweight;
- an adjustment to main engine fuel consumption as a function of the fraction of installed power utilised;
- average engine power required at sea as a function of speed and deadweight; and
- auxiliary fuel requirements as a function of deadweight.

This section describes the methods of deriving each of the above relations. Appendix II contains the parameters contained in input file 4, and details of where the coefficients must be placed within the file. Appendix II also contains information on the significance of the regression equations. As ship and engine design changes occur, the relevance of the regressions may diminish. Hence, users should always consider the relevance of the equations to their particular situation before using the relations available in BTESHIP.

The ship characteristics covered are:

- length
- beam
- draught
- maximum power output of the main engine
- grt
- nrt.

Separate sets of coefficients are presented for each ship type. Coefficients for ro-ro and con-bulk ship types were based on regressions of Lloyd's Register of Shipping (1984b), current at September 1984. The coefficients for the remaining ship types were obtained from BTE (1980). These were based on regressions of Lloyd's Register of Shipping (1977). These relations are only used when values for these items have not been entered in input file 1.

The fuel adjustment relation is derived from *Motor Ship* (1985). It is used when main engine fuel consumption is input in grams per kilowatt hour. Main engine fuel consumption is then multiplied by the adjustment factor obtained from this relation.

Average engine power required at sea is calculated using speed and deadweight. As was the case for the ship characteristics, the coefficients for ro-ro and con-bulk ship types were obtained from regressions of data from Lloyd's Register of Shipping (1984b), and the remainder from BTE (1980). This relation is only used when main engine fuel consumption is entered in grams per kilowatt hour.

The auxiliary fuel equation for bulk ships, ore carriers and tankers at sea was obtained from a regression of auxiliary fuel consumption and deadweight for tankers in the Australian trade from Lloyd's Register of Shipping (1984a). The remaining auxiliary fuel consumption figures were obtained from BTE (1982) and Stubbs (1983). All these estimates of auxiliary fuel consumption relate to the amount of marine diesel oil consumed by diesel engine vessels.

INPUT FILE 5: HEADINGS FOR OUTPUT TABLES

Most column and row headings for the output files are read from a file so that they do not have to be contained in the text of BTESHIP. Chapter 6 fully describes the format of the output files. Appendix III contains a copy of input file 5. It is not envisaged that the user will need to change input file 5 unless the form of the output tables is changed.

MULTI-LEG VOYAGES

When preparing the input data for a multi-leg voyage, care must be taken with the following inputs:

- Cargo load: cargo remaining on board at the start of the current leg must be equal to cargo remaining on board at the end of the previous leg.
- Time in port not stevedoring: this must apply only to the current leg. Hence the total time spent not stevedoring in any one port is the sum of the time applying to the leg ending in that port and the time applying to the leg starting in that port.
- Port charges: if port charges are included, the fraction of port charges attributable to the leg ending in port A plus the fraction attributable to the leg starting from port A must sum to one.

The facility to cost individual legs of a voyage can provide useful details on ship operating costs. However, it may be inconvenient to run the program separately for every leg of the voyage if a vessel is calling at several ports in one trade area and several more ports in another trade area. In such a situation it can be more convenient to consider the model to be costing a voyage from trade area A to trade area B. To correctly cost such a voyage it is necessary to enter the total sea distance for all legs of the voyage as a single figure. Various other parameters need to be entered in a similar manner, for example the total pilotage time for all legs of the voyage, the total time in port not stevedoring, and an average cargo handling rate for all ports within a trade area.

CHAPTER 6 OUTPUTS

This chapter describes the various forms of output from BTESHIP. The program provides a choice of two output formats. The user specifies in input file 2 whether a summary output or an extended output is desired.

The summary output is designed for the user performing numerous runs of the program and seeking only the basic results from each run. The summary output provides run details to identify the run, cargo loadings, duration of the voyage and ship costs which are the primary outputs of the program.

The extended output describes cargo loadings and ship costs in more detail and also provides vessel and voyage parameters. In addition to providing more detail, the extended output is designed to enable the user to determine the values of any vessel parameters that are generated within the program. It is recommended that the extended output be consulted as necessary to ensure that the generated values adequately reflect the parameters for the voyage being costed.

SUMMARY OUTPUT

The summary output format is illustrated in Figure 6.1. The single page output format shown in the figure relates to one ship. BTESHIP can accommodate up to four ships in one execution, in which case one page of summary output will be generated for each ship.

The run details are provided to identify the run and are all obtained directly from input file 1. The summary of cargo loadings includes the tonnage of all cargo on board for the voyage (excluding the weight of containers) and the tonnages of containerised cargo and non-containerised cargo, where appropriate data were entered to calculate these items. For containerised cargo, the number of non-empty teus is also presented.

The ship costs relate to a single-leg voyage from port A to port B and are expressed in the currency specified by the user in input file 2.

FEDERAL BUREAU OF TRANSPORT ECONOMICS : BTESHIP

FROM TO

SHIP :	DWT
TOTAL CARGO ONBOARD	TONNES
NON-EMPTY CONTAINERS	NE TEUs
CONTAINERISED CARGO	TONNES
NON-CONTAINERISED CARGO	TONNES

SHIP COSTS (EXPRESSED IN)

COST ITEM	TOTAL COST ($)	ALL CARGO ($/TONNE)	CONT.CARGO ($/NE TEU)	CONT.CARGO ($/TONNE)	NON-CONT. ($/TONNE)
VESSEL COSTS					
CAPITAL					
FUEL					
CREW					
REPAIRS & MAINT.					
INSURANCE					
VICTUALS & STORES					
ADMINISTRATION					
TOTAL VESSEL COST					
CANAL CHARGES					
PORT CHARGES					
WHARFAGE CHARGES		..	..	..	..
STEVEDORING CHARGES		..	..	..	..
TOTAL		..	..	..	..

.. not applicable

DURATION OF VOYAGE (DAYS)

ITEM	SHIP A	SHIP B	SHIP C	SHIP D
TIME AT SEA				
TIME AT BERTH				
PORT A				
PORT B				
TOTAL AT BERTH				
TOTAL FOR VOYAGE				

Figure 6.1 Summary output format

The program always calculates the components of vessel costs shown in Figure 6.1. Canal charges, port-related charges (including wharfage) and stevedoring charges are only calculated when the respective options for their inclusion are specified by the user in input file 2.

Ship costs are presented as a total cost in dollars for the voyage and, where applicable, as a cost per unit of cargo carried. If the vessel is in ballast and carrying no cargo then only the total cost for the voyage (column 1 of Figure 6.1) will be produced. In other situations, information will also appear in the other columns as appropriate. The costs per unit cargo shown in columns 2, 3, 4 and 5 are all derived using the summary cargo loadings shown above the table of ship costs.

In general, it is not appropriate to include wharfage and stevedoring charges when calculating a cost per unit of cargo carried. Wharfage and stevedoring relate to the cargo loaded at port A and unloaded at port B. They do not relate to the cargo on board for the voyage. Therefore, the total cost of moving, say, one container from port A to port B would be the total vessel cost, canal charge and port charge per non-empty teu plus the wharfage and stevedoring charges incurred for one container.

The duration of the voyage shows the time spent at sea and the time at berth in port A and port B for the single-leg voyage being costed. The time at berth includes both time spent stevedoring and time at berth but not stevedoring. Pilotage time is included in time at sea.

EXTENDED OUTPUT

The extended output format is shown in Figures 6.2 to 6.4. The first page of the extended output presents ship costs and summary cargo loadings. This page is repeated for each ship being considered. The second page of the extended output presents detailed ship loadings. This page is also repeated for each ship. The final page of extended output presents various voyage and vessel parameters. This third page of output is structured so that it can accommodate up to four ships and, hence, is not repeated for each ship considered by the program. If BTESHIP is run for a single ship, three pages of extended output will be generated. If BTESHIP is run for the maximum of four ships, nine pages of extended output will be generated.

Page 1 of the extended output (illustrated in Figure 6.2) is similar in format to the summary output: run details, cargo loadings and ship costs are presented. However, the extended output describes the ship costs in greater detail than does the summary output.

FEDERAL BUREAU OF TRANSPORT ECONOMICS : BTESHIP

FROM TO

SHIP :	DWT
TOTAL CARGO ONBOARD	TONNES
NON-EMPTY CONTAINERS	NE TEUs
CONTAINERISED CARGO	TONNES
NON-CONTAINERISED CARGO	TONNES

SHIP COSTS (EXPRESSED IN)

COST ITEM	TOTAL COST ($)	ALL CARGO ($/TONNE)	CONT.CARGO ($/NE TEU)	CONT.CARGO ($/TONNE)	NON-CONT. ($/TONNE)
VESSEL COSTS					
CAPITAL					
SHIP					
CONTAINERS					
FUEL					
AT SEA					
AT BERTH					
CREW					
REPAIRS & MAINT.					
SHIP					
CONTAINERS					
CONTAINER CLEANING					
INSURANCE					
VICTUALS					
STORES					
ADMINISTRATION					
TOTAL VESSEL COST					
CANAL CHARGES					
PORT CHARGES					
AT PORT A					
VESSEL CHARGES					
TUG & LAUNCH					
NATIONAL LIGHT					
TOTAL AT PORT A					
AT PORT B					
VESSEL CHARGES					
TUG & LAUNCH					
NATIONAL LIGHT					
TOTAL AT PORT B					
TOTAL PORT CHARGES					
CARGO CHARGES					
PORT A : WHARFAGE		..	..	..	..
: STEVEDORING		..	..	..	..
PORT B : WHARFAGE		..	..	..	..
: STEVEDORING		..	..	..	..
TOTAL CARGO CHARGES		..	..	..	..
TOTAL		..	..	..	..

.. not applicable

Figure 6.2 Extended output format: page 1

FEDERAL BUREAU OF TRANSPORT ECONOMICS : BTESHIP

FROM TO

SHIP : DWT

LOADING DETAILS

CARGO TYPE	CARRY OVER AT PORT A	LOADED AT PORT A	TOTAL LOAD	UNLOADED AT PORT B	CARRY OVER AT PORT B
CONTAINERS (TEUs)					
NON-EMPTY CONTAINERS					
DRY					
REEFER					
TOTAL					
EMPTY CONTAINERS					
DRY					
REEFER					
TOTAL					
TOTAL CONTAINERS					
CARGO (TONNES)					
CONTAINERISED					
NON-CONTAINERISED					
TOTAL PAYING CARGO					

CARGO TRANSHIPMENTS

CARGO TYPE	TRANSHIPPED AT PORT A	TRANSHIPPED AT PORT B
CONTAINERS (TEUs)		
NON-EMPTY CONTAINERS		
DRY		
REEFER		
TOTAL		
CARGO (TONNES)		
CONTAINERISED		
NON-CONTAINERISED		
TOTAL PAYING CARGO		

Figure 6.3 Extended output format: page 2

```
              FEDERAL BUREAU OF TRANSPORT ECONOMICS : BTESHIP
             ------------------------------------------------

FROM                                 TO

SHIP LOADING LIMITS
-----------------------------------------------------------------
ITEM                                SHIP A  SHIP B  SHIP C  SHIP D
-----------------------------------------------------------------
ACTUAL WEIGHT (TONNES)
  CARGO
  CONTAINERS
                            -------------------------------------
  TOTAL WEIGHT

WEIGHT LIMIT (TONNES)

ACTUAL VOLUME (CUBIC METRES)
  CARGO
  EMPTY CONTAINERS
                            -------------------------------------
  TOTAL VOLUME

VOLUME LIMIT (CUBIC METRES)
-----------------------------------------------------------------

DURATION OF VOYAGE (DAYS)
-----------------------------------------------------------------
ITEM                                SHIP A  SHIP B  SHIP C  SHIP D
-----------------------------------------------------------------
TIME AT SEA
TIME AT BERTH
  PORT A
  PORT B
                            -------------------------------------
  TOTAL AT BERTH
-----------------------------------------------------------------
TOTAL FOR VOYAGE
-----------------------------------------------------------------

SHIP SIZE, SPEED, POWER AND FUEL CONSUMPTION
-----------------------------------------------------------------
ITEM                                SHIP A  SHIP B  SHIP C  SHIP D
-----------------------------------------------------------------
DEADWEIGHT (TONNES)
NET REGISTERED TONS
GROSS REGISTERED TONS
LENGTH (METRES)
BEAM (METRES)
DRAUGHT (METRES)

SHIP SPEED (KNOTS)

MAIN ENGINE POWER (KW)
  MAXIMUM
  AVERAGE REQUIRED AT SEA

FUEL CONSUMPTION (TONNES)
  MAIN ENGINES
  AUXILIARY ENGINES
                            -------------------------------------
  TOTAL CONSUMPTION
-----------------------------------------------------------------
```

Figure 6.4 Extended output format: page 3

Port-related charges are itemised under three sub-headings and shown separately for port A and port B. Port-related charges associated with the vessel include pilotage, tonnage and conservancy dues. The wharfage cost includes charges relating to both cargo and fuel for the ship's engines.

Page 2 of the extended output (illustrated in Figure 6.3) presents a detailed description of the vessel loadings and cargo transhipments. It includes the number of each type of container carried and the tonnages of non-containerised cargo. Tonnages of containerised cargo are also included when appropriate data are entered. BTESHIP allows for a situation in which a vessel at port A carries cargo that was loaded at a previous port, and for a vessel at port B carrying some cargo on to a further port. The facility to identify these 'carryover' loadings is particularly useful when costing a multi-leg voyage.

Cargo transhipments are also itemised on page 2 of the extended output. Cargo that is transhipped from one vessel for further carriage by another vessel may incur different port and stevedoring charges to other cargo.

Figure 6.4 shows the format for the third page of extended output. This page of output describes the following parameters:

- ship loading limits
- duration of the voyage
- ship capacity and dimensions
- speed, power and fuel consumption.

BTESHIP compares the actual cargo load with both the maximum allowable cargo weight and the maximum allowable cargo volume, when possible, to ensure that the load does not exceed the capacity of the vessel. If loading option 1 or 3 is used and a limit placed on the allowable vessel load, then the loading limits shown in the output table will reflect these allowable limits rather than the actual capacity of the vessel.

The time at berth includes both time spent stevedoring and time at berth but not stevedoring. Pilotage time is included in time at sea.

APPENDIX I INPUT FILES 1, 2 AND 3

This appendix contains the data input skeleton files for input files 1, 2 and 3, as referred to in Chapter 5. These files are used to provide a clear indication of where each data item should be positioned. They do not include any input data. The skeleton files include some conventions, created for this project, which are described below.

SYMBOLS

Each input within the skeleton files has a description of the input beside it. This description is followed by the format type of the input. These are similar to the FORTRAN format statements used within BTESHIP:

- 'A' refers to a character input;
- 'F' refers to a real number input;
- 'I' refers to an integer number input;
- numbers preceding the format type refer to the number of similar inputs;
- numbers after the format type refer to the number of characters in each input field.

For real number inputs, the number of characters in each input field is followed by a decimal point. The number after the point is the number of decimal places in the field.

The skeleton files also contain a series of '-' and '*' symbols to further describe the positioning of data. Only data placed above these symbols are read by the program. The symbols and descriptions are not read by the program, and must not be changed or moved. Additional comments may be entered in the input files, provided they are not above the '-' and '*' symbols, and do not overwrite or misplace the existing descriptions and symbols. Extra lines of notes may be added onto the bottom of the files, but lines must not be inserted elsewhere.

For a real number input, the '*' indicates the units column. Decimal points do not need to be entered. However, if a decimal point is entered, then the fixed format, indicated in the skeleton, is overridden. The input data must still, however, be positioned only over the '-' and '*' symbols. For example,

```
 12345     is read as 12.34, and
---*--
12.345     is read as 12.345.
---*--
```

For an integer number input, the rightmost '-' in the data field is the units column. Columns left blank are assumed to have the value of '0'. For example,

```
  3     is read as 3, but
---
 3      is read as 30.
---
```

For character inputs, data may be entered anywhere within the data field indicated by '-'s. Columns left blank will be assumed to have the value of a blank character.

Numerical inputs can also be negative where appropriate.

The test data contained on the floppy disc which accompanies this Paper is a very useful guide for confirming the manner in which data should be entered.

FORMAT OPTIONS

Some data items need only be entered under certain circumstances. Directions on entering data start four columns to the left of the rest of the descriptions, and should be easily identifiable.

