

## THE OPTIMIZATION OF THE GREEK COASTAL SHIPPING TRANSPORTATION NETWORK

**Konstantinos Chainas**

*Athens University of Economics and Business*

---

*This dissertation presents a heuristic algorithm that improves the coastal network in the Greek Aegean Sea. The Greek coastal shipping - except for its specific role for Greek tourism - becomes of utmost importance after the decision of the European Union to reinforce, for special reasons, the short-distance shipping. This dissertation suggests and describes a methodology for the re-planning of the coastal network of Greece and aims to develop a new model of the coastal shipping network in Greece. This model is documented by the heuristic algorithm for improvement, the NAUTILUS. This algorithm drastically improves the travel times for the Aegean destinations and poses the terms and conditions for the materialisation of a Complete Decision System, for the overall improvement of the Greek coastal shipping.*

---

**Keywords:** *optimization, algorithm, tourism, coastal network, transport*

JEL Classification: *L83, M1, O1*

### INTRODUCTION

The concept of optimizing the coastal transportation takes on a different meaning, depending on the aspect from which one sees improvement and the criteria they set. For a coastal shipping company, which wants to cover a certain island area, the optimal route would be one that could cover the market demand efficiently and effectively taking advantage of its entire fleet by scheduling the appropriate ship type to the respective route; even when a route yields the maximum possible economic results at a minimum cost. Many islands do not provide a commercial interest to coastal shipping companies' owners because, on

---

© University of the Aegean. Print ISSN: 1790-8418, Online ISSN: 1792-6521



Except where otherwise noted, this work is licensed under  
<http://creativecommons.org/licenses/by-nc-nd/3.0/>

one hand, they have few inhabitants and, on the other hand, they are not favourite tourist destinations. This is why the government intervenes with policies, such as subsidising the companies who will cover the connection of these islands with the mainland or with bigger islands' so as to cover the minimal transportation needs of both the islands' inhabitants and the travellers'. The algorithm that is introduced here, named *NAUTILUS*, was applied in the coastal transportations of Greece, for the coastal coverage of the Aegean Islands, according to the routes that took place from June to August 2009, for each island and the coastal ships fleet used. The routes which were created based on the *NAUTILUS* algorithm were compared with the routes which had taken place in the same period in the specific area, as regards the total mileage and, in effect, the overall travel time.

## **THE GREEK COASTAL MARKET**

Greece is a country with 15.000 km of coastline and 115 inhabited islands out of a total of 3.500 islands and islets, 95 of which have some sort of regular connection with the mainland. The Greek coastal market is one of the biggest in Europe, with approximately 45 million passengers every year and with 25% of cargo transportation. The passenger ships of the country, which are above 1000 tons, comprise the 7% of the world fleet of passenger ships. There are 350 coastal shipping routes that serve the Greek islands with their connection to the mainland. The Greek government subsidises 85 of them, as there is no commercial interest by the coastal shipping companies for these destinations. It is also a goal for the tourism industry to integrate contemporary technological ways into the decision making systems used, in order to utilize on time the information related to the market (Kanellopoulos, 2006). The demand for coastal shipping services is extremely seasonal, with 50% of the passengers travelling during the third trimester of each year, when there is a peak in the country's tourist industry. The cargo transport by ferryboats is not equally seasonal because the islands they serve, have had considerable economic growth over the last 35 years, and, at the same time, their population had risen by 10% in 2007 compared to 1980. Undoubtedly, this growth is not independent from the level of the services supplied (Papanastasiou, 2006).

## **The network of Greek coastal transportation in the Aegean**

The Greek coastal transportation network has changed only a little whereas many other factors have changed. These factors are related to the demand and the service quality of the inhabitants as well as the visitors of the Aegean islands (Psaraftis, 2006).

### **Basic characteristics of the present network**

The Law 2932/2001 was voted in order to harmonize the Greek status quo with the directives of European Union regulation 3577/92, which determines the “liberation” of the coastal shipping market. It delineates a network, which is referred to as indicative, but, essentially, it is the network that has been in operation until today with only a few changes and additions (Chlomoudis, 2007).

