

# **SHIPPING OPTIMIZATION SYSTEMS (SOS)**

**SOS DATA, SOS VOYAGER, and UNCOMTRADE Forecast**



## **USER MANUAL**

**For**

**'SOS EDITION B', 'SOS EDITION AB',**

**'SOS EDITION BC' & 'SOS EDITION ABC'**

**Since July, 2008**



**SEAS INFORMATION SYSTEMS**

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## **1. INTRODUCTION**

### **1.1. WHAT IS SHIPPING OPTIMIZATION SYSTEMS (SOS)?**

SOS is a suite of decision support systems developed to help the cargo ship operator optimizing the operational outcome of a fleet of cargo ships. All ship types and cargo types are considered, under the liner, tramp, and industrial shipping services. In addition to SOS DATA, which is developed to store and retrieve the shipping data; three SOS systems are developed to support three management levels. On the operational level, SOS VOYAGER is developed to optimize the outcome of each ship voyage. On the tactical level, SOS ALLOCATOR is developed to optimize the yearly outcome of allocating existing ships to the cargo trade areas. On the strategic level, SOS APPRAISER is developed to appraise the purchase, build, or charter of new ships. See Figure 1.1 for the SOS main menu, which passes the processing control to each system. Brief description of these three systems is shown hereinafter:

#### **1.1.1. SOS VOYAGER**

For a liner ship voyage plan, having all port calls being fixed and a route being pre-determined, SOS VOYAGER selects the optimal (best) cargo mix, considering the available cargo quantities, ship capacity in deadweight, volume, or number of TEU. The optimal cargo mix maximizes the liner voyage gross profit. For a tramp/industrial ship-voyage plan, SOS VOYAGER finds the optimal (best) cargo mix, locates ports of call, and sequences port calls, i.e. routing. Figure 1.2 illustrates the tramp/industrial-cargo-mix selection in the Mediterranean Sea. SOS VOYAGER maximizes the tramp voyage gross profit per day, subject to the available cargo quantities, cargo laycan, and the ship capacity in deadweight, volume, or number of TEU. The gross profit equals the net freight minus port dues, canal and strait dues, cargo handling charges, ship fuel consumption, and the fixed cost (without depreciation). If more than one ship competes in carrying the same cargoes, the system offers these cargoes to all competing ships. The optimal cargo mix in this case maximizes the sum of the gross profit per day for all ships. In industrial shipping, the objective is to minimize the gross cost per day. In case cargo is unconfirmed (not yet offered); a cargo deterministic-equivalent quantity is calculated based on the probability distribution of the cargo transport demand. Sensitivity or what-if analysis is considered for some possible scenarios; in case a change is made in the cargo freight rate and quantity, cargo handling rate and charges, and ship speed and fuel consumption.

#### **1.1.2. SOS ALLOCATOR**

For an existing fleet of ships, SOS ALLOCATOR allocates the ships to the cargo trade areas and determines the number of voyages each ship completes in a coming year in each trade area. A cargo trade area is either a liner, tramp, or an industrial serviced area. SOS VOYAGER generates data on the gross profit of each ship voyage for each possible cargo trade area. This data is then passed to SOS ALLOCATOR to plan for the optimal allocation. The optimal allocation is the one maximizing the yearly total gross profit of the fleet allocated voyages, considering the possible frequency of calls within each cargo trade area and the number of working days available for each ship in this year. Figure 1.3 illustrates the allocation of some ships to cargo trade areas worldwide.

### 1.1.3. SOS APPRAISER

SOS APPRAISER finds the best new ship to purchase, build, or time-charter and where to allocate such ship. A group of new candidate ships is given to SOS VOYAGER to compute the voyage gross profit each ship may earn in each possible cargo trade area, as well as for each year of a given lifetime. This data is then passed to SOS ALLOCATER along with data of already existing ships to compute the yearly gross profit each ship may earn each year of its lifetime. This data along with the cash flow data (investment costs, grants, and taxes) are both passed to SOS APPRAISER for selecting the best new ship.

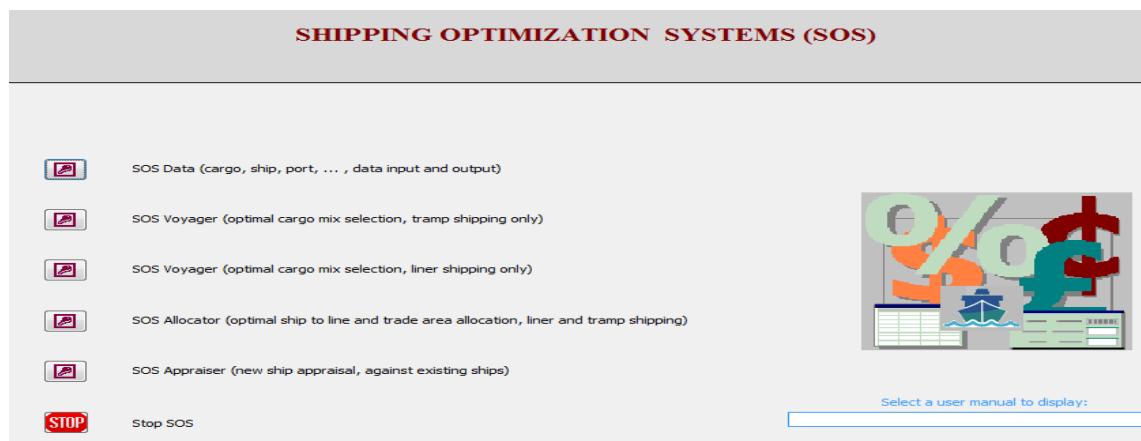


Figure 1.1: SOS main menu.

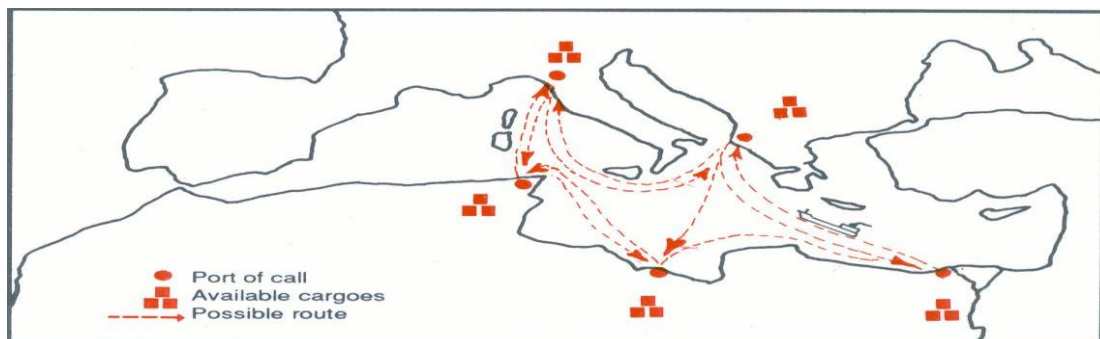


Figure 1.2: Example of the tramp/industrial cargo mix selection in the Mediterranean Sea.

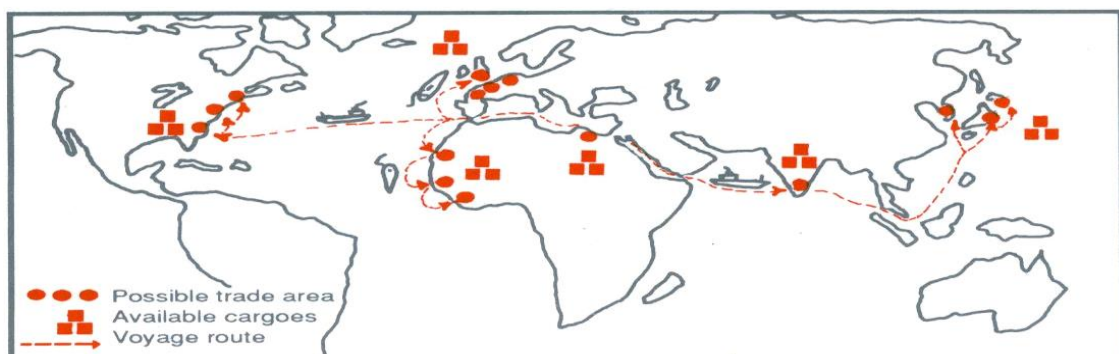


Figure 1.3: Example of allocating some ships to cargo trade areas worldwide.

## 1.2. WHY SOS?

Maximizing the objective of each SOS system results in an optimal *shipping combination* selected from among a number of alternative combinations of: ships, cargo trade areas, ports, possible routes, and cargoes. The more combinations are available (thousands of possible combinations may result in a 10-cargo-3-ship tramp cargo mix case) the more intelligent methods are needed in selecting the optimal shipping combination. These methods are much more needed when the objective is a gross profit per day, as being used in SOS VOYAGER. The Operations Research (OR) and the Statistical Methods (SM) introduce such methods. SOS presentations are provided with SOS software to briefly describe its contents.

Since SOS is a suite of decision support systems, it requires minimal user intervention and no background in OR and SM. Figure 1.4 shows the SOS data flow diagram (level 0), which describes the input data required and the output reports directed to the ship operator through all its three systems.

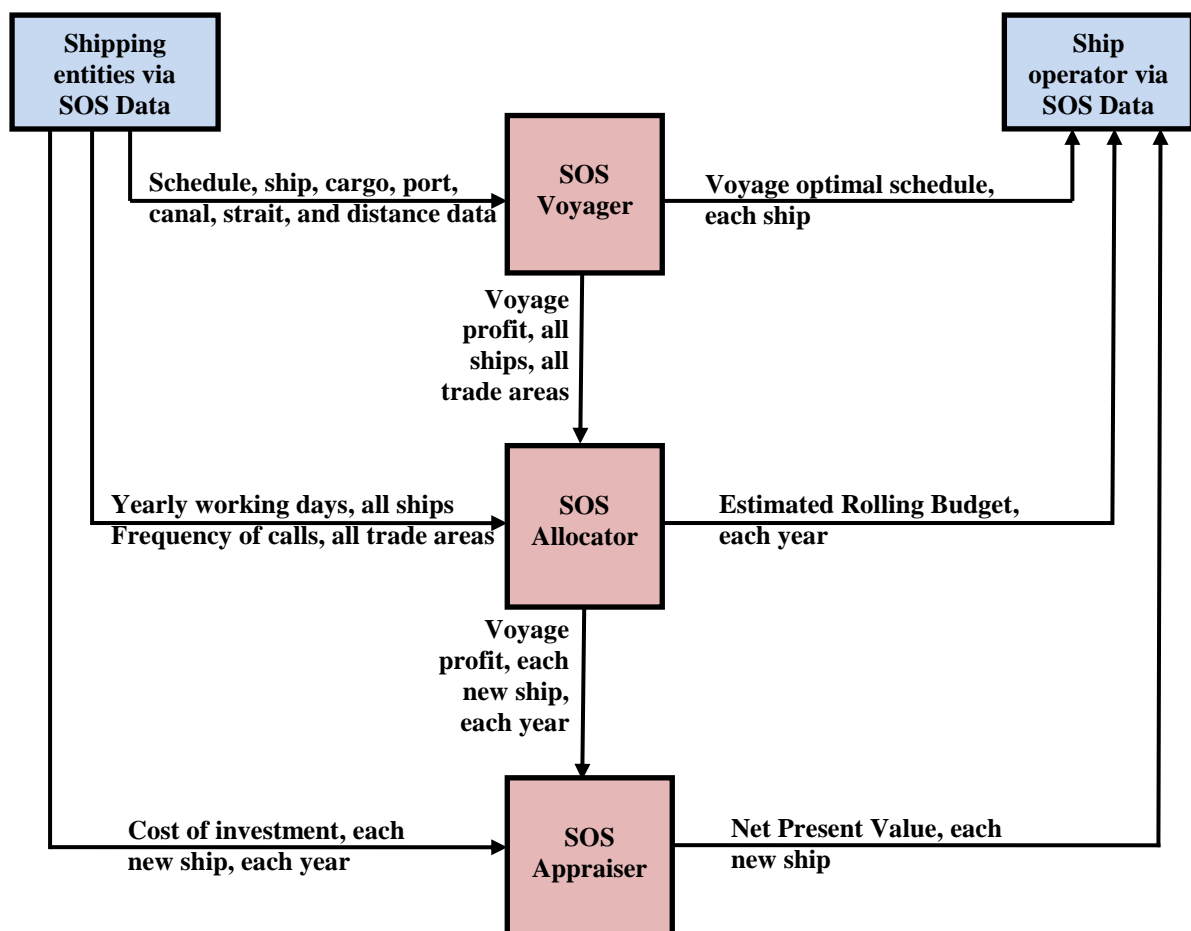


Figure 1.4: SOS data flow diagram (level 0).

Each SOS system includes three subsystems. The first subsystem is called the "Matrix Generator". It reads the shipping data from SOS DATA and automatically generates a matrix of coefficients as required by the OR technique and the statistical methods. The

second subsystem includes the OR technique and the statistical methods used. It reads the matrix, processes it, and locates the optimal shipping combination. The third subsystem is called the "Report Writer". It identifies the optimal shipping combination and writes a shipping and financial report directed to the ship operator (see Figure 1.5 for the SOS subsystem flowchart).

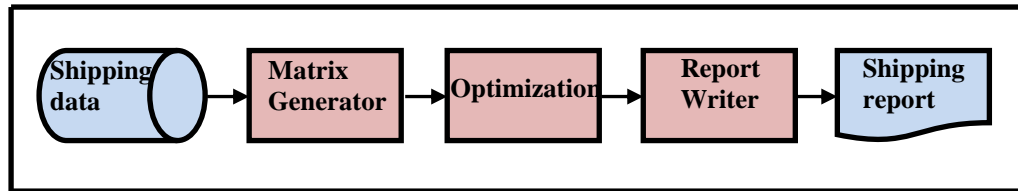


Figure 1.5: SOS subsystem flowchart.

### **1.3. SOS DATA AND SOS VOYAGER STANDARD AND CUSTOMIZED PRODUCTS**

Two products of SOS DATA or SOS VOYAGER are available to the ship operator: standard and customized. SOS ALLOCATOR or SOS APPRAISER has likewise products.

#### **1.3.1. SOS DATA AND SOS VOYAGER STANDARD PRODUCT**

This product is designed as a general-purpose system for the general cargo ship; whether conventional, container, or specialized, liquid and dry bulk carrier, following the liner, the tramp, or the industrial shipping mode. In addition, this product is developed on a PC running under windows so that SOS DATA or SOS VOYAGER can reach every ship operator. Three PC configurations are supported; configuration A, configuration B, and configuration C (Section 3 has details). This manual describes the system components of the standard product.

#### **1.3.2. SOS DATA AND SOS VOYAGER CUSTOMIZED PRODUCT**

For any ship type, the ship operator may ask for a ship-customized SOS DATA or SOS VOYAGER to fit his ship type. In addition, for the computer types other than the PC, the ship operator may wish to have SOS DATA or SOS VOYAGER computer-customized to fit his computer type. By using the supercomputers, an increased number of shipping combinations may be accommodated and optimized in a more reasonable time.

### **1.4. SOS VOYAGER DELIVERABLES**

There are two copies of SOS VOYAGER; whether it is a standard or customized product, a demo copy for demonstration and a final copy for the final delivery. A demo copy has a built-in list of names, deadweights, volumes, number of TEU's, and speeds of some dummy ships. This copy demonstrates the use of SOS by these ships. Upon successful trial of this demo copy, the ship operator may ask for a final copy. In the final copy, the list of ships includes the operator's own ships. When ordering a customized product, the ship operator receives a demo copy (or copies if more than one customized trial is made) before he receives his final copy. Both demo and final copies are delivered in compiled code sent on a physical media or by electronic file transfer (email, or downloadable from SOS, 2023). Special demos, training sessions, along with the systems analysis studies, may be arranged in agreement with the ship operator in order to plant SOS VOYAGER into the operator's setup.

## **2. SOS DATA AND SOS VOYAGER SYSTEM COMPONENTS**

SOS DATA or SOS VOYAGER includes system menus, system input forms, and system output reports. System menus direct SOS to perform the required system tasks. The system input forms capture and retrieve the data to and from SOS DATA. The system reports display the optimization result given by SOS VOYAGER to the ship operator. SOS VOYAGER takes its data from (and stores its result to) SOS DATA.

### **2.1. SYSTEM MENUS**

Two main menus are developed by the system: the Data Entry main menu of SOS DATA and the Optimization main menu of SOS VOYAGER; one for the liner and one for the tramp/industrial. The Data Entry main menu directs SOS to capture and retrieve data on cargo, ship, port, route, charter party, and shipping schedule. The Optimization main menu directs SOS to find the cargo mix to be assigned to each ship voyage that maximizes the total gross profit, if liner, the gross profit per day for all ships, if tramp, or the gross cost per day for all ships, if industrial. It also finds the changes that may occur to this optimal mix if some parameters change; the freight rate and quantity of cargo, cargo handling rate and charges, and the ship speed and fuel consumption. Microsoft Access displays all menus, with an arrangement that permits the data to be separated from the processing code. If new processing requirements are needed, they will be added to SOS VOYAGER; liner or tramp/industrial, without disturbing SOS DATA which contains the already captured data.

#### **2.1.1. Data Entry Menu of SOS DATA**

This menu (displayed by Figure 2.1) shows seven options needed by all systems, whether for SOS VOYAGER, SOS ALLOCATOR, or SOS APPRAISER. Namely, the options of Cargo, Ship, Port, Route, Line/Trade area, Charter Party, and Shipping Schedule. The first six options capture and retrieve data on cargo, ship, port, route, line/trade area, and charter party, while the seventh option captures and retrieves data on the shipping schedule, which identifies what ships, what cargoes, what shipping service, and what sensitivity and what-if analysis are to be considered in one optimization session in what planning period. A detailed menu is assigned to each option as follows:

- Cargo menu, which contains detailed options on cargo (displayed by Figure 2.2).
- Ship menu, which contains detailed options on ship (displayed by Figure 2.3).
- Port menu, which contains detailed options on port (displayed by Figure 2.4).
- Route menu, which contains detailed options on route (displayed by Figure 2.5).
- Line/Trade Area menu, which contains detailed options on line/trade area (displayed by Figure 2.6).
- Contract of Affreightment / Charter Party menu, which contains detailed options on Contract of Affreightment or voyage charter party (displayed by Figure 2.7).
- Shipping schedule menu, which contains detailed options on shipping schedule (displayed by Figure 2.8).

The option eight: Customized Data Entry, is used to customize SOS DATA to serve SOS VOYAGER only or to serve either SOS ALLOCATOR or SOS APPRAISER. This arrangement prevents SOS VOYAGER to save records coming from SOS network users to SOS DATA while it has been customized to serve SOS ALLOCATOR or SOS APPRAISER. The latter systems put a do-not-disturb sign on SOS DATA while running.

