

# **SHIPPING OPTIMIZATION SYSTEMS (SOS)**

## **SOS ALLOCATOR**



## **USER MANUAL**

**For**

**'SOS EDITION B', 'SOS EDITION AB',  
'SOS EDITION BC' & 'SOS EDITION ABC'**

**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.

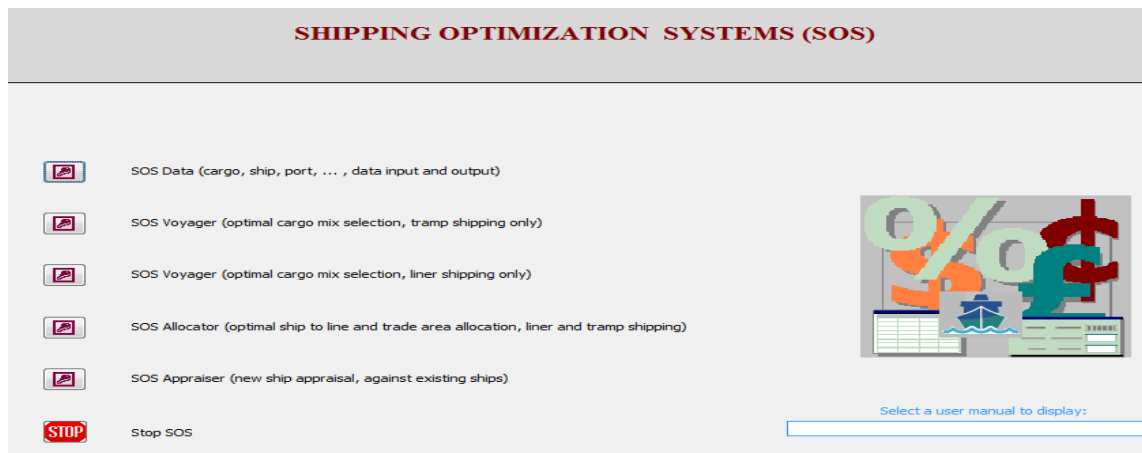


Figure 1.1: SOS main menu.

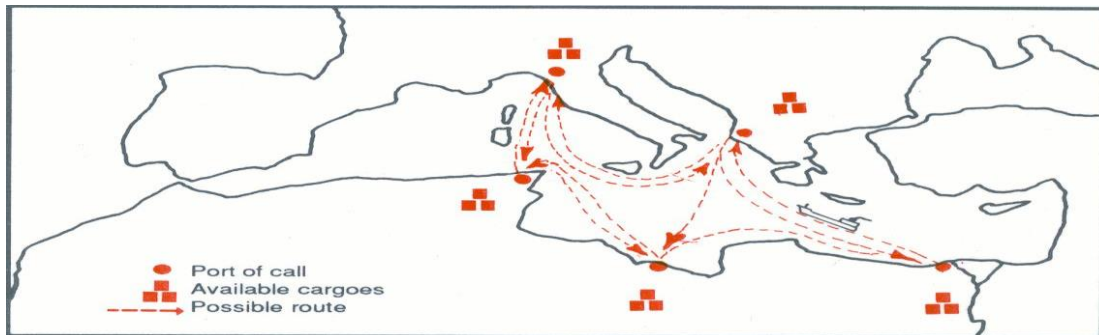


Figure 1.2: Example of the tramp/industrial cargo-mix selection in the Mediterranean Sea.