The main structure of the present coastal shipping network is a serial connection, for the majority of the islands, with the port of Piraeus. This type of network impedes the planning of optimal connections and poses restraints to flexible and alternative routes. Thus, many routes take too long and are very tiresome.

## **ABOUT THE PROBLEM OF OPTIMISING THE COSTAL SHIPPING OF THE AEGEAN**

### **General**

In a Decision System that processes the coastal transportation, the quest for an optimal route lies in a few basic factors. These factors differ, depending on the aspect from which the optimization criteria are determined. Therefore, a coastal shipping company seeks: a) To have all their ships active no matter what the season is, b) To have their ships able to cover routes with continuous and increased demand so that they can minimize the time they stop ships to operate, and c) To be able to select routes with greater yield.

### **The factors influencing a ship route**

A ship route is influenced by: a) The departure port, b) the destination ports c) the travel time, d) the invariable and variable cost of a specific ship which covers a specific route, e) the number of passengers

and vehicles it can carry during the route, g) the services offered, h) the transport cost for a passenger or vehicle, i) the fleet of ships which are available, j) the maximum speed a ship can really travel at, k) seasonality and different demand, l) the weather conditions of each period and their influence on the route schedule, n) the cultural habits and traditions of each island which diversifies the demand each period.

### **Limitations linked with the optimisation of a route**

There are some limitations regarding the optimisation of a route, and some of them are: a) The total distance covered cannot be unlimited, b) the coverage of an area which includes small and bigger islands, with different needs, c) the demand for coastal shipping services, which is not stable and can vary depending on the conditions of uncertainty, d) the demand of the seasons; in other words, the different models of scheduling that should be implemented depending the season, e) the category of the available ship and its special characteristics, such as its capacity, its speed, f) the “time windows” between a ship’s arrival at and departure from each destination port, g) the passengers and the infrastructure of each departure port and its service capabilities of any type and category of ship, as well as the passengers who are interested, h) the class of each destination port and its reception capability of any type and category of vessels, i) the fare which is determined each time for each destination and the services it covers.

### **The subtleties of the Aegean coastal shipping in relation to other distribution systems**

The underlying subtleties of coastal transportation in relation to the typical problem of finding the shorter route (e.g. distribution problem or the Problem of a Travelling Salesman (TSP) is as follows:

a) Regarding the islands for which there is no commercial interest, the government is forced to put them on the scheme of Public Service Routes. The result of this is a multiple framework, with islands even in the same area and, indeed, within a short distance from one another; some of them, and because of high demand, are covered by routes formed by the market and others, because of low demand, need to be covered by Public Service Routes (e.g. the Cyclades).

b) The implementation of each route should have a stable time sequence and regularity for each port, since the people that travel between different destinations should not waste time, waiting at the boarding port.

c) The time each ship stops at each port has some limitations, depended on the infrastructure of the port, the number of embarking and disembarking passengers and vehicles and the ability to accommodate more than one ship at the same time.

d) Each port is served by a specific ship of one or more companies, depending on the declarations of route that each company has registered for each port.

e) There is a specific weekly route regularity for every ship and every port, which is determined either by the government (for the Public Service Routes), or by any shipping company.

f) The fleet of ships of each company includes different ship types, thus, different capacity, size, services, speed, etc.

Based on the above-mentioned peculiarities, the problems of coastal shipping are complicated enough, in order, to develop a heuristic algorithm named *NAUTILUS*, which can give us optimal solutions at polynomial times.

## **IMPLEMENTATION OF THE HEURISTIC ALGORITHM FOR OPTIMAL ROUTING (*NAUTILUS*)**

### **Methodology**

The implementation of the *NAUTILUS* Algorithm was based on heuristic methods. The procedure followed is this:

We registered all data concerning the ports, the islands, the distances, the demand (no. of passengers from 1994 to 2008), the coastal fleet, the type of each vessel, its transportation capacity, its speed, the traffic of ports and a series of other data we collected from the Greek Statistical Service, on a relational database. The comparison period that was chosen for all applications was the third trimester of the year 2009, for the coastal transportations of the Aegean Sea.