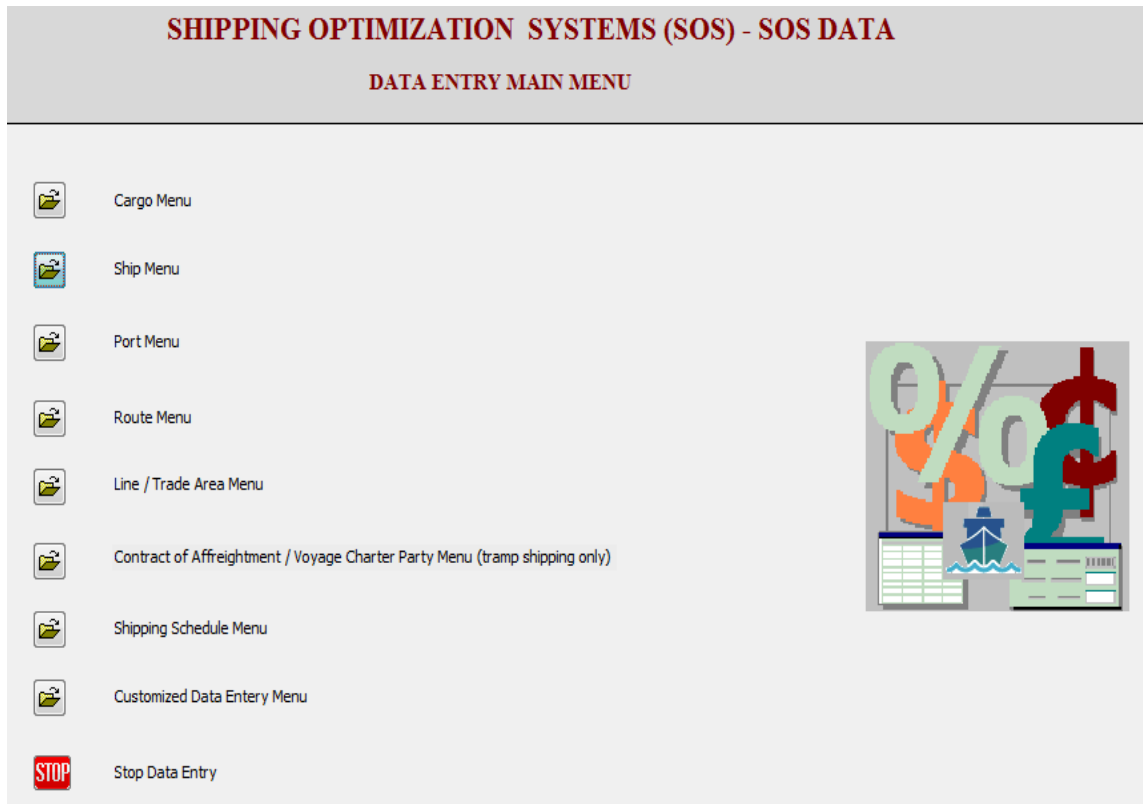


Figure 2.1: Data Entry Main Menu



Figure 2.2: Cargo Menu



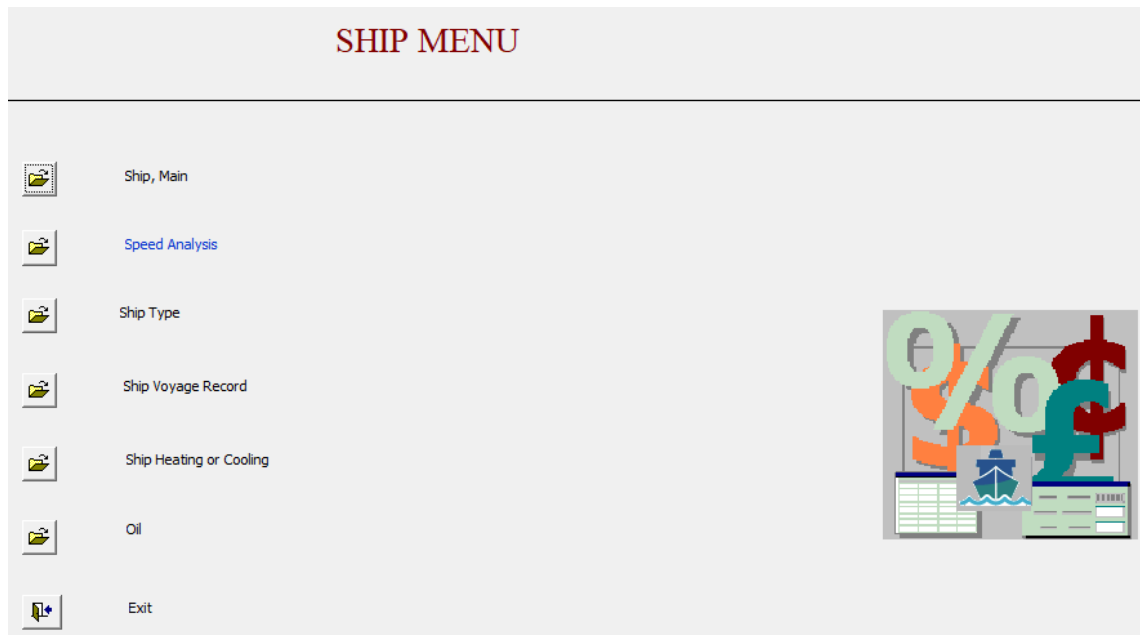


Figure 2.3: Ship Menu

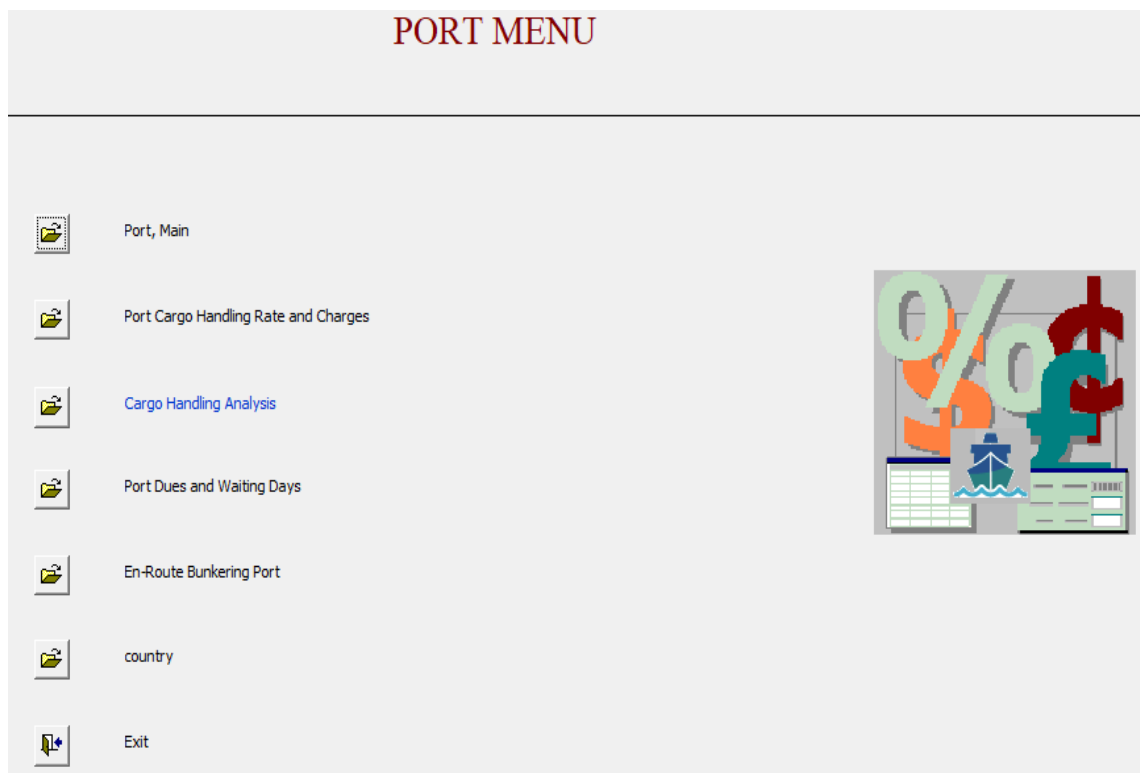


Figure 2.4: Port Menu

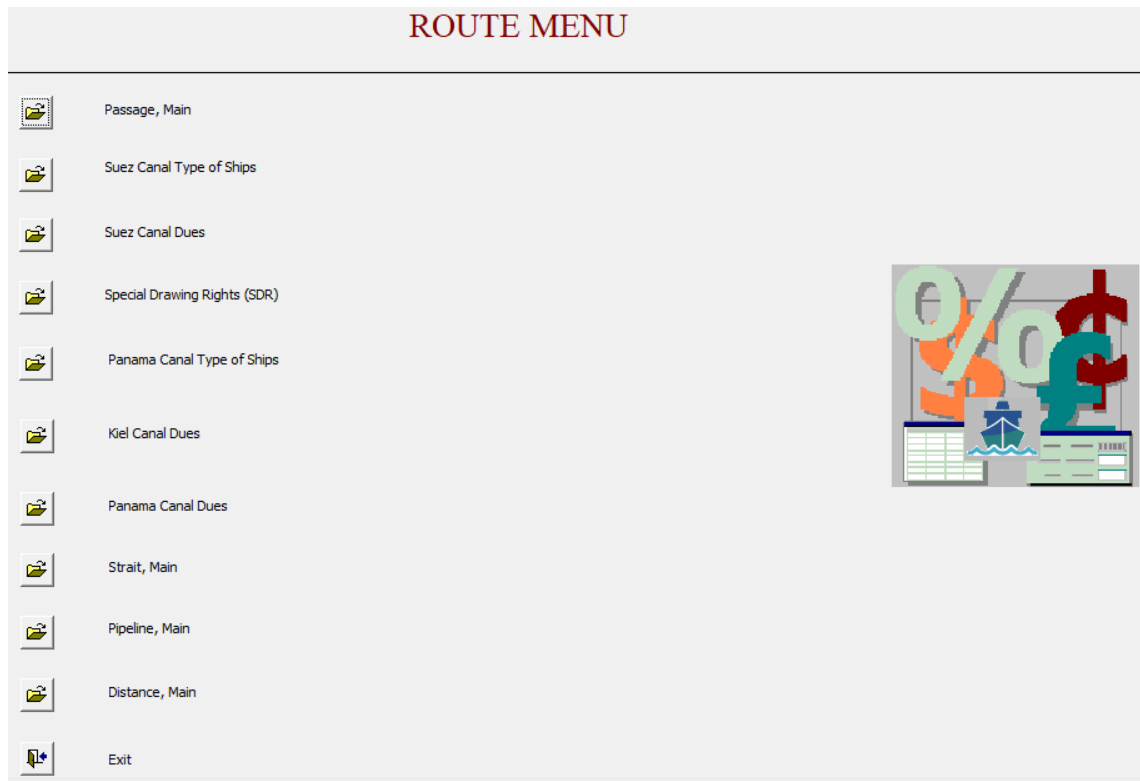


Figure 2.5: Route Menu

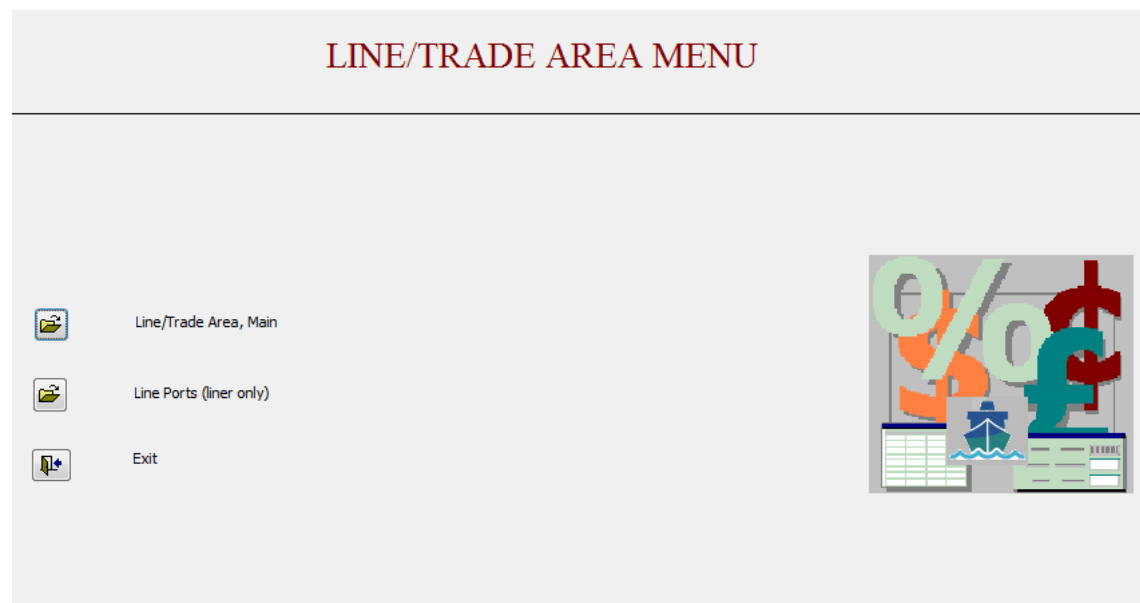


Figure 2.6: Line/Trade Area Menu

## CONTRACT OF AFFREIGHTMENT / VOYAGE CHARTER PARTY MENU




-  Contract of Affreightment / Voyage Charter Party, Main
-  Contract of Affreightment / Voyage Charter Party, Cargo
-  Exit



Figure 2.7: Contract of Affreightment / Voyage Charter Party Menu

## SHIPPING SCHEDULE MENU









-  Schedule, Main
-  Schedule Cargoes
-  Schedule Ships
-  Schedule-Ship Liner Legs, Speed Analysis (liner only)
-  Schedule-Ship Tramp Legs, Speed Analysis (tramp only)
-  Schedule-Ship Gross Profit Details (voyage plan only)
-  Schedule-Ship Gross Profit Details (Estimated Rolling Budget (ERB) only)
-  Exit



Figure 2.8: Shipping schedule Menu

### 2.1.2. Optimization Menu of SOS VOYAGER

This menu (displayed by Figure 2.9a for tramp/industrial and 2.9b for liner) shows five options:

- Optimization and sensitivity analysis. This option does not refer to any additional menus. It only passes the control to an optimization program that reads data on cargoes, ships, ports, routes, lines/trade areas, and contract of affreightments/voyage charter parties referenced by a specified shipping schedule. The program then verifies the relationships among these data. If relationships are feasible, it finds the cargo mix to be assigned to each ship that maximizes the voyage gross profit, if liner, voyage gross profit per day for all ships, if tramp, or minimize the gross cost per day, if industrial. Subject that the quantity and time window available for each cargo, and the deadweight, volume, and TEU capacities available for each ship are not violated. If the shipping service is tramp/industrial, the program finds also the port calls for each ship and the sequence of these calls. If the sensitivity analysis is the type of analysis required by the user, the optimization program applies the changes required by the sensitivity level and finds a new optimal cargo mix to be assigned to each ship based on these changes. The changes might be in cargo quantity and freight, ship speed and fuel consumption, and port handling rate and charges for each cargo. If more sensitivity levels are specified, further changes are made, and the optimization program finds their corresponding optimal solutions. This may be done up to five levels of sensitivity. The optimization program outputs a report containing the initial solution and the subsequent sensitivity level solutions. The sensitivity analysis data is input to the system by the Freight Analysis option in the Cargo menu, the Speed Analysis option in the Ship menu, and the Cargo Handling Analysis option in the Port menu.
- Save the optimal shipping schedule objective for each ship. This option saves the objective output from the shipping schedule, classified by revenue and cost items, for each ship and for each desired sensitivity level. The saved objective is kept in one of two places, pending on the answer to the question 'Is schedule part of Estimated Rolling Budget?' (Asked by the 'Schedule Main' form in the Schedule menu) and whether SOS ALLOCATOR will be used to process the saved objective. The objective will be saved, displayed, and edited by the 'Schedule-Ship Gross Profit Details' form in the Schedule menu. One such form is assigned for the Estimated Rolling Budget (ERB) reporting purpose if the answer is true to the question and SOS ALLOCATOR will not be used. ERB is a next year allocation plan. The other form is assigned for the voyage planning purpose if the answer is false, or, the answer is true, but SOS ALLOCATOR will be used. SOS ALLOCATOR reads the true-answered schedule objective displayed by the second form and creates the optimal allocation objective displayed by the first form.
- What-if Analysis option. This option links to an additional menu with additional options as shown in Figure 2.10a for tramp/industrial and 2.10b for liner. If what-if analysis is the type of analysis required by the user, the fourth option in this menu is selected and control is passed to a what-if analysis program that reads data of the same schedule specified by the optimization, and reads the changes given by the first three options in this menu. The what-if program may start after the completion of the optimization program and its reports are examined by the ship operator. Performing what-if analysis may repeat as many times as desired.

- Save optimal shipping schedule objective for each ship for each what-if analysis. This option saves the schedule objective output from the what-if same way as in the sensitivity analysis, classified by the revenue and cost items, for each ship and for each of the what-if analysis sessions.
- Print Estimated Rolling Budget (ERB). This option prints the already saved optimal objectives of all schedules of a given planning period. If SOS ALLOCATOR is used, printing of such report is also done through it.

**SHIPPING OPTIMIZATION SYSTEMS (SOS) - SOS VOYAGER (TRAMP/INDUSTRIAL)**  
**OPTIMIZATION MAIN MENU**

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Shipping schedule description

Optimization and sensitivity analysis of:

Sensitivity analysis level

Save optimal schedule objective of each ship for:

Whatif analysis of schedule (repeat as desired after optimization and sensitivity analysis)

Save optimal schedule objective of each ship for each whatif analysis

Print Estimating Rolling Budget (ERB)

Stop optimization




Figure 2.9a: Optimization Main Menu – Tramp/industrial Shipping

**SHIPPING OPTIMIZATION SYSTEMS (SOS) - SOS VOYAGER (LINER)**  
**OPTIMIZATION MAIN MENU**

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Shipping schedule description

Optimization and sensitivity analysis of:

Sensitivity analysis level

Save optimal schedule objective of the ship for:

Whatif analysis of same schedule (repeat as desired after optimization)

Save optimal schedule objective of the ship for each whatif analysis

Print Estimating Rolling Budget (ERB)

Stop optimization

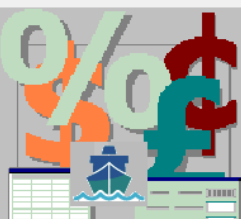







Figure 2.9b: Optimization Main Menu – Liner Shipping

**WHATIF ANALYSIS MENU**

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	<a href="#">Id selection of cargo freight and handling analysis</a>
	<a href="#">Id selection of ship speed analysis (all legs only)</a>
	<a href="#">Id selection of ship tramp legs speed analysis (some legs only)</a>
	<a href="#">Performing whatif analysis</a>
	<a href="#">Exit</a>









Figure 2.10a: What-if Analysis Menu – Tramp/Industrial Shipping

**WHATIF ANALYSIS MENU**

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	<a href="#">Id selection of cargo freight and handling analysis</a>
	<a href="#">Id selection of ship speed analysis (all legs only)</a>
	<a href="#">Id selection of ship liner legs speed analysis (some legs only)</a>
	<a href="#">Performing whatif analysis</a>
	<a href="#">Exit</a>




Figure 2.10b: What-if Analysis Menu – Liner Shipping

Unless SOS DATA and SOS VOYAGER are used as a demo copy with a list of built-in dummy ships, it should be noted that the options in blue shown in all SOS menus, and described hereinafter in blue text, are not enabled unless authorized by the SOS provider.

