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OPTIMIZING MANPOWER ON-BOARD SHIPS TARGETING TO THE INCREASE OF THE COMPETITIVENESS OF THE EU-FLEET THE CASE OF A SHIP ORIENTED AUTOMATION ELECTRONIC TOOL (ACOSTOS™)

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ABSTRACT

In general, the problem of the EU flagged ships' competitiveness is considered to be of extreme importance for the whole marine industry. In this paper we will present a new electronic tool for the calculation of the benefits that a shipowner may have, if the ports in which his vessel operates, would implement automated loading/discharging systems in order to achieve smaller port turnaround times. The electronic tool can also calculate the benefit that a shipowner may have by implementing automated loading/discharging onboard his vessel

KEY WORDS: Port operation, Automated Systems, Cost Benefit Analysis

INTRODUCTION

It is generally recognized that efficient loading and discharging can be a significant factor in determining the competitiveness of a ship because short port turnaround time can be critical (Stephens, 1989). The benefits of an efficient loading and discharging operation can be significant, not only to the shipping company, but also to the shipper, to the port, and to the recipient of the cargo. In this paper, a cost-benefit Analysis electronic tool named "ACOSTOS" is being presented. This electronic tool has been created in order to estimate and document the benefits of an efficient loading and discharging operation. The analysis procedure is based on comparing an existing "conventional" vessel-port system with an "automated" one, both having exactly the same characteristics except the ones referring to loading and discharging. The comparison will be performed using Net Present Value (NPV) for criterion (Psaraftis, 1986).

The cost-benefit analysis is based upon the assumption that we have a so-called "conventional" port-based loading/discharging system which has a specific loading / discharging capacity (speed) which can decrease by using an "automated" Loading/Discharging System. The term "automated" refers to the *port*, meaning that the port has an infrastructure able to increase the port loading/discharging efficiency (decrease the vessel port turnaround time). The scope of this task is not to examine the details of that infrastructure (it is treated as a "black box"), but to estimate possible benefits by the adoption of such an infrastructure. The only characteristic which is significant for the analysis is the loading/discharging time. So it is assumed that the "automated" system, whatever that may be, has lower loading/discharging times than the "conventional" one. According to that difference, the NPV calculations will answer to the question:
"*How much could a shipowner benefit, if the ports in which his vessel operates, would implement automated loading/discharging systems in order to achieve smaller port turnaround times?*"

In adopting such an approach, we have explicitly and very clearly extended the object of our analysis beyond the borders of the ship itself, and into the interface between the ship and the port. This is legitimate because precisely for the ship types for which port turnaround time is important (such as containerships), a ship is an integral component of the intermodal chain, and efficiency cannot be defined only on the ship but on the broader integrated chain. For these scenarios, optimizing only the ship does not necessarily lead to optimal solutions for the chain itself (Mikelis, 1990).

The structure of the paper is as follows. It begins with a short description of the whole procedure followed by another section where a detailed analysis of the methodology for the NPV calculations is presented. The next section presents the electronic tool "ACOSTOS" and it concludes with some sample runs of the software and some remarks

THE PROBLEM OF SHORTENING THE LOADING /DISCHARGING TIME

As mentioned in the introduction, it is recognized that efficient loading and discharging can be a critical factor in determining the competitiveness of a ship. This is particularly true for the liner and ferry trades (criterion of port turnaround time), because it is mainly for those ships that a short port turnaround time can be critical. In the context of the present paper, it was decided that the effort that would be undertaken would collect data that document the benefits from an efficient loading and discharging operation. The benefits from a streamlined loading and discharging operation can be significant, not only to the shipping company, but also to the shipper, to the port, and to the recipient of the cargo. These benefits are more important for cargoes that are perishable (fruits, meats, and vegetables) and/or are of high value (industrial products). It is for this reason that these benefits are more important for ships in the liner trades.