The categories of optimization we dealt with were of four kinds:

a) The quest for an optimal central departure port, based on the current routes that cover the islands of the Aegean Sea. We compared the current routes with Piraeus as the departure port, with routes where we used other mainland ports.

b) The quest for optimal routes with the minimum travel time as a criterion, for specific destinations with specific weekly frequency. We considered as a central departure port the one that resulted from the previous procedure for every area of the Aegean Sea. We implemented the *NAUTILUS* algorithm for the creation of optimal routes for the islands of Cyclades. These routes were compared with the routes of the third trimester of 2009.

c) The quest for the optimal type of ship for specific destinations. Based on the lines and the routes which were created through the previous procedures and, also, in order to meet the demand for specific destinations that gave us the most appropriate type of ship for each route (capacity and speed of ship).

### **Modelling the problem**

The problem of coastal shipping of the Aegean Sea is a hard one with a non-polynomial solution (NP - hard), in the sense that with the conventional algorithms of seeking the optimal route, its solution becomes especially difficult and in exponential times. With this data we transformed the problem so that we can have a polynomial solution. For the formation of the objective function, we define:

- $K$ , the total number of ships  $\{1,2,3,\dots, K\}$
- $q_k$ , the capacity of each ship
- $N$ , the ports in the search area  $\{1,2,3,\dots,N\}$
- $m_i$ , the demand for each port
- $c_{ij}$ , the cost of connection of two ports  $i$  and  $j$
- $t_{ij}$ , the time of each connection of port  $i$  with port  $j$

We took under consideration, the following:

- Each route departs from the central departure port (starting point).
- The number of routes is the same as the number of ships.
- The demand of every port is depended from the ship's capacity.
- Every ship of a certain route goes to each port only once.
- The time for a ship to stop at each port is called the servicing time of the ship and the aim is to minimize it. In the *NAUTILUS* algorithm, we defined a value  $t$  equal to  $\frac{1}{4}$  of an hour, which is a logical time for disembarking and embarking of passengers and/or vehicles.
- The route must be completed within a specific time ( $<24$  hours).
- We define  $X = \{x_{ijk}\}$   $i, j = 1,2,3,\dots,N$  and  $k=1,2,3,\dots,K$  with  $i \neq j$

- With  $x_{ijk}=1$  if a ship  $k$  connects port  $i$  with port  $j$
- And  $x_{ijk}=0$  different

The problem is the minimization of the objective function

$$F = \sum_{i=0}^N \sum_{j=0}^N \sum_{k=1}^N C_{ij} X_{ijk}$$

Limitations :

a.  $K$  ships leave from the central departure port

$$\sum_{i=1}^N \sum_{j=1}^N X_{jk} = k$$

b. Only one ship at each destination port

$$\sum_{k=1}^N \sum_{j=1}^N X_{ijk} = 1, i = 1, 2, 3, \dots, N$$

c. The total capacity smaller than, or equal to the overall demand

$$\sum_{i=0}^N m_i \sum_{j=0}^N X_{ijk} \leq q_k \forall k \in [1, K]$$

For the simplification of the problem and the application of the algorithm to the routes, which were implemented in the area of the Cyclades during the third trimester of 2009, we consider that the ships are of the same type, in other words, they have the same speed and capacity and can meet the demand. These considerations simply help us to present the algorithm in a better way, as after this they can be included in a second stage of optimization of the routes, which will be created in the first stage. For the formation of the new simplified objective function we define:

- $P_i$ ,  $i=1, 2, 3, \dots, N$  the number of ports to cover
- Each Port has specific coordinates  $(x_{kpi}, y_{lpi})$ ,  $i=1, 2, 3, \dots, N$
- $p_d$ , the first departure port of each route
- $p_a$ , the final destination port of each route
- $d_{ij}$ , the distance of the  $P_i$  Port from the  $P_j$  port
- $x_{ij}$  the decision parameter
- where  $x_{ij} = 1$  when the port  $i$  belongs to route  $j$
- and  $x_{ij} = 0$  otherwise

The Objective function takes this form:

$$\sum_i^N \sum_j^N d_{ij} X_{ij}$$

Our goal in its minimization

Limitations :

When all ports belong to the same route

$$\sum_j X_{ij} = 1, j=1,2,3,\dots,N$$

In order for the route to be financially sustainable, the demand for the ports is less than the maximum capacity of ships and more than the minimum.