## 2.2 SYSTEM INPUT FORMS

The system input forms are used to input data and write it to SOS DATA tables, whether for cargo, ship, port, route, line/trade area, charter party, or the shipping schedule.

All forms have two tabs in common; Identification tab and Note tab. The Identification tab contains one or more fields that identify the table keys. The Note tab is used to write notes about the table. All Forms, unless otherwise specified, use as a default the US dollar for monetary values, the metric system for measurement, and mm/dd/yyyy mask for dates. The distances between ports and the ship speed are measured in nautical miles. If the numeric data must be entered in a numeric field, a field caption note is displayed down the form to show the format of data to be entered. The word 'integer' means integer digits have to be entered and no fractions are permitted, whereas 'fractional' means additional digits may be added as a fraction. If this is a required field, a red '\*' appears left to the field name with a '0' or a 'Null' value displayed as a default value. If an alpha-numeric data must be entered in a text field, a field caption note is displayed down the form to show that a 'text' data is to be entered. If a field is not

required, it may be left blank. A dimmed field needs no entry. SOS VOYAGER has the option of getting the currency exchange rate from an online source via web API. In the following subsections, several important tabs and fields in some forms are detailed.

## **SOS DATA**

### **2.2.1. Cargo Main Form**

This form is used to input data to cargo table. The following are some tabs and fields found in this form:

- Identification tab: It includes a unique id number, a cargo commodity; selected from a predefined list of commodities, and a cargo package; selected from a predefined list of packages. The form checks to see whether the commodity and package is recorded in the 'Cargo, Ship Type, and Handling in Compatibility' table (see Subsection 2.2.3). Failure to have corresponding record, results in unrecognized cargo stowage factor and hence a cargo volume, and unrecognized ship type or handling type this cargo may conform to. As a rule, the user has to check the compatibility before the input of the cargo data. The Commodity and package are listed into major and subgroups. If a major group is selected to describe a cargo rather than one of its subgroups, a general stowage factor and a handling identifier will be used rather than an exact one.
- Loading and Discharging Details tab: It includes the fields defining the port of loading and the port of discharging, along with the loading laycan and the discharging laycan. The form checks to see whether the data of the two ports is recorded in the Port table and whether the cargo handling type is recorded in the 'Cargo Handling Rate and Charges' table for these ports (see Subsection 2.2.8). Failure to have corresponding records results in unrecognized cargoes. In addition, a check is made to see whether the distance between these two ports is entered in the Distance table (see Subsection 2.2.9). If the cargo can be transported by passing or bypassing a canal, an entry in the Distance table must be recorded for each case. If a laycan date is entered, the date-from is entered first followed by the date-to. A check is made to verify whether the date-to is greater or equal the date-from. [Cargo laycan date, like the cargo quantity and freight rate, might be considered as not-yet-known \(unconfirmed\). If a cargo Laycan date is not-yet-known, it is assumed to follow a probability distribution of occurrences. In this case, a corresponding field next to the laycan date has to contain the least probability the ship operator stipulates his ship can arrive before this date. SOS DATA uses this field to calculate a deterministic-equivalent date.](#)
- Shipping Events, Dates, and Persons tab: It includes a field containing the latest cargo shipping event, whether not-yet offered (unconfirmed), offered (confirmed), booked (fixed), loaded, or discharged. If not-yet offered, the cargo has unconfirmed quantity and freight. If not-yet offered or offered, the ship operator may accept or reject the transport of this cargo, as a whole or part of it. The partial shipment is allowed only for liner shipping. If booked, the ship operator must consider the transport of this cargo by any ship, or, if a ship name is specified in this tab, the ship operator must consider the transport of this cargo by this ship. If loaded, a ship name has to be specified in this tab. Cargo shipping event must be consistent with the data entered for the fields indicated in the next tabs. Earliest Cargo Available Date is another field to contain the earliest date when cargo becomes available. This could be the date of cargo offered, booked, or loaded event, which one happens first.

- Weight, Volume, and Numbers tab: It includes the fields specifying the cargo weight, volume, and number. If the actual weight is missing, the Volume to Weight checkbox is checked to allow weight calculation based on the cargo volume and the stowage factor entered in the 'Cargo, Ship Type, and Handling in Compatibility', which appears dimmed in this form. Similar arrangement is made if the volume is missing. No data is required in all fields if the 'not-yet offered' is the current cargo event.
- Min Weight, Max Weight, and deterministic-equivalent Weight fields are automatically calculated from the data entered by the Freight Analysis form (next form). The min and max weight and freight show boundaries of the changes that might occur in cargo weight, freight, and its associated probability, if any. If the cargo is not-yet-offered, probabilities associated with the cargo quantities and freights must be entered in the Freight Analysis form where a deterministic-equivalent weight and freight are calculated based on the value of the 'Least probability of transporting cargo within demand' (next field). Similar arrangement is done for the volume and number. Since no data entry is allowed in these fields, they appear as dimmed. The ship operator may validate the deterministic-equivalent quantities against the data shown in the 'Forecast of percentage increase in commodity flow of country pair' and 'Forecast of percentage increase in overall flow of exporting country' fields which display the data of the current year.
- 'Least Probability of Transporting Cargo within Demand' field must be filled only if cargo is not-yet-offered and the probability data is entered via the Freight Analysis form. In this case, a least probability needs to be estimated to know how much the ship operator stipulates he can transport the cargo within the transport demand.
- 'Is Partial Shipment Allowed?' field is checked only if the cargo shipper accepts to ship part of the quantity specified in the quantity fields. This field is used by the liner optimization programs and is NOT used by the tramp/industrial optimization programs.
- Freight, Additions, and Deductions tab: It includes fields on the gross and net freight. The freight includes any surcharge. The freight currency exchange rate is entered via the Currency form, which appears dimmed in this form. If the cargo is transshipped, four fields are assigned for its original and destination ports. If the cargo has the option to be transported by a chartered-in ship, in competition with the owned ships, seven fields are assigned for the voyage gross profit and days, and the fixed cost and days. This option is applied only to the tramp shipping mode. The Min Freight, Max Freight, and Probable Freight are automatically calculated from the Freight Analysis form in metric-equivalent value after deducting the taxes and commissions. These fields are dimmed.
- Sensitivity Analysis tab: It includes fields on the sensitivity analysis calculated from the Freight Analysis form. The Number of Analysis IDs field displays the total number of changes included in the Freight Analysis corresponding to the cargo, while the Number of Sensitivity Levels displays how many sensitivity levels are to be considered for the cargo. Both fields are dimmed.

### 2.2.2. Freight Analysis Form

This form is used to enter the changes in the freight and quantity of the confirmed (offered) and unconfirmed (not-yet offered) cargoes. For the confirmed cargo offer, where the agreement with the shipper is still in the negotiation stage and where the cargo freight or (and) quantity is subject to change. The changes in the cargo freight and quantity may be used to perform sensitivity analysis or what-if analysis. In case of



the sensitivity analysis, a sensitivity analysis level is associated to each change. If the same level is given to two changes; one for the ship speed and the other for the cargo handling rate in port of loading, this means that SOS VOYAGER is going to apply the two changes at the same time. After the initial optimization, subsequent optimizations of sensitivity levels are done automatically one after the other. In case of What-if analysis, the ship operator is allowed, after the initial optimization and the examination of its report, to manually select a single set of changes to be applied in the next optimization session. A change is selected by its unique id. This process can be repeated as desired for other sets of change.

An unconfirmed cargo is a cargo that is not offered or negotiable yet, but there is a possibility that it might be offered some time during the voyage. The ship operator may wish to optimize the cargo mix while some cargoes are unconfirmed to see the effect of these cargoes on the voyage gross profit per day. For these cargoes, the Freight Analysis form is used to enter the change in cargo freight and quantity, associated with its probability of occurrence. This data is used in calculating the deterministic-equivalent values of the cargo quantity and freight. This freight and quantity is used within the optimization process along with the freights and quantities of other cargoes.

All cargoes that are already booked or loaded are not subject to change in the freight or quantity. Unconfirmed cargoes are also not subject to what-if or sensitivity analysis.

The following are some tabs and fields in this form:

- Identification tab: It includes the cargo description, analysis ID, and the sensitivity level number. The analysis id is used by what-if analysis to identify a certain change. The sensitivity level number is entered only if sensitivity analysis is required for a certain change.
- Weight, Volume, and Number tab: It includes the changed weight, volume, and number.
- Freight, Additions, and Deductions tab: It includes the changed freight and the associated probability value. Probability value is entered only if the change is of the unconfirmed cargo.

### **2.2.3. Cargo, Ship Type, and Handling in Compatibility Form**

The cargo stowage factor is identified by the cargo commodity and package. The stowage factor of a cargo like oil in bulk; specific gravity in this case, is identified at 15°C temperature. Attached to this form, there is a sub-form that is used to enter, for the same commodity and package, all the compatible and conformable ship types and handling descriptions. The handling description identifies the handling equipment that is highly dependent on the commodity, package, and the ship type. This form includes the following tabs and fields:

- Identification tab: It includes the commodity and package fields. The commodity and package are listed into major and subgroups. If a major group is selected to describe a cargo rather than one of its subgroups, a general stowage factor and a handling identifier will be used rather than an exact one.
- Stowage/Specific Gravity tab: It includes the stowage factor or specific gravity.
- Ship Type and Handling description tab: It includes, on a separate sub-form, the compatible and conformable ship types and handling descriptions.

#### **2.2.4. Cargo Archive Form**

When a cargo is being deleted in the Cargo Main form by the form shown in Subsection 2.2.1, the user is allowed to save a brief copy of the cargo record in the cargo archive identified by the cargo Id, commodity type, package type, loading port, discharging port, and the earliest available date. This data permits SOS VOYAGER, after some years, to build and maintain a probability distribution for the cargo transport demand classified by the cargo category, trade area, and the year season. The user may display and edit the cargo probability distribution via the Freight Analysis form shown in Subsection 2.2.2. The user may then use the freight analysis data either in the sensitivity and what-if analysis if the cargo is confirmed, or to calculate a deterministic-equivalent cargo quantity and freight if the cargo is unconfirmed. Same arrangement is used to calculate a deterministic-equivalent date for the cargo laycan, if it is unconfirmed.

#### **2.2.5. Ship Main Form**

This form captures the main ship data such as the capacities, speeds, and fuel consumption. For the capacity, it is not assumed to have a refrigerated space and a non-refrigerated space in one ship. It is possible however to have a refrigeration facility in the liner container ship only. A working speed and its associated fuel consumption are specified for both the laden and ballast ship situation. SOS VOYAGER can identify whether the ship is in laden or in ballast situation and hence calculates the corresponding fuel consumption. The fuel consumption is also being specified for the main and auxiliary engines. While ship is in port or at sea, SOS VOYAGER calculates the main and auxiliary engine fuel consumption. While ship is in port, SOS VOYAGER calculates main engine fuel consumption if cargo operation is carried out. Other speeds and their associated fuel consumptions are considered in the Speed Analysis form given by the Ship menu. The main features of the Freight Analysis form apply to the Speed Analysis form except that of the probability distribution. Refrigerating facility is assumed to use the power of the main engine. The form checks to see whether the ship type is recorded in the Port Dues and Waiting Days table for each port the ship is calling at (see Subsection 2.2.7). Failure to have this data results in unrecognized ship type in this port.

In SOS VOYAGER's demo copies, it is not allowed to run any ships other than the built in. Built-in ships are Ibn Elwaleed, Ibn Maged, Mersa Alam, Safaga, El Kosseir, Sidi Kirear, Wadi Safaga, Esna, and Edfu. The first two are conventional ships, while the third is a container ship, the following three are dry-bulk carriers, and the last three are tankers. This form displays the ship specification for each ship.

#### **2.2.6. Port Main Form**

The form captures data on port capacity. Capacity includes water draught in low and high tide and tide period. This data is used to calculate the ship capacity while in port.

#### **2.2.7. Port Dues and Waiting Days Form**

This form captures the ship-type-port-related data, including the data on port waiting time, port dues (lights, accostage, pilotage, towage, and other port expenses) classified by the ship type and ship deadweight. The form includes the following tabs and fields:

- Identification tab: It includes the port name, ship type, and dwt class fields.
- Port Dues and Waiting Days tab: It includes the dues per ship (lights, pilotage, and towage) and the dues per day (accostage, telephone, and quarantine).

### **2.2.8. Cargo Handling Rate and Charges Form**

The data inputs in this form are the cargo-handling-port-related data, including the cargo-handling rate and charges classified by the cargo handling description. Tabs and fields are:

- Identification tab: It includes the port name and cargo handling description fields.
- Cargo Handling Rate and Charges tab: It includes the cargo handling rate and charges fields. It is assumed that these rates and charges are of only one work-shift; usually the morning shift. Other rates and charges may be considered in the Cargo Handling Analysis form given by the Port menu. The main features of the Speed Analysis form apply also in the Cargo Handling Analysis form.

### **2.2.9. Distance Main Form**

This form is used to capture data on the distances between ports. Because a route between two ports may contain a canal, therefore more than one distance record is allowed for the same two ports. The difference between distances has an impact on the ship voyage time and expenses. Using a canal in one distance may shorten time but may cost more. When a canal is specified, SOS VOYAGER can identify its dues based on whether the ship is in laden or in ballast situation. This permits SOS VOYAGER to compare the voyage gross profit per day when cutting each distance. The form includes the following tabs and fields:

- Identification tab: It includes the start port name, end port name, and the passing-by canal name.
- 'Distance, Min DWT, Waiting Days, and En-route Bunkering' tab: It includes the fields of distance, min DWT permitted in this distance, and the possible waiting days. It also includes data on the en-route bunkering port, if any.

SOS VOYAGER has the option of getting the distance from an online source via web API.

### **2.2.10. Line Ports Form (liner only)**

If the shipping service is liner, this form captures names of the line ports, calling sequence, voyage id, and calling dates at these ports. In the standard product of SOS VOYAGER, no more than 60 ports may be specified in each line. Although it is called a line, the port calls follow a round robin fashion, where cargo may flow from the ports before the first port or from the last port to the following ports in sequence. The form includes the following tabs and fields:

- Identification tab: It includes the line description, port name, sequence number of port call, and the voyage id.
- Port calling date.

### **2.2.11. Contract of Affreightment / Voyage Charter Party Main Form**

A voyage charter party (V/C) may contain one cargo that may be assigned to one ship. A Contract of Affreightment (COA) may contain more than one cargo that may be assigned to more than one ship. The cargo in a V/C or COA may be accepted or rejected for transport by the ship owner. This form is used to capture the data on the header part

of a V/C or COA. This includes revenues and cost elements such as the demurrage and dispatch rate. The form includes the following tabs and fields:

- Identification tab: It includes the V/C or COA id and description.
- Revenues and Cost tab: It includes the demurrage and dispatch rate, and late arrival penalty.
- Ship Specification tab: It includes the data on the candidate ship that may be used to carry the cargo.

### **2.2.12. Contract of Affreightment / Voyage Charter Party Cargo Form**

This form is used to capture the data on the details part of a V/C or COA. This includes the loading and discharging rate and days associated with each cargo. The form also captures the data on the time counting rules and reversibility. If the time is reversible, the demurrage or dispatch is calculated based on the loading and discharging days combined. If the time is irreversible, the demurrage or dispatch is calculated based on loading and discharging days separately. The form includes the following tabs and fields:

- Identification tab: It includes the V/C or COA description, ship name, and the cargo description.
- Load and Discharge NOR, Rate, and Days tab: It includes the load and the discharge NOR, rate, and days. It also includes the data on whether loading and discharging time is reversible or irreversible.

### **2.2.13. Schedule Main Form**

The shipping schedule includes the data needed for the scheduling of a selected ship or a group of ships to a selected set of cargoes within a given period, following a given shipping service; tramp/industrial or liner. The SOS VOYAGER's optimization session must refer to such a schedule. In the tramp/industrial shipping, no regular calls are allowed. In liner shipping, no optional calls are allowed. The form captures data on the schedule name, period, shipping service, voyage id, and the total number of sensitivity levels, if any. The form includes the following tabs and fields:

- Identification tab: It includes the schedule name.
- Shipping Service and Scheduling Period tab: It includes the shipping service, whether estimated rolling budget (ERB) is required, whether gross profit/cost per day is required (if tramp/industrial), line/trade area, voyage id (if liner), schedule frequency (if ERB), and the schedule starting date and the schedule ending date. The scheduling period should be long enough to accommodate both the ship voyage open and close time specified by the 'Schedule ship' form; and the non-loaded-cargo load open laycan and all-cargo discharge open laycan specified by 'Cargo' form. In addition, it includes the question on whether the ship is to consider passing or (and) bypassing the Panama Canal, or (and) the Suez Canal. If passing the canal is considered, the canal dues are calculated and added to the fuel cost calculations. If bypassing the canal is considered, only the fuel cost is calculated. If both passing and bypassing the canal are considered, passing the canal is taken as one alternative and bypassing the canal is taken as a second alternative.

- Sensitivity Count tab: It includes the total number of sensitivity levels this schedule is to perform. This count must be equal in all sensitivity analysis, whether it is of cargo freight, ship speed, or cargo handling in port.

#### **2.2.14. Schedule Cargoes Form**

The form inputs the data of the set of cargoes to be considered in one schedule and whether the sensitivity analysis or what-if analysis is desired for the cargo freight and cargo handling at port of loading or (and) discharging. In the standard product of SOS VOYAGER, no more than 60 scheduled cargoes may be specified in one-tramp/industrial schedule and 10,000 scheduled cargoes in one-liner schedule. However, a tramp/industrial problem may have a computational condition; due to excessive shipping elements and rules, which requires lesser number of scheduled cargoes to be specified. The form includes the following tabs and fields:

- Identification tab: It includes the schedule name and cargo description fields.
- Cargo Temperature tab: It includes the temperature that most prevail during the schedule. This data is used to calculate the fuel consumption needed for heating the cargo up to this temperature.
- Analysis Data tab: It includes options available for the freight analysis, loading analysis, and discharging analysis. The options are deterministic-equivalent, sensitivity analysis, what-if analysis, or none.

#### **2.2.15. Schedule Ships Form**

The form inputs the data of the set of ships to be considered in the schedule and whether the sensitivity analysis or the what-if analysis is desired for speed; whether the analysis is desired for all route legs or some selected legs. In the standard product of SOS VOYAGER, the max number of scheduled ships to be specified in one tramp/industrial schedule is 60 ships, while no more than one scheduled ship may be specified in one-liner schedule. However, a tramp/industrial problem may run on a computer configuration with a limited memory size, which requires a lesser number of scheduled ships to be specified.