It is a common fact that *the efficiency of loading/discharging exhibits little or no dependency on the vessel itself, but depends mostly or totally on the port (port facilities, operational & organizational structure, etc.).* In the opinion of most people providing information (mostly from the ship-owning side), "*vessel-based loading/discharging systems are as efficient as they can be"*. On the contrary, ports were judged responsible for low loading/discharging times due to inefficient infrastructure.

The whole methodology for the software tool "ACOSTOS" was developed in a such way that it would cover on the one hand the case of an "automated loading/discharging system" that can be implemented on the vessel and on the other hand the case of an "automated port-based loading/discharging procedure".

This paper is not examining either the level or the details of these "automated" systems; they are treated as "black boxes". The NPV calculations are done according to a user-defined case study (so called 'scenario'), which includes a full description of a specific vessel route. Systematic changes on the scenario characteristics lead to the desired estimation of the benefits (if any) of the automated system

METHODOLOGY

Scenario Design

Different scenario set-ups have been developed according to the specifications of each vessel type. The vessel types for which the Analysis has been implied, are: Bulk Carriers, Container Carriers, General Dry Cargo Ships, Tankers, Chemical Carriers and Ore/Bulk/Oil Carriers.

According to the ship type, a "Two-Ports" or a "Multiple-Ports" scenario option can be selected. The "Two-Ports" scenario assumes that the vessel operates between two predefined ports, while the "Multiple-Ports" scenario assumes that the vessel operates between '*n*' user-defined ports. The number of ports in that case varies between 3 and 10. In the "Two-Ports" case, both ports have the same loading/discharging characteristics (times); in "Multiple-Ports", each port has its own characteristic times.

The scenario concept for Bulk Carriers, OBO Carriers and General Cargo ships assumes that a vessel departs from a port with or without load and arrives at another port to discharge or to load. The whole loaded amount is being discharged each time. No partial loading or discharge is allowed. It is not necessary to load or discharge at every intermediate port in the scenario, but it is required to have a call at both the first and the last port. Each trip with load may have its own charter rate, while 'ballast' trips' given charter rates do not affect the calculations.

The data needed for the Cost-Benefit Analysis can be grouped in three categories: vessel data, ports data, and general data.
Vessel data: main dimensions, size (GRT), flag, speed, horsepower (BHP), fuel consumption, crew size, capacity (m^3, TEU), operating costs, economic life of the vessel (years).
Port data: distance tables, port costs, loading/discharging times.
General data: interest rate, acquisition cost of automations, and annual cost of automations.

Vessel data has been retrieved from the LRS Database. Operating cost, fuel cost and port data have been retrieved from relevant projects data and from questionnaires sent to various shipping companies, after personal interviews. Port cost data has been collected either through direct contact, or from other sources like the Fairplay Ports Guide. The rest of the data is to be defined by the user (this will form the scenario variables). A more detailed description of the scenarios according to vessel type, can be found in the next paragraphs.

Container Carriers

<u>Two-Ports Scenario</u>:

The vessel is loaded with a number of *x* TEUs at port #1 that are discharged at port #2. The same number of TEUs is then loaded at port#2, and is discharged at port#1. The vessel does this route continuously for its whole economic life, except for the off-duty days (these are the days in which the vessel may be normally off-duty due to various reasons, measured as an annual percentage). The gross profit is measured in *USD/TEU*. Both ports have the same loading/discharging speeds. The "conventional" case is always slower than the "automated" one. Speed is measured in *moves/hr*.

As mentioned earlier, the evaluation of the loading/discharging systems will be done by applying the Net Present Value (NPV) criterion, comparing a "conventional" with an "automated" vessel. Starting with the "conventional" vessel, the series of calculations are shown in the next rows (Dilzas, 1994).