Based on this model, the optimization is implemented taking into account the stage that the total distance is travelled. Also, the total of optimal routes that were selected based on the total distance; one can define more parameters that were excluded in order to simplify the algorithm, such as the demand of each island in conjunction with the capacity and the speed of the ship. This way, we can have more optimization stages, which will result in the optimal routes with multiple optimisation criteria.

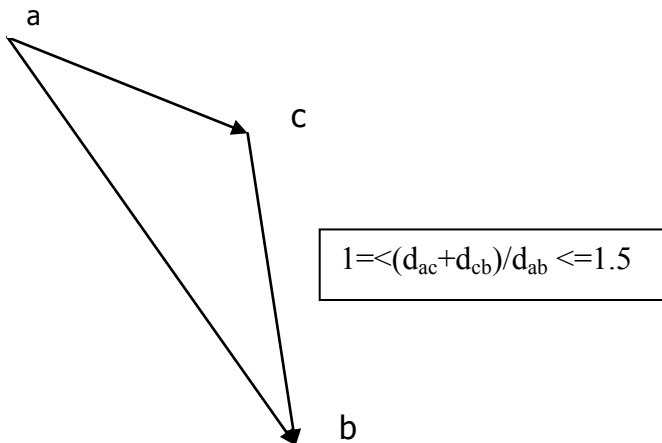
### Basic concepts and assumptions used

- Departure port is the port that the route starts from ( $p_d$ ).
- Destination port is the port where the journey will end, which cannot be the same as the departure port ( $p_a$ ).
- The time that a ship remains at an intermediate port for disembarking-embarking ( $t_w$ ).
- Total travel time is the time the trip takes ( $t_s$ ).
- Connectivity value of three ports (a, b, c). We have two ports a, b, with a distance  $d_{ab}$  between them and we wish to intercalate a third port c, which has a distance  $d_{ac}$  from a and a distance  $d_{cb}$  from b. The quotient of the division  $(d_{ac}+d_{cb})/d_{ab}$  is called connectivity value. This value is compared with a parameter, which takes values in the space [1.1,1.5], depending on whether we want a smaller or bigger divergence from the route defined by the connection AB. Thus, if the connectivity parameter takes the value 1.1 we have the so-called inflexible connectivity and in this case this route ac-cb diverges relatively little compared to



route ab, while if it takes the value 1.5 we have the so-called flexible connectivity and in this case route ac-cb diverges more than route ab. Obviously, fewer ports take part in the 1<sup>st</sup> case, while more in the 2<sup>nd</sup> one. We consider that the algorithm is applied to short sea distances (coastal shipping), because in longer ones we would need the length of the sea arches, which would require a different approach.

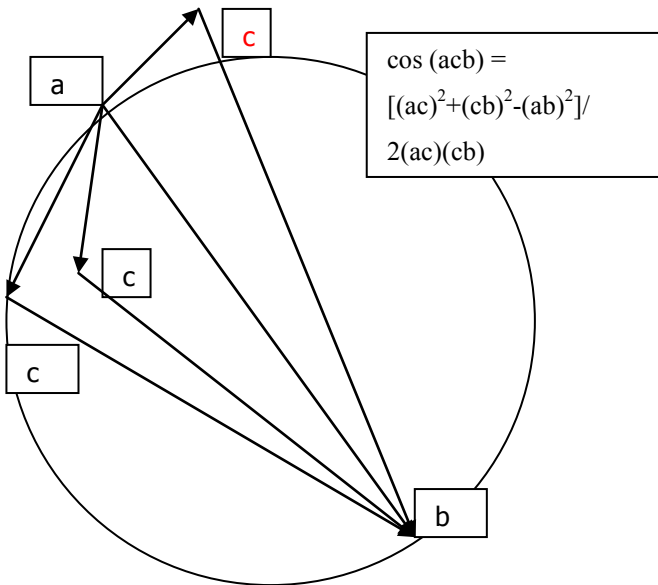
**Figure 1** Schema of two ports a, b, and the intercalation of a third c, according to the value of connectivity