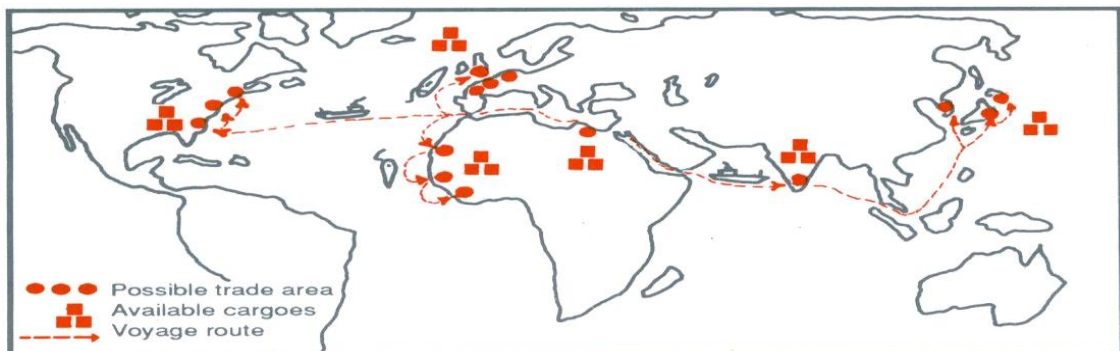


Figure 1.3: Example of allocating some ships to cargo trade areas worldwide.

## 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. Papers, which discuss these methods and their application in SOS, are El Noshokaty (2013, 2014, 2017, 2019, 2020, 2021, and 2023). SOS presentations are provided with SOS (2023) to briefly describe these papers.

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.