The form includes the following tabs and fields:

- Identification tab: It includes the schedule name, and the ship name fields.
- Voyage Fixed Cost and Days, and Opportunity Cost tab: It includes the voyage fixed cost, such as the itinerary advertisement, and the fixed days, such as the idle days before start, and the opportunity cost, which represents the minimum gross profit per day the ship operator is expecting as an outcome from this schedule. The more the opportunity cost is closer to the real gross profit per day the lesser time SOS VOYAGER needs to reach the optimality. When more cargoes and ships are added and the problem becomes large, the need to specify the proper opportunity cost becomes crucial. In the same time, if the opportunity cost happens to be more than the optimal gross profit per day, SOS VOYAGER does not report any optimal solution since it is not within the ship operator's expectation.

- **Chartering Data tab:** It includes the question on the chartering operation, whether to consider the voyage charter only, both the voyage and the time charter, or neither the voyage nor the time charter. If the voyage charter is only considered for a certain ship, all cargoes that are covered by the charter parties are considered plus all cargoes that are not covered. If both voyage and the time charter are considered, the voyage charter is taken as one alternative and the time charter is taken as a second alternative. In this case, the time-charter hire per day mentioned in this tab is compared to the gross profit per day. If neither the voyage nor the time charter is considered, only cargoes that are not covered by a contract of affreightment or a voyage charter party are considered.
- **Open and Close Ports tab:** It includes the date and the bunkering quantities at open and close port, and whether bunkering is required at en-route bunkering port. Open port is cargo load port if the cargo was loaded onboard the ship before open date.
- **Voyage Canals tab:** If passing a canal, a question is displayed on whether the lightening of the shipload is desired. Lightening may be done using another ship or a pipeline. Lightening is used for the cargo of large quantity, larger than the canal capacity. If the cargo original quantity is to be lightened, sensitivity quantities are assumed to be lightened too. However, if the cargo original quantity is not lightened, sensitivity quantities are not assumed to be lightened.
- **Analysis Data tab:** It includes options available for the speed, if all route legs are subject to analysis. The options are sensitivity analysis, what-if analysis, or none. If the first two options are chosen for a scheduled ship, sections 2.2.16-17 are disregarded.

#### **2.2.16. Schedule Ship Liner Legs, Speed Analysis Form**

If the shipping service is liner and the speed analysis is only desired for some legs of the ship route, then this form is used to enter the legs that are subject to speed analysis. A leg is identified by the name of the leg ending port, if the leg starting port is the one, only one, port back in sequence. The analysis options available for the leg are sensitivity analysis or what-if analysis. The form includes the following tabs and fields:

- **Identification tab:** It includes the schedule name, ship name, and the name of the leg ending port.
- **Speed Analysis tab:** It includes the analysis options.

#### **2.2.17. Schedule Ship Tramp/Industrial Legs, Speed Analysis Form**

The difference between this form and the form in Subsection 2.2.16 is that this form is used when the shipping service is tramp/industrial, and not all legs leading to the loading or (and) the discharging of a specific cargo is subject to analysis. Tabs and fields in this form are:

- **Identification tab:** It includes the schedule name, ship name, cargo description, and the leg ending operation (load or discharge).
- **Speed Analysis tab:** It includes analysis options.

#### **2.2.18. Schedule Ship Gross Profit Details Form (voyage plan only)**

This form is used to display and update the schedule gross profit details saved by SOS VOYAGER optimization, if in the Schedule Main form the question 'Is Schedule Part of Estimated Rolling Budget?' is answered as false, or answered as true and SOS

ALLOCATOR is used. In the latter case, the created ERB records are saved and displayed by the form given by Section 2.2.19. This form includes the following tabs and fields:

- Identification tab: It includes the schedule name, ship name, and the line/trade area name.
- The tabs and fields are included same as the previous form except that no frequency of calls is specified for each voyage.

### **2.2.19. Schedule Ship Gross Profit Details Form (ERB only)**

This form is used to display and update the schedule gross profit details saved by SOS VOYAGER optimization, if in the Schedule Main form the question 'Is Schedule Part of Estimated Rolling Budget?' is answered as true and SOS ALLOCATOR is not used. The following are the tabs and fields:

- Identification tab: It includes the schedule name, ship name, and the line/trade area name.
- Voyage Gross Profit, Dates, Days, and Frequency tab: It includes the net freight tab, port dues tab, handling cost tab, canal and strait dues tab, fuel cost tab, and the fixed cost tab.

## **SOS VOYAGER**

### **2.2.20. Id Selection of Cargo Freight and Handling Analysis Form (tramp or liner)**

This form is used when the What-If Analysis of Schedule is selected in the Optimization menu and the Id Selection of the 'Cargo Freight and Handling Analysis' option is chosen. In this form, all analysis ids are dimmed, so that the user can only select, in an interactive mode, the cargo freight, the cargo-handling rate in the port of loading, and the cargo-handling rate in the port of discharging. This form includes the following tabs and fields:

- Identification tab: It includes the schedule name and cargo description.
- Cargo Analysis Ids tab: It includes the ids displayed for the freight, handling in the loading port, and handling in the discharging port. Click once to select an id and click once again to deselect an id. The 'Selected Analysis Id' field automatically confirms the selection.

### **2.2.21. Id Selection of Speed Analysis Form (all legs, tramp/industrial or liner)**

This form is used when the What-If Analysis of Schedule is selected in the Optimization menu and the Id Selection of the Speed Analysis option is chosen. If the speed what-if analysis is desired for all route legs by a specific ship, this form is used to display all the speeds stored in the speed analysis table, so that the user can select one of these speeds in a what-if interactive session. The tabs and fields are:

- Identification tab: It includes the schedule name and ship name.

- Analysis IDs tab: It includes list of speeds from which the user selects the desired speed. Click once to select or deselect an id.

#### **2.2.22. Id Selection of Ship Liner Legs Speed Analysis Form** (liner-selected legs)

This form is used in case if the speed what-if analysis is desired for a specific route leg. This form includes the following tabs and fields:

- Identification tab: It includes the schedule name, ship name, and the leg ending port name.
- Analysis IDs tab: It includes the list of the speeds from which the user selects the desired speed. Click once to select or deselect an id. The 'Selected Analysis Id' field automatically confirms the selection.

#### **2.2.23. Id Selection of Ship Tramp/industrial Legs Speed Analysis Form** (tramp/industrial-selected legs)

Like the liner legs, this form captures the what-if analysis id for a specific ship tramp/industrial leg. Tabs and fields are:

- Identification tab: It includes the schedule name, ship name, cargo description, and the leg ending operation.
- Analysis Id tab: It includes the list from which speeds are selected. Click once to select or deselect an id. The 'Selected Analysis Id' field automatically confirms the selection.

### **2.3. SOS VOYAGER OUTPUT REPORT**

SOS VOYAGER outputs the Schedule Optimization Report for the liner or tramp/industrial. The report is printed automatically at the end of the optimization session, at the end of each sensitivity analysis level, and at the end of what-if analysis session. The report outputs the outcome of the optimization of a specific schedule. For each ship in the schedule, the report outputs the sailing-to port, i.e. the route. For each port, it specifies the ship arrival time and the cargoes the ship may load and discharge. The report is divided into two parts. Figure 3.1 shows part one: Schedule and Ship part. This part includes the following items:

Schedule part:

- Schedule description, earliest starting date, and latest ending date.
- Sensitivity analysis description.
- Optimal solution value, reporting time and date.

Ship part:

- Ship name, voyage or time charter date (if any), deadweight, volume, and total TEU.
- Opening port and opening date.
- Working speed and laden and ballast fuel consumption of main engine.



Figure 3.2 shows part two of the report: Route and Cargoes part. This part includes the following items:

- Sailing-to port name (route).
- Shipping operation: voyage charter operation such as loading; L, unloading; U, closing; C, and time charter operation; T.
- Operation starting date.
- Description of loaded or unloaded cargo (L or U), loading or discharging date (identified by optimization), loading or discharging opening and closing dates (time window), bill of lading (B) or charter party (C), shipping event and event date, weight, volume, and numbers, net freight, freight terms (world scale; W, freight rate; R, or Lump-sum; L), freight base of calculation (weight; W, volume; V, or number; N), handling base of calculation (ton; T, cubic meter; M, or number; N), handling terms (liner in, liner out; L, free in, free out; F), handling rate and charges, passing-by canal name (if any), and loading status (laden; L, or in ballast; B).

### **Schedule Optimization Report**

<b>Schedule data</b>	
Schedule description:	Mersa Alam in Liner 2
Schedule earliest starting date:	01/12/2014
Schedule latest ending date:	17/12/2014
Sensitivity analysis description:	Optimal solution before or when no sensitivity
Optimum solution time of schedule:	15:01
Optimum solution date of schedule:	24/11/2013
Optimum total gross profit per day of schedule in US \$/day:	15020.58
<b>Ship data</b>	
Ship name:	Mersa Alam
Voyage or time charter	N
Deadweight in mt:	9000
Volume in cum:	10000
Number in teu:	600
Home port name:	Venice
Voyage open date:	01/12/2014
Working/Sensitive speed in m/h:	13
Laden fuel consumption of main engine in mt/day of working/sensitive speed:	16
Ballast fuel consumption of main engine in mt/day of working/sensitive speed:	12

Figure 3.1: Schedule Optimization Report-Part 1

<b>Route and cargo data</b>	
Sailing-to port name: L/U/C/T	Date: Cargo description:
	Load open and close date in dd/mm/yyyy:
	Unload open and close date in dd/mm/yyyy:
	C/P (C) or B/L (B):
	Shipping event and event date in dd/mm/yyyy:
	Original/Probable/Sensitive weight in mt:
	Original/Probable/Sensitive volume in cum:
	Original/Probable/Sensitive number in ones:
	Original/Probable/Sensitive net freight in US\$:
	Freight terms (W/R/L): Freight base (W/V/N):
	Handling terms (L/F): Handling base (T/M/N)
	Original/Sensitive handling units/day:
	Original/Sensitive handling charges in US \$/unit
	Passing-By canal name: Loading status (L/B):

Figure 3.2: Schedule Optimization Report-Part 2

## **3. SOS DATA AND SOS VOYAGER SOFTWARE AND HARDWARE REQUIREMENTS**

The standard product of SOS DATA and SOS VOYAGER can run on one of the following configurations:

**Configuration A:** Min hardware is one single-core Intel 3.0 GHz 64-bit PC processor, 4.0 GB RAM, 1.0 MB L2 cache, 0.8 GHz bus speed, and 80 GB HD 5400 RPM. Software used is MS Windows 10 and MS Access 2016. SOS standard product is processed sequentially using one database.

**Configuration B:** Min hardware is one i5 3.2 GHz 64-bit PC processor, 4.0 GB RAM, 6.0 MB L2 cache, 1.6 GHz bus speed, 80 GB HD 5400 RPM, and 100-MBS Ethernet network if more than one PC is used. Software used is MS Windows 10, MS Access 2016 database (front-end), and any recent version of MS SQL Server (back-end). MS Message Passing Interface (MS MPI) V10 is used for parallel processing. SOS standard product is processed in parallel using multiple PCs or (and) multiple processor cores. This configuration is accessed remotely, faster, more reliable, and can accommodate more data volumes.

**Configuration C:** Any other configurations, either hardware or software, where SOS DATA and SOS VOYAGER can integrate with via web Application Programming Interface (API), including Open Database Connectivity (ODBC). The reason for integration is that this configuration might contain the database where SOS DATA and SOS VOYAGER need to pull data from.

In all configurations, the more memory and processor speed, the more ships and cargoes may be processed in a reasonable time. Moreover, in configuration B, the more PCs and processor cores, the more ships may be processed in parallel in a reasonable time.

#### **4. SOS VOYAGER OPTIMIZATION CASES**

This part of the user manual guides the user in using the menus and forms mentioned in Section 2 to perform the optimization process mentioned in Section 1 using the minimum H/W of configuration B or C mentioned in Section 3. The optimization process selects an optimal cargo mix for each ship to maximize the ship voyage gross profit, if liner, the ship voyage gross profit per day, if tramp, or to minimize the ship voyage gross cost per day, if industrial. The optimization constraints are ship carrying capacity, cargo quantity, and cargo laycan.

The optimization is not only done to the cargoes that have been confirmed (offered) with a predefined quantity and freight but is also done to the unconfirmed (not-yet offered) cargoes that might be offered some time during the ship voyage. For an unconfirmed cargo, instead of calculating an average or an expected quantity or freight and insert it as a parameter in the optimization model, SOS VOYAGER puts the optimization itself into a stochastic state. Through the pre-optimal analysis, constraints on unconfirmed cargo are itself considered probable and its quantity and freight are converted to deterministic-equivalent values. This arrangement permits the ship operator to stochastically optimize and select from the offered cargoes the optimal ones, taken into account any probable cargoes. If the pre-optimal analysis of unconfirmed cargoes is not possible, due to lack of data on the cargo probable quantity, freight, and its associated probability, SOS VOYAGER applies the post-optimal analysis. This analysis permits the ship operator to change a cargo quantity or freight and then calculates its corresponding optimal solution without the need to re-optimize a schedule from the beginning. The changes are not limited to the cargo availability; it also applies to the cargo handling and the ship speed. SOS VOYAGER permits concurrent changes in:

- Cargo quantity and freight.
- Cargo handling rate and charges.
- Ship speed and fuel consumption.

Trying these changes permits the ship operator to explore ways to improve the gross profit, gross profit per day, or the gross cost per day and to offer profitable freight rates when negotiating the shippers and the charterers. Two types of analysis are permitted: sensitivity analysis and what-if analysis. Sensitivity analysis is sometimes desired to show the effect of continuous variation of one or more of the above-mentioned parameters on the optimal solution, and to see when the solution becomes less (or more) sensitive to change. In one of these variations the ship operator may include certain values of cargo quantity, freight, handling rate, handling charges, ship speed, and fuel consumption. In another variation, the ship operator may try other values. SOS VOYAGER calls each variation a 'sensitivity level', since it represents one of several continuous levels of variation. After the optimization, with or without the sensitivity analysis, and upon reviewing the optimization report, the ship operator may decide to do what-if analysis. In this case, he can make some changes to the cargo quantity, freight, handling rate, handling charges of some cargoes and ship speed and fuel consumption of some ships in an attempt to see the effect of these changes on the gross profit or gross profit per day. The ship operator may repeat the what-if analysis as much as he desires. Same as sensitivity, each what-if analysis session does not start from the beginning. It starts from where initial optimization has ended. The ship operator must choose a change from within a set of changes already stored by the Freight Analysis form, the Port Cargo Analysis form, or (and) the Speed Analysis form.

The following three subsections describe three optimization cases. Subsection 4.1 describes a liner optimization case, Subsection 4.2 describes a tramp optimization case, and Subsection 4.3 describes the case when optimal solution is not found. Before start, the user has to check the existence of 'SOS Edition B', which uses Configuration B, described by the following databases and files in the path shown corresponding each:

<b><u>Database/File</u></b>	<b><u>Path</u></b>	<b><u>Description</u></b>
shipping optimization systems.accde	C:\sos	SOS main menu used to pass control to data and programs.
sosdata.accdb	C:\sos	Data capture for cargo, ship, port, route, line/trade area, charter party, and schedule, used for tramp/ind and liner.
sosdata.mdf	C:\sos	SQL Server back-end database.
sosvoyagerprog.accde	C:\sos	Optimization program for tramp/industrial service only.
sosvoyagerproglah.dll	C:\sos	Optimization program for tramp/industrial service only.
sosvoyagerproglah1.exe	C:\sos	Optimization program for tramp/industrial service only.
sosvoyagerprog2.accde	C:\sos	Optimization program for liner service only.
sosvoyagerproglah2.dll	C:\sos	Optimization program for liner service only.
sosvoyagerproglah3.exe	C:\sos	Optimization for liner service only.
libiomp5md.dll	C:\sos	Runtime library for tramp/industrial and liner services.
MSMPI	C:\sos	Directory containing mspisdk.msi and msmpisetup.exe.
include	C:\sos	MS MPI include directory, containing mpif.h file.
smpdcall.exe	C:\sos	Calling Simple Multipurpose Daemon, process manager.
UNCOMTRADEforecast.accdb	C:\sos	UN ComTrade bilateral trade commodity forecast.

For users who are interested in fast processing only, they may use 'SOS Edition AB' or 'SOS Edition ABC'. They use part of configuration A and part of configuration B. If SOS integrates with configuration C, the users may use 'SOS Edition BC' or 'SOS Edition ABC'. All these editions are also covered by this manual. Consult your SOS provider for such editions.

The '.accde', '.dll', and '.exe' files are protected against code viewing. If the database files provided are not protected, the user has to check that all libraries required are

incorporated into the database. To do this, click the Database Tools on the database tool bar, click the Visual Basic on the drop-down menu, click the Tools on the visual basic tool bar, and then click the References on the drop-down menu and check that the libraries shown in Figure 4.1 with check marks are selected.

When a non-protected database file is opened and a message bar appears at top notifying the blocking of contents, select the database options, trust center, trust center settings, message bar, and then select 'Never show information about blocked contents'. If there is a problem in running macros, select the database options, trust center, trust center settings, macro settings, and then select 'Enable all macros'.

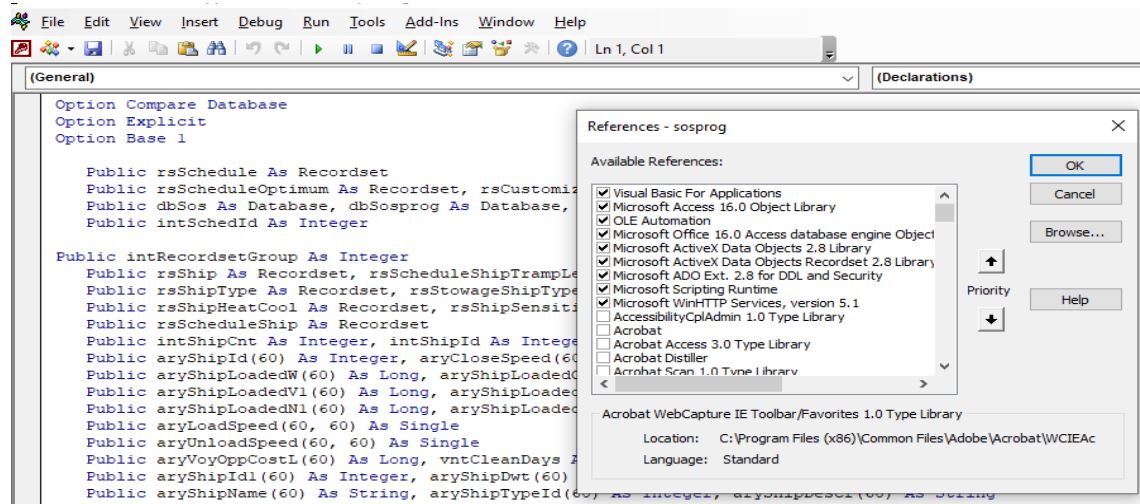


Figure 4.1: Libraries referenced by SOS VOYAGER (Access 2016)

'sosdata.mdf' is attached to MS SQL Server, where all Access tables are linked to it. '.dsn'. 'msmpisdk.msi' in MSMPI directory is installed. 'include' is a directory needed by '.exe' programs. If more than one PC is used in parallel, each additional PC should contain in its C:\sos directory the following files:

- sosvoyagerproglah1.exe and sosvoyagerproglah3.exe,
- libiomp5md.dll,
- mpiexec.exe,
- Include,
- smpdcall.exe.