Scanning angle is the angle which is formed by the points of the two ports a and b after the intercalation of port c, in other words the angle acb. This angle takes values from 90° to 180°, that is, the top of the angle lies within the so-called scanning circle. A scanning circle is the part of the circle, which is formed every time in the procedure of connecting two ports a and b, and the intercalation of the third port c. The diameter of this circle is the distance  $d_{ab}$ , that is, the distance between ports a and b. The third port will be searched for in the circular area formed, the centre of which lies in the middle of distance  $d_{ab}$  and its ray is  $d_{ab}/2$ . This limitation gives a direction to the route from port a to port b, as it rejects connections which will be outside the circular area and prevents

“setbacks” in the routes. The limitation is secured by measuring the cosine of angle  $acb$  from the lengths of the sides of triangle  $abc$ , applying the cosine theorem for angle  $acb$ . In other words, we calculate value  $\cos(acb) = [(ac)^2 + (cb)^2 - (ab)^2] / 2(ac)(cb)$  and decide if we will accept the intercalation of port  $c$ , or not, if the value of the cosine is smaller than or equal to zero. This value assures that port  $c$  lies within the circular area, which is formed, based on the distance  $ab$ . The values that the scanning angle can take is in the space  $[90^\circ, 180^\circ]$ ; values which make sure that port  $c$  lies within the circle which has the distance  $ab$  as its diameter.

**Figure 2** The circular area for searching intercalated ports



### Steps of the *NAUTILUS* algorithm for optimal routes

STEP ONE: Provide the departure port ( $p_d$ ), the destination port ( $p_a$ ), the search area, the connectivity parameter of three islands, the time the ship stops at the port ( $t_w$ ), the speed of the ship ( $v_s$ ). The original table of

optimal routes is the table, which has the ports of departure and destination.

STEP TWO: Loading all the ports of the search area onto a table  $p[1..n]$  except for the ports in the table of optimal route, which are arranged based on the distance from the departure port. Selection of the  $p_i$  port (FOR  $i=1$  to  $n$ ).

STEP THREE: Check the connectivity parameter of this port ( $p_i$ ) with the ports of departure ( $p_d$ ) and destination ( $p_a$ ). If the value of connectivity of the three islands ( $d_i = (d_{di}+d_{ia})/d_{da}$ ) is smaller than or equal to the connectivity parameter we inserted  $d_s$  (that is, if condition  $d_i \leq d_s$  is valid). At the same time, estimate the travel time from the departure port to the port  $p_i$  ( $t = t + t_{wi} + t_i$ ), taking into consideration the time the ship stays at each port ( $t_{wi}$ ). If the condition is valid for port  $i$  then put this port ( $p_i$ ) into the table of optimal routes. Otherwise, go to STEP 2 and continue with the next port until you find a port for which the connectivity condition is valid.

STEP FOUR: We check whether the new port belongs to the scanning area. We check if the intercalated port  $p_i$  for which the value of connectivity is valid belongs to the circular area, which has the distance between the two, ports  $p_d$  and  $p_a$  as its diameter. If this is true, put port  $p_i$  into the table of optimal routes. Otherwise, go to STEP B and continue with the next port until you find the port for which the connectivity condition is valid, and belongs to the scanning area.

STEP FIVE: The same procedure is repeated for all the ports in the search area, checking for those for which the connectivity parameter is valid, thus forming the final lists of the ports of an optimal route.

STEP SIX: Arrange the final lists of optimal routes based on the total time distance.