DATA OPTIONS

For some inputs, an indication of choice between several options is required. This is done using integer codes. An example of this is inputs relating to the input currency of certain cost items, contained in input file two. The options for this input are:

1 = $A
2 = US$
3 = $PORT A
4 = $PORT B

Hence, whenever input is required on the currency of an item, the number corresponding to the correct currency should be used (eg '2' for US$).

```
FEDERAL BUREAU OF TRANSPORT ECONOMICS : BTESHIP
-----------------------------------------------
SKELETON INPUT FILE ONE
USE EDITOR IN OVERTYPE MODE TO INSERT DATA ABOVE APPROPRIATE "-"s.
AN "*" SIGNIFIES THE UNITS COLUMN IN A REAL NUMBER i.e. AN IMPLIED
DECIMAL POINT COMES BETWEEN AN "*" AND THE NEXT "-"

                                  GENERAL DESCRIPTION : A30
------------------------------
                                  ORIGIN : A30
------------------------------
                                  DESTINATION : A30
------------------------------

                              SHIP TYPE : I1 -  1 = CONTAINER
-                                               2 = ROLL-ON ROLL-OFF
                                                3 = GENERAL CARGO
                                                4 = CONTAINER-BULK
                                                5 = BULK
                                                6 = ORE
                                                7 = TANKER

                          INSERT THE FOLLOWING FOR EACH SHIP

                              SHIP DEADWEIGHT (TONNES) :4F6.0
-----* -----* -----* -----*
                              CONTAINER CAPACITY (TEUs) :4F6.0
-----* -----* -----* -----*
                              OTHER CARGO CAPACITY (CUBIC METRES)
-----* -----* -----* -----*    : 4F6.0

                          ENTER THE FOLLOWING IF DESIRED

                              DEADWEIGHT CORRECTION VALUE : F8.3
----*---

                          ENTER THE FOLLOWING

                              LIFE OF THE SHIP IN YEARS : I2
--
                              AGE OF THE FIRST SHIP AT THE START OF
--                            THE ANALYSIS PERIOD : I2

                          INSERT THE FOLLOWING FOR EACH SHIP.
                          IF ANY OF THE SHIP CHARACTERISTICS (LENGTH
                          TO NET TONNAGE ) ARE LEFT BLANK, THEN THEY
                          WILL BE GENERATED IN THE PROGRAM.
```

```
                        SHIP'S LENGTH (METRES) : 4F5.1
---*- ---*- ---*- ---*-
                        SHIP'S BEAM (METRES) : 4F5.2
--*-- --*-- --*-- --*--
                        SHIP'S DRAUGHT (METRES) : 4F5.2
--*-- --*-- --*-- --*--
                        SHIP'S MAXIMUM ENGINE POWER (KW) : 4F5.0
----* ----* ----* ----*
                        SHIP'S GROSS REGD TONS : 4F5.0
----* ----* ----* ----*
                        SHIP'S NET REGD TONS : 4F5.0
----* ----* ----* ----*

                        SHIP CREWING LEVEL FOR EACH SHIP
-- -- -- --             (NUMBER OF BERTHS) : 4I2

                        SHIP SPEED INPUT OPTION : I1
-                           - 1 = INPUT IN KNOTS
                              2 = INPUT IN FROUDE NUMBER
                              3 = INPUT AS THE NUMBER OF DAYS
                                  FOR THE VOYAGE

                        SHIP SPEED FOR EACH SHIP : 4F5.2
--*-- --*-- --*-- --*--
                    INSERT ONE OF THE FOLLOWING TWO DATA ITEMS

                        TONNES OF FUEL PER DAY FOR MAIN ENGINES
--*-- --*-- --*-- --*-- WHILE AT SEA FOR EACH SHIP : 4F5.2

                        GRAMS OF FUEL PER KILOWATT HOUR FOR MAIN
--*-- --*-- --*-- --*-- ENGINES AT SEA FOR EACH SHIP :4F5.2

                      AUXILIARY FUEL INPUT OPTION : I1
-                       - 1 = ALREADY INCLUDED IN MAIN ENGINE
                              FUEL, OR EQUAL TO ZERO
                          2 = ENTER IN TONNES PER DAY
                          3 = ENTER POWER REQUIREMENTS AND
                              CONSUMPTION PER KILOWATT HOUR
                          4 = TO BE ESTIMATED IN PROGRAM

                    ENTER THE FOLLOWING IF AUXILIARY FUEL
                    OPTION = 2 OR 3

                        DO AUXILIARY POWER REQUIREMENTS INCLUDE
-                       AN ALLOWANCE FOR REEFER CONTAINERS?
                        'Y' OR 'N' : A1
```

```
                                    ENTER THE FOLLOWING FOR EACH SHIP
                                    IF THE AUXILIARY FUEL OPTION = 2

                                        TONNES OF FUEL PER DAY FOR AUXILIARY
--*-- --*-- --*-- --*--                 ENGINES WHILE AT SEA : 4F5.2

                                        TONNES OF FUEL PER DAY FOR AUXILIARY
--*-- --*-- --*-- --*--                 ENGINES WHILE IN PORT : 4F5.2

                                    ENTER THE FOLLOWING FOR EACH SHIP
                                    IF AUXILIARY FUEL OPTION = 3

                                        AUXILIARY POWER REQUIRED AT SEA (KW)
---*- ---*- ---*- ---*-                  : 4F5.1

                                        AUXILIARY POWER REQUIRED IN PORT (KW)
---*- ---*- ---*- ---*-                  : 4F5.1

                                        GRAMS OF FUEL PER KILOWATT HOUR FOR
--*-- --*-- --*-- --*--                 AUXILIARY ENGINES AT SEA : 4F5.2

                                        GRAMS OF FUEL PER KILOWATT HOUR FOR
--*-- --*-- --*-- --*--                 AUXILIARY ENGINES IN PORT : 4F5.2


                                    INSERT THE FOLLOWING

                                        OPTIONS FOR UP TO THREE CANALS TO BE
-          -          -                 TRAVERSED DURING THE VOYAGE : 3A1
                                           - P = PANAMA
                                             S = SUEZ
                                             C = OTHER CANAL

                                        HOURS TO TRAVERSE EACH CANAL : 3F4.1
--*-       --*-       --*-

                                        YEARS IN THE ANALYSIS PERIOD : F2.0
-*

                                        NUMBER OF DAYS FOR WHICH THE SHIP IS IN
--*                                     OPERATION EACH YEAR : F3.0

                                        HOURS EXITING PORT A, AND THEN
--*- --*-                               ENTERING PORT B : 2F4.1

                                        HOURS NOT STEVEDORING IN PORT A, AND
--*- --*-                               IN PORT B : 2F4.1
```

SEA DISTANCE FOR VOYAGE
(NAUTICAL MILES) : F5.0

----*

BAD WEATHER FACTOR : F5.4

*----

CONTAINER LIFE (YEARS) : F2.0

_*

EMPTY CONTAINER WEIGHT (TONNES) : F5.3

_*___

CONTAINER SLOT RATIO : F5.3

_*___

INSERT THE REMAINING DATA IF A CHANGE IN VESSEL PARAMETERS OCCURS DURING THE ANALYSIS PERIOD

EFFECT OPTION : I1
- 1 = AFFECTS EXISTING SHIP ONLY
  2 = AFFECTS EXISTING AND
  REPLACEMENT SHIPS

-

YEARS FROM THE START OF ANALYSIS PERIOD
UNTIL THE INTRODUCTION OF CHANGE : I2

--

FRACTIONAL DECREASE IN FUEL CONSUMPTION
AFTER INTRODUCTION OF CHANGE : F5.3

_*___

FRACTIONAL INCREASE IN SHIP CONSTRUCTION
COST AFTER INTRODUCTION OF CHANGE : F5.3

_*___

EXTRA SHIP COST AT TIME OF CHANGE
($A) : F7.0

------*

EXTRA SHIP COST PER KILOWATT CAPACITY
OF THE SHIP'S ENGINE AT TIME OF CHANGE
($A/KW) : F7.3

---*---

INCREASE IN SHIP REPAIR AND MAINTENANCE
COSTS AFTER CHANGE ($A/YEAR) : F5.3

--*--

REDUCTION IN SHIP CREWING LEVEL : I2

--

FEDERAL BUREAU OF TRANSPORT ECONOMICS : BTESHIP

SKELETON INPUT FILE TWO
USE EDITOR IN OVERTYPE MODE TO INSERT DATA ABOVE APPROPRIATE "-"s.
AN "*" SIGNIFIES THE UNITS COLUMN IN A REAL NUMBER i.e. AN IMPLIED DECIMAL POINT COMES BETWEEN AN "*" AND THE NEXT "-" . WHERE FOUR INPUT FIELDS ARE PROVIDED, SEPARATE ENTRIES SHOULD BE MADE FOR EACH SHIP SPECIFIED IN INPUT FILE ONE.

```
                              ANNUAL DISCOUNT RATE FOR USE IN CAPITAL
-*---                         COSTING : F5.3

                              EXCHANGE RATES
                                - US$ TO BUY $A1 : F8.5
--*-----
                                - $PORT A TO BUY $A1 : F8.5
--*-----
                                - $PORT B TO BUY $A1 : F8.5
--*-----
                                - $CREW PAYMENTS TO BUY $A1 : F8.5
--*-----
                              OUTPUT CURRENCY OPTION : I1 - 1 = $A
-                                                           2 = US$

                              OPTION FOR OUTPUT FORMAT : I1
-                                   - 1 = SUMMARY OUTPUT
                                      2 = EXTENDED OUTPUT

                              CURRENCY OPTION FOR SHIP CAPITAL COSTS
-                              : I1  - 1 = $A
                                       2 = US$
                                       3 = $PORT A
                                       4 = $PORT B

                              NEW SHIP PRICE (MILLIONS) : 4F5.3
-*--- -*--- -*--- -*---
                              SHIP SCRAP VALUE (MILLIONS) : 4F5.3
-*--- -*--- -*--- -*---
                              SHIP VALUE AT THE START OF THE
-*--- -*--- -*--- -*---       ANALYSIS PERIOD (MILLIONS) : 4F5.3

                              VALUE OF A SHIP OF THE SAME AGE AS THE
-*--- -*--- -*--- -*---       LAST SHIP WILL BE AT THE END OF THE
                              ANALYSIS PERIOD (MILLIONS) : 4F5.3
```

CURRENCY OPTION FOR INSURANCE,
- MAINTENANCE AND ADMINISTRATION COSTS :I1

ENTER ONE OF THE FOLLOWING THREE DATA ITEMS

ANNUAL SHIP INSURANCE AS A FRACTION OF
*---- SHIP REPLACEMENT COST : F5.4

SHIP INSURANCE COST PER YEAR : 4F6.0
-----* -----* -----* -----*

SHIP INSURANCE COST PER DAY SHIP IS IN
-----* -----* -----* -----* OPERATION : 4F6.0

ENTER ONE OF THE FOLLOWING THREE DATA ITEMS

ANNUAL SHIP REPAIR & MAINTENANCE COST AS
*---- A FRACTION OF NEW SHIP PRICE : F5.4

SHIP REPAIR AND MAINTENANCE COST
-----* -----* -----* -----* PER YEAR : 4F6.0

SHIP REPAIR AND MAINTENANCE COST PER DAY
-----* -----* -----* -----* SHIP IS IN OPERATION : 4F6.0

ENTER ONE OF THE FOLLOWING TWO DATA ITEMS

SHIP ADMINISTRATION COST AS A FRACTION
*---- OF SHIP COST EXCLUDING FUEL : F5.4

SHIP ADMINISTRATION COST PER DAY : 4F6.2
---*-- ---*-- ---*-- ---*--

ENTER THE FOLLOWING

CURRENCY OPTION FOR CONTAINER CAPITAL
- COSTS :I1

COST OF A NEW REEFER CONTAINER : F5.0
----*

SALVAGE VALUE OF A REEFER CONTAINER:F5.0
----*

COST OF A NEW DRY CONTAINER : F5.0
----*

SALVAGE VALUE OF A DRY CONTAINER : F5.0
----*

INSERT ONE OF THE FOLLOWING TWO DATA ITEMS

```
                ANNUAL MAINTENANCE COST PER TEU : F5.2
--*--  -        AND CURRENCY OPTION : I1

                TOTAL ANNUAL CONTAINER MAINTENANCE COST
-------*  -      : F8.0 AND CURRENCY OPTION : I1

                CONTAINER CLEANING COSTS PER TEU IN
--*--  -        PORT A : F5.2 AND CURRENCY OPTION : I1

                ANNUAL CREW COSTS PER BERTH : F6.0
-----*

                VICTUALS EXPENDITURE
----*           ($PORT A /PERSON/DAY) : F5.0

                ANNUAL SHIP STORES EXPENDITURE :F6.0
-----*  -       AND CURRENCY OPTION : I1

                CURRENCY OPTION FOR FUEL PRICES : I1
--

                MAIN ENGINE FUEL PRICE PER TONNE : F7.2
----*--

                AUXILIARY ENGINE FUEL PRICE PER TONNE
----*--          : F7.2

              CANAL CHARGES :

                OPTION TO EXCLUDE CANAL CHARGES : I1
-                 - 1 = INCLUDE CANAL CHARGES
                    2 = EXCLUDE CANAL CHARGES

                CURRENCY OPTION FOR CANAL CHARGES :I1
--

                CHARGES PER TRANSIT OF CANAL : F6.0

                   PANAMA CANAL
-----*

                   SUEZ CANAL
-----*

                   THIRD CANAL
-----*

              PORT CHARGES :

                OPTION TO EXCLUDE PORT CHARGES : I1
-                 - 1 = INCLUDE PORT CHARGES
                    2 = EXCLUDE PORT CHARGES
```

```
                         CURRENCY OPTION FOR EACH PORT : 2I1
 -  -
                         FRACTION OF PARTIALLY ATTRIBUTABLE
 *---- *----             PORT CHARGES TO BE ATTRIBUTED TO THE
                         CURRENT VOYAGE IN EACH PORT : 2F5.4

                       PARTIALLY ATTRIBUTABLE PORT CHARGES

                         OPTION OF TONNAGE MEASUREMENT FOR
 -    -                  NATIONAL LIGHT CHARGES IN EACH COUNTRY
                           - 1 = NET REGD TONS
                             2 = GROSS REGD TONS  : 2I1

                         NUMBER OF PORT CALLS IN EACH COUNTRY
 --   --                 DURING TIME COVERED BY ONE CHARGE : 2I2

                         NATIONAL LIGHT CHARGE PER SHIP TON IN
 *---- *----             EACH COUNTRY : 2F5.4

                       OTHER PARTIALLY ATTRIBUTABLE CHARGES
                       FOR EACH PORT

                         FIXED CHARGE : 2F8.2
 -----*-- -----*--
                         CHARGE PER SHIP NET REGD TON : 2F8.4
 ---*---- ---*----
                         CHARGE PER SHIP GROSS REGD TON : 2F8.4
 ---*---- ---*----
                         CHARGE PER METRE OF SHIP BEAM : 2F8.4
 ---*---- ---*----
                         CHARGE PER METRE OF SHIP LENGTH : 2F8.4
 ---*---- ---*----
                         CHARGE PER METRE OF SHIP DRAUGHT : 2F8.4
 ---*---- ---*----
                       TOTALLY ATTRIBUTABLE PORT CHARGES

                         NUMBER OF TUGS REQUIRED PER MOVEMENT
 -*   -*                 IN EACH PORT : 2F2.0

                         NUMBER OF LAUNCHES REQUIRED PER MOVEMENT
 -*   -*                 IN EACH PORT : 2F2.0

                         OPTION OF TONNAGE MEASUREMENT FOR TUG
 -  -                    AND LAUNCH CHARGES IN EACH PORT : 2I1
                           - 1 = NET REGD TONS
                             2 = GROSS REGD TONS
```

	INSERT ONE OF THE FOLLOWING TWO DATA ITEMS
*---- *----	TUG CHARGE PER SHIP TON PER MOVEMENT IN EACH PORT : 2F5.4
-------* -------*	TUG CHARGE PER MOVEMENT IN EACH PORT : 2F8.0
	INSERT ONE OF THE FOLLOWING TWO DATA ITEMS
*---- *----	LAUNCH CHARGE PER SHIP TON PER MOVEMENT IN EACH PORT : 2F5.4
-------* -------*	LAUNCH CHARGE PER MOVEMENT IN EACH PORT : 2F8.0
	OTHER TOTALLY ATTRIBUTABLE CHARGES FOR EACH PORT
---*---- ---*----	DAILY CHARGE : 2F8.4
---*---- ---*----	DAILY CHARGE PER NET REGD TON : 2F8.4
---*---- ---*----	DAILY CHARGE PER GROSS REGD TON : 2F8.4
	WHARFAGE CHARGES PER
---*---- ---*----	- DRY CONTAINER (TEU) : 2F8.4
---*---- ---*----	- REEFER CONTAINER (TEU) : 2F8.4
---*---- ---*----	- EMPTY CONTAINER (TEU) : 2F8.4
---*---- ---*----	- TRANSHIPPED CONTAINER (TEU) : 2F8.4
---*---- ---*----	- TONNE OF NON-CONTAINERISED CARGO : 2F8.4
---*----	- TONNE OF FUEL (PORT A) : F8.4
	STEVEDORING CHARGES :
-	OPTION TO EXCLUDE STEVEDORING CHARGES : I1 - 1 = INCLUDE STEVEDORING CHARGES 2 = EXCLUDE STEVEDORING CHARGES
- -	CURRENCY OPTION FOR EACH PORT : 2I1