The days at sea (T_S) for a single one-way route are calculated as follows:

$$T_S = \frac{PortsDistance}{VesselSpeed \times 24} \qquad \text{[days]} \qquad (1)$$

For each port call, the vessel spends T_P days at port (T_{LD} for loading/discharging and T_R as port time other than loading/discharging):

$$T_P = T_{LD} + T_R \qquad \text{[days]} \qquad (2)$$

Loading/discharging time is calculated as follows:

$$T_{LD} = \frac{TEUsCarried}{24 \times \left(\frac{moves}{hr}\right)} \qquad \text{[days]} \qquad (3)$$

Time T_R is approximately 25% of T_{LD}. This value has resulted from vessel and port traffic data.
Hence, a single one-way route lasts

$$T_T = T_S + 2 \times 1.25 \times T_{LD} \qquad \text{[days]} \qquad (4)$$

The total number of single one-way trips per year for the vessel is equal to

$$T_Y = \frac{(365 - OffDutyDays)}{T_T} \qquad (5)$$

Vessel's annual gross income is

$$IN = TEUsCarried \times T_Y \times \left(\frac{USD}{TEU}\right) \quad [\$] \qquad (6)$$

As a detailed definition of running costs is beyond the scope of this paper, vessel annual running cost is assumed to be equal to the annual manning cost (for normal annual operation, this is the most significant cost anyway). The annual manning cost is set approximately at about USD 45000 per crew member, hence

$$Running\ Cost = 45000 \times Crew\ Size \quad [\$] \qquad (7)$$

Fuel oil cost is a function of fuel price, specific consumption and vessel's BHP:

$$FuelCost = 24 \times SpecificConsumption \times \times FOPrice \times BHP \times T_Y \times T_S \quad [\$] \qquad (8)$$

Diesel Oil (for electric generators) cost consists of a 'Sea' and a 'Port' cost, as different specific consumptions are reported at port and on sea:

$$DOCost = 24 \times T_Y \times DOPrice \times \times (SpCons_{SEA} \times T_S + SpCons_{PORT} \times T_P) \quad [\$] \qquad (9)$$

Port Cost is calculated according to each port tariff. All relevant data is taken from the Fairplay Ports Guide.

Vessel Annual Net Benefit is calculated as follows

$$AnnualBenefit_C = IN_C - RunningCost_C - - Fuel_C - PortCost_C \quad [\$] \qquad (10)$$

where index 'C' refers to the "conventional" vessel.

The same set of equations is applied for the "automated" vessel too. The differences between the two vessels arise from the different loading/discharging times. Hence, the "automated" Vessel's Annual Net Benefit is

$$AnnualBenefitt_A = IN_A - RunningCost_A - -Fuel_A - PortCost_A\ [\$] \quad [\$] \qquad (11)$$

As the "automated" vessel spends less time for loading/discharging, the vessel makes more trips, gross profit and operating cost increase. Assuming that the applied automations have an initial cost of buying c_{init}, and the annual automations' maintenance cost is c_{maint}, the NPV Criterion is applied through the following equation:

$$NPV = \sum_{t=1}^{N} \frac{(AnnualBenefit_A - AnnualBenefit_C)}{(1+i)^t} - - \sum_{t=1}^{N} \frac{C_{maint}}{(1+i)^t} - C_{ini} \quad [\$] \qquad (12)$$

Where:
C_{maint} is automations annual maintenance cost (in the case of a ship based automation system)
C_{ini} is automations initial cost(in the case of a ship based automation system)
i is the annual interest rate, and N is the total economic life of the vessel in years.

This must now be compared to zero. Namely, If NPV>0, the owner benefits from the assumed increase of loading/discharging speed, hence, he will be willing to pay (as extra port dues or as extra automations on board) up to the NPV value. If NPV<0, the owner loses from the assumed increase of loading/discharging speed, hence, the "conventional" case is the optimal for the owner. If NPV=0, there's no loss or gain for the owner (Dilzas, 1994).

Multiple-Ports Scenario:

The vessel departs from port #1 and passes from all intermediate ports until the last one, loading and/or discharging any desired number of TEUs at each port. For the way-back, the vessel departs from the last port, passes from all intermediate ports and ends the route at port#1, loading/discharging any desired number of TEUs at each port. The vessel does this route continuously throughout its entire economic life, except for the off-duty days. This setup has one constraint: at any moment, the total number of TEUs onboard should not exceed vessel's total TEU capacity. Each port has its own loading/discharging characteristics (times and dues). Vessel gross profit is measured in *USD/TEU*, and port speeds are measured in *moves/hr*.