## **RESULTS FROM THE IMPLEMENTATION OF THE NAUTILUS ALGORITHM**

### **Optimal Selection of Central Departure Ports**

As regards the optimal selection of central departure port, the Aegean Sea was divided into three areas: North-East, Central and South Aegean. For the North-East Aegean the optimal departure port proved to be the one of Kymi, (Table 1) while for the areas of Central and South Aegean, the optimal departure port proved to be the port of Lavrion (Table 2). The issue is that, firstly, the present infrastructure of these ports is insufficient

to assume such a role and, secondly, the access to these ports has many limitations (road and railway network, etc.). In order to assume this role in the future, the government needs to take strategic decisions, which will allow the funding of the necessary infrastructure construction for these ports.

**Table 1** Comparison of travel time (Piraeus vs Kymi)

Serial number	Coastal shipping routes (July 27 <sup>th</sup> , 2009)	Difference (%) Piraeus vs Kymi
1	Chios – Mytilene	-46%
2	Icaria – Samos	-14%
3	Mytilene	-54%

**Table 2** Comparison of travel time (Piraeus vs Lavrio), Cyclades and Dodecanese: Lavrio

Serial number	Coastal shipping routes (July 27 <sup>th</sup> , 2009)	Difference (%) Piraeus vs Lavrio
1	Paros, Naxos	-35%
2	Sifnos, Folegandros, Thera	-22%
3	Ios, Thera	-25%
4	Syros, Tenos, Mykonos	-35%
5	Paros, Naxos, Thera	-38%
6	Cythnos, Serifos, Sifnos, Kimolos, Melos	-26%
7	Paros, Naxos, Mykonos, Tenos	-24%
8	Serifos, Sifnos, Melos	-24%
9	Syros, Tenos, Mykonos	-35%
10	Paros, Naxos	-35%
11	Cythnos, Serifos, Sifnos, Kimolos, Melos, Folegandros, Sikinos, Ios, Thera, Anafi, Thera	-13%
12	Sifnos, Folegandros, Thera, Katapola	-22%
13	Syros, Mykonos, Tenos	-32%
14	Syros, Mykonos, Patmos, Leros, Calymnos, Kos, Rhodes	-11%

15	Thera, Ios	-19%
16	Paros, Naxos, Mykonos, Tenos	-23%
17	Paros, Naxos, Egiali, Astypalea	-17%
18	Serifos, Sifnos, Melos	-24%
19	Melos, Thera, Heraklion, Seteia, Cassos, Carpathos, Diafani, Halki, Rhodes	-5%
20	Syros, Kos, Rhodes	-12%
21	Paros, Naxos, Agios Kerykos, Fouri, Karlovasi, Vathi	-15%
22	Paros	-42%
23	Mykonos, Evdelos, Carlovasi, Vathi	-16%

### Optimal routes for the Cyclades area

The optimal routes created for the Cyclades area by using the *NAUTILUS* algorithm were compared to the real routes that are implemented based on the present system. The results are shown in Table 3.

**Table 3** Optimal routes created for the Cyclades area by using the *NAUTILUS* algorithm

Code	Optimal routes	miles	Opt1	Opt2
1	PIRAEUS-SERIFOS-KIMOLOS-MELOS	100	9%	10%
2	PIRAEUS-PAROS-IOS	117	25%	
3	PIRAEUS-SIFNOS-KOUFONISI	114	76%	
4	PIRAEUS-SYROS-MYKONOS	95	11%	
5	PIRAEUS-IOS-THERA	128	0%	4%
6	PIRAEUS-SYROS-THNOΣ	89	25%	
7	PIRAEUS-KIMOLOS-FOLEGANDROS	108	0%	8%
8	PIRAEUS-NAXOS-AMORGOS KATAPOLA	135	15%	
9	PIRAEUS-IOS-THERA-ANAFE	148	17%	
10	PIRAEUS-SIFNOS-KIMOLOS	91	49%	