CHARGE TO LOAD IN PORT A AND UNLOAD IN PORT B PER

- DRY CONTAINER (TEU) : 2F7.4

--*---- --*----

- REEFER CONTAINER (TEU) :2F7.4

--*---- --*----

- EMPTY CONTAINER (TEU) : 2F7.4

--*---- --*----

- TRANSHIPPED CONTAINER (TEU) : 2F7.4

--*---- --*----

- TONNE OF NON-CONTAINERISED CARGO : 2F7.4

--*---- --*----

- TONNE OF FUEL (PORT A) : F7.4

--*----

```
FEDERAL BUREAU OF TRANSPORT ECONOMICS : BTESHIP
-----------------------------------------------
SKELETON INPUT FILE THREE           SHIP LOADING OPTION = 1
USE THIS VERSION TO RUN VOYAGE LOADING INPUT OPTION
USE EDITOR IN OVERTYPE MODE TO INSERT DATA ABOVE APPROPRIATE "-"s.
AN "*" SIGNIFIES THE UNITS COLUMN IN A REAL NUMBER i.e. AN IMPLIED
DECIMAL POINT COMES BETWEEN AN "*" AND THE NEXT "-". WHERE FOUR
INPUT FIELDS ARE PROVIDED, SEPARATE ENTRIES SHOULD BE MADE FOR EACH
SHIP SPECIFIED IN INPUT FILE ONE.

                              MAXIMUM ALLOWABLE LOADING OF ALL CARGO &
--*--                         CONTAINERS (PER CENT OF CAPACITY) : F5.2

                            CARGO REMAINING ON BOARD AT PORT A
                            ---------------------------------

                              DRY CONTAINERS
                                - NON-EMPTY TEUs : 4F6.0
-----* -----* -----* -----*
                                - EMPTY TEUs : 4F6.0
-----* -----* -----* -----*
                              REEFER CONTAINERS
                                - NON-EMPTY TEUs : 4F6.0
-----* -----* -----* -----*
                                - EMPTY TEUs : 4F6.0
-----* -----* -----* -----*
                              NON-CONTAINERISED CARGO (TONNES) : 4F6.0
-----* -----* -----* -----*

                            CARGO LOADED AT PORT A
                            ----------------------

                              NON-TRANSHIPPED CARGO
                                DRY CONTAINERS
                                  - NON-EMPTY TEUs : 4F6.0
-----* -----* -----* -----*
                                  - EMPTY TEUs : 4F6.0
-----* -----* -----* -----*
                                REEFER CONTAINERS
                                  - NON-EMPTY TEUs : 4F6.0
-----* -----* -----* -----*
                                  - EMPTY TEUs : 4F6.0
-----* -----* -----* -----*
                                NON-CONTAINERISED CARGO (TONNES):4F6.0
-----* -----* -----* -----*
```

```
                              TRANSHIPPED CARGO
                                DRY CONTAINERS (TEUs) : 4F6.0
-----* -----* -----* -----*
                                REEFER CONTAINERS (TEUs) : 4F6.0
-----* -----* -----* -----*
                                NON-CONTAINERISED CARGO (TONNES):4F6.0
-----* -----* -----* -----*

                          CARGO UNLOADED AT PORT B
                          ------------------------

                              NON-TRANSHIPPED CARGO
                                DRY CONTAINERS
                                  - NON-EMPTY TEUs : 4F6.0

-----* -----* -----* -----*
                                  - EMPTY TEUs : 4F6.0
-----* -----* -----* -----*
                                REEFER CONTAINERS
                                  - NON-EMPTY TEUs : 4F6.0
-----* -----* -----* -----*
                                  - EMPTY TEUs : 4F6.0
-----* -----* -----* -----*
                                NON-CONTAINERISED CARGO (TONNES):4F6.0
-----* -----* -----* -----*

                              TRANSHIPPED CARGO
                                DRY CONTAINERS (TEUs) : 4F6.0
-----* -----* -----* -----*
                                REEFER CONTAINERS (TEUs) : 4F6.0
-----* -----* -----* -----*
                                NON-CONTAINERISED CARGO (TONNES):4F6.0
-----* -----* -----* -----*

                              CONTAINER LOADING RATE IN PORT A
---* ---* ---* ---*           (TEUs/DAY) : 4F4.0

                              CONTAINER UNLOADING RATE IN PORT B
---* ---* ---* ---*           (TEUs/DAY) : 4F4.0

                              LOADING RATE FOR NON-CONTAINERISED CARGO
--*-- --*-- --*-- --*--       IN PORT A ('000 TONNES/DAY) : 4F5.2

                              UNLOADING RATE FOR NON-CONTAINERISED
--*-- --*-- --*-- --*--       CARGO IN PORT B ('000 TONNES/DAY) : 4F5.2
```

--*-- AVERAGE WEIGHT OF CARGO PER NON-EMPTY TEU (TONNES) : F5.2

--*-- AVERAGE DENSITY OF NON-CONTAINERISED CARGO (TONNES/CUBIC METRE) : F5.2

```
FEDERAL BUREAU OF TRANSPORT ECONOMICS : BTESHIP
-----------------------------------------------
SKELETON INPUT FILE THREE           SHIP LOADING OPTION = 2
USE THIS VERSION TO RUN PERCENTAGE LOADING INPUT OPTION
USE EDITOR IN OVERTYPE MODE TO INSERT DATA ABOVE APPROPRIATE "-"s.
AN "*" SIGNIFIES THE UNITS COLUMN IN A REAL NUMBER i.e. AN IMPLIED
DECIMAL POINT COMES BETWEEN AN "*" AND THE NEXT "-".

                           ENTER LOADINGS OF CARGO AND CONTAINERS FOR
                           THE VOYAGE IN ONE OF THE FOLLOWING WAYS

                             - BY WEIGHT
                               PERCENTAGE OF TOTAL CARGO CAPACITY
--*--                          UTILISED : F5.2

                               PERCENTAGE OF CARGO WHICH IS NON-
--*--                          CONTAINERISED :F5.2

                             - BY VOLUME
                               PERCENTAGE OF TOTAL CARGO CAPACITY
--*--                          UTILISED : F5.2

                               PERCENTAGE OF CARGO WHICH IS NON-
--*--                          CONTAINERISED :F5.2

                           ENTER THE FOLLOWING

                             CARGO AND CONTAINERS LOADED IN PORT A
--*--                        (PER CENT OF ALL CARGO ON VOYAGE) : F5.2

                             CARGO AND CONTAINERS UNLOADED IN PORT B
--*--                        (PER CENT OF ALL CARGO ON VOYAGE) : F5.2

                             PERCENTAGE OF CONTAINERS WHICH ARE EMPTY
--*--                         : F5.2

                             PERCENTAGE OF CONTAINERS WHICH ARE
--*--                        REEFERS : F5.2

                             PERCENTAGE OF CONTAINERS WHICH ARE
--*--                        TRANSHIPPED IN PORT A : F5.2

                             PERCENTAGE OF CONTAINERS WHICH ARE
--*--                        TRANSHIPPED IN PORT B : F5.2

                             PERCENTAGE OF NON-CONTAINERISED CARGO
--*--                        WHICH IS TRANSHIPPED IN PORT A : F5.2
```

--*--	PERCENTAGE OF NON-CONTAINERISED CARGO WHICH IS TRANSHIPPED IN PORT B : F5.2
---* ---* ---* ---*	CONTAINER LOADING RATE IN PORT A (TEUs/DAY) : 4F4.0
---* ---* ---* ---*	CONTAINER UNLOADING RATE IN PORT B (TEUs/DAY) : 4F4.0
--*-- --*-- --*-- --*--	LOADING RATE FOR NON-CONTAINERISED CARGO IN PORT A ('000 TONNES/DAY) : 4F5.2
--*-- --*-- --*-- --*--	UNLOADING RATE FOR NON-CONTAINERISED CARGO IN PORT B ('000 TONNES/DAY) : 4F5.2
--*--	AVERAGE WEIGHT OF CARGO PER NON-EMPTY TEU (TONNES) : F5.2
--*--	AVERAGE DENSITY OF NON-CONTAINERISED CARGO (TONNES/CUBIC METRE) : F5.2

```
FEDERAL BUREAU OF TRANSPORT ECONOMICS : BTESHIP
-----------------------------------------------
SKELETON INPUT FILE THREE          SHIP LOADING OPTION = 3
USE THIS VERSION TO RUN YEARLY LOADING INPUT OPTION.
USE EDITOR IN OVERTYPE MODE TO INSERT DATA ABOVE APPROPRIATE "-"s.
AN "*" SIGNIFIES THE UNITS COLUMN IN A REAL NUMBER i.e. AN IMPLIED
DECIMAL POINT COMES BETWEEN AN "*" AND THE NEXT "-".

                           MAXIMUM ALLOWABLE LOADING OF ALL CARGO &
--*--                      CONTAINERS (PER CENT OF CAPACITY) : F5.2

                        TOTAL ANNUAL CARGO LOADED AT PORT A
                        -----------------------------------

                           NON-TRANSHIPPED CARGO
                             DRY CONTAINERS
                               - NON-EMPTY TEUs : F8.0
-------*
                               - EMPTY TEUs : F8.0
-------*
                             REEFER CONTAINERS
                               - NON-EMPTY TEUs : F8.0
-------*
                               - EMPTY TEUs : F8.0
-------*
                             NON-CONTAINERISED CARGO (TONNES) : F8.0
-------*
                           TRANSHIPPED CARGO
                             DRY CONTAINERS (TEUs) : F8.0
-------*
                             REEFER CONTAINERS (TEUs) : F8.0
-------*
                             NON-CONTAINERISED CARGO (TONNES) : F8.0
-------*
                        TOTAL ANNUAL CARGO ON BOARD DURING VOYAGE
                        -----------------------------------------

                           DRY CONTAINERS
                             NON-EMPTY TEUs : F8.0
-------*
                             EMPTY TEUs : F8.0
-------*
                           REEFER CONTAINERS
                             NON-EMPTY TEUs : F8.0
-------*
```

```
                         EMPTY TEUs : F8.0
-------*
                       NON-CONTAINERISED CARGO (TONNES) : F8.0
-------*
                   TOTAL ANNUAL CARGO UNLOADED AT PORT B
                   -------------------------------------

                       NON-TRANSHIPPED CARGO
                         DRY CONTAINERS
                           - NON-EMPTY TEUs : F8.0
-------*
                           - EMPTY TEUs : F8.0
-------*
                         REEFER CONTAINERS
                           - NON-EMPTY TEUs : F8.0
-------*
                           - EMPTY TEUs : F8.0
-------*
                         NON-CONTAINERISED CARGO (TONNES) : F8.0
-------*
                       TRANSHIPPED CARGO
                         DRY CONTAINERS (TEUs) : F8.0
-------*
                         REEFER CONTAINERS (TEUs) : F8.0
-------*
                         NON-CONTAINERISED CARGO (TONNES) : F8.0
-------*

                       NUMBER OF TIMES THAT THIS VOYAGE IS
--*--                  MADE EACH YEAR : F5.2

                       CONTAINER LOADING RATE IN PORT A
---* ---* ---* ---*    (TEUs/DAY) : 4F4.0

                       CONTAINER UNLOADING RATE IN PORT B
---* ---* ---* ---*    (TEUs/DAY) : 4F4.0

                       LOADING RATE FOR NON-CONTAINERISED CARGO
--*-- --*-- --*-- --*--  IN PORT A ('000 TONNES/DAY) : 4F5.2

                       UNLOADING RATE FOR NON-CONTAINERISED
--*-- --*-- --*-- --*--  CARGO IN PORT B ('000 TONNES/DAY) : 4F5.2
```

AVERAGE WEIGHT OF CARGO PER NON-EMPTY
--*-- TEU (TONNES) : F5.2

AVERAGE DENSITY OF NON-CONTAINERISED
--*-- CARGO (TONNES/CUBIC METRE) : F5.2

APPENDIX II INPUT FILE 4: COEFFICIENTS FOR EQUATIONS

Tables II.1 to II.7 show the regression coefficients applicable to the relations that can be used to estimate length, beam, draught, maximum engine power, grt, nrt and required engine power of the ship under consideration. The coefficients are contained in input file 4. The coefficients of determination (R^2) shown indicate how closely the particular relation matches the data on which it is based. An R^2 value of 1.00 means that the relation matches the data perfectly. All of the regression relations tabulated below match their respective data sets fairly well.

TABLE II.1 REGRESSION COEFFICIENTS AND STATISTICS FOR MODEL: LENGTH = $\alpha.(\text{dwt})^{\beta}$

Ship type	α	β	R^2
Container	3.84	0.399	0.94
Ro-ro	10.49	0.304	0.87
General cargo	5.38	0.349	0.90
Con-bulk	8.50	0.297	0.93
Bulk	9.40	0.288	0.92
Ore	10.82	0.276	0.97
Tanker	11.90	0.268	0.97

Note Length is measured in metres, dwt in tonnes.

Sources BTE (1980). BTE estimates.

TABLE II.2 REGRESSION COEFFICIENTS AND STATISTICS FOR MODEL: BEAM = $\alpha.(\mathrm{dwt})^{\beta}$

Ship type	α	β	R^2
Container	1.21	0.311	0.92
Ro-ro	2.35	0.251	0.86
General cargo	1.45	0.281	0.93
Con-bulk	1.04	0.311	0.92
Bulk	1.00	0.313	0.92
Ore	0.76	0.341	0.98
Tanker	0.79	0.337	0.99

Note Beam is measured in metres, dwt in tonnes.

Sources BTE (1980). BTE estimates.

TABLE II.3 REGRESSION COEFFICIENTS AND STATISTICS FOR MODEL: DRAUGHT = $\alpha.(\mathrm{dwt})^{\beta}$

Ship type	α	β	R^2
Container	0.414	0.320	0.91
Ro-ro	0.495	0.296	0.87
General cargo	0.375	0.334	0.88
Con-bulk	0.598	0.280	0.92
Bulk	0.625	0.275	0.93
Ore	0.613	0.274	0.95
Tanker	0.483	0.299	0.98

Note Draught is measured in metres, dwt in tonnes.

Sources BTE (1980). BTE estimates.

TABLE II.4 REGRESSION COEFFICIENTS AND STATISTICS FOR MODEL: MAXIMUM ENGINE POWER = $\alpha.(\text{dwt})^{\beta}$

Ship type	α	β	R^2
Container	0.19	1.16	0.86
Ro-ro	11.25	0.733	0.77
General cargo	2.24	0.836	0.83
Con-bulk	33.96	0.530	0.73
Bulk	20.23	0.579	0.66
Ore	4.88	0.701	0.66
Tanker	25.39	0.561	0.84

Note Maximum engine power is measured in kilowatts, dwt in tonnes.

Sources BTE (1980). BTE estimates.

TABLE II.5 REGRESSION COEFFICIENTS AND STATISTICS FOR MODEL: grt = $\alpha + \beta.(\text{dwt})$

Ship type	α	β	R^2
Container	-2 510	1.160	0.92
Ro-ro	403	0.720	0.89
General cargo	-129	0.659	0.95
Con-bulk	2 238	0.526	0.98
Bulk	2 310	0.514	0.97
Ore	1 860	0.499	0.93
Tanker	4 180	0.469	0.99

Note Dwt is measured in tonnes.

Sources BTE (1980). BTE estimates.

TABLE II.6 REGRESSION COEFFICIENTS AND STATISTICS FOR MODEL: $nrt = \alpha + \beta.(dwt)$

Ship type	α	β	R^2
Container	-1 440	0.699	0.89
Ro-ro	-107	0.391	0.84
General cargo	-226	0.415	0.94
Con-bulk	468	0.378	0.97
Bulk	361	0.372	0.95
Ore	2 240	0.172	0.84
Tanker	-868	0.387	0.98

Note Dwt is measured in tonnes.

Sources BTE (1980). BTE estimates.

TABLE II.7 REGRESSION COEFFICIENTS AND STATISTICS FOR MODEL: REQUIRED POWER = $\alpha.(dwt)^{\beta}.(speed)^{\gamma}$

Ship type	α	β	γ	R^2
Container	0.030	0.526	2.66	0.96
Ro-ro	0.193	0.471	2.25	0.87
General cargo	0.099	0.539	2.17	0.94
Con-bulk	1.327	0.489	1.36	0.80
Bulk	0.794	0.521	1.43	0.71
Ore	0.161	0.586	1.74	0.72
Tanker	0.154	0.504	2.10	0.90

Note Required engine power is measured in kilowatts, dwt in tonnes and speed in knots.

Sources BTE (1980). BTE estimates.

Input file 4 also contains the coefficients for the following equations:

Fuel adjustment for fraction (F) of installed power used

$$= \alpha + \beta.F + \gamma.F^2$$

where $\alpha = 1.27074$

$\beta = -0.65283$

$\gamma = 0.39425$ (II.1)

Auxiliary fuel consumption for a bulk vessel at sea (tonnes per day)

$$= \alpha + \beta.dwt + \gamma.dwt^2$$

where $\alpha = 1.3$

$\beta = 3.5 \times 10^{-5}$

$\gamma = 1.7 \times 10^{-10}$ (II.2)

Finally, input file 4 contains the following constants:

0.6 tonnes per day of auxiliary fuel for a non-bulk vessel

0.04574 additional auxiliary fuel consumption per reefer

3.0 tonnes per day auxiliary fuel consumption for a bulk vessel while in port

36.246 cubic metres per teu.

Table II.8 indicates where all these coefficients and constants are positioned in input file 4.

TABLE II.8 POSITIONING OF DATA FOR INPUT FILE 4

Item	*Coefficient*	*Lines*	*Column*
Length	α	6-12	1-11
	β	6-12	13-23
Beam	α	6-12	25-35
	β	6-12	37-47
Draught	α	15-21	1-11
	β	15-21	13-23
Maximum main engine power	α	15-21	25-35
	β	15-21	37-47
Gross registered tonnage	α	24-30	1-11
	β	24-30	13-23
Net registered tonnage	α	24-30	25-35
	β	24-30	37-47
Fuel adjustment	α	33	1-11
	β	33	13-23
	γ	33	25-35
Power requirement	α	36-42	1-11
	β	36-42	13-23
	γ	36-42	25-35
Auxiliary fuel			
Non-bulk vessel	..	45	1-11
Additional per reefer	..	46	1-11
Bulk vessel, in port	..	47	1-11
Bulk vessel, at sea	α	48	1-11
	β	48	13-23
	γ	48	25-35
Cubic metres per teu	..	50	1-11

.. Not applicable.