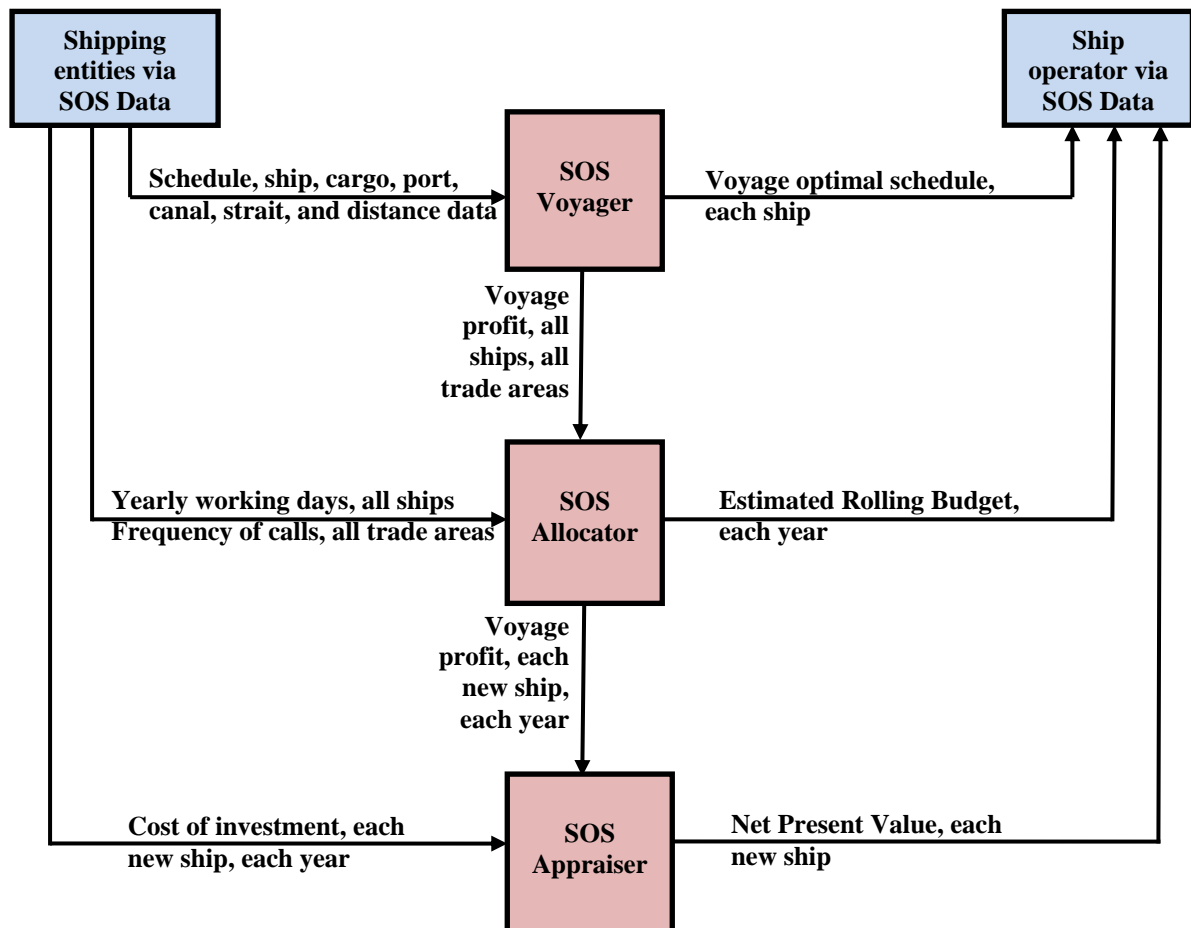


Figure 1.4: SOS data flow diagram (level 0).

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).

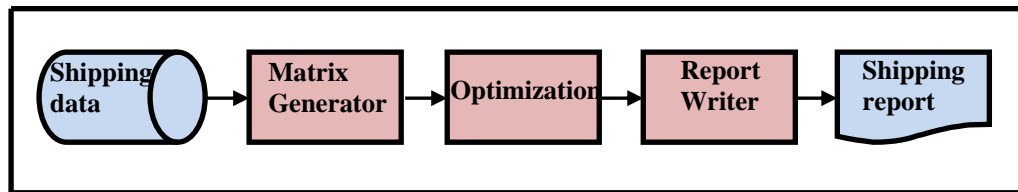


Figure 1.5: SOS subsystem flowchart.

### **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 ALLOCATOR SYSTEM COMPONENTS

SOS ALLOCATOR includes one system menu and one system output report. System menu directs SOS ALLOCATOR to optimize the allocation of ships to trade areas, while the system report displays the optimization result directed to ship operator.

### 2.1. SYSTEM MENU

SOS ALLOCATOR, as shown in Figure 2.1, displays the system menu. The optimization option on this menu passes control to an optimization program. This program reads the optimal ship gross profit details saved by SOS VOYAGER for each ship on different lines, as liner, or on different trade areas, as tramp/industrial. These profit details represent possible financial results of a planning period, say next year, which may be displayed by the 'Schedule Ship Gross Profit Details (voyage plan only)' form. This form is selected from the 'Shipping Schedule Menu' of SOS DATA. SOS ALLOCATOR requires that the following steps have been completed in SOS DATA:

- In the 'Schedule, Main' form, the question 'Is the schedule part of Estimated Rolling Budget?' should have been checked for each schedule in the planning period.
- The field 'Let Data Entry be customized' in the 'Customized Data Entry, Main' form has the option 'Data entry is customized to fit SOS ALLOCATOR' has been selected, and the Customization Period, i.e. the planning period, has been specified.

SOS ALLOCATOR optimization program reads the saved profit details and allocates each ship to the most promising lines and trade areas, and decides the frequency of calls to be completed on these lines and trade areas. This allocation maximizes the yearly total gross profit of all ships, subject to the possible frequency of calls within each cargo trade area and the number of working days available for each ship in this year. Optimal allocation may be then displayed by the 'Schedule Ship Gross Profit Details (Estimated Rolling Budget (ERB) only)' form, which is selected from the 'Shipping Schedule Menu' of SOS DATA.