Make sure that c:\sos in these PCs is shared and write enabled and then execute 'smpdcall' on each PC before running any SOS optimization program.

In case networking and big data volumes of SOS DATA is not so desired, while the shipping problems in hand are large enough and need fast processing, like in editions 'SOS Edition AB' and 'Edition ABC', MS SQL Server and 'sosdata.mdf' may not be used. In this case, 'sosdata.accdb', 'sosvoyagerprog.accde', and 'sosvoyagerprog2.accde' version of configuration A is used instead of that of configuration B.

## 4.1 LINER OPTIMIZATION CASE

Mersa Alam is a small full container ship of 600 TEU. Relevant data on ship is shown in Table 4.1.1. The ship is working on the East Mediterranean line almost twice a month.

The East Mediterranean line ports are Venice (Italy), Tartus (Syria), and Alexandria (Egypt). For the first half of December, the ship itinerary reads: Venice (12/1) – Tartus (12/7) – Alexandria (12/10) – Venice (12/15). Ship open and close port is Venice. Ship open date is 12/1 and close date is 12/17. The Voyage fixed cost is \$ 100 and the fixed time is 0.1 day. The relevant data on port is shown in Table 4.1.2. One week before voyage start, 15 container cargoes were identified, of which 10 cargoes have confirmed (offered) quantity and freight and 5 cargoes are unconfirmed (not yet offered). Two of the 10 confirmed cargoes are booked (fixed), while 8 cargoes are waiting to be booked. The relevant data on all cargoes is shown in Table 4.1.3.

Table 4.1.1: Ship data

Ship name	Mersa Alam
Total capacity in TEU	600
Refrigerating capacity in TEU	150
Deadweight capacity in mt* (capacity other than cargo is ignored)	9000
Speed level 1,2, and 3 in knots (level 1 is the economic speed)	13, 15, and 17, respectively
Main engine fuel consumption at speed 1,2, and 3 in mt*/day	16, 19, and 24, respectively
Auxiliary engine fuel consumption in mt*/day	1
Cooling fuel consumption in mt of main engine fuel/day/100 mt* of cargo	0.2
Fuel cost for main engine in US\$ /mt*	450
Fuel cost for auxiliary engine in US\$ /mt*	675
Running cost in US\$ /day	5000

\* mt = metric ton

Table 4.1.2: Port data

Data item Port name	Cost/call in US\$ (Lights, towage)	Cost/day in US\$ (Quay services)	Waiting days (Anchor, rain)	Cargo handling TEU/day
Venice	7,000	700	0.5	400
Tartus	5,000	500	0.5	400
Alexandria (home)	1,500	150	0	400

Table 4.1.3: Cargo data

Data item Cargo*	Shipping event	Load port	Discharge port	Weight in mt**	Number in TEU**	Freight In US\$/TEU**
Vegetables	Offered	Venice	Tartus	100	70	800
Spare Parts 11	Booked	Venice	Tartus	200	100	300
Machines	Offered	Venice	Tartus	230	130	300
Vegetables 1	Offered	Venice	Alexandria	75	50	1000
Spare Parts 12	Offered	Venice	Alexandria	250	80	400
Machines 1	Booked	Venice	Alexandria	270	110	400
Milk Powder	Offered	Venice	Alexandria	170	160	400
Fruits	Not-yet offered	Tartus	Alexandria	uc	uc	uc
Chemicals 16	Not-yet offered	Tartus	Alexandria	uc	uc	uc
Spices	Offered	Tartus	Alexandria	135	130	200
Fruits 1	Not-yet offered	Tartus	Venice	uc	uc	uc
Chemicals 17	Offered	Tartus	Venice	360	160	400
Vegetables 2	Not-yet offered	Alexandria	Venice	uc	uc	uc
Furniture	Not-yet offered	Alexandria	Venice	uc	uc	uc
Textiles	Offered	Alexandria	Venice	175	175	300

\* Vegetables and Fruits require cooling. Partial shipments are allowed

\*\* uc = unconfirmed. Freight is FIOS base

For the five unconfirmed (not-yet offered) cargoes, shown in Table 4.1.3, the ship operator anticipates probabilities for five classes of quantity and freight for each cargo. The ship operator also stipulates, with a least probability, he can transport a quantity of each cargo within its transport demand. The additional data of the unconfirmed cargoes is shown in Table 4.1.4. The Unconfirmed cargo deterministic-equivalent quantity and freight are shown in Table 4.1.5.

Table 4.1.4: Unconfirmed cargo additional data

Cargo	Fruits	Chemical 16	Fruits 1	Vegetables 2	Furniture
<u>Class 1</u>					
Weight in mt	120	220	240	50	155
Number in TEU	40	110	120	50	155
Freight in US\$ /TEU	600	200	1000	800	300
Probability in %	5	10	5	10	5
<u>Class 2</u>					
Weight in mt	135	230	260	55	160
Number in TEU	45	115	130	55	160
Freight in \$ US\$ /TEU	600	200	1000	800	300
Probability in %	15	25	15	20	15
<u>Class 3</u>					
Weight in mt	150	240	280	60	165
Number in TEU	50	120	140	60	165
Freight in US\$ /TEU	600	200	1000	800	300
Probability in %	50	40	60	40	60
<u>Class 4</u>					
Weight in mt	165	250	300	65	170
Number in TEU	55	125	150	65	170
Freight in US\$ /TEU	600	200	1000	800	300
Probability in %	20	15	15	20	12
<u>Class 5</u>					
Weight in mt	180	260	320	70	175
Number in TEU	60	130	160	70	175
Freight in US\$ /TEU	600	200	1000	800	300
Probability in %	10	10	5	10	8

Table 4.1.5: Unconfirmed cargo deterministic-equivalent quantity and freight

Cargo	Fruits	Chemical 16	Fruits 1	Vegetables 2	Furniture
Weight in mt	165	230	300	65	165
Number in TEU	55	115	150	65	165
Freight in US\$ /TEU	600	200	1000	800	300
Least probability of transporting cargo within demand in %	70	95	40	40	80

From the 15 cargoes (2 confirmed and booked, 8 confirmed but not yet booked, and 5 unconfirmed), the ship operator needs to know the optimal cargo mix to select, assuming an initial ship speed of 13 knots, followed by 15 and 17 knots for the sensitivity and what-if analysis. To perform this task, do the following:

- Open SOS DATA to read more on the case schedule, cargoes, ship, line, line ports, route, and fuel cost. To see the details of the schedule, click 'Shipping Schedule Manu', then open the 'Schedule, Main' form and search the 'Mersa Alam in Liner 2'

schedule. The details of the cargoes are shown in the 'Schedule Cargoes' form, 'Cargo, Main' form, and 'Freight Analysis' form. The details of the ship are shown in the 'Schedule Ships' form, 'Ship' form, and 'Speed Analysis' form. The details of the line are shown in 'Line/Trade Area, Main' form and 'Line Ports (liner only)' form. The details of the line ports are shown in 'Port, Main' form, 'Port Cargo Handling Rate and Charges' form, 'Cargo Handling Analysis' form, and the 'Port Dues and Waiting Days' form. The details of the route are shown in the 'Distance' form. The details of the fuel cost are shown in the 'Oil' form and the 'Ship Heating or Cooling' form.

- Open the 'Customized Data Entry' form in the 'Data Entry Main' form. Check that the field 'Let Data Entry be customized' has the option 'Data entry is customized to fit SOS VOYAGER' been selected.
- To be prepared ahead for ship speed what-if analysis, open the 'Schedule, Main' form and search for 'Mersa Alam in Liner 2' schedule, click the 'Sensitivity Count' tab, and set 'No. of Sensitivity Analysis Levels' to 0. Open 'Schedule Ships' form and search for the records corresponding to 'Mersa Alam in Liner 2' schedule and Mersa Alam, click the 'Analysis Data' tab, and check the 'Is Speed Analysis Required?' and 'Are All Routes Subject to Analysis?' fields, then select 'What-if Analysis' from the 'Analysis Required' pop-up menu.
- To be prepared ahead for cargo quantity what-if analysis, open the 'Schedule Cargoes' form and search for 'Mersa Alam in Liner 2' schedule and 'Vegetables'. From 'Freight Analysis Required' pop-up menu, select 'What-if Analysis'.
- To be prepared ahead for cargo handling what-if analysis, open the 'Schedule Cargoes' form and search for 'Mersa Alam in Liner 2' schedule and 'Vegetables'. From 'Loading Analysis Required' pop-up menu, select 'What-if Analysis'. A message is then output to ask whether this selection applies to all cargoes loaded from 'Vegetables' loading port.
- Quit SOS DATA by selecting the 'Stop' option from 'Data Entry Main' menu.
- Open SOS VOYAGER for liner. Select the Optimization and Sensitivity Analysis, specifying 'Mersa Alam in Liner 2' as the schedule name. The output report suggests, at 13 knots ship speed on all legs, the following results. Load Vegetables (70 containers), Spare Parts 11 (100 containers), and Machines (82 containers) from Venice to Tartous. Then load Vegetables 1 (50 containers), Machines 1 (110 containers), and Milk Powder (17 containers) from Venice to Alexandria. Then load Fruits 1 (100 containers) and Chemical 17 (160 containers) from Tartous to Venice. Then load Vegetables 2 (50 containers), Furniture (51 containers), and Textiles (175 containers) from Alexandria to Venice. Gross profit/day is US\$ 18,377. (the 'gross profit per day' objective results the same as 'gross profit', since voyage days are constant).
- It takes SOS VOYAGER for liner 0.3 seconds (0.5 seconds if configuration A), to read and validate the data of the ship, ports, and cargoes, explore all possible mixes, generate the mathematical model, and finally find the optimal cargo mix.
- To allow speed what-if analysis, stay on SOS VOYAGER for liner main menu, then select 'What-if Analysis of the Same Schedule' menu option. From the 'What-if Analysis Menu', select 'Id Selection of Ship Liner Legs Speed Analysis (Some Legs

Only)' form. Search for 'Mersa Alam in Liner 2' schedule, 'Mersa Alam' ship, and 'Venice' as leg ending port. Select the analysis id corresponding to 17 knots. Go back to 'What-if Analysis Menu' and select 'Perform What-if Analysis'. If Mersa Alam speeds up at 17 knots between Alexandria and Venice (24 mt/day main engine fuel consumption) to allow more stay in Alexandria, it will be able to load different quantities of Milk Powder (98 containers), Fruits 1 (85 containers), Chemical 17 (110 containers), Vegetables 2 (65 containers), and Furniture (165 containers). It will also be able to load Chemical 16 (2 containers) and Spices (130 containers) from Tartous to Alexandria, and Fruits (15 containers) from Tartous to Venice. Machines are disregarded in this case, with a gross profit/day equals US\$ 21,506.

- To allow cargo quantity what-if analysis, stay on SOS VOYAGER for liner main menu, then select 'What-if Analysis of the Same Schedule' menu option. From the 'What-if Analysis Menu', select 'Id Selection of Cargo Freight and Handling Analysis' form. Search for 'Mersa Alam in Liner 2' schedule, 'Vegetables' cargo, and select the freight analysis id corresponding to 90 containers. Go back to 'What-if Analysis Menu' and select 'Perform What-if Analysis'. If Vegetables quantity, after negotiation with the shipper, could be increased from 70 to 90 containers with the same freight rate, the action suggests the same cargoes loaded after speed analysis, except that Milk Powder is decreased to 78 containers, Spices cargo is decreased to 112 containers, and Chemicals 16 cargo is disregarded. Gross profit/day can then improve to US\$ 21,748.
- To allow cargo handling what-if analysis, stay on SOS VOYAGER for liner main menu, then select 'What-if Analysis of the Same Schedule' menu option. From the 'What-if Analysis Menu', select 'Id Selection of Cargo Freight and Handling Analysis' form. Search for 'Mersa Alam in Liner 2' schedule, 'Vegetables' cargo, and select the loading handling analysis id corresponding to 500 containers per day. Go back to 'What-if Analysis Menu' and select 'Perform What-if Analysis'. If a new container handling terminal in Venice will be opened by the time Mersa Alam calls at Venice, where the handling rate is changed from 400 to 500 containers per day for the same handling charges, the following are the changes. Machines cargo is back again with 33 containers and Spices cargo is decreased to 78 containers. The gross profit/day improves to US\$ 23,775.
- To enable en-route bunkering in SOS DATA, select 'Schedule Ships' from 'Shipping Schedule Menu' and search for 'Mersa Alam in Liner 2' schedule and Mersa Alam ship. Under the 'Open and Close Ports; Calling Date and Bunker', check 'Is Bunkering Required at Ports ...' question. Enter the en-route bunkering port name and its related data elements. If en-route bunkering is provided from Mersin on Venice-Tartous route, where main engine fuel is 11% cheaper and 7% for auxiliary engine. Bunker to be provided is 700 and 70 mt for main and auxiliary, respectively. However, Mersa Alam has to deviate for 100 miles to reach Mersin. The action although it decreases fuel cost but it also decreases the time needed to pick up cargoes. No need to report changes, since gross profit/day went back to US\$ 18,976.
- To allow Mersa Alam to arrive late at some ports, in SOS DATA select 'Line/Trade Area Menu' from main menu and then select 'Line Ports'. Search 'Mersa Alam in Liner 2' schedule', voyage id, port calling sequence, and port name. Under 'Port Calling Date', enter the late arrival penalty. An alternative action to speed analysis, as to allow more stay in Alexandria, is to permit Mersa Alam, voyage id 12 and port calling sequence 4, to violate Venice arrival date against a late penalty, say US\$ 2000/day. The action suggests same cargoes as speed analysis except that the quantity of



Chemical 17 changes to 160 containers, Textiles to 161 containers, and Spices to 82 containers. Furniture and Chemicals 16 are disregarded in this case. Gross profit/day turns back to US\$ 19,113.

- The unconfirmed cargoes may be discarded to see the effect of their absence on the gross profit per day. Open SOS DATA, then open the 'Schedule Cargoes' form and delete all records corresponding to the unconfirmed cargoes of the 'Mersa Alam in Liner 2' schedule. Quit SOS DATA and open SOS VOYAGER for liner again. Select the 'Optimization and Sensitivity Analysis', specifying 'Mersa Alam in Liner 2' as the schedule name. At 13-knots speed, the selected cargo mix includes Spices (100 containers) from Tartus to Alexandria instead of Fruits 1 from Tartus to Venice as specified by the first report. The Total gross profit per day becomes US\$ 10,120 instead of US\$ 18,377 as specified by the first report. As perhaps noticed, if the ship operator decides on the mix containing the confirmed cargoes only, he will not be able to select 'Fruits 1' when it is confirmed later, losing US\$ 8,257 gross profit per day. The decision highly depends on whether the 150-TEU-deterministic-equivalent quantity of 'Fruits 1' at a 40% stipulated least probability is true. In general, if an unconfirmed cargo has a known probability distribution, it is recommended to use the pre-optimal analysis as already described. If not, SOS VOYAGER for liner can use sensitivity and what-if analysis to try several random quantities and freight levels and see their effect on the gross profit per day.
- Sensitivity analysis may be used as an alternative to what-if analysis. It permits, in one optimization session, trying several analysis levels rather than one. It shows how far the changes can take place without affecting the gross profit per day. In case neither sensitivity nor what-if analysis is required for cargoes, in SOS DATA, open the 'Schedule, Main' form and search for the 'Mersa Alam in Liner 2' schedule, and then set its sensitivity count to zero. Open the 'Schedule Cargoes' form and change 'Analysis Data' of all schedule cargoes so that they have 'Freight Analysis Required', 'Loading Analysis Required, or 'Discharging Analysis Required' set to 'None'. Similar arrangement may be done if neither the sensitivity nor the what-if analysis is required for the ship. Open the 'Schedule Ships' form and change the analysis data of the scheduled ship and let 'Is speed analysis required?' and 'Are all routes subject to analysis?' fields blank, then select 'None' from 'Analysis required' pop-up menu.
- Similar runs of SOS VOYAGER for liner may repeat again before arriving Tartus and before arriving Alexandria. At that time, old offers may become booked or loaded and new offers may be added.
- SOS VOYAGER for liner may have other liner optimization cases which may be tried as well. Cases may be retried with different schedules, where cargoes and schedule parameters are different.
- SOS VOYAGER for liner follows linear and integer-linear programming mathematical models.

## **4.2 TRAMP OPTIMIZATION CASES**

### **4.2.1 DRY BULK**

Esna, Wadi Safaga, and Edfu are three dry-bulk carriers. In the last quarter of the year, these carriers are planning to compete in carrying 10 dry-bulk cargoes. Three of these

cargoes are to be transported from Kuwait to USA, another three from Ukraine to China, and four from Venezuela to Latvia. Relevant data on ships is shown in Table 4.2.1. For Esna and Edfu, the open port is Alexandria. For Wadi Safaga, the open port is Odessa. For all ships, the close port is the last port of call, the open date is October 1, the close date is December 31, the voyage fixed cost is US\$ 1000, and the fixed time is 0.3 day. Relevant data on port is shown in Table 4.2.2. Before the open date, 7 cargoes were offered while 3 are not yet offered, but expected to be offered in the near future. The relevant data on cargoes is shown in Table 4.2.3.

Table 4.2.1: Ship data

Ship	Esna	Wadi Safaga	Edfu
Data item			
-Deadweight in mt* (capacity other than cargo is ignored)	40,000	50,000	70,000
-Low, medium, and high speed in knots	15, 17, 19	14, 16, 18	13, 15, 17
-Main engine laden fuel consumption** in mt*/day	37, 54, 75	35, 52, 74	35, 55, 79
-Main engine ballast fuel consumption** in mt*/day	22, 32, 44	22, 33, 47	20, 31, 45
-Auxiliary engine fuel consumption*** in mt*/day	0.5	0.6	1
-Sues Canal dues, laden and ballast in \$	158,960; 135,180	172,310; 146,560	185,650; 157,940
-Panama Canal dues, laden and ballast in \$	79,000; 62,900	98,250; 78,150	117,500; 93,400
-Bosporus and Dardanelles dues in \$	9,640	12,150	13,850
-Running cost in \$ /day	5,000	7,000	7,700

\* mt = metric ton      \*\* Fuel cost for main engine is \$ 450 /mt      \*\*\* Fuel cost for auxiliary engine is \$ 675 /mt

Table 4.2.2: Port data

Port name	Data item	Cost/call in \$ (Lights, towage)	Cost/day in \$ (Quay services)	Waiting days* (Anchor, idle)	Cargo handling mt/day
Alexandria		1,500	150	0	34,000
Baltimore		12,000	1,200	0.3	40,000
Shuaiba		8,000	800	0.5	37,000
Maracaibo		10,700	1,070	0.5	37,000
Odessa		10,000	1,000	0.5	35,000
Riga		11,000	1,100	0.3	35,000
Shanghai		9,000	900	0.4	35,000

\* Port waiting days are classified as 'force majeure' and hence are not part of any demurrage or dispatch time counts.