APPENDIX III INPUT FILE 5: HEADINGS FOR OUTPUT TABLES

Input file 5 contains column and row headings for both the summary and extended forms of BTESHIP output. The user should not alter this input file.

```
CONTAINER SHIP
ROLL-ON ROLL-OFF SHIP
GENERAL CARGO SHIP
CONTAINER-BULK SHIP
BULK SHIP
ORE CARRIER
TANKER

 ALL CARGOCONT.CARGOCONT.CARGO NON-CONT.
 ($/TONNE)($/NE TEU)($/TONNE)  ($/TONNE)

VESSEL COSTS
  CAPITAL
  FUEL
  CREW
  REPAIRS & MAINT.
  INSURANCE
  VICTUALS & STORES
  ADMINISTRATION
  TOTAL VESSEL COST
CANAL CHARGES
PORT CHARGES
WHARFAGE CHARGES
STEVEDORING CHARGES
TOTAL
..  not applicable

VESSEL COSTS
  CAPITAL
    SHIP
    CONTAINERS
```

FUEL
  AT SEA
  AT BERTH
CREW
REPAIRS & MAINT.
  SHIP
  CONTAINERS
  CONTAINER CLEANING
INSURANCE
VICTUALS
STORES
ADMINISTRATION
TOTAL VESSEL COST
CANAL CHARGES
PORT CHARGES
  AT PORT A
    VESSEL CHARGES
    TUG & LAUNCH
    NATIONAL LIGHT
    TOTAL AT PORT A
  AT PORT B
    VESSEL CHARGES
    TUG & LAUNCH
    NATIONAL LIGHT
    TOTAL AT PORT B
  TOTAL PORT CHARGES
CARGO CHARGES
  PORT A : WHARFAGE
         : STEVEDORING
  PORT B : WHARFAGE
         : STEVEDORING
  TOTAL CARGO CHARGES
TOTAL
.. not applicable

CONTAINERS (TEUs)
  NON-EMPTY CONTAINERS
    DRY
    REEFER
    TOTAL
  EMPTY CONTAINERS
    DRY
    REEFER
    TOTAL
  TOTAL CONTAINERS

CARGO (TONNES)
  CONTAINERISED
  NON-CONTAINERISED
  TOTAL PAYING CARGO

END OF FILE

APPENDIX IV STRUCTURE OF THE PROGRAM

This appendix explains the structure of BTESHIP and describes each subroutine of the program. It is designed to enable the user to easily reference the description of each part of the program. The material presented in this appendix should enable the exact workings of the program to be verified and, if necessary, enable anyone familiar with FORTRAN to change the program to suit the needs of a particular user.

The next section deals with the aims and methods used in designing BTESHIP. This is followed by a description of the main program, and then by descriptions, in alphabetical order, of each of the subroutines within BTESHIP.

PROGRAM DESIGN

An important aim in the design of BTESHIP was to enable any FORTRAN programmer to easily understand the workings of the program. To achieve this, structured programming techniques were employed wherever possible. These include:

- Use of subroutines. Each routine performs one specific task. This limits the length and complexity of each routine. Complicated tasks are then performed by a series of these simple routines.
- The routines are split up into process routines and utility routines. A process routine relates to a specific aspect of the program, and is accessed by a clearly defined route from the main program. A utility routine performs a simple task, and may be called from anywhere in the program. An example of a utility routine is subroutine SPREAD which calculates an annual payment over the analysis period equivalent to a given sum at a given time.
- Limited use of unrestricted transfers of control. This does not mean that the 'GOTO' statement is not used within the program, but rather that it is mainly restricted to implementing loop or iteration structures, where these are not provided for in FORTRAN.

To help the programmer read BTESHIP, the following techniques were also used:

- insertion of comments, especially to indicate the task performed by each subroutine;
- use of blank comment lines to separate blocks of associated text;
- indenting of text to indicate program structure (for example, loops, conditionals);
- naming of variables and routines to indicate the purpose of the variable or routine as much as possible;
- explicit declaration of each variable used within each routine, at the start of each routine;
- maintenance of a dictionary of variables, and their purposes;
- grouping of 'FORMAT' statements at the end of each routine;
- logical numbering of statement labels; and
- exclusion of numerical values from the program by reading them from the input files, unless defined by a 'PARAMETER' statement.

Appendix VI contains the dictionary of variables used within BTESHIP. Details about the operation of BTESHIP are contained in Chapter 4.

MAIN PROGRAM

The execution of BTESHIP starts and stops in the main program. Other routines can only be executed when called by the main program or when called by a routine subsequently being executed. Figure IV.1 uses a Nassi-Shneiderman flowchart to show the structure of the main program and the subroutines called (see Appendix V for a detailed explanation of Nassi-Shneiderman flowcharts).

BTESHIP begins by reading four of the input data files.[1] Each input file is read by a separate subroutine. These subroutines convert the data items to appropriate units and currencies where necessary, check for inconsistencies in the input data, and set default values.

The program then repeats the route and cost calculations for each ship being costed. Up to four ships can be costed in a single run of BTESHIP. The route calculations involve the estimation of any ship

---

1. Input file 5 contains the headings for the output tables and is read from subroutine OUTPUT.

read input file 1 (INPUT1)

read input file 2 (INPUT2)

read input file 3 (INPUT3)

read input file 4 (INPUT4)

FOR each ship being costed

- calculate any ship physical characteristics not entered (SHIPGC)
- calculate route times, cargo loading, and fuel consumptions (SCHEDULE)
- calculate total costs for the voyage (COSTS)
- calculate costs per cargo unit for the voyage (DISTRIBUTE)

output all calculated costs, route times, cargo loadings, fuel consumptions and ship characteristics (OUTPUT)

stop

Figure IV.1 Flowchart for BTESHIP

characteristics not input by the user, and the calculation of ship speed, cargo load, route times and fuel consumption. These calculations are performed by subroutines SHIPGC and SCHEDULE. The costing routines calculate and sum each of the component costs for a single-leg voyage, and then distribute these costs across each cargo unit. Subroutines COSTS and DISTRIBUTE perform these tasks.

Finally, after all of the route and cost calculations are performed, the costs for each ship are output by subroutine OUTPUT.

SUBROUTINES

Each of the subroutines in BTESHIP is described below in alphabetical order. Flowcharts are used to aid description of some of these routines.

Subroutine ADMIN

ADMIN calculates the vessel administration cost for the voyage. It is called from subroutine COSTS, and does not call any other routines.

If administration cost is entered as a fraction of vessel costs (which includes administration costs), then the administration cost for the voyage is obtained by multiplying this fraction by the sum of capital, repairs and maintenance, insurance, crew and victuals and stores costs. This is then divided by one minus the input fraction, so that administration cost is the required proportion of vessel costs *including administration costs* (but excluding fuel). If administration cost is input as a daily cost, the administration cost for the voyage is obtained by multiplying the daily cost by the number of days for the voyage.

Subroutine CANAL

CANAL is called from subroutine COSTS if canal charges are to be included in total costs. The option to exclude canal charges is contained in input file 2, which also contains costs for traversing canals should this option be exercised.

Input file 1 contains an indication of which canals, if any, are traversed during the voyage. Subroutine CANAL determines the canal charges for the voyage by simply adding the charges for each canal traversed.

Subroutine CARGO1

CARGO1 is called from subroutine SCHEDULE when loading input option 1 is used. Loading option 1 requires the user to specify the amount of carryover cargo at port A (that is, the amount of cargo remaining on board from the previous single-leg voyage), the amount of cargo loaded at port A and the amount of cargo unloaded at port B.

CARGO1 calculates the amount of each type of cargo on board the vessel during the voyage and the amount of cargo remaining on board at port B (that is, the carryover at port B). The cargo quantities for the voyage are obtained by summing the values for cargo remaining onboard at port A, and for cargo loaded at port A. The quantities of cargo remaining on board at port B are obtained by subtracting the values for cargo unloaded at port B from the calculated voyage load. The total cargo load is subsequently compared with the maximum allowable load by subroutine MAXSTOP. No routines are called from CARGO1.

Subroutine CARGO2

CARGO2 is called from subroutine SCHEDULE when loading input option 2 is used. Loading option 2 requires the user to specify the amount of cargo on board for the voyage as a percentage of the cargo capacity of the vessel. The user is also required to specify the amount of cargo loaded at port A and unloaded at port B as a percentage of all cargo on board.

CARGO2 converts these percentages into a total load, then into container loadings (in teus) and non-containerised loadings (in tonnes) and checks, if possible, that the total cargo load does not exceed the maximum allowable cargo load for the vessel. If the allowable load is exceeded, CARGO2 reduces the total load to the maximum allowable. Finally, CARGO2 uses the percentages of the various cargo types entered by the user to calculate the actual loadings of each cargo type on board. The following paragraphs describe this process in more detail. The structure of CARGO2 is shown in Figure IV.2.

To calculate the total load, the percentage of total cargo capacity utilised is multiplied by the total cargo capacity. The former is entered in input file 3 as a percentage by either weight or volume. Total cargo volume capacity is read from input file 1. Total cargo weight capacity is calculated by subroutine MAXIMUM, using deadweight and an upper estimate of the cargo load.

The non-containerised load is obtained by simply multiplying the percentage of cargo which is non-containerised by the total load. The containerised load is then the remainder of the load. If these inputs were expressed as a percentage of weight, and containerised cargo is carried, then the amount of containerised cargo is converted from tonnes to teus using the weight of cargo per teu, also from input file 3. Conversely, if volumes are used and non-containerised cargo is carried, the density of non-containerised cargo is required. If a required density is not entered, a message will be output and program execution stopped.

Where cargo densities have been entered for the cargoes being carried, these are used to calculate the total volume or total weight of the cargo, whichever was not previously used in obtaining the total load. This can then be checked against the total capacity of the vessel. If

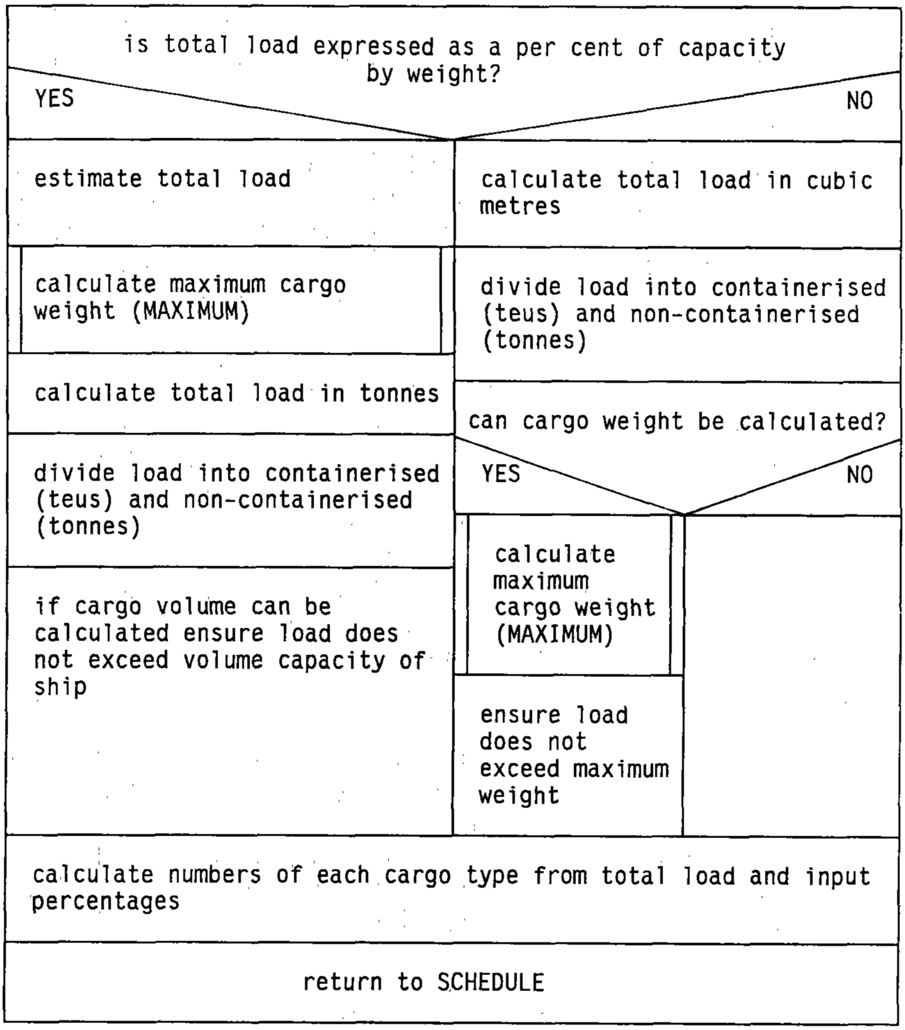


Figure IV.2 Flowchart for subroutine CARGO2

the previously calculated load exceeds this capacity, then the load is reduced to equal that limiting capacity.

The cargo load and the input percentages of each cargo type are then used to calculate the amount of each cargo type in the:

- carryover cargo at port A
- cargo loaded at port A
- cargo on board

- cargo unloaded at port B
- carryover cargo at port B.

It is assumed that dry and reefer containers each include the same proportion of empty containers and that these proportions are the same for cargo loaded, cargo on board and cargo unloaded. It is also assumed that all transhipped containers are non-empty.

Subroutine CARGO3

CARGO3 is called from subroutine SCHEDULE when loading input option 3 is used. Loading option 3 requires the user to specify the yearly cargo loadings at port A, the yearly cargo on board and the yearly cargo unloaded at port B. The user also inputs the number of times per year that the voyage is made.

The amounts of each cargo type loaded, on board and unloaded for the voyage are calculated by dividing the input yearly loadings by the annual number of times that the voyage is made. The amounts of cargo remaining on board at each port are calculated by subtracting the cargo loaded or unloaded from the amount of cargo on board during the voyage. The total cargo load is later compared with the maximum allowable load by subroutine MAXSTOP. No routines are called from CARGO3.

Subroutine CHGCOST

BTESHIP has been structured to enable several vessel parameters to be varied during the analysis period. For example, the user may wish to assume that the ship will be fitted with new engines five years into the analysis period and that fuel costs will therefore alter from that point in time. Function CHGCOST calculates an equivalent constant annual cost for the entire analysis period that reflects such changes in cost. The parameter value changes are included in input file 1, and described in detail in Chapter 5.

CHGCOST first calculates the time period for which costs are affected by the change. This is done using the time of the change, the age of the ship at the start of the analysis period, ship life, whether the change affects only the existing ship or not, and the length of the analysis period. These values are also contained in input file 1.

The stream of annual cost increments (or reductions) is then discounted to an equivalent amount at the introduction of the change. The relations used for discounting and annualising costs are discussed in Chapter 2. Subroutine SPREAD is called to discount this total change in cost to an equivalent sum at the start of the analysis period, and then to annualise it to produce a constant annual cost over the entire analysis period.

Subroutine COSTS

COSTS is called from the MAIN program to calculate total costs for the voyage. Figure IV.3 shows the components of total cost and the routines which calculate each component. Canal charges, port charges and stevedoring charges are only calculated if the user specifies their inclusion (using the options contained in input file 2). If any ship prices are not entered, then subroutine SHIPRICE is called. Subroutine COSTS calculates stores costs by converting the input yearly cost to a daily cost, and then to a cost for the voyage.

Subroutine CREWCST

CREWCST is called from subroutine COSTS to calculate crew costs for the voyage. The annual crew cost is the annual cost per berth (from input file 2) multiplied by the number of berths on the ship (from input file 1). The annual cost is converted into a cost for the voyage by dividing by the number of ship working days per year and multiplying by the number of days for the voyage.

If the user has specified that the crewing level will decrease during the analysis period (from input file 1), then CREWCST multiplies the decrease (or in fact negative increase) in crewing positions by the annual crew cost per berth. This decrease in annual crew cost will only be experienced in the years after the change occurs. Hence, subroutine CHGCOST is called to calculate an equivalent annual cost that is constant over the entire analysis period. CREWCST then subtracts this decrease in cost from the previously calculated annual crew cost.

Subroutine CTRCAP

CTRCAP is called from subroutine COSTS to calculate container capital costs for the voyage. The costs calculated are the average cost over the analysis period of owning the stock of containers plus the cost of replacing a proportion of the containers each year (see Chapter 2). The average cost of a container is calculated from the proportions of dry and reefer containers in the vessel and their respective prices.[2]

2. Implicit in the calculation of container capital cost for the voyage is the assumption that the proportions of dry and reefer cargo on this voyage are indicative of the proportions of dry and reefer containers that would be owned or leased for this ship by the shipping company.

Total ship cost

- Vessel costs
  - Capital costs
    - Ship capital (SHIPCOST)
    - Container capital (CTRCAP)
  - Repair and maintenance costs
    - Ship repair and maintenance (SHIPREP)
    - Container repair and maintenance (CTRREP)
    - Container cleaning (CTRCLEAN)
  - Insurance costs (SHIPINS)
  - Crew costs (CREWCST)
  - Victuals cost (VICTLS)
  - Stores costs (COSTS)
  - Fuel costs (FUEL)
  - Administration costs (ADMIN)
- Canal charges (CANAL)
- Port charges
  - Port vessel charges (PORTVESS)
  - Wharfage charges (PORTCARG)
  - Tug and launch costs (TUGLNCH)
  - National light and pollution dues (NATLT)
- Stevedoring charges (STEV)

Notes 1. The names of the subroutines in which items are calculated are shown in brackets.
2. Items which are underlined are totals calculated by subroutine COSTS.

Figure IV.3 Components of total ship cost

The total number of containers owned or leased by the shipping company for the ship is determined by multiplying the teu capacity of the ship by the container slot ratio (from input file 1).