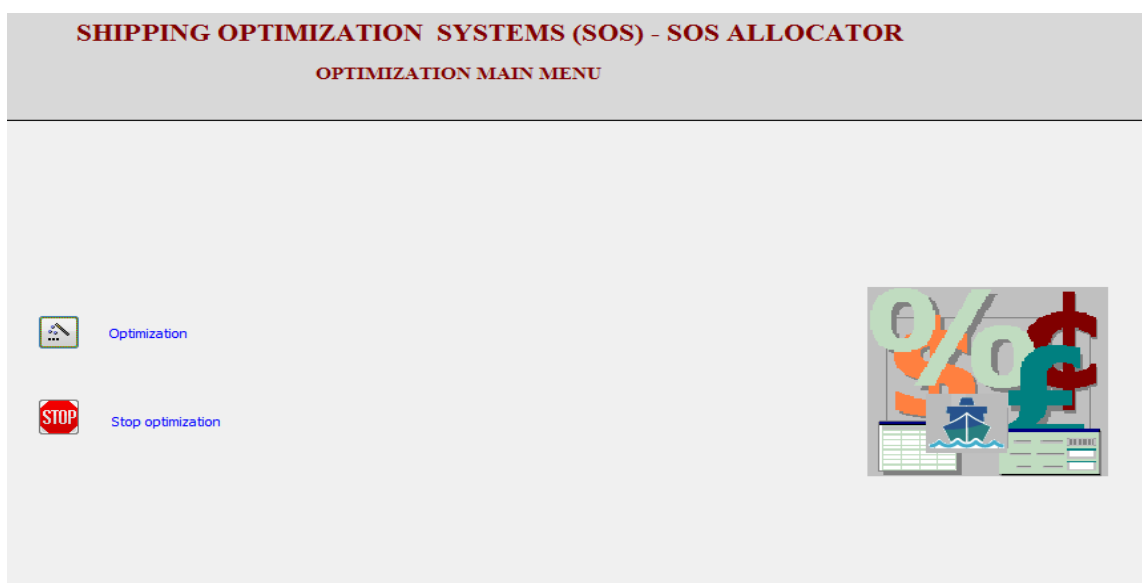


Figure 2.1: SOS ALLOCATOR main menu.

## 2.2. SYSTEM OUTPUT REPORT

SOS ALLOCATOR outputs the Estimated Rolling Budget report according to the report displayed in Figure 2.2. The report is printed automatically at the end of the optimization.



Figure 2.2: SOS ALLOCATOR output report.

## 3. SOS ALLOCATOR SOFTWARE AND HARDWARE REQUIREMENTS

The standard product 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.

## 4. SOS ALLOCATOR OPTIMIZATION CASE

This part of the user manual guides the user in using the menu mentioned in Section 2 to perform the optimization process mentioned in Section 1, using configuration B mentioned in Section 3.



The optimization process assigns an optimal set of lines and trade areas to each ship in an attempt to maximize the yearly ship gross profit for all working ships minus layup cost for all the laid ships. The Optimization constraints are the yearly ship working days, and the transport demand on the line or trade area.

Before start, the user has to check the existence of 'SOS Edition B', 'SOS Edition AB', 'SOS Edition BC', and 'SOS Edition ABC', described by following databases and files in the path shown corresponding each:

<b>Database/File</b>	<b>Path</b>	<b>Description</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 and liner.
sosdata.mdf	C:\sos	SQL Server back-end database.
sosallocatorprog.accde	C:\sos	Optimization program for tramp and liner.
sosallocatorproglah.dll	C:\sos	Optimization program for tramp and liner.
sosallocatorproglah1.exe	C:\sos	Optimization for tramp and liner.
libiomp5md.dll	C:\sos	Runtime library for tramp and liner services.
MSMPI	C:\sos	Directory containing msmppisdsk.msi, and msmppisetup.exe.
include	C:\sos	MS MPI include directory, containing mpif.h file.
smpdcall.exe	C:\sos	Call Simple Multipurpose Daemon, process manager.

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'.