## **Selection of optimal ship type**

The recommended ship type for the central routes that connect the central ports with the basic hubs are the ones that are big, fast and of new technology. But, for the intermediate routes the smaller and fast ships are more preferable. Based on the hub and spoke model, the algorithm gave us the following results for the Aegean Sea: a) For the connection of the hub-ports of the Cyclades (Paros-Naxos, Syros-Myconos, Milos-Santoniri) with the departure port the recommended optimal ship types are the big, modern and fast passenger-vehicle ships (30 knots speed, 2.000 passengers, 150 cars and lorries 1.700m in length). b) The same ship type is recommended for the coverage of the islands of the North Aegean and the hubs of the Dodecanese (Rhodes, Kos) as well as the ports of Crete. c) For the connection of the islands of the Cyclades and the Dodecanese with the hubs of these areas, we recommend the smaller, fast ships (40 knots, 850 passengers, 100 cars and lorries 120m in length).

## **CONCLUSIONS**

The coastal transportation in Greece comprises a complex field of study, connected to historical, geophysical, cultural and political factors. Greece has one of the most powerful shipping and transportation industries in the world, and is a member of the European Union. It has taken decisive steps towards the modernization of the institutional framework, which concerns the function of coastal shipping. Needless to say that more steps have to be taken to that direction and one of them is the full delineation of the operation rules of the coastal market. Also, the Greek Government is responsible for the implementation of specific development projects regarding the infrastructure of ports and the whole system of coastal transportation. Government investments, in combination with the introduction of other measures, can provide the coastal shipping companies with motivation to modernize their fleet with each ship type that is required and to meet the special needs of the Greek islands.

The optimization algorithm *NAUTILUS*, for optimal coastal routes, which was presented in this study, can help the coastal shipping companies significantly in order to select the most lucrative routes and schedule their ships more efficiently. The main characteristics of network evaluation will be the effective coverage of the demand, the existence of alternative solutions regarding the cost and duration of a trip, the utilization of each ship type for meeting the demand under special

circumstances and the appropriate handling of emergencies. Also, the selection of two new ports, as basic ports for connecting the mainland with the islands, which was documented by the *NAUTILUS* algorithm, is another suggestion of the present study; on condition that the necessary infrastructure is implemented and their connection with the rest of the national transportation system (road, railway, airports) is ensured.

Issues for further study is the design and implementation of a complete system of coastal shipping scheduling, based on the suggested, in the present study, structure of the network. In addition, it is important to design and implement a software application for optimal routes based on the *NAUTILUS* algorithm, which will provide the Administrators with a powerful tool.

Another sector that could employ the algorithm is the sector of selecting a homeport for the cruise companies acting in the Aegean Sea (Lekakou, 2009).

Finally, it is a matter of great importance for the government to implement a Complete System of Decision Support for the sector of coastal transportations.

## REFERENCES

- Chlomoudis, K., Lekakou, M., Panou, K., Papademetriou, E., Syriopoulos, Th. & Jannatos, E. (2007). *Transportations - Life arteries for the islands*. Athens, ITA Publications.
- Kanellopoulos, D. (2006). The advent of semantic web in tourism information systems. *Tourismos*, Vol. 1, No.2, pp.77-93.
- Lekakou, M., Pallis, A. & Vaggelas, G. (2009). Which homeport in Europe: the cruise industry's selection criteria. *Tourismos*, Vol. 4, No.4, pp.15-29.
- Papanastasiou, J., Lazaridis I. & Noulas A. (2006). Tourists' preferences for quality of services: empirical investigation of Lesbos, Samos and Chios islands. *Tourismos*, Vol. 1, No.2, pp.95-101.
- Psarafitis, Ch.N. (2006). *Greek coastal shipping and Cabotage*. Athens, Evgenides Foundation Publications.

*SUBMITTED: DEC 2010*

*1st REVISION SUBMITTED: APR 2011*

*2nd REVISION SUBMITTED: JUN 2011*

*ACCEPTED: JULY 2011*

*REFEREED ANONYMOUSLY*

Konstantinos Chainas

**Konstantinos Chainas** (xainas@otenet.gr) is a Candidate Phd at Athens University of Economics and Business, Department of Informatics, 76 Patission Str., GR10434 Athens, Greece.