On with the calculations now, the days at sea (T_S) are calculated as follows:

$$T_S = \frac{\sum_{port\#1}^{port\#n} PortsDistance}{VesselSpeed \times 24} \quad [days] \qquad (13)$$

For each port call, the vessel spends T_{Pj} days at port (T_{LDj} for loading/discharging and T_{Rj} as port time other than loading/discharging), as shown in Eq. (2), hence the total days at port will be:

$$T_P = \sum_{port\#1}^{port\#n} (T_{LD_j} + T_{R_j}) \quad [days] \qquad (14)$$

Loading/discharging time at each port will be

$$T_{LD_j} = \frac{(TEUsLoad + TEUsDisch)_{GO}}{24 \times \left(\frac{moves}{hr}\right)} + \frac{(TEUsLoad + TEUsDisch)_{RETURN}}{24 \times \left(\frac{moves}{hr}\right)} \quad [days] \qquad (15)$$

where 'GO' and 'RETURN' refer to the trip direction (port#1→port#n or port#n→port#1).
Time T_{Rj} is approximately 25% of T_{LDj}, as on Two-Ports scenario.

A route port#1…port#n…port#1 lasts

$$T_T = 2 \times T_S + 1.25 \times \sum_{port\#1}^{port\#n} T_{LD} \quad [days] \qquad (16)$$

and the total number of trips per year for the vessel is equal to

$$T_Y = \frac{(365 - OffDutyDays)}{T_T} \quad (17)$$

Vessel annual gross income is

$$IN = TotalTEUsCarried \times T_Y \times \left(\frac{USD}{TEU}\right) [\$] \quad (18)$$

Running, Fuel, Port Cost, as well as Vessel Annual Benefit ("conventional" and "automated"), are calculated in the same way as in Two-Ports Scenario.

Finally, the NPV Criterion is applied:

$$NPV = \sum_{t=1}^{N} \frac{(AnnualBenefit_A - AnnualBenefit_C)}{(1+i)^t} - \\ - \sum_{t=1}^{N} \frac{C_{maint}}{(1+i)^t} - C_{ini} \quad [\$] \quad (19)$$

Tankers, Chemical Carriers, Bulk Carriers, Ore/Bulk/Oil Carriers, General Dry Cargo Ships

Two-Ports Scenario:

The vessel is supposed to be loaded with an amount of cargo of *x* m^3at port#1 and discharge that cargo at port#2. The same amount of cargo is then loaded at port#2, which is discharged at port#1. The vessel does this route continuously throughout its entire economic life, except for the off-duty days. Gross profit is measured in *USD/day*, and cargo capacity in m^3. Both ports have the same loading/discharging speeds. Speeds are measured in m^3/hr.

The days at sea (T_S) for a single one-way route are calculated as previous:

$$T_S = \frac{PortsDistance}{VesselSpeed \times 24} \quad [days] \quad (20)$$

For each port call, the vessel spends T_P days at port (T_{LD} for loading/discharging and T_R as port time other than loading/discharging):

$$T_P = T_{LD} + T_R \quad [days] \quad (21)$$

while loading/discharging time is

$$T_{LD} = \frac{CargoCarried}{24 \times \left(\frac{m^3}{hr}\right)} \quad [days] \quad (22)$$

Port Rest Time T_R is approximately 25% of T_{LD}, and a single one-way route lasts

$$T_T = T_S + 2 \times 1.25 \times T_{LD} \quad [days] \quad (23)$$

The total number of single one-way trips per year for the vessel is equal to

$$T_Y = \frac{(365 - OffDutyDays)}{T_T} \quad (24)$$

Vessel's annual gross income is

$$IN = T_S \times T_Y \times \left(\frac{USD}{day}\right) \quad [\$] \quad (25)$$

Running, Fuel, Port Costs, as well as Vessel's Annual Benefit ("conventional" and "automated"), are calculated in the same way as on Two-Ports Scenario for Container Carriers .