It is assumed that worn out containers are replaced at a constant rate. The annual cost of replacing worn out containers is based on the average cost of a container, its average scrap value and its average life.

The cost of owning the stock of containers is set equal to the value of the total stock at the start of the analysis period less the discounted value of the container stock at the end of the analysis period. This difference is then converted into an annuity. The value of the total stock of containers (at both the start and the end of the analysis period) is set equal to half of the net replacement value plus the total salvage value of the containers. This is consistent with a straight line depreciation in value over the life of a container. The net replacement value is the average cost of a new container less the average scrap value, multiplied by the number of containers in the stock.

The annual cost of replacing worn out containers plus the annuity associated with the stock of containers itself equals the total annual capital cost associated with containers. This total annual cost is converted into a cost for the voyage using the number of ship working days per year and the number of days for the voyage.

Subroutine CTRCLEAN

CTRCLEAN is called from subroutine COSTS to calculate container cleaning costs for the voyage. It is assumed that containers are only cleaned before they are filled, hence empty containers, containers transhipped in port A and containers remaining on board from the previous single leg voyage do not incur cleaning costs. Cleaning costs per container are contained in input file 2.

Subroutine CTRREP

CTRREP is called from subroutine COSTS to calculate container repair and maintenance costs for the voyage. These costs may be input as an annual cost per container or a total annual cost.

Annual costs are converted to daily costs using the number of ship working days per year, and subsequently to voyage costs using the number of days for the voyage. No routines are called from this subroutine.

Subroutine DISTRIBUTE

DISTRIBUTE is called from the MAIN program to calculate costs per revenue cargo unit for the voyage. Figure IV.4 shows the structure of DISTRIBUTE. The cost categories are those previously calculated by subroutine COSTS. Costs that can be allocated to containerised cargo are container capital, auxiliary fuel costs to chill reefer containers, container repairs and maintenance, container cleaning, container stevedoring charges and any port charges relating directly to containers. Costs incurred directly as a result of shipping empty containers (that is stevedoring and wharfage) are also distributed over the containerised cargo.

Charges that can be allocated to non-containerised cargo are stevedoring charges and any port charges relating directly to non-containerised cargo. All other costs are distributed over both containerised and non-containerised cargo by proportioning an equal cost to each unit of cargo weight. When only one cargo type is present the costs per unit of cargo can be determined by simply dividing each cost category by the amount of cargo. Weight of containerised cargo can only be calculated if the weight of cargo per teu is entered in input file 3.

Subroutine EXCHANGE

EXCHANGE is a utility routine called from various points in subroutine INPUT2. It ensures that input costs are converted, if necessary, to the required currency for the output. Options for input costs are:

1 = $A
2 = US$
3 = $ Port A
4 = $ Port B

The output currency options are contained in input file 2, and are coded:

1 = $A
2 = US$

INPUT2 will have read the exchange rates used for converting currencies. Where necessary, EXCHANGE converts a cost to the correct currency for output.

Subroutine FUEL

FUEL is called from subroutine COSTS to calculate fuel costs for the voyage. This is calculated from the fuel consumption for both the main and auxiliary engines, calculated in subroutine FUELWT, and the price of fuel for each of these engines. Figure IV.5 shows the structure of FUEL.

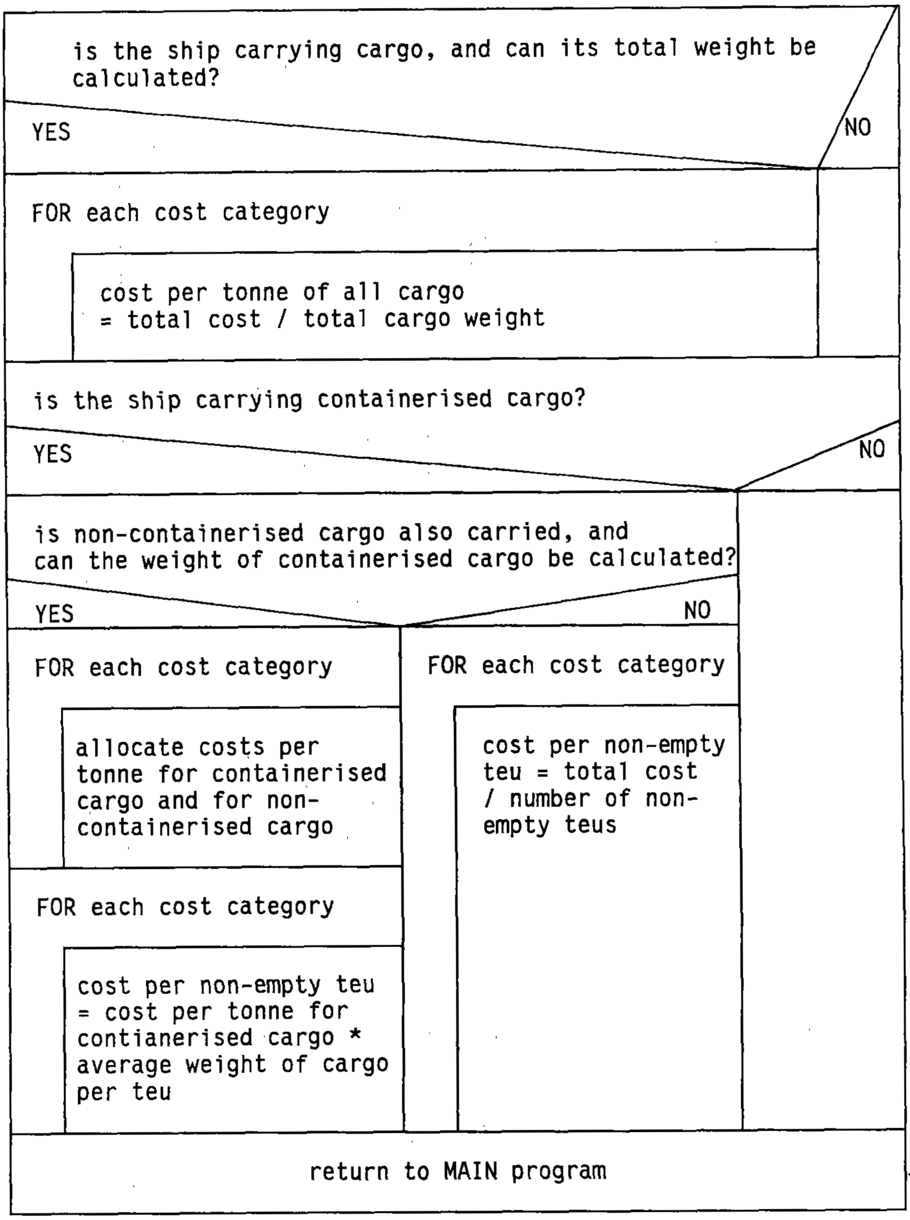


Figure IV.4 Flowchart for subroutine DISTRIBUTE

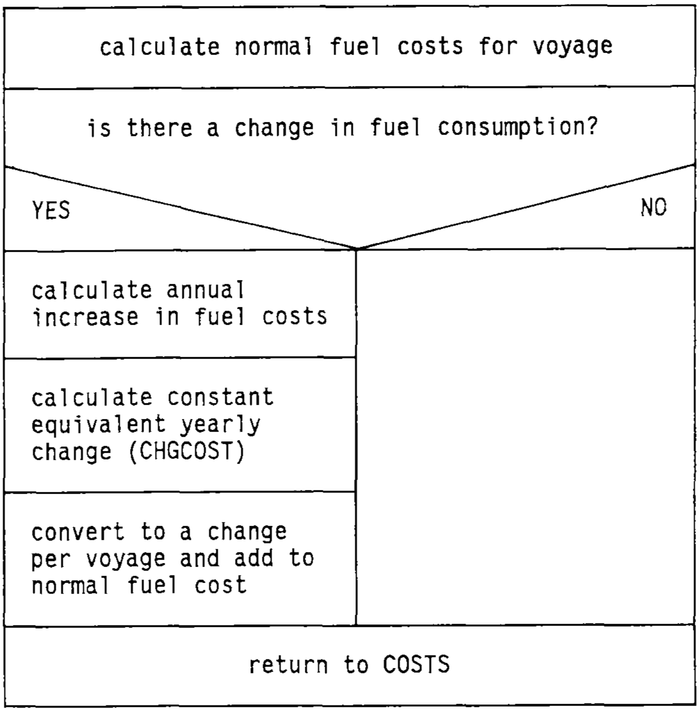


Figure IV.5 Flowchart for subroutine FUEL

The user may specify a fractional change in the fuel consumption rate during the analysis period (see input file 1). This is used to calculate the change in fuel costs per voyage. The difference in cost per voyage is converted to an annual total on the basis of the number of days for each voyage and the annual number of ship working days.

This change in annual fuel cost will only be experienced in the years after the change occurs. Hence, subroutine CHGCOST is called to calculate an equivalent annual cost difference that is constant over the entire analysis period. This is converted, in turn, to the cost change for each voyage.

An estimate of the amount of total auxiliary fuel costs which is attributable to reefer containers is also calculated. This enables the distribution of fuel costs between cargo types (in subroutine DISTRIBUTE) if both containerised and non-containerised cargoes are carried.

Subroutine FUELWT

FUELWT calculates the weight of main engine and auxiliary engine fuel consumed during the voyage, both at sea and in port. Inputs to this subroutine include route times, required engine power, maximum engine power and fuel consumption rates.

If a deadweight correction value is not entered, FUELWT may be called from subroutine MAXIMUM to estimate fuel consumption, in order to determine the maximum allowable cargo weight. In this case, route times and required power are set at estimated maximums before FUELWT is called.

FUELWT is called from SCHEDULE to determine actual fuel consumptions, once route times and power requirements are known.

Figure IV.6 shows the structure of FUELWT. The adjustment of main engine fuel consumption for the percentage of installed power used is performed using an equation based on data in Motor Ship (1985). The coefficients for this equation are contained in input file 4, and described in Chapter 5. The auxiliary engine fuel input options are as follows:

1 = already included in main engine fuel, or equal to zero
2 = entered in tonnes per day
3 = power requirements and consumption per kilowatt hour entered
4 = to be estimated in program

Under option 4 auxiliary engine fuel consumption is estimated using equations derived from Lloyd's Register of Shipping (1984a) and BTE (1982). Auxiliary fuel requirements to chill reefer containers are also calculated, if required, from equations derived from BTE (1982). The coefficients for all these equations are contained in input file 4, and discussed in Chapter 5.

Subroutines INPUT1, INPUT2, INPUT3 and INPUT4

The input subroutines are called from the MAIN program to read each input file. Chapter 5 describes the input files in detail. Appendix I contains the input skeletons for the first three input files. It also briefly describes the format specifications, and the conventions used within the skeleton files. Appendix II discusses the information in input file 4 which consists of the coefficients for any regression relations used in the program.

The input subroutines also convert the data items to appropriate units and currencies where necessary, check for inconsistencies in the data and set default values. These tasks are performed as soon as practicable after the data items are read.

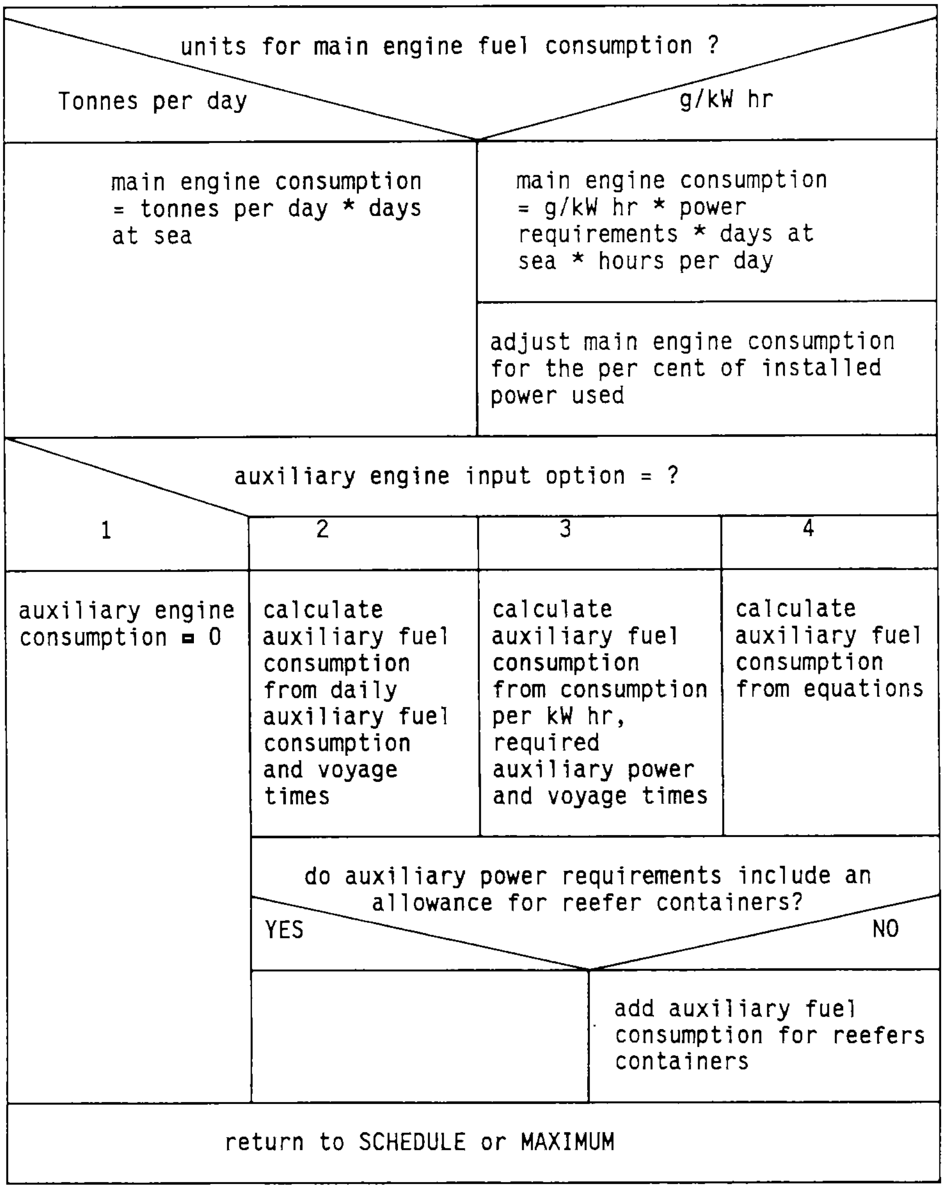


Figure IV.6 Flowchart for subroutine FUELWT

Subroutine MAXIMUM

MAXIMUM is called from CARGO2 to calculate the cargo weight capacity for the ship. CARGO2 is only called when the percentage loading option is chosen. Figure IV.7 illustrates the structure of the subroutine.

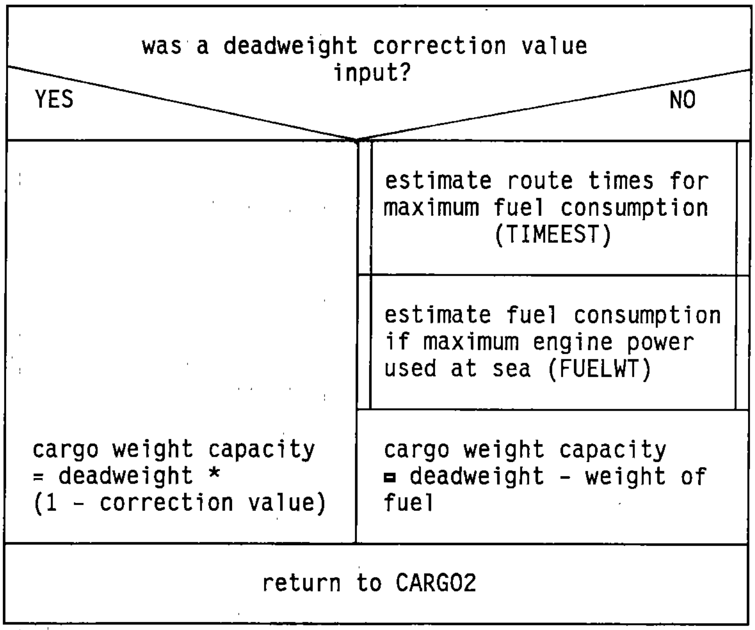


Figure IV.7 Flowchart for subroutine MAXIMUM

If a deadweight correction value is entered in input file 1, then the cargo weight capacity is calculated as:

cargo weight capacity = ship deadweight * (1 - correction value)

If a deadweight correction value is not entered, the cargo weight capacity is calculated using:

cargo weight capacity = ship deadweight - weight of fuel.

In this latter case, the allowance for weight of fuel is calculated by subroutine FUELWT, which uses estimates of route times and power requirements. Upper limits for these items are calculated so as not to underestimate the weight of fuel. Subroutine TIMEEST estimates route times. Power requirements are set to the maximum engine power. Actual fuel consumptions are calculated later in the program once the actual cargo load is set.