Table 4.2.3: Cargo data

Cargo*	Shipping event**	Load port	Load Laycan	Discharge port	Discharge Laycan	Weight in mt**	Freight In \$ /mt***
Fertilizers	Offered	Shuaiba	10/1-10	Baltimore	11/1-11	40,000	50
Sulphur	Offered	Shuaiba	10/20-27	Baltimore	11/20-27	60,000	60
Wheat	Offered	Odessa	10/5-15	Shanghai	11/5-15	35,000	40
Maize	Offered	Odessa	11/3-16	Shanghai	12/3-16	40,000	50
Iron	Offered	Maracaibo	12/5-15	Riga	12/20-30	30,000	30
Copper	Offered	Maracaibo	11/20-28	Riga	12/10-25	45,000	35
Steel	Offered	Maracaibo	12/1-10	Riga	12/20-30	40,000	40
Sands	nyo	Shuaiba	10/1-31	Baltimore	11/1-30	uc	uc
Seeds	nyo	Odessa	11/1-30	Shanghai	12/1-31	uc	uc
Timber	nyo	Maracaibo	11/1-30	Riga	11/1-30	uc	uc

\* All cargoes require hold cleaning before loading for US\$ 1000 and 1 day. Freight is FIO base, load or discharge laydays are restricted to 35,000 mt per day, reversible laydays are subject to demurrage rate of US\$ 8,000 per day, and dispatch rate of US\$ 4,000 per day. Fertilizers, Sulphur, and Sands are transported directly (10,147 miles with 1.5 days waiting) or via Suez Canal (8,602 miles with 2 days waiting), Wheat, Maize, and Seeds are transported directly (14,169 miles with 1 day waiting) or via Suez Canal (8,264 miles with 1 day waiting), and Iron, Copper, Steel, and Timber are transported only directly (5,274 miles with 0.5 day waiting). Distance between ballast transport links may be found in any distance table, where waiting days are assumed zero. \*\* nyo = not-yet offered. \*\*\* uc = unconfirmed quantity or freight

For the three unconfirmed (not-yet-offered) cargoes, shown in Table 4.2.3, the ship operator anticipates the probabilities for five classes of quantity and freight for each cargo. This data is shown in Table 4.2.4. The ship operator stipulates, with a least probability, he can transport a quantity of each cargo within its transport demand as shown in Table 4.2.5.

Table 4.2.4: Unconfirmed cargo additional data

Cargo	Sands	Seeds	Timber
<u>Class 1</u>			
Weight in mt	45,000	40,000	30,000
Freight in \$ /mt	50	45	35
Probability in %	5	10	5
<u>Class 2</u>			
Weight in mt	47,000	42,000	32,000
Freight in \$ /mt	50	45	35
Probability in %	15	25	15
<u>Class 3</u>			
Weight in mt	49,000	44,000	34,000
Freight in \$ /mt	50	45	35
Probability in %	50	40	60
<u>Class 4</u>			
Weight in mt	51,000	46,000	36,000
Freight in \$ /mt	50	45	35
Probability in %	20	15	15
<u>Class 5</u>			
Weight in mt	53,000	48,000	38,000
Freight in \$ /mt	50	45	35
Probability in %	10	10	5

Table 4.2.5: Unconfirmed cargo deterministic-equivalent quantity and freight

Cargo	Sands	Seeds	Timber
Weight in mt	51,000	42,000	36,000
Freight in \$ /mt	50	45	35
Least probability of transporting cargo quantity in %	70	95	40

From the 10 cargoes, the ship operator wants to select the optimal (best) cargo mix for each ship in order to fix the selected confirmed cargoes, considering the unconfirmed cargoes, and assuming an initial ship speed of low speed, followed by the medium and high speed for the sensitivity and what-if analysis. To perform this task, do the following:

- Open SOS DATA to read more on the case schedule, cargoes, ships, ports, routes, charter parties, and the fuel cost. The details of the schedule are shown in the 'Schedule, Main' form under the name 'Esna/Wadi Safaga/Edfu in Charter'. The details of the cargoes are shown in the 'Schedule Cargoes' form, 'Cargo' form, and the 'Freight Analysis' form. The details of the ships are shown in the 'Schedule Ships' form, 'Ship' form, and the 'Speed Analysis' form. The details of the ports are shown in the 'Port' form, 'Port Cargo Handling Rate and Charges' form, 'Cargo Handling Analysis' form, and the 'Port Dues and Waiting Days' form. The details of the routes are shown in the 'Distance' form. The details of the charter parties are shown in the 'Contract of Affreightment / Voyage Charter Party, Main' form and the 'Contract of Affreightment / Voyage Charter Party, Cargo' form. The details of the fuel cost are shown in the 'Oil' form.

- Open the 'Customized Data Entry' form in the 'Data Entry Main' menu. Check that the field 'Let Data Entry be customized' has the option 'Data entry is customized to fit SOS VOYAGER' been selected.
- To get prepared for the what-if analysis after the optimization, the user has to do some steps ahead. To enable ship speed what-if analysis on some route legs, open the 'Schedule, Main' form and search for 'Esna/Wadi Safaga/Edfu in Charter' schedule, click the 'Sensitivity count' tab, and set 'No. of sensitivity analysis levels' to '0'. Open the 'Schedule ships' form and search for the records corresponding to the desired ships of 'Esna/Wadi Safaga/Edfu in Charter' schedule, click the 'Analysis data' tab, and check the 'Is speed analysis required?' field and leave the 'Are all routes subject to analysis?' field blank, then select the 'What-if analysis' from the 'Analysis Required' pop-up menu. Now, open the 'Schedule-Ship Tramp/Industrial Legs, Speed Analysis' form and select the record corresponding to the required schedule, ship, cargo, and the leg ending operation, which is subject to analysis. Click the 'Analysis Data' tab, then select 'What if analysis' from the 'Analysis Required' pop-up menu.
- To enable freight and handling what-if analysis of some cargoes, open the 'Schedule Cargoes' form and search for the records corresponding to the 'Esna/Wadi Safaga/Edfu in Charter' schedule and the desired cargoes. Click the 'Analysis Data' tab and select the 'What-if Analysis' from the 'Freight Analysis Required', 'Loading Analysis Required', and 'Discharging Analysis Required' pop-up menus, whatever applicable.
- Quit SOS DATA by selecting the 'Stop' icon from the 'Data Entry Main' menu.
- Open SOS VOYAGER for tramp/industrial. Click the 'Optimization and Sensitivity Analysis' icon, specifying 'Esna/Wadi Safaga/Edfu in Charter' as the schedule name. At the low ship speed on all legs, the output report suggests Sulphur (Shuaiba-Baltimore, passing by Suez Canal) then Iron and Steel (Maracaibo-Riga), all goes to Edfu. Wheat (Odessa-Shanghai, passing by Sues Canal) goes to Esna. Maize (Odessa-Shanghai) goes to Wadi Safaga. Gross profit/day is US\$ 79,170. Leave SOS VOYAGER for tramp/industrial open.
- It takes SOS VOYAGER for tramp/industrial 7 seconds to do the following tasks:
  - a) Read and validate the data of cargoes, ships, ports, routes, and charter parties.
  - b) Explore all possible transport links for each ship.
  - c) Generate the mathematical model, and find the optimal cargo mix for each ship.

In comparison, using minimum H/W of configuration A, it takes SOS VOYAGER for tramp/industrial 9 seconds to do the same tasks. For notification, it took SOS VOYAGER for tramp 8 minutes to process an extended case of 3-ship-30-cargo without sensitivity analysis (using minimum H/W of configuration A, it took SOS VOYAGER for tramp/industrial 20 minutes to do the same task.) and 50 minutes to process an extended case of 6-ship-50-cargo without sensitivity analysis. As mentioned in Section 3, under configuration B, more ships will not increase processing time considerably since all ships can be processed in parallel.

- As observed from the output, Fertilizers' (Shuaiba-Baltimore) load laycan cannot be met by any ship in low speed. To change ship speed using what-if analysis, on SOS VOYAGER for tramp/industrial menu, click 'What If Analysis of Schedule' icon. From the 'What If Analysis' menu, click 'Id Selection of Ship Tramp/Industrial Legs Speed Analysis' and select the record corresponding to the required schedule, ship, cargo, and the leg ending operation, which are subject to analysis. Click the 'Analysis Data'

tab. Now, enable Esna takes Fertilizers followed by Timber if it speeds-up at high speed towards Shuaiba and Maracaibo. Back to the 'What If Analysis' menu. Click 'Performing What If Analysis'. This action suggests same cargoes for Edfu, Fertilizers followed by Timber to Esna, passing by Suez Canal towards Baltimore. It also suggests Wadi Safaga takes Wheat with a gross profit/day equals US\$ 90,807.

- Upon negotiation with the charterer, the quantity of Maize could be increased from 40,000 to 50,000 mt with the same freight rate. To see the effect of this change on the gross profit per day, from the 'What If Analysis' menu, click the 'Id Selection of Cargo Freight and Handling Analysis' form. In this form, select the record corresponding to the required schedule and cargo, which are subject to analysis. Click the 'Analysis Data' tab. Now, enable the Maize quantity to reach 50,000 mt. Back to the 'What If Analysis' menu. Click 'Performing What If Analysis'. The action suggests Wadi Safaga takes Maize instead of Wheat with a Gross profit/day improved to US\$ 98,005.
- To see whether changing the Maize handling rate and charges in Odessa have an effect on the gross profit per day, from the 'What If Analysis' menu, click the 'Id Selection of Cargo Freight and Handling Analysis' form. In this form, select the record corresponding to the required schedule and cargo, which are subject to analysis. Click the 'Analysis Data' tab. Now, enable the Maize load-handling rate to change from 35,000 mt/day at US\$ 5/mt to 20,000 mt/day at US\$ 3/mt due to reduced number of working shifts. The action suggests the same results but with a Gross profit/day improved to US\$ 98,120. Although Wadi Safaga spends more Odessa's port dues, it collects the due amount of demurrage. Meanwhile, the charterer could save US\$ 100,000 handling cost minus the amount of demurrage. This action could be taken while negotiating the charterer to increase the quantity of Maize.
- The speed-route-quantity-handling what-if analysis suggests Wheat, Copper, Sands, and Seeds are left to voyage charter-in ships.
- Sensitivity analysis may be used instead of what-if analysis if continuous change is required in speed and fuel consumption, cargo quantity and freight rate, and cargo handling rate and charges. This kind of analysis permits the user to know how far the continuous change has an impact on the gross profit per day. SOS DATA permits five levels of change. Each level represents one collective change in one combination of speed, cargo quantity, and cargo handling. To enable speed sensitivity analysis for example, select 'Ship Menu' from 'SOS DATA Main' menu. From 'Ship Menu', open 'Speed Analysis' form and search for the ship and the analysis id required. From the 'Sensitivity Analysis Level Assigned to This Id' pop-up menu, select the required sensitivity level. Do the same thing for cargo freight and cargo handling analysis. Now, open the 'Schedule, Main' form and search for 'Esna/Wadi Safaga/Edfu in Charter' schedule, click the 'Sensitivity count' tab, and set 'No. of sensitivity analysis levels' to the required number. Open the 'Schedule ships' form and search for the records corresponding to the desired ships of 'Esna/Wadi Safaga/Edfu in Charter' schedule, click the 'Analysis data' tab, and check the 'Is speed analysis required?' field and check the 'Are all routes subject to analysis?' field as required, then select the 'Sensitivity analysis' from the 'Analysis Required' pop-up menu. If some route legs are subject to analysis, open the 'Schedule-Ship Tramp/Industrial Legs, Speed Analysis' form and select the record corresponding to the required schedule, ship, cargo, and the leg ending operation, which is subject to analysis. Click the 'Analysis Data' tab, and then select 'Sensitivity Analysis' from the 'Analysis Required' pop-up menu. Do the same thing for cargo freight and cargo handling analysis.

- An alternative action to speed analysis as to meet the Fertilizers laycan is to permit any ship to violate the cancellation dates against a late penalty, say US\$ 2000/day. To see the effect of this penalty on the gross profit per day, from the 'SOS DATA Main' menu, click the 'Contract of Affreightment / Voyage Charter Party' icon, and open the 'Contract of Affreightment / Voyage Charter Party, Main' form. In this form, select Chart 4, where Maize belongs to and click the 'Revenue and Cost Items' tab. Change late arrival penalty to US\$ 2000/day. Close SOS DATA and run SOS VOYAGER for tramp/industrial. Click the 'Optimization and Sensitivity Analysis' icon, specifying 'Esna/Wadi Safaga/Edfu in Charter' as the schedule name. The action suggests same cargoes go to Edfu, Timber then Maize go to Esna, and Fertilizers then Copper go to Wadi Safaga. Gross profit/day is improved to US\$ 90,931 instead of US\$ 90,807 in speed analysis.
- Suppose now that en-route bunkering can be provided from Antwerp in all Maracaibo-Riga routes, where main engine fuel is 11% cheaper and 7% for auxiliary engine. Bunker to be provided is 500 and 50 mt for main and auxiliary engines for Esna and Wadi Safaga, and 1000 and 100 mt for Edfu. However, ships have to deviate for 200 miles to reach Antwerp. To enable en-route bunkering, from the 'Data Entry Main' menu, select 'Shipping Schedule' menu then open the 'Schedule ships' form and search for the records corresponding to the desired ships of 'Esna/Wadi Safaga/Edfu in Charter' schedule, click the 'Open and Close Ports; Calling Date and Bunker' tab. Enter the required data for bunkering from Antwerp. Close SOS DATA and Open SOS VOYAGER for tramp/industrial and optimize, specifying 'Esna/Wadi Safaga/Edfu in Charter' as the schedule name. The action disables Esna from taking Maize after Timber with a gross profit/day decreased to US\$ 84,802.
- The laycan-en-route-bunkering analysis suggests Wheat, Maize, Sands, and Seeds are left to voyage charter-in ships.
- Assume that Sands, Seeds, and Timber have no identifiable probability distribution and are not going to be considered any more. In addition, if the gross-profit-per-day criterion is considered less attractive because of the disability to identify future transport demand, then the gross-profit criterion may be used instead in selecting the optimal cargo mix for each ship. To do this, click the 'Shipping Schedule Menu', and open the 'Schedule, Main' form. Search for the record corresponding to 'Esna/Wadi Safaga/Edfu in Charter' schedule. Click the 'Shipping Service and Scheduling Period' tab, and then set the question 'Is Gross Profit Calculated per Day?' to blank. Open the 'Schedule Cargoes' form and then delete all records corresponding to the unconfirmed cargoes of 'Esna/Wadi Safaga/Edfu in Charter' schedule. Quit SOS DATA and open SOS VOYAGER for tramp/industrial. Select 'Optimization and Sensitivity Analysis', specifying 'Esna/Wadi Safaga/Edfu in Charter' as the schedule name. SOS VOYAGER for tramp/industrial reports the following results, when the ships are at the low speed. Esna selects Maize from Odessa to Shanghai, via Suez Canal, Wadi Safaga selects Copper from Maracaibo to Riga, and Edfu selects the Sulphur from Shuaiba to Baltimore, directly, followed by Iron and Steel from Maracaibo to Riga. Summed for all ships, the total gross profit is US\$ 5,782,679, which is equivalent to US\$ 72,278 per day for 223 days. The gross-profit-per-day criterion reports US\$ 79,170 per day, all cargoes at the low speed, which is equivalent to US\$ 6,157,234 gross profit for 187.8 days. The difference in gross profit and gross profit per day are in favor of the gross-profit per day criterion.
- Even if the probability distribution cannot be identified for the not-yet-offered cargoes, still the gross-profit-per-day criterion may be used plus the freight sensitivity analysis and the ship operator's own judgment. To explain, suppose that Seeds and

Timber become offered with quantities and freights shown in Table 4.2.5, while Sands is still not-yet-offered with no such probability distribution as shown in Table 4.2.4. Suppose now that the ship operator wants to evaluate the effect of the change in the quantity of Sands on gross profit per day at the low ship speed; namely at the quantities 45,000 mt, 49,000 mt, and 53,000 mt with freights US\$ 50, all quantities. In this case, Sands will be considered as if it is offered with the sensitivity analysis applied to its quantity. To do this, open the 'Freight Analysis' form and make sure the sensitivity level is selected for each change. Then open the 'Schedule Cargoes' form and search the record corresponding to 'Esna/Wadi Safaga/Edfu in Charter' schedule and Sands, click 'Analysis Data' tab, and then select 'Sensitivity Analysis' from the 'Freight Analysis Required' pop-up menu. Quit SOS DATA and open SOS VOYAGER for tramp/industrial. Select the Optimization and Sensitivity Analysis, specifying 'Esna/Wadi Safaga/Edfu in Charter' as the schedule name. The gross profit-per-day at the low speed results in the same cargo mix as what was reported earlier, for all the possible cargo quantities. In other words, the objective is not sensitive to the change in the quantity of Sands.

- In case neither the sensitivity nor the what-if analysis is required for all cargoes, open 'Schedule, Main' form in SOS DATA and search the 'Esna/Wadi Safaga/Edfu in Charter' schedule, and then set its sensitivity count to zero. Open the 'Schedule Cargoes' form and change analysis data of all schedule cargoes so that they have the 'Freight Analysis Required', 'Loading Analysis Required', or 'Discharging Analysis Required' set to 'None'. Similar arrangement may be done if neither the sensitivity nor the what-if analysis is required for all ships. Open the 'Schedule Ships' form and change analysis data of all schedule ships and let 'Is speed analysis required?' and 'Are all routes subject to analysis?' fields blank, then select 'None' from 'Analysis required' pop-up menu.
- The above-mentioned analysis assumes all ships are owned. What-if the ship operator decides to charter-in a ship as to compete in carrying, for example, Copper. The estimated gross profit of the chartered-in ship is US\$ 400,000 in 25 days with US\$ 1,000 voyage fixed cost and one day voyage fixed time. To enable this data to take place, open the 'Cargo, Main' form and search for Copper. Click the 'Freight, additions, and Deductions' tab and enter the data in the chartered-in fields. Assume the ships are at low speed with no analysis. Assume also that the gross-profit-per-day criterion is applied to the case study. The report displays the same result with Copper transported by the charter-in ship. The Gross profit/day is now US\$ 94,516.
- Similar runs of SOS VOYAGER for tramp/industrial may repeat again after some time, when some confirmed cargoes become fixed or loaded, unconfirmed cargoes become confirmed or stay the same, and new cargoes are either confirmed or unconfirmed.
- SOS VOYAGER for tramp/industrial may have other tramp optimization cases, such as the one for 'El Kosseir/Safaga/Sidi Kirear in Charter 1' schedule, which could be tried as well. Cases may be retried with different schedules, where cargoes, charter parties, and schedule parameters are different.
- SOS VOYAGER for tramp/industrial follows a decomposition principle and linear-ratio programming mathematical model.