NPV Criterion is applied using Eq. (12):

$$NPV = \sum_{t=1}^{N} \frac{(AnnualBenefit_A - AnnualBenefit_C)}{(1+i)^t} - \\ - \sum_{t=1}^{N} \frac{C_{maint}}{(1+i)^t} - C_{ini} \quad [\$] \quad (26)$$

Multiple-Ports Scenario:

The multiple-ports Scenario is not applying to Tankers because for the Tankers, only a two-ports-scenario is realistic, applicable, and reliable.

For all the other ship types (Bulk Carriers, Ore/Bulk/Oil Carriers, General Dry Cargo Ships, Chemical Carriers) the multiple-ports scenario is as follows:

The vessel departs from port #1 and sails to port #n, loading/discharging the desired amount of cargo at any port. The same thing happens on the way back (port#n to port#1). This setup should meet the following requirement: the cargo discharged at any port should be equal to the amount of cargo, which has been previously loaded. *Example*: A vessel loads at port#4 a cargo of *x* m^3. This amount of cargo should have been loaded at port#3, or at port#2 (without any cargo exchange at port#3), or at port#1 (without any cargo exchange at port#2 and port#3).

The vessel does this route continuously for its whole economic life, except for the off-duty days. Vessel's gross profit per loaded trip is measured in *USD/day*, and cargo in m^3. A 'loaded' trip is a trip in which the vessel carries an amount of cargo. Each port has its own characteristics (loading/discharging speeds and dues). Speeds are measured in m^3/hr.

The days at sea (T_S) are calculated as follows:

$$T_S = \frac{\sum_{j=1}^{n-1} \sum_{port\#j}^{port\#(j+1)} PortsDistance}{VesselSpeed \times 24} \quad [days] \quad (27)$$

For each port call, the vessel spends T_{Pj} days at port (T_{LDj} for loading/discharging and T_{Rj} as port time other than loading/discharging), as shown in Eq. (2), hence the total days at port will be:

$$T_P = \sum_{port\#1}^{port\#n} (T_{LD_j} + T_{R_j}) \quad [days] \quad (28)$$

Loading/discharging time at each port will be

$$T_{LD_j} = \frac{(CargoLoad + CargoDis)_{GO}}{24 \times \left(\frac{m^3}{hr}\right)} + \quad \text{[days]} \quad (29)$$

$$+ \frac{(CargoLoad + CargoDis)_{RETURN}}{24 \times \left(\frac{m^3}{hr}\right)}$$

where 'GO' and 'RETURN' refer to the trip direction (port#1→port#n or port#n→port#1).
Time T_{Rj} is approximately 25% of T_{LDj}. A route port#1…port#n…port#1 lasts

$$T_T = 2 \times T_S + 1.25 \times \sum_{port\#1}^{port\#n} T_{LD} \qquad \text{[days]} \qquad (30)$$

and the total number of trips per year for the vessel is equal to

$$T_Y = \frac{(365 - OffDutyDays)}{T_T} \qquad (31)$$

Vessel's annual gross income is

$$IN = \sum_{j=1}^{n-1} T_{S_j} \times \left(\frac{USD}{day}\right)_j \qquad [\$] \qquad (32)$$

Running, Fuel, Port Costs, as well as Vessel's Annual Benefit ("conventional" and "automated"), are calculated in the same way as on all previous cases.
Subsequently, the NPV Criterion is applied using Eq. (12):

$$NPV = \sum_{t=1}^{N} \frac{(AnnualBenefit_A - AnnualBenefit_C)}{(1+i)^t} -$$

$$- \sum_{t=1}^{N} \frac{C_{maint}}{(1+i)^t} - C_{ini} \qquad [\$] \qquad (33)$$

ELECTRONIC TOOL –"ACOSTOS™"

The software application that developed in order to apply the above Cost-Benefit Analysis methodology and evaluate the effectiveness of loading/discharging systems has been named as ACOSTOS™. The software documented here has been developed on an Intel Pentium[1] platform, using Windows 95™ environment and Microsoft Visual FoxPro™ database management system.