Subroutine MAXSTOP

MAXSTOP is called from subroutine SCHEDULE to stop execution of BTESHIP if the actual ship load exceeds the maximum allowable load. Figure IV.8 illustrates the structure of the subroutine. MAXSTOP is only called if loading input options 1 or 3 are used. If loading

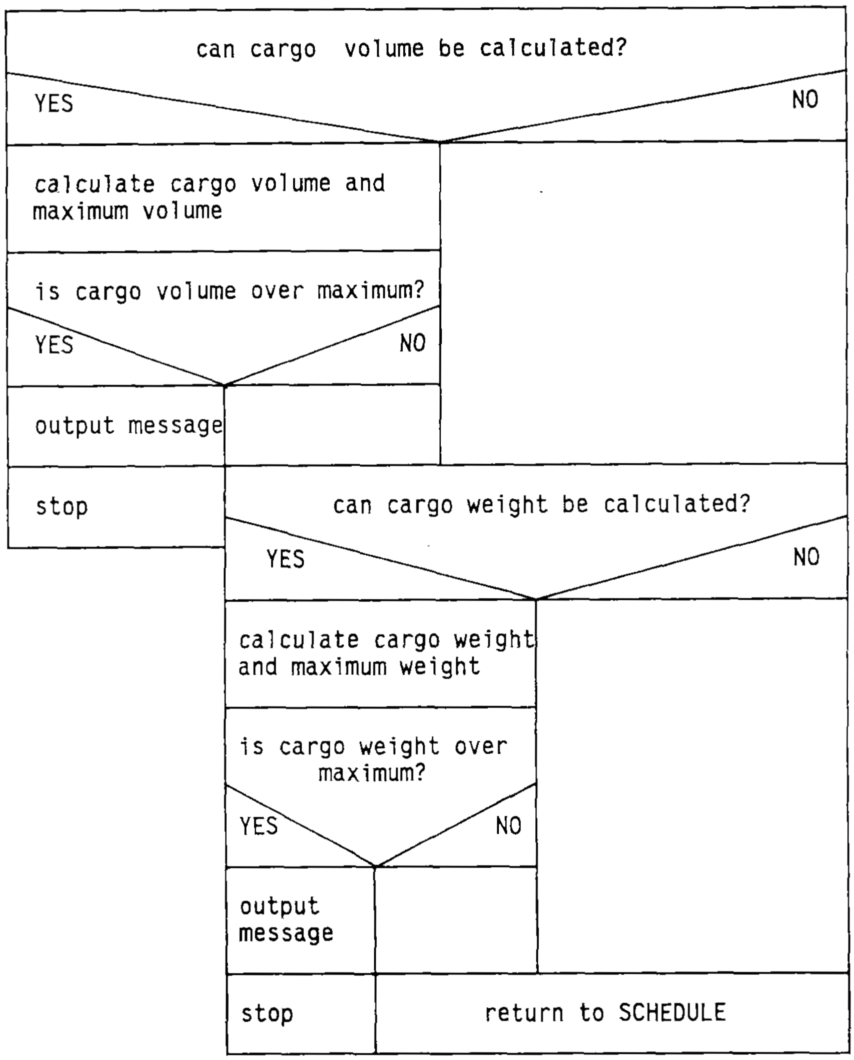


Figure IV.8 Flowchart for subroutine MAXSTOP

input option 2 is used, then subroutine CARGO2 will have calculated a cargo load that does not exceed the maximum allowable load.

When non-containerised cargo is carried, the cargo volume can only be calculated if the density for that cargo was entered. Similarly, when containerised cargo is carried, the cargo weight can only be calculated if the weight of cargo per container was entered.

Maximum cargo volume is read from input file 1. Maximum cargo weight is calculated from ship deadweight, using the deadweight correction value if it was entered in input file 1. Otherwise this is calculated by subtracting the weight of fuel consumed.

Subroutine NATLT

NATLT may be called from subroutine COSTS to calculate the amount of national light dues attributable to the single-leg voyage being costed. National light dues are part of port costs, which are only calculated if the user desires, as indicated in input file 2.

National light dues are paid in the form of a charge on the vessel which covers a fixed period of time, say 6 months. Thus, if a vessel makes several port calls in the one country within the specified time period, only a portion of the charge will be attributable to any one port call.

The numbers of port calls that the vessel will make in the country of port A and in the country of port B during the specified time period are read from input file 2. The national light dues for a particular port call are therefore estimated by multiplying the charge per ship tonnage by the tonnage and dividing by the appropriate number of port calls. In order to ensure that the estimates of national light dues for each leg of a multi-leg voyage can be summed, the charge attributable to one port call is then multiplied by the fraction of port dues that can be attributed to this leg of the vessel's total voyage.

Subroutine OUTPUT

All output, except for error messages, is written by subroutine OUTPUT. It is called once from the MAIN program after all the cost calculations have been performed. OUTPUT reads the stubs for the output tables from input file 5. No calculations are performed by subroutine OUTPUT. Chapter 6 describes the output files in detail.

Subroutine PORTCARG

PORTCARG may be called from subroutine COSTS to calculate port cargo charges (wharfage), for one port at a time. Port charges are only calculated if the user specifies their inclusion, as indicated in input file 2. Port charges are entered in input file 2 under a variety of different categories, as discussed in Chapter 5.

Port cargo charges are calculated by multiplying each unit cost by the appropriate number of units. Charges for containerised and non-containerised cargo have been kept separate so that they can be appropriately distributed over the cargo types in subroutine

DISTRIBUTE. Total port cargo charges are obtained by summing the charges for containerised and non-containerised cargo, and adding charges for fuel loaded in port A. Detailed container loadings will have been previously calculated by subroutine SUMUP.

Subroutine PORTTIME

PORTTIME calculates the time spent in port given a total cargo load. Time in port excludes pilotage time. Time in port A is the sum of the following components:

- time taken to load containers (calculated using number of teus loaded and their loading rate);
- time taken to load other cargo (calculated using weight of cargo and its loading rate); and
- time spent not stevedoring.

Unloading rates are used in a similar manner to derive the time spent in port B. The time in both ports is then summed to obtain the total time spent in port for the voyage.

PORTTIME is called from subroutines TIMEDIST and TIMEEST, and calls no other routines.

Subroutine PORTVESS

PORTVESS may be called from subroutine COSTS to calculate port vessel charges for each port. Port charges are only calculated if the user specifies their inclusion as indicated in input file 2. Port charges are entered in input file 2 under a variety of different categories, as discussed in Chapter 5.

The port charges on the vessel are split into two groups: those that are totally attributable to the single-leg voyage under consideration and those that are only partially attributable to this leg. Charges that are dependent on the time spent in port are totally attributable to this leg. Charges which relate to the size of the vessel and which are independent of the length of time spent in port are partly attributable to the current leg, partly attributable to the previous leg in the case of port A and partly attributable to the next leg in the case of port B. The fractions of these port charges in each port that are attributable to the current leg are contained in input file 2.

Ship characteristics such as gross or net registered tons are either read from input file 1 or estimated previously by subroutine SHIPGC.

Time in port will have been previously calculated by subroutine PORTTIME.

Subroutine POWER

POWER is called from SCHEDULE to calculate the engine power required to travel at a particular speed. This is achieved using regressions of engine power against deadweight and speed for each ship type. Data for the regressions come from Lloyd's Register of Shipping (1984b). The coefficients for these equations are contained in input file 4, and discussed in Chapter 5.

If the user has entered a value for maximum engine power, then POWER can adjust the estimate of required engine power obtained from the equations to ensure that it models the ship as closely as possible.

If the engine power required to travel at the given speed is greater than the maximum engine power of the ship, then a warning message is printed to the output file. No routines are called from POWER.

Subroutine SCHEDULE

SCHEDULE is called from the MAIN program to calculate route times, cargo loadings and fuel consumptions. Figure IV.9 shows the structure of SCHEDULE.

The actual ship load is calculated by subroutine CARGO1, CARGO2 or CARGO3. CARGO2 requires speed in either knots or voyage time. Speed is used in calculating the maximum allowable cargo weight for the ship, which will determine the load carried when the percentage loading option is used.

Route times are calculated by subroutine TIMEDIST, which requires data on the amount of cargo loaded and unloaded in order to determine the time spent stevedoring. If speed was input as a number of days for the voyage, it is converted to knots by subroutine SPEED2 which requires the time spent stevedoring. Average power requirements at sea are then calculated by subroutine POWER, which requires the speed in knots. This is then used by subroutine FUELWT to calculate fuel consumption for the voyage.

If the voyage or yearly loading options were chosen, the load is checked by subroutine MAXSTOP to ensure that it does not exceed the maximum allowable weight or maximum allowable volume. If the load does exceed the maximum, an error message will be printed and execution of the program stops. Fuel consumption and voyage times are required to calculate the maximum allowable weight and volume of cargo.

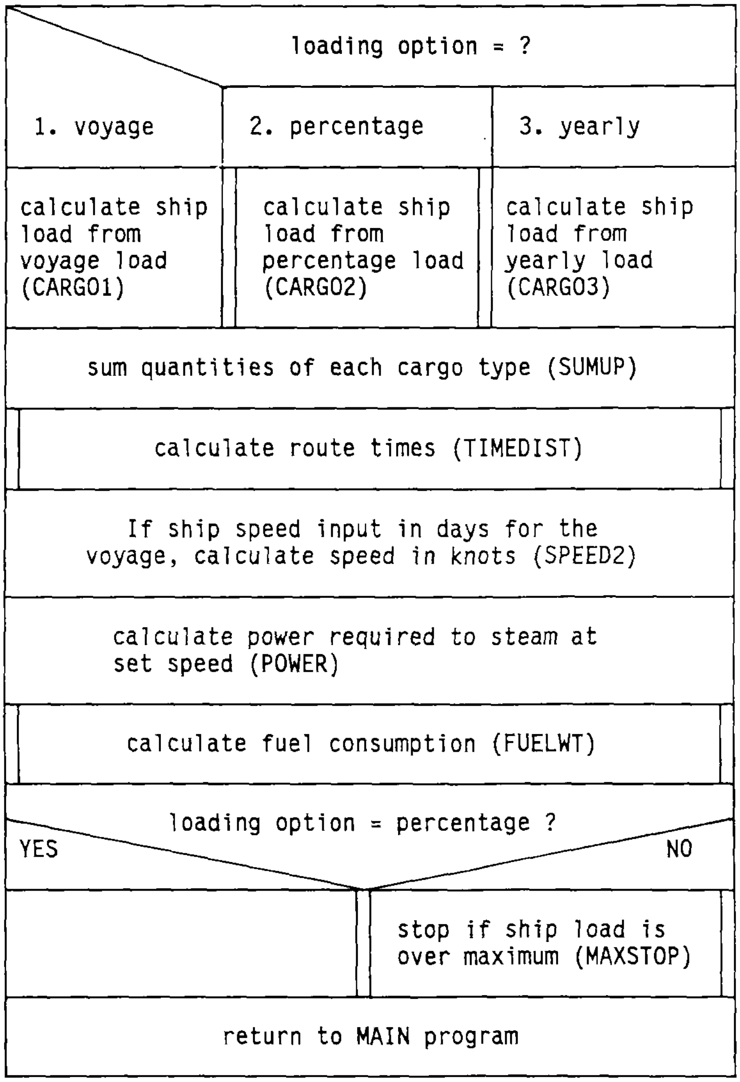


Figure IV.9 Flowchart for subroutine SCHEDULE

Subroutine SHIPCOST

SHIPCOST is called by subroutine COSTS to calculate ship capital costs for the voyage. Figure IV.10 shows the structure of SHIPCOST. Ship capital costs are calculated as a constant cost per year, equivalent to the costs of purchasing vessels for the period, less the revenue from resale of vessels for the period. The components used to calculate capital costs are:

- resale value of the existing vessel at the start of the period;

- scrap value of the existing vessel;
- newbuilding price of the replacement vessel; and
- resale value of the replacement vessel at the end of the analysis period.

Each capital cost is discounted to the start of the analysis period, and then annualised by subroutine SPREAD. Input file 2 contains the discount rate used for this purpose. These various capital costs are then summed to obtain a single annual cost which is converted to a cost for the voyage by dividing by the number of ship working days per year, and multiplying by the number of days for the voyage.

The user may specify a change in ship capital costs during the analysis period. This may be entered into BTESHIP as any combination of the following:

- a dollar amount at the time of change;
- an extra cost per kilowatt capacity of the ship's engine at the time of the change; and
- a fractional increase in ship construction cost from the time of the change.

Each time a ship is replaced during the analysis period, a check is made to see if the construction cost of the new vessel is affected by the change. An extra cost per kilowatt capacity of the ship's engine refers to the engine capacity of the ship before the change, if this is also altered at the time of change.

Subroutine SHIPGC

SHIPGC is called from the MAIN program to estimate any ship characteristics not entered by the user. These characteristics are:

- length
- beam
- draught
- maximum engine power
- gross registered tonnage
- net registered tonnage.

An estimate of the ship's maximum engine power is always calculated by SHIPGC for use in subroutine POWER. If the maximum engine power was entered, then the estimate is used as an adjustment factor when

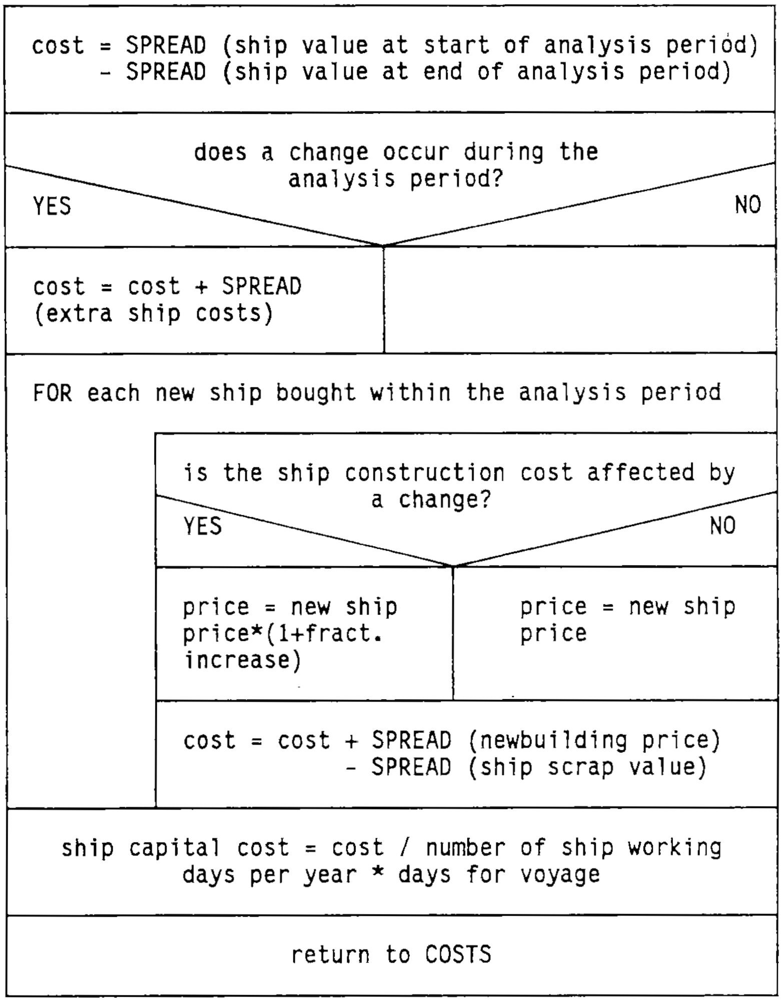


Figure IV.10 Flowchart for subroutine SHIPCOST

calculating required engine power (see subroutine POWER). Each of the other characteristics are only estimated by SHIPGC if they are not entered by the user.

SHIPGC estimates the various ship characteristics using regressions of data from Lloyds Register of Shipping (1984b) and BTE (1980). The coefficients for the regression equations are contained in input file 4, and will have been read by subroutine INPUT4.

Subroutine SHIPINS

SHIPINS is called from subroutine COSTS to calculate ship insurance costs for the voyage. Ship insurance will have been previously read from input file 2 as one of the following:

- an annual cost expressed as a fraction of ship replacement cost
- an annual cost in dollars
- a cost per day that the ship is in operation.

The insurance cost associated with the voyage is calculated from the annual cost on a proportional basis using the number of days a ship is in operation each year, and the voyage duration. The number of days that the ship is in operation each year will have been read from input file 1, and the voyage time will have been calculated by subroutine TIMEDIST.

If insurance costs are input as a fraction of ship replacement costs, then an annual cost is obtained by multiplying this fraction by the cost of a new ship.

If an annual dollar cost or a daily cost is input, a change in the ship construction cost during the analysis period will not affect insurance costs. However, if insurance costs are input as a fraction of ship replacement costs, it is assumed that the replacement cost, and hence the insurance cost, varies at the time of the change, irrespective of whether or not the ship is actually replaced at that time. An equivalent constant annual change in insurance cost is calculated by subroutine CHGCOST, and added to the basic annual insurance cost. This is converted to a cost for the voyage as described above.

Subroutine SHIPREP

SHIPREP is called from subroutine COSTS to calculate ship repair and maintenance costs for the voyage. This will have been previously read from input file 2 in one of the following forms:

- an annual cost expressed as a fraction of the ship newbuilding price
- an annual cost in dollars
- a cost per day that the ship is in operation.

Each of these costs is converted appropriately into the costs associated with the voyage using the duration of the voyage and the number of operational days of the ship per annum. The number of days that the ship is in operation each year will have been read from input file 1, and the voyage time will have been calculated by subroutine TIMEDIST.

The user may specify a change in ship repair and maintenance cost during the analysis period. If a change is specified, then an equivalent constant annual change in repair and maintenance cost is calculated by subroutine CHGCOST. This is then converted to a cost for the voyage in the same way an input annual cost is converted. The ship repair and maintenance cost will be unaffected if the user specifies a change to the ship construction cost during the analysis period. This will be the case even if repairs and maintenance have been entered as a fraction of ship newbuilding price.