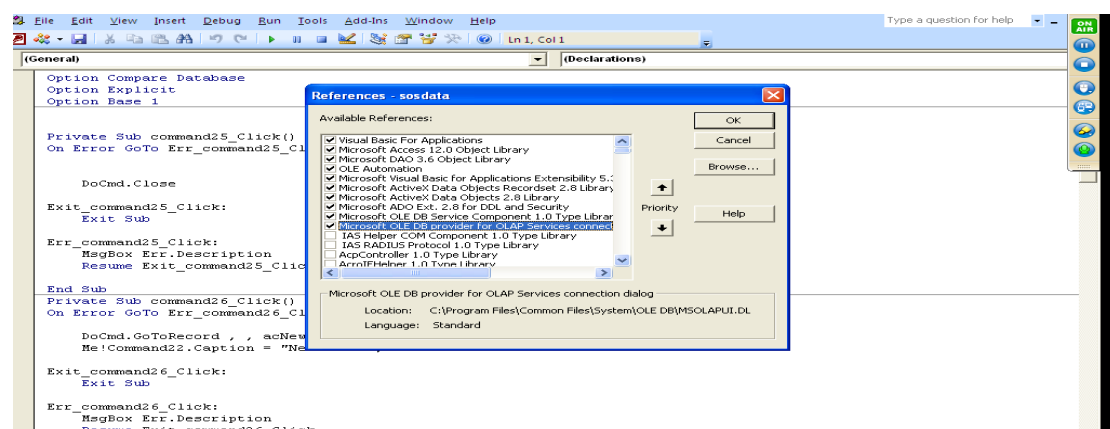


Figure 4.1: Libraries referenced by SOS ALLOCATOR (Access 2016)

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

- sosallocatorproglah1.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, MS SQL Server and 'sosdata.mdf' may not be used. In this case, the user can using 'SOS Edition AB' or 'SOS Edition ABC', where 'sosdata.accdb', and 'sosallocatorprog.accde' versions of configuration A are used instead of that of configuration B.

Seas Shipping Company (SSC) owns six oil tankers. At the end of last year, the shipping and financial reports showed a gross profit much less than expected. The cargo quantities and freight rates have decreased in some trade areas. To restore the balance between supply of tonnage and transport demand in the next year, the CEO of the company has decided to revise the current allocation of ships to crude-oil trade areas. For this purpose, he tried to figure out the different voyages for each ship, which could be completed on each trade area. The cargo transport demand (quantity and freight rate) was then being anticipated for a typical voyage most representing each trade area. SOS VOYAGER were applied to calculate the voyage gross profit for each ship on each trade area. Voyages failed to earn any gross profit were discarded. SOS ALLOCATOR was then run to see what ship best fit on each trade area, and the frequency of calls it best complete on this trade area. Table 4.1 shows the data of each ship classified by the ship working days and its daily fixed cost for the next year. The trade-area maximum frequency of calls anticipated for the next year is displayed in Table 4.2. The typical ship-voyage gross profit for the next year, classified by trade area, is displayed in Table 4.3. The typical ship-voyage time for the next year, classified by trade area, is displayed in Table 4.4.

In other words, these tables present all candidate alternatives of the voyage gross profits and days for all ships on all trade areas, calculated according to an anticipated cargo transport demand in each trade area. Table 4.1 presents the supply of ships in terms of the available working days and ship daily fixed cost in the next year, while Table 4.2 presents the maximum permissible frequency of calls in each trade area. The Data in tables 4.1 and 4.2 is input to SOS DATA, while the data in tables 4.3 and 4.4 is generated by SOS VOYAGER.

Table 4.1: Ship working days and daily fixed cost in the next year

Ship name	Yearly working days	Daily fixed cost in US\$
El Kosseir	350	5000
Ibn Elwaleed	345	6000
Ibn Maged	345	3500
Mersa Alam	355	5000
Safaga	350	7000
Sidi Kirear	360	7700

Table 4.2: Trade area maximum permissible frequency of calls in the next year

Trade area	Yearly frequency of calls
Arabian Gulf-US	18
Black Sea-Far East	24
Latin America-Black Sea	12
North Africa-South Europe	36
West Africa-North Europe	9

Table 4.3: Typical voyage gross profit in the next year (in US\$) classified by ship and trade area

Trade area Ship name	Arabian Gulf-US*	Black Sea- Far East*	Latin America -Black Sea*	North Africa- South Europe*	West Africa- North Europe
El Kosseir	752,500	810,300	510,300	np	310,100
Ibn Elwaleed	np	np	np	116,500	342,200
Ibn Maged	np	np	np	125,100	290,200
Mersa Alam	np	701,500	524,600	166,200	328,500
Safaga	730,800	650,200	581,100	np	365,200
Sidi Kirear	884,000	694,300	644,600	np	355,200