The user may select one of six different ship types, namely *Bulk Carrier*, *Container Carrier*, *OBO Carrier*, *General Cargo*, *Chemical Carrier* and *Tanker*. Each type has its own scenario setup which follows right after the Ship Size Selection Screen. The Ship Size Selection Screen displays those ships from the LRS Ships Database, which match the selected ship type but also have all the necessary data for the cost-benefit analysis. Once type and size (GRT) of the vessel-in-question have been selected, the user has to decide whether it will be a "*Two-Ports-Scenario*" or a "*Multiple-Ports-Scenario*". "*Two-Ports-Scenario*" uses a pre-defined route (Port "A" → Port "B" → Port "A") while "*Multiple-Ports-Scenario*" gives the user the opportunity to select a route by specifying the ports. In both cases, a set of additional data is needed in order to define the scenario completely:

Two-Ports-Scenario

In the "*Two-Ports-Scenario*", the user has to define the amount of the *Cargo Carried*, the relevant *Charter Rate*, the annual *Off-Duty* days, the total *Duration* of the scenario, the *Interest Rate*, the "conventional" and "automated" *Loading/Discharging speeds*, as well as the relevant *Automations' Costs (in case of studying a ship-oriented automation system).*

After completion of the scenario setup screens, the program starts computing all the necessary terms in order to define the Net Present Value of the 'Automated' versus the 'Conventional' system. The results' screen contains both the Scenario Characteristics and the Results. A sample of a results' screen for a case of a Bulk Carrier of 5301 GRT is shown in the Figure 1.

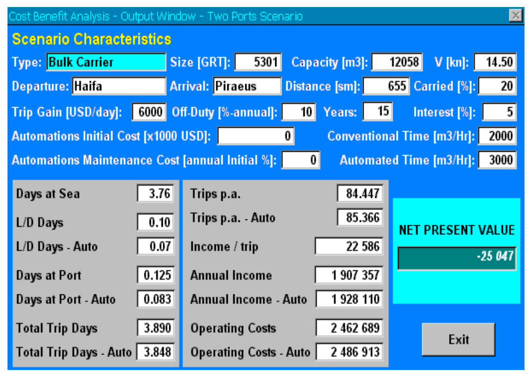

Figure 1: ACOSTOS ™ result screen for the "two ports scenario"- The case of a Bulk Carrier

Multiple-Ports-Scenario

On the "*Multiple-Ports-Scenario*", the user defines initially the number of ports he wishes to examine in the scenario. ACOSTOS™ can manage a scenario of 3 up to 10 ports. In each case, the user defines the ports as well as the calls sequence. The available ports are retrieved from a database with various port data, which has been created for determining ports, port cost and distances between ports. The user also defines the cargo characteristics at each port. The tool gives default values for all data needed, however the user has the ability to specify each and every value separately. The cargo characteristics are: *Loading/Discharging Capacities* on both directions (Port 1 → Port 5 and Port 5 → Port 1), relevant *Charter Rates*, as well as "*Conventional*" and "*Automated*" Loading/Discharging speeds for each port. On the screen, the vessel's total capacity is also displayed. In the case of Container Carriers, the scenario concept assumes that the ship may be loaded and/or discharged at every port, having only two constraints: i) The total number of TEUs onboard at any time should not exceed the vessel total TEU Capacity, and ii) at the final port in each direction, the ship should discharge all TEUs in order to complete the one-way trip. Hence, the relevant Cargo Characteristics Definition Screen is slightly different for Container Carriers, and is divided in two parts: Loading/Discharging TEU Capacity Definition and Ports Times Definition . On the first one, *Loading/Discharging* data are defined for both directions (Port 1 → Port 5 and Port 5 → Port 1) while on screen, the vessel maximum TEU capacity is displayed. If the user enters data that does not match the concept assumptions described earlier, there's an error message prompting for corrections.