Subroutine SHIPRICE

SHIPRICE is called from subroutine COSTS if any ship capital costs for the ship size being considered have not been entered by the user. If two costs should be identical, and one of these is entered by the user (and the other is not), then the cost not entered is set equal to the entered cost. Cases where two costs should be identical are:

- new ship cost, and cost at the start of the analysis period if the ship is new at the start of the analysis period; and
- ship scrap value, and value at the end of the analysis period if the end of the analysis period corresponds to the end of the life of the ship.

Any other ship prices that are not entered will retain a zero value.

Subroutines SPEED1 and SPEED2

SPEED1 is called from subroutine SCHEDULE to convert speed in Froude number to speed in knots.[3] This requires the ship length, force of gravity at sea level, and a conversion factor from metres per second to knots per hour. The ship length will have been read from input file 1 or estimated by subroutine SHIPGC. The force of gravity and the conversion factor are constants set in the MAIN program.

SPEED2 calculates speed in knots using route times, sea distance and the bad weather factor. It is called from subroutine SCHEDULE if speed was entered as a number of days for the voyage. Route times will have been previously calculated by subroutine TIMEDIST. The sea distance and bad weather factor are contained in input file 1.

---

3. It is not expected that this form of speed specification would normally be used.

Subroutine SPREAD

SPREAD is a utility routine called from subroutine CHGCOST and subroutine SHIPCOST. It calculates a constant annual cost for the entire analysis period, equivalent to a given value at a given time. This is done by discounting the given value to an equivalent amount at the start of the analysis period, and then calculating an equivalent annual cost over the whole analysis period. The relations used for discounting and annualising costs are discussed in Chapter 2. The length of the analysis period will have been read from input file 1, and the discount rate will have been read from input file 2. A real discount rate is used and all costs are expressed in constant dollars.

Subroutine STEV

STEV is called from subroutine COSTS to calculate stevedoring charges for the voyage, if the user has specified their inclusion in total costs. The option to exclude stevedoring charges is contained in input file 2 which also contains the relevant information on these charges when required.

The charges include charges to load each cargo type in port A, charges to unload each cargo type in port B and charges to load fuel. The number of units of each cargo type will have been calculated by subroutine SCHEDULE. Charges for containerised and non-containerised cargo are added into the total stevedoring charge, but are also retained separately for use in subroutine DISTRIBUTE.

Fuel weights for the voyage will have been calculated by subroutine FUELWT. Voyage time will have been calculated by subroutine TIMEDIST.

Subroutine SUMUP

SUMUP is called from SCHEDULE to sum the quantities of various cargo types. The following quantities (in teus) of containerised cargo are summed:

- total container load
- reefer container load
- empty container load
- non-empty container load.

Also calculated for each port are:

- cargo quantities loaded or unloaded
- cargo quantities remaining on board.

These cargo quantities are calculated in number of teus of containerised cargo, tonnes of containerised cargo, tonnes of non-containerised cargo and tonnes of all cargo.

Subroutine TIMEDIST

TIMEDIST is called from subroutine SCHEDULE to calculate route times when the ship load is known. Figure IV.11 shows the structure of TIMEDIST. Route times are:

- time in port
- time at sea
- voyage time.

Time in port is obtained from subroutine PORTTIME, which requires the ship load to calculate stevedoring times. If the voyage time was entered in input file 1, then the time at sea is set to the voyage time less the time in port. Otherwise, the speed in knots will be known and is used to calculate time at sea from the sea distance and bad weather factor. Time spent in canals and pilotage time are also included in time at sea. These will have been read by subroutine INPUT1. Voyage time is the sum of time in port and time at sea.

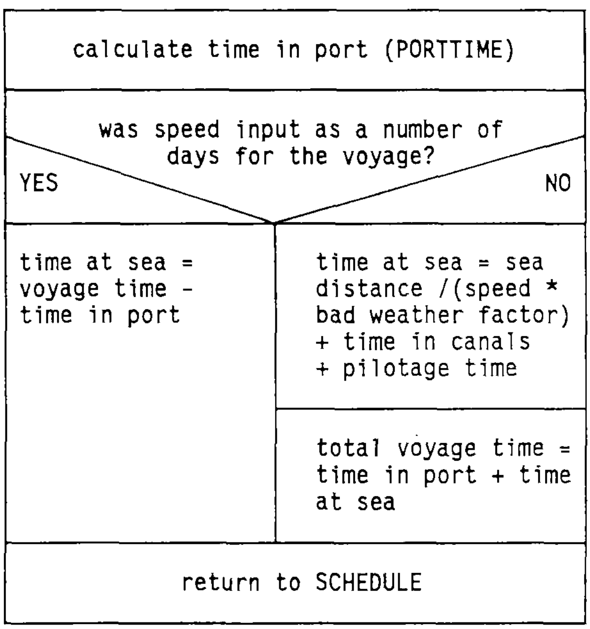


Figure IV.11 Flowchart for subroutine TIMEDIST

Subroutine TIMEEST

TIMEEST is called from MAXIMUM if a deadweight correction value is not entered in input file 1. MAXIMUM is called to estimate the maximum allowable cargo load for the ship when the percentage loading option is chosen. TIMEEST estimates route times to be used in calculating an upper limit for the weight of fuel consumed. Figure IV.12 shows the structure of TIMEEST.

If the speed was entered as a number of days for the voyage, then time in port is minimised by assuming that no time is spent stevedoring (it is assumed that more fuel is consumed at sea than in port). The time at sea is then the voyage time less the time in port.

If, however, the voyage time is unknown the speed in knots will be known. This is then used to calculate time at sea, together with the sea distance and bad weather factor from input file 1. The time spent in canals and pilotage time is also added to time at sea.

Data on the ship cargo load will have been read from input file 3, and estimates of the actual voyage load calculated in subroutine CARGO2. This voyage load is transferred to subroutine PORTTIME. This may result in an estimate of time in port that exceeds the time actually in port. This is because the cargo load obtained from CARGO2 may be slightly greater than the allowable limit for the vessel.

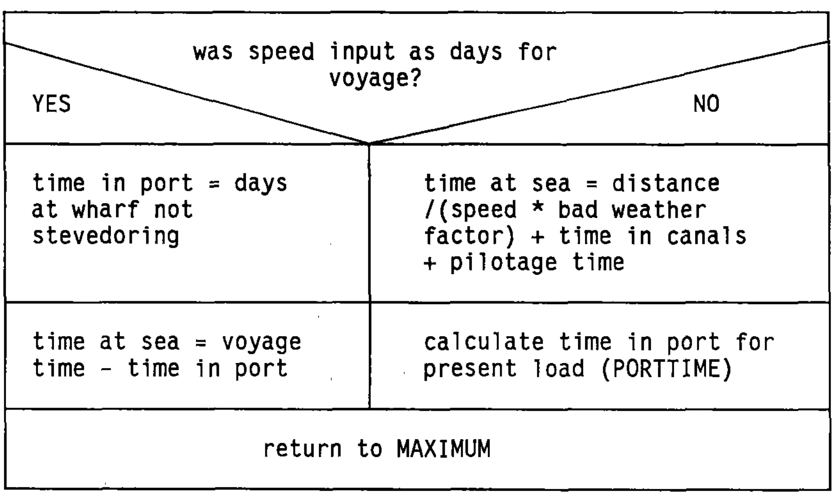


Figure IV.12 Flowchart for subroutine TIMEEST

Subroutine TUGLNCH

TUGLNCH is called from subroutine COSTS to calculate tug and launch charges if port charges are to be included in the total cost. The option to exclude port charges is contained in input file 2.

Tug and launch charges and the number of tugs and launches required in each port are also read from input file 2. The charge per tug or launch may be input as either a charge per movement or a charge per movement per ship ton. Tug and launch charges are only calculated for departure from port A and entry to port B. The ship tonnage may be either the nrt or the grt, as indicated in input file 2. These tonnages will have either been read from input file 1 or estimated in subroutine SHIPGC.

Subroutine VICTLS

VICTLS is called from subroutine COSTS to calculate the cost of victuals for the voyage. This is entered in input file 2 as an expenditure per person per day. The total daily expenditure is calculated using the crew size, and this in turn is converted to total victuals cost for the voyage. The crew size comes from input file 1, and the voyage time will have been calculated by subroutine TIMEDIST.

The user may specify a change in the crew size during the analysis period. If this is the case, the change in annual victuals cost is calculated. Subroutine CHGCOST calculates a constant annual change in cost over the analysis period. The change in victuals cost for a voyage is calculated using voyage time and the number of days that the ship is in operation each year.

APPENDIX V DESCRIPTION OF NASSI-SHNEIDERMAN CHARTS

Nassi-Shneiderman charts are a graphical representation of an algorithm. The charts shown in Appendix IV are based on concepts presented in Nassi and Shneiderman (1973). They are a combination of what are called process symbols and control structures.

Process symbols are boxes containing descriptions of processes such as assignment, input and output, procedure and function calls and returns. Any process symbol may also represent a complete Nassi-Shneiderman chart; or a null action. In this Paper, if a process is carried out by a procedure or function call, then the name of the procedure or function will appear in brackets. If a separate chart is presented for that procedure or function, then the process symbol will appear in Appendix IV with double lines at its sides.

There are three basic control structures:

- sequences
- selection
- iteration.

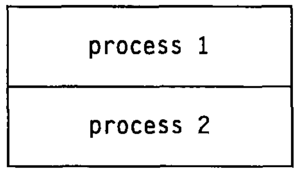
More powerful structures may be used, although they are not necessary. The structures used in this Paper are described below.

Sequences

A sequence is a set of process symbols, each above the next. The symbol at the top is executed first, and the symbol at the bottom is executed last. See Figure V.1.

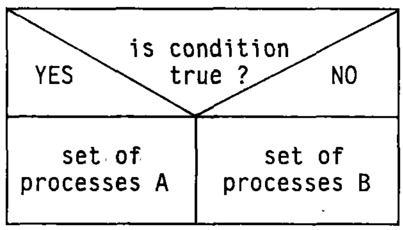
Selections

A selection is a conditional expression which indicates possible outcomes and process symbols to be performed depending on the outcome of the test. See Figures V.2 and V.3 for examples.



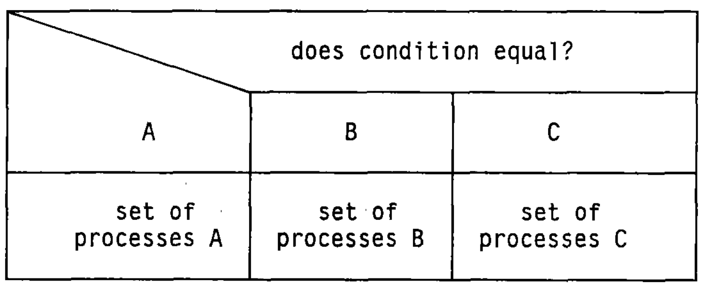
Source Adapted from Nassi and Shneiderman (1973).

Figure V.1 An example of sequence in a flowchart



Source Adapted from Nassi and Shneiderman (1973).

Figure V.2 An example of simple selection in a flowchart



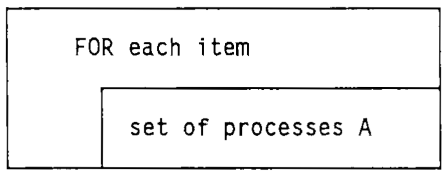
Source Adapted from Nassi and Shneiderman (1973).

Figure V.3 An example of three-way selection in a flowchart

Iteration

An iteration is a set of processes that can be repeated. A test is made, either before or after execution of the set of processes, to determine if a further execution of the processes will occur. Hence, if the test is above the set of processes, they may or may not be executed at all.

Figure V.4 is a flow chart for a FOR loop. This type of iteration executes a set of processes once for each item in a list of items.



Source Adapted from Nassi and Shneiderman (1973).

Figure V.4 An example of a FOR loop

APPENDIX VI DICTIONARY OF VARIABLES USED IN BTESHIP

The following list describes the major variables used in program BTESHIP. Each variable name is accompanied by its variable type and a description of its use in the program. The following characters are used to denote variable type:

- C - character variable
- I - integer variable
- R - real variable.

The system used to describe variables relating to vessel cargo loadings is explained at the end of the list of variable names.

ADMDAY(X)	R	Administration cost per day for ship X.
ADMFRAC	R	Ship administration cost as a fraction of ship cost excluding fuel.
AGEINTRO	I	Age of ship at time of change.
AGEND	I	Age of ship at end of analysis period.
ALLCARG(X,Y)	R	Cost item X for all cargo on ship Y ($/tonne).
ANNINC	R	Equivalent annual cost when an increase in an annual cost occurs due to a change.
AUXBP	R	Auxiliary fuel consumption for bulk ships in port from input file 4 (tonnes/day).
AUXBSA	R	Auxiliary fuel consumption for bulk ships at sea from input file 4: coefficient α.
AUXBSB	R	Auxiliary fuel consumption for bulk ships at sea from input file 4: coefficient β.
AUXBSC	R	Auxiliary fuel consumption for bulk ships at sea from input file 4: coefficient γ.
AUXNB	R	Base auxiliary fuel consumption for non-bulk ships from input file 4 (tonnes/day).
AUXOPT	I	Auxiliary fuel input option.
AUXPDAY(X)	R	Auxiliary fuel consumption for ship X in port from input file 1 (tonnes/day).
AUXPKW(X)	R	Auxiliary fuel consumption for ship X in port from input file 1 (grams/kilowatt hour).
AUXPORT	R	Auxiliary fuel consumption in port (tonnes).

AUXPPOW(X)	R	Auxiliary power requirements for ship X in port from input file 1 (kilowatts).
AUXPRICE	R	Auxiliary engine fuel price.
AUXREEF	R	Additional auxiliary fuel consumption per reefer for containerised or part containerised ships from input file 4 (tonnes/day).
AUXSDAY(X)	R	Auxiliary fuel consumption for ship X at sea from input file 1 (tonnes/day).
AUXSEA	R	Auxiliary fuel consumption at sea (tonnes).
AUXSKW(X)	R	Auxiliary fuel consumption for ship X at sea from input file 1 (grams/kilowatt hour).
AUXSPOW(X)	R	Auxiliary power requirements for ship X at sea from input file 1 (kilowatts).
AUXTOT(X)	R	Auxiliary engine fuel consumption for ship X (tonnes for voyage).
AVPRICE	R	Average price of a new container.
AVSCRAP	R	Average scrap value of a container.
BEAM(X)	R	Beam of ship X (metres).
BLKCARG(X)	R	Wharfage charge for non-containerised cargo in port X.
BLKSTEV(X)	R	Stevedoring charge for non-containerised cargo in port X.
BLKTON(X,Y)	R	Cost item X for non-containerised cargo on ship Y ($/tonne).
BLKVERPC	R	Per cent of cargo by volume which is non-containerised.
BLKWPERC	R	Per cent of cargo by weight which is non-containerised.
BLR(X,Y)	R	Loading or unloading rate for non-containerised cargo in port Y for ship X.
BTPERC(X)	R	Percentage of non-containerised cargo which is transhipped in port X.
BULK(X)	R	Tonnes of non-containerised cargo on board ship X during the voyage.
BULKPERC	R	Percentage of cargo by volume which is non-containerised cargo.
BWFACTOR	R	Bad weather factor.
CANALOPT	I	Option to include or exclude canal charges.
CANCH(X)	R	Charge to traverse canal X.
CANTIME	R	Time spent in canals during voyage (days).
CANTYPE(X)	C	Name indicator for the Xth canal.
CARGPERC	R	Total loading of cargo and containers for voyage when ship loading option = 2 (per cent of capacity).
CARGVOL(X)	R	Volume of cargo on ship X, excluding empty

		containers (cubic metres).
CARGWT(X)	R	Weight of cargo on ship X, excluding weight of containers (tonnes).
CLR(X,Y)	R	Loading or unloading rate for containerised cargo in port Y for ship X.
CMTCON	R	Container maintenance cost per teu.
CMTTOT	R	Annual container maintenance cost for ship.
COLUMNS	I	Number of cost columns in output table 1.
CONCARG(X)	R	Wharfage charge for containerised cargo in port X.
CONCLEAN	R	Cost to clean a container in port A.
CONSTEV(X)	R	Stevedoring charge for containerised cargo in port X.
CONT(X)	R	Total number of containers on ship X (teus).
CONTAINER	R	Volume of a container (cubic metres per teu).
CONTEU(X,Y)	R	Cost item X for containerised cargo on ship Y ($/non-empty teu).
CONTLIFE	R	Average life of a container (years).
CONTON(X,Y)	R	Cost item X for containerised cargo on ship Y ($/tonne).
CONTWT(X)	R	Weight of containerised cargo on ship X (tonnes).
COST	R	Temporary variable.
CRER	R	Exchange rate: $crew payments per $A.
CREW(X)	I	Crewing level for ship X.
CREWCOST	R	Annual crew costs per berth.
CREWDEC	I	Decrease in ship crewing level after change.
CSR	R	Container slot ratio.
CTPERC(X)	R	Percentage of containers which are transhipped in port X.
CUROPT	I	Input currency option.
CURRENCY	I	Output currency option.
CURROPT(X)	I	Input currency option for port X.
DISCR(X)	C	Run description, part X.
DRAFT(X)	R	Draught of ship X (metres).
DRYFRAC	R	Fraction of all containers which are dry containers.
DRYPRICE	R	Price of a new dry container.
DRYRES	R	Scrap value of a dry container.
DWT(X)	R	Deadweight of ship X (tonnes).
DWTCOR	R	Deadweight correction value.
EDC(X)	R	Number of empty, dry containers on ship X.
EFFECT	I	Option indicating the effect of a change.
EMPT(X)	R	Number of empty containers on ship X.
EMPTPERC	R	Percentage of containers which are empty.