#### **4.2.2 LIQUID BULK**

El Kosseir, Safaga, and Sidi Kirear are three liquid-bulk carriers. In the last quarter of the year, these carriers are planning to compete in carrying 10 liquid-bulk cargoes. Three of these cargoes are to be transported from Kuwait to USA, another three from Ukraine to

China, and four from Venezuela to Latvia. Relevant data on ships is shown in Table 4.2.1. For El Kosseir and Sidi Kirear, the open port is Alexandria. For Safaga, the open port is Odessa. For all ships, the close port is the last port of call, the open date is October 1, the close date is December 31, the voyage fixed cost is US\$ 1000, and the fixed time is 0.3 day. Relevant data on port is shown in Table 4.2.2. Before the open date, 7 cargoes were offered while 3 are not yet offered, but expected to be offered in the near future. The relevant data on cargoes is shown in Table 4.2.3.

Table 4.2.1: Ship data

Ship	El Kosseir	Safaga	Sidi Kirear
Data item			
-Deadweight in mt* (capacity other than cargo is ignored)	40,000	50,000	70,000
-Low, medium, and high speed in knots	15, 17, 19	14, 16, 18	13, 15, 17
-Main engine laden fuel consumption** in mt*/day	37, 54, 75	35, 52, 74	35, 55, 79
-Main engine ballast fuel consumption** in mt*/day	22, 32, 44	22, 33, 47	20, 31, 45
-Auxiliary engine fuel consumption*** in mt*/day	0.5	0.6	1
-Pump capacity in mt*/hour	1250	1300	1400
-Heating fuel consumption in mt* of main engine fuel/day/ 100 mt* of cargo	0.125	0.11	0.15
-Sues Canal dues, laden and ballast in \$	158,960; 135,180	172,310; 146,560	185,650; 157,940
-Panama Canal dues, laden and ballast in \$	79,000; 62,900	98,250; 78,150	117,500; 93,400
-Bosporus and Dardanelles dues in \$	9,640	12,150	13,850
-Running cost in \$ /day	5,000	7,000	7,700

\* mt = metric ton      \*\* Fuel cost for main engine is \$ 450 /mt      \*\*\* Fuel cost for auxiliary engine is \$ 675 /mt

Table 4.2.2: Port data

Port name	Data item	Cost/call in \$ (Lights, towage)	Cost/day in \$ (Quay services)	Waiting days* (Anchor, idle)	Cargo handling** mt/day
Alexandria		1,500	150	0	34,000
Baltimore		12,000	1,200	0.3	40,000
Shuaiba		8,000	800	0.5	37,000
Maracaibo		10,700	1,070	0.5	37,000
Odessa		10,000	1,000	0.5	35,000
Riga		11,000	1,100	0.3	35,000
Shanghai		9,000	900	0.4	35,000

\* Port waiting days are classified as 'force majeure' and hence are not part of any demurrage or dispatch time counts.

\*\* May apply only if ship pumps are not working.

Table 4.2.3: Cargo data

Data item	Shipping event**	Load port	Load Laycan	Discharge port	Discharge Laycan	Weight in mt**	Freight In \$ /mt***
Cargo*							
Crude Oil 1	Offered	Shuaiba	10/1-10	Baltimore	11/1-11	40,000	50
Crude Oil 2	Offered	Shuaiba	10/20-27	Baltimore	11/20-27	60,000	60
Crude Oil 3	Offered	Odessa	10/5-15	Shanghai	11/5-15	35,000	40
Crude Oil 4	Offered	Odessa	11/3-16	Shanghai	12/3-16	40,000	50
Crude Oil 5	Offered	Maracaibo	12/5-15	Riga	12/20-30	30,000	30
Crude Oil 6	Offered	Maracaibo	11/20-28	Riga	12/10-25	45,000	35
Crude Oil 7	Offered	Maracaibo	12/1-10	Riga	12/20-30	40,000	40
Crude Oil 8	nyo	Shuaiba	10/1-31	Baltimore	11/1-30	uc	uc
Crude Oil 9	nyo	Odessa	11/1-30	Shanghai	12/1-31	uc	uc
Crude Oil 10	nyo	Maracaibo	11/1-30	Riga	11/1-30	uc	uc

\* All cargoes require hold cleaning before loading for US\$ 1000 and 1 day. Freight is FIO base, load or discharge laydays are restricted to 35,000 mt per day, reversible laydays are subject to demurrage rate of US\$ 8,000 per day, and dispatch rate of US\$ 4,000 per day. Crude Oil 1, 2, and 8 are transported directly (10,147 miles with 1.5 days waiting) or via Suez Canal (8,602 miles with 2 days waiting), Crude Oil 3, 4, and 9 are transported directly (14,169 miles with 1 day waiting) or via Suez Canal (8,264 miles with 1 day waiting), and Crude Oil 5, 6, 7, and 10 are transported only directly (5,274 miles with 0.5 day waiting). Distance between ballast transport links may be found in any distance table, where waiting days are assumed zero. \*\* nyo = not-yet offered. \*\*\* uc = unconfirmed quantity or freight



For the three unconfirmed (not-yet-offered) cargoes, shown in Table 4.2.3, the ship operator anticipates the probabilities for five classes of quantity and freight for each cargo. This data is shown in Table 4.2.4. The ship operator stipulates, with a least probability, he can transport a quantity of each cargo within its transport demand as shown in Table 4.2.5.

Table 4.2.4: Unconfirmed cargo additional data

Cargo	Crude Oil 8	Crude Oil 9	Crude Oil 10
<u>Class 1</u>			
Weight in mt	45,000	40,000	30,000
Freight in \$ /mt	50	45	35
Probability in %	5	10	5
<u>Class 2</u>			
Weight in mt	47,000	42,000	32,000
Freight in \$ /mt	50	45	35
Probability in %	15	25	15
<u>Class 3</u>			
Weight in mt	49,000	44,000	34,000
Freight in \$ /mt	50	45	35
Probability in %	50	40	60
<u>Class 4</u>			
Weight in mt	51,000	46,000	36,000
Freight in \$ /mt	50	45	35
Probability in %	20	15	15
<u>Class 5</u>			
Weight in mt	53,000	48,000	38,000
Freight in \$ /mt	50	45	35
Probability in %	10	10	5

Table 4.2.5: Unconfirmed cargo deterministic-equivalent quantity and freight

Cargo	Crude Oil 8	Crude Oil 9	Crude Oil 10
<u>Class 1</u>			
Weight in mt	51,000	42,000	36,000
Freight in \$ /mt	50	45	35
Least probability of transporting cargo quantity in %	70	95	40

From the 10 cargoes, the ship operator wants to select the optimal (best) cargo mix for each ship in order to fix the selected confirmed cargoes, considering the unconfirmed cargoes, and assuming an initial ship speed of low speed, followed by the medium and high speed for the sensitivity and what-if analysis. To perform this task, do the following:

- Open SOS DATA to read more on the case schedule, cargoes, ships, ports, routes, charter parties, and the fuel cost. The details of the schedule are shown in the 'Schedule, Main' form under the name 'El Kosseir/Safaga/Sidi Kirear in Charter 1'. The details of the cargoes are shown in the 'Schedule Cargoes' form, 'Cargo' form, and the 'Freight Analysis' form. The details of the ships are shown in the 'Schedule Ships' form, 'Ship' form, and the 'Speed Analysis' form. The details of the ports are shown in the 'Port' form, 'Port Cargo Handling Rate and Charges' form, 'Cargo Handling Analysis' form, and the 'Port Dues and Waiting Days' form. The details of the routes are shown in the 'Distance' form. The details of the charter parties are shown in the 'Contract of Affreightment / Voyage Charter Party, Main' form and the 'Contract of

Affreightment / 'Voyage Charter Party, Cargo' form. The details of the fuel cost are shown in the 'Oil' form.

- Open the 'Customized Data Entry' form in the 'Data Entry Main' menu. Check that the field 'Let Data Entry be customized' has the option 'Data entry is customized to fit SOS VOYAGER' been selected.
- To get prepared for the what-if analysis after the optimization, the user has to do some steps ahead. To enable ship speed what-if analysis on some route legs, open the 'Schedule, Main' form and search for 'El Kosseir/Safaga/Sidi Kirear in Charter 1' schedule, click the 'Sensitivity count' tab, and set 'No. of sensitivity analysis levels' to '0'. Open the 'Schedule ships' form and search for the records corresponding to the desired ships of 'El Kosseir/Safaga/Sidi Kirear in Charter 1' schedule, click the 'Analysis data' tab, and check the 'Is speed analysis required?' field and leave the 'Are all routes subject to analysis?' field blank, then select the 'What-if analysis' from the 'Analysis Required' pop-up menu. Now, open the 'Schedule-Ship Tramp/Industrial Legs, Speed Analysis' form and select the record corresponding to the required schedule, ship, cargo, and the leg ending operation, which is subject to analysis. Click the 'Analysis Data' tab, then select 'What if analysis' from the 'Analysis Required' pop-up menu.
- To enable freight and handling what-if analysis of some cargoes, open the 'Schedule Cargoes' form and search for the records corresponding to the 'El Kosseir/Safaga/Sidi Kirear in Charter 1' schedule and the desired cargoes. Click the 'Analysis Data' tab and select the 'What-if Analysis' from the 'Freight Analysis Required', 'Loading Analysis Required', and 'Discharging Analysis Required' pop-up menus, whatever applicable.
- Quit SOS DATA by selecting the 'Stop' icon from the 'Data Entry Main' menu.
- Open SOS VOYAGER for tramp/industrial. Click the 'Optimization and Sensitivity Analysis' icon, specifying 'El Kosseir/Safaga/Sidi Kirear in Charter 1' as the schedule name. At the low ship speed on all legs, the output report suggests Crude Oil 2 (Shuaiba-Baltimore, passing by Suez Canal) then Crude Oil 5 and Crude Oil 7 (Maracaibo-Riga), all goes to Sidi Kirear. Crude Oil 10 (Maracaibo-Riga) goes to El Kosseir. Crude Oil 4 (Odessa-Shanghai) goes to Safaga. Gross profit/day is US\$ 25,050. Leave SOS VOYAGER for tramp/industrial open.
- It takes SOS VOYAGER for tramp/industrial 7 seconds to do the following tasks:
  - d) Read and validate the data of cargoes, ships, ports, routes, and charter parties.
  - e) Explore all possible transport links for each ship.
  - f) Generate the mathematical model, and find the optimal cargo mix for each ship.

In comparison, using minimum H/W of configuration A, it takes SOS VOYAGER for tramp/industrial 9 seconds to do the same tasks. For notification, it took SOS VOYAGER for tramp 8 minutes to process an extended case of 3-ship-30-cargo without sensitivity analysis (using minimum H/W of configuration A, it took SOS VOYAGER for tramp/industrial 20 minutes to do the same task.) and 50 minutes to process an extended case of 6-ship-50-cargo without sensitivity analysis. As mentioned in Section 3, under configuration B, more ships will not increase processing time considerably since all ships can be processed in parallel.

- As observed from the output, Crude Oil 1 (Shuaiba–Baltimore) load laycan cannot be met by any ship in low speed. To change ship speed using what-if analysis, on SOS VOYAGER for tramp/industrial menu, click 'What If Analysis of Schedule' icon. From the 'What If Analysis' menu, click 'Id Selection of Ship Tramp/Industrial Legs Speed Analysis' and select the record corresponding to the required schedule, ship, cargo, and the leg ending operation, which are subject to analysis. Click the 'Analysis Data' tab. Now, enable El Kosseir takes Crude Oil 1 followed by Crude Oil 10 if it speeds-up at high speed towards Shuaiba and Maracaibo. Back to the 'What If Analysis' menu. Click 'Performing What If Analysis'. This action suggests same cargoes for Sidi Kirear, Crude Oil 1 followed by Crude Oil 10 to El Kosseir, passing by Suez Canal towards Baltimore. It also suggests Safaga takes Crude Oil 4 with a gross profit/day equals US\$ 30,797.
- Upon negotiation with the charterer, the quantity of Crude Oil 4 could be increased from 40,000 to 50,000 mt with the same freight rate. To see the effect of this change on the gross profit per day, from the 'What If Analysis' menu, click the 'Id Selection of Cargo Freight and Handling Analysis' form. In this form, select the record corresponding to the required schedule and cargo, which are subject to analysis. Click the 'Analysis Data' tab. Now, enable the Crude Oil 4 quantity to reach 50,000 mt. Back to the 'What If Analysis' menu. Click 'Performing What If Analysis'. The action suggests Safaga takes Crude Oil 4 instead of Crude Oil 3 with a Gross profit/day improved to US\$ 34,886.
- Cargo handling rate analysis is not applicable in this case, where El Kosseir, Safage, and Sidi Kirear are all oil tankers loading and discharging the crude oil via their own pumps. Refer to the dry bulk presentation, where cargo is handled by port facilities and therefore cargo-handling analysis is applicable.
- The speed-route-quantity-handling what-if analysis suggests Crude Oil 3, Crude Oil 6, Crude Oil 8, and Crude Oil 9 are left to voyage charter-in ships.
- Sensitivity analysis may be used instead of what-if analysis if continuous change is required in speed and fuel consumption, cargo quantity and freight rate, and cargo handling rate and charges. This kind of analysis permits the user to know how far the continuous change has an impact on the gross profit per day. SOS DATA permits five levels of change. Each level represents one collective change in one combination of speed, cargo quantity, and cargo handling. To enable speed sensitivity analysis for example, select 'Ship Menu' from 'SOS DATA Main' menu. From 'Ship Menu', open 'Speed Analysis' form and search for the ship and the analysis id required. From the 'Sensitivity Analysis Level Assigned to This Id' pop-up menu, select the required sensitivity level. Do the same thing for cargo freight and cargo handling analysis. Now, open the 'Schedule, Main' form and search for 'El Kosseir/Safaga/Sidi Kirear in Charter 1' schedule, click the 'Sensitivity count' tab, and set 'No. of sensitivity analysis levels' to the required number. Open the 'Schedule ships' form and search for the records corresponding to the desired ships of 'El Kosseir/Safaga/Sidi Kirear in Charter 1' schedule, click the 'Analysis data' tab, and check the 'Is speed analysis required?' field and check the 'Are all routes subject to analysis?' field as required, then select the 'Sensitivity analysis' from the 'Analysis Required' pop-up menu. If some route legs are subject to analysis, open the 'Schedule-Ship Tramp/Industrial Legs, Speed Analysis' form and select the record corresponding to the required schedule, ship, cargo, and the leg ending operation, which is subject to analysis. Click the 'Analysis

Data' tab, and then select 'Sensitivity Analysis' from the 'Analysis Required' pop-up menu. Do the same thing for cargo freight and cargo handling analysis.

- An alternative action to speed analysis as to meet the Crude Oil 1 laycan is to permit any ship to violate the cancellation dates against a late penalty, say US\$ 2000/day. To see the effect of this penalty on the gross profit per day, from the 'SOS DATA Main' menu, click the 'Contract of Affreightment / Voyage Charter Party' icon, and open the 'Contract of Affreightment / Voyage Charter Party, Main' form. In this form, select Chart 4, where Crude Oil 4 belongs to and click the 'Revenue and Cost Items' tab. Change late arrival penalty to US\$ 2000/day. Close SOS DATA and run SOS VOYAGER for tramp/industrial. Click the 'Optimization and Sensitivity Analysis' icon, specifying 'El Kosseir/Safaga/Sidi Kirear in Charter 1' as the schedule name. The action suggests same cargoes go to Sidi Kirear, Crude Oil 10 goes to El Kosseir, and Crude Oil 1 then Crude Oil 6 go to Safaga. Gross profit/day is improved to US\$ 33,111 instead of US\$ 30,797 in speed analysis.
- Suppose now that en-route bunkering can be provided from Antwerp in all Maracaibo-Riga routes, where main engine fuel is 11% cheaper and 7% for auxiliary engine. Bunker to be provided is 500 and 50 mt for main and auxiliary engines for El Kosseir and Safaga, and 1000 and 100 mt for Sidi Kirear. However, ships have to deviate for 200 miles to reach Antwerp. To enable en-route bunkering, from the 'Data Entry Main' menu, select 'Shipping Schedule' menu then open the 'Schedule ships' form and search for the records corresponding to the desired ships of 'El Kosseir/Safaga/Sidi Kirear in Charter 1' schedule, click the 'Open and Close Ports; Calling Date and Bunker' tab. Enter the required data for bunkering from Antwerp. Close SOS DATA and Open SOS VOYAGER for tramp/industrial and optimize, specifying 'El Kosseir/Safaga/Sidi Kirear in Charter 1' as the schedule name. Gross profit/day is improved to US\$ 36,752.
- The laycan-en-route-bunkering analysis suggests Crude Oil 3, Crude Oil 4, Crude Oil 8, and Crude Oil 9 are left to voyage charter-in ships.
- Assume that Crude Oil 8, Crude Oil 9, and Crude Oil 10 have no identifiable probability distribution and are not going to be considered any more. In addition, if the gross-profit-per-day criterion is considered less attractive because of the disability to identify future transport demand, then the gross-profit criterion may be used instead in selecting the optimal cargo mix for each ship. To do this, click the 'Shipping Schedule Menu', and open the 'Schedule, Main' form. Search for the record corresponding to 'El Kosseir/Safaga/Sidi Kirear in Charter 1' schedule. Click the 'Shipping Service and Scheduling Period' tab, and then set the question 'Is Gross Profit Calculated per Day?' to blank. Open the 'Schedule Cargoes' form and then delete all records corresponding to the unconfirmed cargoes of 'El Kosseir/Safaga/Sidi Kirear in Charter 1' schedule. Quit SOS DATA and open SOS VOYAGER for tramp/industrial. Select 'Optimization and Sensitivity Analysis', specifying 'El Kosseir/Safaga/Sidi Kirear in Charter 1' as the schedule name. SOS VOYAGER for tramp/industrial reports the following results, when the ships are at the low speed. El Kosseir selects Crude Oil 4 from Odessa to Shanghai, via Suez Canal, Safaga selects Crude Oil 6 from Maracaibo to Riga, and Sidi Kirear selects the Crude Oil 2 from Shuaiba to Baltimore, directly, followed by Crude Oil 5 and Crude Oil 7 from Maracaibo to Riga. Summed for all ships, the total gross profit is US\$ 1,832,471, which is equivalent to US\$ 21,485 per day for 223.5 days. The gross-profit-per-day criterion reports US\$ 25,050 per day, all cargoes at the low speed, which is equivalent to US\$

1,994,665 gross profit for 201.1 days. The difference in gross profit and gross profit per day are in favor of the gross profit per day criterion.