On the second one, the user defines both "*Conventional*" and "*Automated*" Loading/Discharging speeds for each port. The 'conventional' and 'automated' speeds are defined as described earlier as well as the relevant *Automations' Costs (in case of studying a ship-oriented automation system)* By now, the scenario setup has been completed, and the program continues with the Net Present Value calculations. An extra utility is available to the users in order to view the previously ran scenarios. A sample of a results screen for a Container Carrier is shown in Figure 2

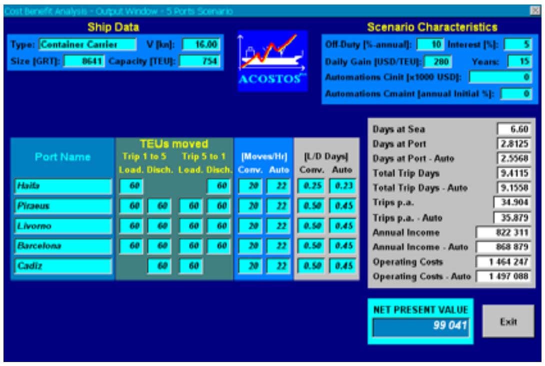

Figure 2: ACOSTOS TM result screen for the "multiple ports scenario" – The case of a Container Carrier

RUNS OF THE SOFTWARE

Some sample runs of the electronic tool were done for 10 ships. These ships are: 3 Container Carriers, 2 General Cargo ships, 2 Tankers and 2 Chemical Carriers. The information needed for these ten ships was provided by Greek Shipping companies.

Table I provides some general information about these ships, while Table II shows the number of vessels' trips per year for the conventional and for the automated case. Table III shows the results of the ACOSTOS TM (NPV) for the selected ships.

	SIZE (GRT)	GRAIN (m^3)	TEU (No)	SPEED (knots)
Container Carrier	5096	0	260	13,75
Container Carrier	8908	0	976	17,2
Container Carrier	23291	0	1234	19
General Cargo	1508	2797	0	10
General Cargo	15446	30923	0	18
General Cargo	26942	42223	0	14,5
Chemical Carrier	5547	5512	0	14
Chemical Carrier	26113	44819	0	14,5
Tanker	5547	5512	0	14
Tanker	26113	44819	0	14,5

Table I : General Particulars of the selected vessels

	CONVENTIONAL TRIPS PER YEAR	AUTOMATED TRIPS PER YEAR
Container Carrier	56,01	57,7
Container Carrier	31,92	34,07
Container Carrier	20,89	22,56
General Cargo	58,62	59,13
General Cargo	70,75	80
General Cargo	55,09	62,81
Chemical Carrier	78,48	80,31
Chemical Carrier	53,86	61,74
Tanker	11,82	11,86
Tanker	11,37	11,69

Table II: Number of trips per year for the conventional and for the automated status.

	NPV (US$)
Container Carrier	419501
Container Carrier	4659635
Container Carrier	5982420
General Cargo	170999
General Cargo	3304021
General Cargo	3082156
Chemical Carrier	891556
Chemical Carrier	4647216
Tanker	141800
Tanker	1603835

Table III: ACOSTOS `TM results for the selected vessels

Figures 3,4,5and 6 illustrate the ACOSTOS `TM results for the selected vessels in a graph format.