EMPTVOL(X)	R	Volume of empty containers on ship X (cubic metres).
EQUIV	R	Output from subroutine SPREAD.
ERC(X)	R	Number of empty, reefer containers on ship X.
ESTHPR	R	Estimate of maximum engine power (kilowatts).
EXCOL	I	Equivalent to COLUMNS less one.
FCONDEC	R	Decrease in fuel consumption after change (grams/kilowatt hour).
FDC(X)	R	Number of non-empty, dry containers on ship X.
FNAME	C	Name for an input or output file.
FRC(X)	R	Number of non-empty, reefer containers on ship X.
FREQ	R	Number of times that this voyage is made each year.
FROUDE	R	Froude number from input file 1.
FTMETRE	R	Feet per metre.
FUEL	R	Fuel cost for voyage.
FUELTOT(X)	R	Total fuel consumption for ship X (tonnes for voyage).
FULL(X)	R	Number of non-empty containers on ship X.
GRAVITY	R	Force of gravity at sea level (m/s^2).
GRT(X)	R	Gross registered tonnage for ship X.
GTONNE	R	Grams per tonne.
HEAD(X,Y)	C	Line Y of headings for column X+1 of output page 1.
HLINE	I	Width of table body on output page 1.
HPOW(X)	R	Average required engine power for ship X at sea (kilowatts).
HRDAY	R	Hours per day.
INCPORT	R	Annual increase in fuel costs in port when a change occurs.
INCSEA	R	Annual increase in fuel costs at sea when a change occurs.
INSDAY(X)	R	Insurance cost per day ship X is in operation.
INSFRAC	R	Ship insurance cost as a fraction of ship replacement cost.
INSYR(X)	R	Insurance cost per year for ship X.
INTEREST	R	Annual real interest rate.
INTRO	I	Time until introduction of change (years).
KNOTS	R	(metres/second)/(knots/hour).
LDBULK(X,Y)	R	Total non-containerised cargo loaded/unloaded in port Y for ship X for voyage.
LDCON(X,Y)	R	Total containers loaded or unloaded in port Y for ship X for voyage.
LDEMPT(X,Y)	R	Number of empty containers loaded or unloaded

		in port Y for ship X for voyage.
LDFDAL(X,Y)	R	Number of laden dry containers loaded or unloaded in port Y for ship X for voyage.
LDFRAL(X,Y)	R	Number of laden reefer containers loaded or unloaded in port Y for ship X for voyage.
LDFULL(X,Y)	R	Number of laden containers loaded or unloaded in port Y for ship X for voyage.
LDTALL(X,Y)	R	Number of laden containers transhipped in port Y for ship X for voyage.
LDTON(X,Y)	R	Weight of containerised cargo loaded or unloaded in port Y for ship X for voyage.
LDTOT(X,Y)	R	Weight of all cargo loaded or unloaded in port Y for ship X for voyage.
LDTTON(X,Y)	R	Weight of containerised cargo transhipped in port Y for ship X for voyage.
LDTTOT(X,Y)	R	Weight of all cargo transhipped in port Y for ship X for voyage.
LENGTH(X)	R	Length of ship X (metres).
LFDV(X)	R	Number of laden dry containers loaded or unloaded in port X for voyage.
LFRV(X)	R	Number of laden reefer containers loaded or unloaded in port X for voyage.
LNCH(X)	R	Launch charge in port X per movement.
LNCHT(X)	R	Launch charge in port X per ship ton per movement.
LOAD	R	Number of containers cleaned for voyage.
LOADOPT	I	Ship loading input option.
LOADPERC(X)	R	Per cent of cargo and containers on board during voyage which is loaded or unloaded in port X.
MAINDAY(X)	R	Main engine fuel consumption at sea (tonnes/day).
MAINKW(X)	R	Main engine fuel consumption (grams/kilowatt hour).
MAINPRICE	R	Main engine fuel price ($/tonne).
MAINSEA(X)	R	Main engine fuel consumption for ship X (tonnes for voyage).
MAINTINC	R	Fractional increase in ship repair and maintenance costs after change.
MAXPERC	R	Maximum allowable loading of all cargo and containers (per cent of capacity).
MAXPOW(X)	R	Maximum engine power for ship X (kilowatts).
MAXVOL(X)	R	Volume limit for ship X (cubic metres).
MAXWT(X)	R	Weight limit for ship X (tonnes).
NA	C	Eight character string used in output tables

		to indicate 'not applicable'.
NAME(X)	C	For use in output tables to indicate Ship A, B, C or D.
NATLTCH(X)	R	National light charge per ship ton in port X.
NEWPRICE	R	New ship price.
NOSTEV(X)	R	Time not stevedoring in port X (days).
NRT(X)	R	Net registered tonnage for ship X (tonnes).
NUMLN(X)	R	Number of launches required in port X.
NUMPORT(X)	I	Number of port calls in port X's country during time covered by one national light charge.
NUMSIZE	I	Number of similar ships to be costed in one run.
NUMTUG(X)	R	Number of tugs required in port X.
OPER	R	Vessel cost for voyage, excluding administration costs.
OPTION	C	Indicates whether default file name is to be used.
OUTOPT	I	Option for extended or summary output formats.
P1ER	R	Exchange rate: $port 1 per $A.
P2ER	R	Exchange rate: $port 2 per $A.
PERIOD	I	Years in the analysis period.
PILOT(X)	R	Pilotage time for port X (days).
PORT	I	Indicates whether port A or port B is being costed
PORTBLK(X)	R	Wharfage charge per tonne of non-containerised cargo in port X.
PORTBM(X)	R	Charge in port X per metre of ship beam.
PORTCH(X)	R	Fixed charge for port X.
PORTCONT(X)	R	Wharfage charge per dry container in port X.
PORTCST	R	Total fuel cost in port.
PORTDAY(X)	R	Port charge per day in port X.
PORTDGRT(X)	R	Port charge per day per gross registered ton in port X.
PORTDNRT(X)	R	Port charge per day per net registered ton in port X.
PORTDRF(X)	R	Charge in port X per metre of ship draught.
PORTEMPT(X)	R	Wharfage charge per empty container in port X.
PORTFRAC(X)	R	Fraction of partially attributable port charges to be attributed to the current voyage in port X.
PORTFUEL	R	Wharfage charge per tonne of fuel loaded in port A.
PORTGRT(X)	R	Charge in port X per gross registered ton.
PORTLEN(X)	R	Charge in port X per metre of ship length.

PORTNRT(X)	R	Charge in port X per net registered ton.
PORTOPT	I	Option to include or exclude port charges.
PORTRAN(X)	R	Wharfage charge per transhipped container in port X.
PORTREEF(X)	R	Wharfage charge per reefer container in port X.
POWPERC	R	Fraction of ship's maximum engine power utilised at sea.
REEFFRAC	R	Fraction of all containers which are reefers.
REEFOPT	C	Indicates if auxiliary power requirements include an allowance for reefer containers.
REEFPCH	R	Total auxiliary fuel cost for reefers in port.
REEFPERC	R	Percentage of containers which are reefers.
REEFPORT	R	Total auxiliary fuel consumption for reefers in port (tonnes).
REEFPRICE	R	Price of a new reefer container.
REEFRES	R	Scrap value of a reefer container.
REEFSCH	R	Total auxiliary fuel cost for reefers at sea.
REEFSEA	R	Total auxiliary fuel consumption for reefers at sea (tonnes).
REEFTOT	R	Number of reefer containers on board ship.
REGADJ(X)	R	Coefficient X for fuel adjustment as a function of the fraction of installed power utilised.
REGBEM(X,Y)	R	Coefficient X for beam of ship type Y.
REGDRF(X,Y)	R	Coefficient X for draught of ship type Y.
REGGRT(X,Y)	R	Coefficient X for gross registered tonnage of ship type Y.
REGLEN(X,Y)	R	Coefficient X for length of ship type Y.
REGMPW(X,Y)	R	Coefficient X for maximum engine power of ship type Y.
REGNRT(X,Y)	R	Coefficient X for net registered tonnage of ship type Y.
REGRPW(X,Y)	R	Coefficient X for power requirements of ship type Y.
REMCAP(X)	R	Cargo capacity other than container capacity for ship X.
REMCON(X,Y)	R	Number of containers remaining on board ship X in port Y.
REMEMPT(X,Y)	R	Number of empty containers remaining on board ship X in port Y.
REMFULL(X,Y)	R	Number of laden containers remaining on board ship X in port Y.
REMTON(X,Y)	R	Weight of containerised cargo remaining on board ship X in port Y.

REMTOT(X,Y)	R	Weight of all cargo remaining on board ship X in port Y.
SEACOST	R	Total at sea fuel cost.
SEADIST	R	Sea distance for voyage (nautical miles).
SHEXKW	R	Extra ship cost per kilowatt capacity of the ship's engine at time of change ($/kilowatt).
SHEXTRA	R	Extra ship cost at time of change ($).
SHIPAGE	I	Age of ship at the start of the analysis period.
SHIPLIFE	I	Expected ship life (years).
SHIPTYPE	I	Ship type option.
SHPINC	R	Fractional increase in ship construction cost after change.
SHPRICE(X,Y)	R	Price of ship Y at age indicated by X.
SHWD	R	Number of days for which the ship is in operation each year.
SIZENUM	I	Counter for similar ships.
SMALL	R	A positive number close to zero.
SMTDAY(X)	R	Ship repair and maintenance cost per day ship X is in operation.
SMTFRAC	R	Ship repair and maintenance cost as a fraction of annual capital cost.
SMTYR(X)	R	Repair and maintenance cost per year for ship X.
SNUM	I	Counter for similar ships.
SPACE	I	Width of table on output page 1.
SPEED(X)	R	Average speed for ship X at sea (knots).
SPEEDOPT	I	Ship speed input option.
SPRICE(X)	I	Indicates whether all values for ship X were entered in input file 2.
STEVBLK(X)	R	Charge to load or unload non-containerised cargo in port X ($/tonne).
STEVEMPT(X)	R	Charge to load or unload an empty container in port X.
STEVFD(X)	R	Charge to load or unload a dry container in port X.
STEVFR(X)	R	Charge to load or unload a reefer container in port X.
STEVFUEL	R	Charge to load fuel in port A ($/tonne).
STEVOPT	I	Option to include or exclude stevedoring charges.
STEVP1	R	Stevedoring charges in port A for voyage.
STEVP2	R	Stevedoring charges in port B for voyage.
STEVTRAN(X)	R	Charge to load or unload a transhipped container in port X.

STOCK	R	Total number of containers required for ship.
STOCKO	R	Value of container stock at the start of the analysis period, annualised over the entire analysis period.
STOCKP	R	Value of container stock at the end of the analysis period, annualised over the entire analysis period.
STOCKVAL	R	Value of stock of containers.
STOREXP	R	Annual ship stores expenditure.
STUB(X)	C	Cost item descriptions for output page 1.
STUB2(X)	C	Cargo type descriptions for output page 2.
STYPE(X)	C	Ship type descriptor for output files.
TCAN(X)	R	Time to traverse the Xth canal (days).
TEU(X)	R	Container capacity of ship X (teus).
TONLT(X)	I	Option of tonnage measurement for national light charges in port X.
TONTUG(X)	I	Option of tonnage measurement for tug and launch charges in port X.
TOTAL(X,Y)	R	Cost item X for voyage on ship Y ($).
TOTVOL(X)	R	Volume of cargo and empty containers on ship X (cubic metres).
TOTVPERC	R	Total cargo capacity utilised (per cent by volume).
TOTWPERC	R	Total cargo capacity utilised (per cent by weight).
TOTWT(X)	R	Weight of cargo and containers on ship X (tonnes).
TPORT(X)	R	Time spent in port X (days).
TPORTA(X)	R	Time spent in port A by ship X (days).
TPORTB(X)	R	Time spent in port B by ship X (days).
TPORTEST	R	Estimate of total time spent in port (days).
TPORTT(X)	R	Total time spent in port by ship X (days).
TSEA	R	Time at sea, excluding time in canals and pilotage (days).
TSTEAM(X)	R	Time at sea, including time in canals and pilotage for ship X (days).
TSTEAMEST	R	Estimate of time steaming (days).
TUGCH(X)	R	Tug charge per ship ton in port X.
TUGCHT(X)	R	Tug charge per ship ton per movement in port X.
UNIT(X,Y)	R	Column X of cost item Y for output page 1.
USER	R	Exchange rate: US$ per $A.
VICTUAL	R	Victuals expenditure ($/person/day).
VOGT(X)	R	Voyage time for ship X (days).
VOGTEST	R	Estimate of voyage time (days).

WTACON(X)	R	Weight of containers on ship X, excluding cargo (tonnes).
WTBULK	R	Average density of non-containerised cargo (tonnes/cubic metre).
WTCON	R	Average weight of cargo per non-empty teu (tonnes).
WTEMCON	R	Weight of an empty container (tonnes).

The following system is used to name variables containing details of cargo loadings. Variables are of the form 'abcd', where:

a = LD for cargo loaded or unloaded
ONBD for cargo on board during voyage
REM for cargo remaining on board the vessel

b = E for empty containers
F for laden containers, non-transhipped
T for laden containers, transhipped

c = D for dry containers
R for reefer containers
BK for bulk cargo ('b' is ignored in this case)

d = V for voyage
Y for year.

Hence, LDEDV (X,Y) is the number of empty dry containers loaded or unloaded in port Y for ship X for one voyage.

REFERENCES

Abbreviations

AGPS	Australian Government Publishing Service
BTE	Federal Bureau of Transport Economics
HMSO	Her Majesty's Stationery Office

BTE (1980), *Regression Analysis of Ship Characteristics*, Occasional Paper 38, AGPS, Canberra.

__ (1982), *An Estimate of Operating Costs for Bulk, Ro-Ro and Container Ships*, Information Paper 4, AGPS, Canberra.

__ (1986), *A Study of Liner Shipping Services into and out of Australia*, Report 60, AGPS, Canberra.

Caney, R. W. & Reynolds, J. E. (1981), *Reeds Marine Distance Tables*, Thomas Reed Publications, London.

Cargo Systems International, Monthly, CS Publications Ltd., Surrey, England.

Containerisation International, (1986), Japan's Miracle Box Builders Laid Low, August, The National Magazine Co. Ltd., London, 61-63.

Downard, J. M. (1981), *Running Costs*, Ship Management Services, Fairplay Publications, London.

Economic and Social Commission for Asia and the Pacific (1979), *Model and Tool System for Shipping Analysis and Decision Making*, Bangkok.

Fairplay International Shipping Weekly, Weekly, Fairplay Publications Ltd., London.

Federal Department of Transport (1984), *Sea Transport Statistics 1982-83*, AGPS, Canberra.

Gallagher, F. D. & Meyrick, S. J. (1984), *ASEAN - Australian Liner Shipping: A Cost-Based Simulation Analysis*, ASEAN - Australia Economic

Papers no. 12, ASEAN - Australia Joint Research Project, Kuala Lumpur.

Gilman, S., Williamson, G. & Hughes, C. (1978), *Roll-on/Roll-off Ships for the Deep Sea Trades,* Marine Transport Centre, University of Liverpool, U.K.

Lloyd's Register of Shipping (1977), *Register of Ships,* magnetic tape, May, Lloyd's Register Printing House, West Sussex.

__ (1984a), *Register of Ships,* 1984-85, Lloyd's Register Printing House, West Sussex.

__ (1984b), *Register of Ships,* September Quarter, magnetic tape, Lloyd's Register Printing House, West Sussex.

Lloyd's Ship Manager, Monthly, Lloyd's of London Press, London.

Lloyd's Voyage Record, Lloyd's of London Press, Colchester.

McCracken, D. D. (1984), *Computing for Engineers and Scientists with Fortran 77,* John Wiley & Sons, New York.

Motor Ship (1985), March, 65:no. 776, Special Supplement, 21.

Nassi, I. & Shneiderman, B. (1973), *Flowchart Techniques for Structured Programming,* Department of Computer Science, State University of New York at Stony Brook L.I., New York.

Shipping Statistics and Economics (1985), no. 172, February, Drewry Shipping Consultants Ltd, London.

Stubbs, P. (1983), *Australia and the Maritime Industries,* Australian Industries Development Association Research Centre, Melbourne.

The World Bank, Transportation Department (1985), SHIPCOST User's Manual, Vessel and Voyage Costing Model, Washington D.C.

Zerby, J. A., Conlon, R. M. & Kaye-Kucharzewski, S. L. (1981), *Some Estimates of Costs of Liner Vessels in the Australian Export Trade,* Report to Bureau of Transport Economics, University of New South Wales, School of Economics.

ABBREVIATIONS

$A	Australian dollars
BTE	Bureau of Transport Economics
CC	Concurrent Computer
con-bulk	container-bulk
DoT	Federal Department of Transport
dwt	deadweight tonnes
ESCAP	Economic and Social Commission for Asia and the Pacific
grt	gross registered tons
IBM PC	International Business Machines Personal Computer
ISO	International Standards Organisation
kW	kilowatt
ldt	light displacement tons
nrt	net registered tons
reefer	refrigerated container
ro-ro	roll-on roll-off
teu	twenty-foot equivalent unit
US$	United States dollars