- Even if the probability distribution cannot be identified for the not-yet-offered cargoes, still the gross-profit-per-day criterion may be used plus the freight sensitivity analysis and the ship operator's own judgment. To explain, suppose that Crude Oil 9 and Crude Oil 10 become offered with quantities and freights shown in Table 4.2.5, while Crude Oil 8 is still not-yet-offered with no such probability distribution as shown in Table 4.2.4. Suppose now that the ship operator wants to evaluate the effect of the change in the quantity of Crude Oil 8 on gross profit per day at the low ship speed; namely at the quantities 45,000 mt, 49,000 mt, and 53,000 mt with freights US\$ 50, all quantities. In this case, Crude Oil 8 will be considered as if it is offered with the sensitivity analysis applied to its quantity. To do this, open the 'Freight Analysis' form and make sure the sensitivity level is selected for each change. Then open the 'Schedule Cargoes' form and search the record corresponding to 'El Kosseir/Safaga/Sidi Kirear in Charter 1' schedule and Crude Oil 8, click 'Analysis Data' tab, and then select 'Sensitivity Analysis' from the 'Freight Analysis Required' pop-up menu. Quit SOS DATA and open SOS VOYAGER for tramp/industrial. Select the Optimization and Sensitivity Analysis, specifying 'El Kosseir/Safaga/Sidi Kirear in Charter 1' as the schedule name. The gross profit-per-day at the low speed results in the same cargo mix as what was reported earlier, for all the possible cargo quantities. In other words, the objective is not sensitive to the change in the quantity of Crude Oil 8.
- In case neither the sensitivity nor the what-if analysis is required for all cargoes, open 'Schedule, Main' form in SOS DATA and search the 'El Kosseir/Safaga/Sidi Kirear in Charter 1' schedule, and then set its sensitivity count to zero. Open the 'Schedule Cargoes' form and change analysis data of all schedule cargoes so that they have the 'Freight Analysis Required', 'Loading Analysis Required', or 'Discharging Analysis Required' set to 'None'. Similar arrangement may be done if neither the sensitivity nor the what-if analysis is required for all ships. Open the 'Schedule Ships' form and change analysis data of all schedule ships and let 'Is speed analysis required?' and 'Are all routes subject to analysis?' fields blank, then select 'None' from 'Analysis required' pop-up menu.
- The above-mentioned analysis assumes all ships are owned. What-if the ship operator decides to charter-in a ship as to compete in carrying, for example, Crude Oil 6. The estimated gross profit of the chartered-in ship is US\$ 400,000 in 25 days with US\$ 1,000 voyage fixed cost and one day voyage fixed time. To enable this data to take place, open the 'Cargo, Main' form and search for Crude Oil 6. Click the 'Freight, additions, and Deductions' tab and enter the data in the chartered-in fields. Assume the ships are at low speed with no analysis. Assume also that the gross-profit-per-day criterion is applied to the case study. The report displays the same result with Crude Oil 6 transported by the charter-in ship. The Gross profit/day is now US\$ 49,396.
- Similar runs of SOS VOYAGER for tramp/industrial may repeat again after some time, when some confirmed cargoes become fixed or loaded, unconfirmed cargoes become confirmed or stay the same, and new cargoes are either confirmed or unconfirmed.
- SOS VOYAGER for tramp/industrial may have other tramp optimization cases, such as the one for 'Esna/Wadi Safaga/Edfu in Charter' schedule, which could be tried as well. Cases may be retried with different schedules, where cargoes, charter parties, and schedule parameters are different.

- SOS VOYAGER for tramp/industrial follows a decomposition principle and linear-ratio programming mathematical model.

### **4.3 INDUSTRIAL OPTIMIZATION CASE**

The industrial shipping is the same as tramp shipping with two exceptions. The first is that the cargo event status is assumed "Booked (fixed)" and the freight is assumed to have zero value. To enable such settings, open SOS DATA, select 'Cargo Menu', and then select and open 'Cargo, Main'. Assume that Maize, Seeds, and Wheat in the case study of subsection 4.2.1 are to have booked event status and zero freight. Run SOS VOYAGER for tramp/industrial. The optimization report suggests Wheat goes to Wadi Safaga, Maize goes to Esna, and Seeds goes to Edfu, with a gross cost/day equals to US\$ 57,899.

### **4.4 CASE OF NO OPTIMAL SOLUTION FOUND**

It may happen that the optimal solution cannot be found because the problem has no solution because ships and cargoes do not match, or it may have a solution but has a gross profit per day below a certain acceptable opportunity cost. In this case the ship operator receives the report containing the message 'No optimal solution found'. Following are three details for having no solution, which normally happen in the tramp/industrial shipping:

- Ships' open date is late or sailing days are long enough so that ships can't meet laycan of all cargo loading or discharging port.
- Ships' carrying capacity is smaller than cargo weight, volume, or number of TEUs.
- More shipping elements are added (see Section 5) which cause the solution to go infeasible or feasible but at low gross profit per day.

To check the ship open date, open the 'Schedule Ships' form in SOS DATA, select the schedule and ship of choice, and check the ship open date compared to the cargo lay can of cargoes of choice. To check the ship carrying capacity, open the 'Ship, Main' form; select the ship of choice, and check the ship deadweight, volume, and number of TEUs compared to the cargo weight, volume and number of TEUs. To check whether adding shipping elements is the cause, review each added element to see if it is the one causing the problem.

If there is no evidence for the above-mentioned three reasons, then check the opportunity cost. Open the 'Schedule Ships' form, select the schedule and ship of choice, and try to reduce its opportunity cost specified under 'Voyage Fixed Cost and Days, and Opportunity Cost' tab.

## **5. ADDING MORE SHIPPING ELEMENTS**

In the previous sections, the following shipping elements were considered:

- The total weight, volume, and number of all cargoes carried on board the ship, at any time, must not exceed its deadweight, volume, and TEU capacity.
- The total quantity of the cargoes planned to be carried on board a ship must target the maximum profitability whether the ship is 'full and down' or otherwise. Maximum profitability is achieved by optimizing the stochastic gross-profit-per-day objective.
- The optimal cargo mix is required even if the total quantity of the cargoes offered is less the total capacity of the ships.

- The date of loading or (and) discharging of a given cargo must be within its loading or (and) discharging time window.
- A contract of affreightment may contain more than one cargo.
- The discharged cargo from a ship is checked, cleaning wise, whether it is compatible with the loaded cargo on the same ship. If they are not compatible, a cleaning expense is considered.
- The en-route bunkering of the ship is allowed when the bunker price from an en-route bunkering port will reduce the operating cost.
- The rate of loading or (and) discharging of a cargo may be limited to a nominal rate. The demurrage and dispatch may result if the actual rate is less or greater than the nominal rate, respectively. The demurrage and dispatch may be calculated for the loading and discharging separately (irreversible calculation), or for the loading and discharging combined (reversible calculation).
- If the ship arrives before the cargo loading or discharging open date, the ship has to wait until this date. This waiting time is added to the total ship elapsed time. The cost of this waiting time is added to the total cost.
- The starting and ending dates of the ship operation must be within a given schedule date window.
- The starting and ending ports of the ship is restricted to the ports indicated by the schedule. If the ending port is not indicated, the last calling port is the ending port.
- A ship may be chartered-in to compete in carrying a certain cargo.
- The ship has the option, if permitted, to pass or (and) bypass the Suez Canal or (and) the Panama Canal, which ever contributes more to the gross profit per day.
- A differentiation is made to whether the ship is in laden or ballast situation, so that the sea fuel consumption is calculated accurately.
- Most of the shipping elements are considered fixed; namely, the cargo quantity, cargo freight rate, ship speed, fuel consumption, cargo handling rate, and the cargo handling charges. All these elements are subject to post-optimal analysis by sensitivity and what-if analysis. Moreover, Cargo quantity and freight rate are subject to pre-optimal analysis.
- The cargo quantity may be offered in two options. Option one, is to accept or reject the whole shipment. Option two, is to accept a partial shipment. The latter option is useful in decreasing number of variables requiring an accept-or-reject decision, which will save the computer processing time. This option is used only in case of the liner shipping.

The following shipping elements can also be added:

- The ship may start operation with some cargoes on-board. In this case, the weight, volume, and number of TEU of these cargoes decrease the ship available deadweight, volume, and number of TEU at the voyage start.
- The ship operator may consider the charter-out of a specified ship in the scheduling period as a time charter. To test the profitability of the ship with and without the time charter, the ship is tried as voyage charter as one alternative, and is tried for a time charter, as a second alternative. The ship operator may accept the time charter if the ship hire contributes more to the gross profit per day.
- The ship operator may agree to book a cargo space with or without naming the carrying ship.
- The ship has the option, if equipped enough and if permitted by the ship operator, to heat or cool the cargoes while on-board. The cost of heating or cooling is added to the total cost.
- The ship has the option, if permitted by ship operator, to lighten weight before passing canals. For the Suez Canal, SOS has the option to lighten the ship weight before passing the canal, either through the SUMED pipeline or through the so called 'Daughter-ship' arrangement.
- The ship may select the winter, summer, or tropical dwt according to the seasons of the year, which affects the ship carrying capacity. Also, the ship may specify the weather condition prevailing while at sea, which affects the ship speed.
- The actual ship draught is measured according to the weight of the cargoes already loaded on board the ship. This allows the ship, if the actual draught permits, to pass canals and call at ports when tide is low.

The user may try the above-mentioned additional elements.

## **6. ESTIMATED ROLLING BUDGET**

Now that SOS VOYAGER for tramp/industrial has optimized the gross profit/cost or the gross profit/cost per day for all ships working in the liner or tramp/industrial shipping, the gross profit for each ship may be saved and displayed, classified by the revenue and cost items. SOS VOYAGER gives the user two options in this respect. Option one, which considers the optimization result of each ship as the ONLY representative of its voyage on a certain line or trade area in the next year, and is expected to repeat by a certain frequency of calls. The saved data is then used to write the 'Estimated Rolling Budget (ERB)' report. It is 'rolling' since the sensitivity and what-if analysis may roll back to create many versions of the same schedule. It is a 'budget' since it includes the revenue and cost items estimated for the next year. Option two, considers the optimization result of each ship as an ALTERNATIVE representative of its voyage on a certain line or trade area in the next year. Other alternatives may be created in other lines or trade areas. The saved data is then used by SOS ALLOCATOR to optimally allocate the ships' voyages to the lines and trade areas. The output of SOS ALLOCATOR may then be used to write the ERB report. Therefore, option one is used to write the ERB report directly, and option two is used to write it indirectly via SOS ALLOCATOR.

To perform option one, do the following:



- In the 'Schedule, Main' form of SOS DATA, select the schedule of choice, and check the question 'Is the schedule part of Estimated Rolling Budget?'
- Open SOS VOYAGER for liner or SOS VOYAGER for tramp/industrial as appropriate, optimize the schedule of choice, and then click 'Save Optimal Schedule Objective of Each Ship' icon, for either the sensitivity level or what-if analysis as appropriate.
- To display the gross profit details, open SOS DATA, click the 'Shipping Schedule Menu', and then open the 'Schedule-Ship Gross Profit Details (Estimated Rolling Budget (ERB) only)' form. Search the schedule, ship, and the line or trade area of choice.

To perform option two, do the following:

- In 'Schedule, Main' form of SOS DATA, select the schedule of choice, and set the question 'Is the schedule part of Estimated Rolling Budget?' to blank.
- To save the gross profit details, do as described in option one
- To display the gross profit details, open SOS DATA, click the 'Shipping Schedule Menu', and then open the 'Schedule-Ship Gross Profit Details (voyage plan only)' form. Search the schedule, ship, and line or trade area of choice.

Figure 6.1 shows a sample of an Estimated Rolling Budget report. It displays the gross profit details of sex ships working as trampers for the planning period.

In the report displayed in Figure 6.1, the following trade areas: Arabian Gulf–US, Black Sea–Far East, Latin America–Black Sea, North Africa–South Europe, and West Africa– North Europe are designated by 510, 511, 512, 513, and 514, respectively. The following Schedules: 'Mersa/Elwaleed/Maged in Charter' and 'El Kosseir/Safaga/Sidi Kirear in Charter 1' are designated by 5 and 15, respectively. The following ships: Ibn Elwaleed, Mersa Alam, Ibn Maged, El Kosseir, Safaga, and Sidi Kirear are designated by 1, 2, 3, 4, 5, and 6 respectively. The trade area or the schedule named 'Layup Line or Trade Area' is designated by 15000.

Estimated Rolling Budget					Period from date		Period to date				
					01/01/2013		31/12/2013				
Line/trade area id	Schedule id	Ship id	Frequency	Voyage days	Gross profit	Net freight	Port dues	Handling cost	Canal and strait dues	Fuel cost	Fixed cost
510	15	4	6	222	4384800	13154400	2520000	0	1500000	3195600	1554000
		5	8	272	6020000	18060000	3760000	0	2240000	4680000	1360000
		6	4	164	3536000	10608000	2040000	0	1280000	2489200	1262800
Summary for 'sched_id' = 15 (3 detail records)											
Sum					13940800	41822400	8320000	0	5020000	10364800	4176800
Summary for 'line_id' = 510 (3 detail records)											
Sum					13940800	41822400	8320000	0	5020000	10364800	4176800
511	5	2	3	228	2104500	6313500	1200000	0	630000	1239000	1140000
Summary for 'sched_id' = 5 (1 detail record)											
Sum					2104500	6313500	1200000	0	630000	1239000	1140000
511	15	5	1	77	810300	2430900	485000	0	270600	480000	385000
Summary for 'sched_id' = 15 (1 detail record)											
Sum					810300	2430900	485000	0	270600	480000	385000
Summary for 'line_id' = 511 (2 detail records)											
Sum					2914800	8744400	1685000	0	900600	1719000	1525000
512	5	2	3	99	1573800	4721400	690000	0	825000	1137600	495000
Summary for 'sched_id' = 5 (1 detail record)											
Sum					1573800	4721400	690000	0	825000	1137600	495000
512	15	4	3	123	1743300	5229900	750000	0	930000	945600	861000
		6	6	192	3867600	11602800	1354200	0	2253000	2649600	1478400
Summary for 'sched_id' = 15 (2 detail records)											
Sum					5610900	16832700	2104200	0	3183000	3595200	2339400
Summary for 'line_id' = 512 (3 detail records)											
Sum					7184700	21554100	2794200	0	4008000	4732800	2834400
513	5	1	32	160	3728000	11184000	4160000	0	0	2336000	960000
		2	4	28	664800	1994400	620000	0	0	569600	140000
Summary for 'sched_id' = 5 (2 detail records)											
Sum					4392800	13178400	4780000	0	0	2905600	1100000
Summary for 'line_id' = 513 (2 detail records)											
Sum					4392800	13178400	4780000	0	0	2905600	1100000
514	5	1	9	126	3079800	9239400	2790000	0	0	2991600	378000
Summary for 'sched_id' = 5 (1 detail record)											
Sum					3079800	9239400	2790000	0	0	2991600	378000
Summary for 'line_id' = 514 (1 detail record)											
Sum					3079800	9239400	2790000	0	0	2991600	378000
15000	15000	1	0	59	-354000	0	0	0	0	0	354000
		3	0	345	-1207500	0	0	0	0	0	1207500
		4	0	5	-35000	0	0	0	0	0	35000
		5	0	1	-5000	0	0	0	0	0	5000
		6	0	4	-30800	0	0	0	0	0	30800
Summary for 'sched_id' = 15000 (5 detail records)											
Sum					-1632300	0	0	0	0	0	1632300
Summary for 'line_id' = 15000 (5 detail records)											
Sum					-1632300	0	0	0	0	0	1632300
Grand Total					29880600	94538700	20369200	0	9928600	22713800	11646500

Figure 6.1: Sample of Estimated Rolling Budget

## 7. UNCOMTRADE Forecast

This database is used to capture data on bilateral trade flow and inflation rates for some years back, and to forecast the trade flow for some years to come. The past trade flow data is provided by COMTRADE of the United Nations (UN) and the inflation rates are provided by the International Monetary Fund (IMF). The COMTRADE data is given by UN in values and may be discounted by 'UNCOMTRADEforecast.accde' using the inflation rates provided by IMF. Another trade flow data is provided by IMF but for overall exports

of each country rather than exports of each commodity from one country and another, as given by the UN. Unlike the COMTRADE, IMF provides also forecasts of both the inflation rates and the overall exports for some years to come.

To capture data of COMTRADE, perform the following steps:


- a) Visit the UN COMTRADE site on the internet to extract data from its database. A list of options is displayed to choose from. Select 'Goods' as the 'Type of Product', 'Annual' for the 'Frequency', 'SITC Rev. 4' for 'Classification', desired years for the 'Period' (the longer the period is the more accurate forecast you get), the desired countries for the 'Reporter', the desired countries for the 'Partner', export for the 'Trade Flows', and the desired 2-digit commodity codes for the 'SITC Classification Code'. Download the report in '.csv' file format then convert it in '.xls' format. Replace the column headings with the field names as they appear in the BilateralTrade table of UNCOMTRADEforecast.accde. Import the '.xls' file to the BilateralTrade table (.csv' file format may be imported as well but checking duplicate records cannot be guaranteed). Repeat this step as many times to capture all commodities, reporter and partner countries, and all years.
- b) Visit IMF site on the internet to extract data from its World Economic Outlook (WEO) database. Download WEO data by countries. Several lists are displayed with options to choose from. In first list, select the country group. In the second, select the country. In the third, under 'Monetary', select 'Inflation, Average Consumer Prices' and under 'Trade', select 'Volume of Exports of Goods'. In the fourth, select the desired years (which equals the number of past years selected under item (a) above plus two coming years), then deselect options under 'Notes', select 'WEO Country Code', 'ISO Alpha-3 code', 'Subject Description', and 'WEO subject code' under 'Fields to show on Report'. Download the report in '.xls' file format. Replace the column headings with the field names as they appear in the InflationRate table of UNCOMTRADEforecast.accde. Import the '.xls' file to InflationRate table.

Figure 7.1 shows the UNCOMTRADEforecast.accde's main menu. The first has to do with the bilateral trade forecast for the coming two years based on the time series of choice. The following three menu items have to do with the tables' maintenance.

SOS Data gets use of UNCOMTRADEforecast.accde when the 'Cargo, Main' form of SOS Data is displayed for any cargo. In the 'Weight, Volume, and Number' tab, there are two fields located at the bottom right corner. The first is headed by 'Forecast of percentage increase in commodity flow of country pair' and the second has the heading 'Forecast of percentage increase in overall flow of exporting country'. The commodity refers to that of the cargo, and the country pair refers to the country of the cargo loading port and the country of the cargo discharging port. The overall flow refers to the flow of all exports made by the country of the cargo loading port, including the cargo commodity. These two fields are useful in validating the cargo 'deterministic-equivalent' quantities when the cargo is 'not-yet-offered'. In other words, the stochastic formulation of the SOS Voyager optimization model has now been empowered by the commodity trade forecast, the way, which leads to more refined and accurate optimal shipping solutions. The stochastic formulation is based on the cargo descending probability distribution and a least probability the ship owner stipulates he can transport the cargo within its demand. Both the probabilities and the ship owner stipulation are sometimes difficult to anticipate and therefore the commodity trade forecast is useful in this respect to shed more lights on the future-cargo-transport demand.

SHIPPING OPTIMIZATION SYSTEMS (SOS)

UN Commodity Trade Forecast




year

year

year

Bilateral trade forecast of the  and its next year, using the time series from the  to the




year

year

year

year

Delete inflation records of old time series from the  to the  and its forecast records from the  to the




year

year


year

year

Delete bilateral trade records of old time series from the  to the  and its forecast records from the  to the



Find bilateral trade duplicate records and delete if any (in case csv file format is imported)



Stop bilateral trade forecas




Figure 7.1: UNCOMTRADE Forecast Main Menu