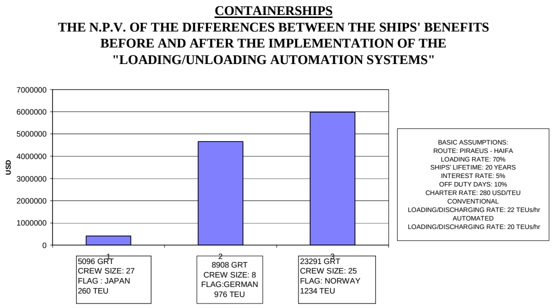

Figure 3: The ACOSTOS^{TM} results for the selected Containerships

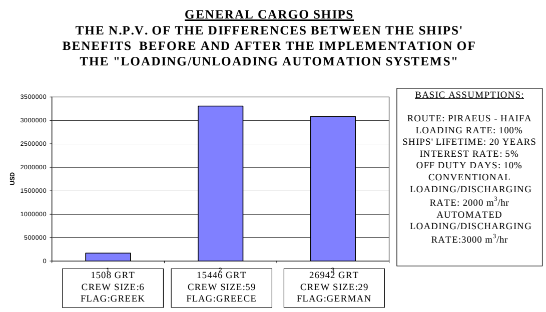

Figure 4: The ACOSTOS^{TM} results for the selected General Cargo Ships

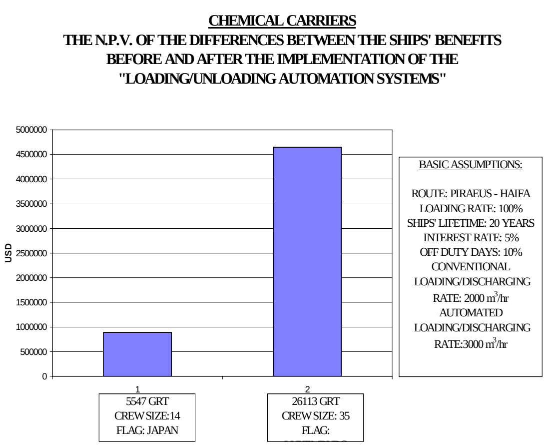

Figure 5: The ACOSTOS^{TM} results for the selected Chemical Carriers

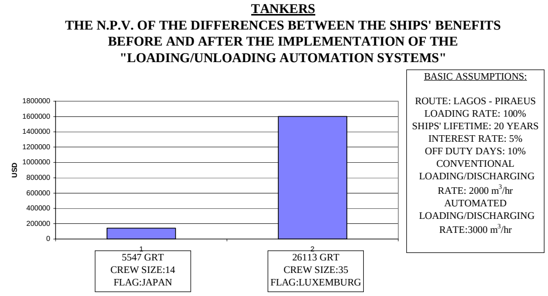

Figure 6: The ACOSTOS^{TM} results for the selected Tankers

CONCLUSIONS

In general, the focus has been set on loading and discharging systems, as these systems can strongly influence the competitiveness of a ship. A method has been proposed which allows the detailed evaluation of the relevant costs and benefits. Moreover, a software application has been developed in order to test the methodology on a series of vessels.

For the purposes of the cost-benefit analysis, it has been decided that instead of analysing *vessel-based systems*, an analysis of benefits for port-based systems (if such benefits in fact exist) has been done. Please note that the software has been developed in order to be able to analyse vessel-based systems too.

"ACOSTOS^{TM}" is the name of an electronic tool that was created in order to calculate the benefits of using an "automated" loading/ discharging system instead of a conventional one either based on port or based onto the ship itself.

The most significant result from the analysis can be that the time the ship spends in an automated environment port is reduced for all ship types. This ranges from about 10% for a containership to about 50% for other ship types. Therefore, a ship may use more days per year for transporting cargo and, thus, there is a corresponding increase in her number of round trips per year as shown in Table II. A tanker has a very small increase, a container ship will average a 5% increase but this may be more substantial for a general cargo vessel that may reach 15%. Assuming also that there is a fixed number of off duty days, this means that there is a definite increase in the ships carrying capacity. Therefore, there will also be an increase in the ship owner's total income, which ranges from 5 to 7% for a container ship to 14% for general cargo ships, although much less is expected for a tanker. On the other hand the increase of round trips per year has a definite effect on the ship operating cost and on the Diesel and fuel oil consumed.

The result of the above is an increase of the owner's annual profit when he opts for an automated situation. The Net Present Value over the ship lifetime of this difference is given in the Table III. As it can be seen, it ranges from about US$ 150,000 to about US$ 5,000,000 depending on the ship type and size. In the cases we examined there was always a small but evident increase on the annual profits and this looks promising.

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