\* np = not profitable

Table 4.4: Typical voyage time\* in the next year (in days) classified by ship and trade area

Trade area Ship name	Arabian Gulf-US**	Black Sea- Far East**	Latin America - Black Sea**	North Africa- South Europe**	West Africa- North Europe
El Kosseir	34	77	38	np	12
Ibn Elwaleed	np	np	np	5	14
Ibn Maged	np	np	np	5	11
Mersa Alam	np	76	33	7	13
Safaga	37	74	41	np	15
Sidi Kirear	41	70	32	np	14

\* Typical voyage time = Difference between calling date at first port and operation finishing date at last port + voyage fixed time.

\*\* np = not profitable

Given the data shown in tables 4.3 and 4.4, SOS ALLOCATOR finds the optimal allocation of ships to the trade areas and layup days of each ship satisfying the data in tables 4.1 and 4.2. If the optimal allocation finds that the total voyage days is less than the available working days, some ships have to lay up for some days. On the other hand, if the optimal allocation finds that the total voyage days is greater than the available working days, the services on some trade areas have to stop. To perform the allocation, do the following:

- Open SOS DATA to read more on the ships, trade areas, voyage gross profit, and the voyage time. The details of the ships are shown in the 'Ship, Main' form. For the purpose of this case study, all the ships are assumed to be tankers. The details of the trade areas are shown in the 'Line/Trade Area, Main' form. The Details of the voyage gross profit and days are shown in the 'Schedule Ship Gross Profit Details form (voyage plan only)' form selected from the 'Shipping Schedule Menu'.
- Quit SOS DATA by selecting the Stop option from the Data Entry Main menu.
- Run SOS ALLOCATOR, and click the Optimization option on the Optimization Main menu. The Estimated Rolling Budget (ERB) report is printed, which suggests the

total voyages classified by ship and trade area as shown in Table 3.5. The total gross profit for all ships is US\$ 29,880,600.

Table 4.5: total voyages classified by ship and trade area

Trade Area Ship	Arabian Gulf–US	Black Sea- Far East	Latin America- Black Sea	North Africa–South Europe	West Africa- <u>North</u> Europe	Layup days
El Kosseir	8	1	-	-	-	1
Ibn Elwaleed	-	-	-	32	9	59
Ibn Maged	-	-	-	-	-	345
Mersa Alam	-	3	3	4	-	-
Safaga	6	-	3	-	-	5
Sidi Kirear	4	-	6	-	-	4
Shortage in calling frequency	-	20	-	-	-	-

- The ERB report, although it tells where each ship best fit on each trade area, it shows a long lay up for Ibn Maged and a shortage in servicing Black Sea-Far East trade area. This might suggest substituting Ibn Maged by another ship which can make profits on Black Sea-Far East.
- It takes SOS ALLOCATOR few milliseconds to optimize (much less time than configuration A).
- If the data is changed, SOS DATA and SOS VOYAGER may re-run and another ERB report could be output from SOS ALLOCATOR. The change in data might be used for analysis purposes as to see the effect of the following possible scenarios on the flow of cargo transport in different trade areas:
  - a) Conducting possible trade agreements between countries on a trade area.
  - b) Changing the port dues or (and) cargo dues of some ports on a trade area.
  - c) Shortage in the quantity of goods transported by sea due to war or fire.
  - d) Fluctuations in the prices of fuel oil.
- SOS ALLOCATOR follows the mathematical model that is fully described in El Noshokaty (2013) for liner and El Noshokaty (2017) for tramp.

Figure 4.2 shows the ERB report. The 'Schedule Ship Gross Profit Details (Estimated Rolling Budget only)' form in the 'Shipping Schedule Menu' of SOS DATA displays the same results.

In the report displayed in Figure 4.2, the 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 schedules: 'Mersa/Elwaleed/Maged in Charter' and 'Kosseir/Safaga/Sidi Kirear in Charter 1' are designated by 5 and 15, respectively. The 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 '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 4.2: Estimated Rolling Budget report

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