Proposal for short sea commuter transportation system for Alexandria north coast

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Recent serious efforts had been done to ease the traffic problems in Alexandria. These efforts aimed at relieving the traffic congestion particularly in the city centers. This was done by broadening the main coastal road through removal of old chalets and buildings, reclaiming parts of the sea, and, construction of bridges. The results are highly appreciated by Alexandria inhabitants and visitors as well. However, these measures may be good as immediate and short term solutions. In few coming years, with growing number in both population and need for mobility we will be faced with the fact that similar efforts to relieve traffic congestion are no longer possible. No more other buildings or chalets to remove and no more sea area to reclaim without harmful effect on the environment. Solutions based on bridges and tunnels are quite expensive and not very practical particularly in crowded urban cities. Hence, we have to look for unconventional solutions. The only solution as suggested in this work, is to use short sea transportation. A proposed study is given here where a specific sea route is selected as well as the particulars of the suitably assigned vehicles. The impacts of the new sea route on the environment are estimated and compared to those of existing inland routes.

تم مؤخرا بذل جهود كبيرة للتخفيف من مشاكل المرور في مدينة الإسكندرية وخصوصا الأختناقات المرورية في مناطق وسط المدينة وميادينها. تمثلت هذه الجهود في توسيع وتعريض الشوارع الرئيسية الساحلية وذلك بإزالة المباني والشاليهات القديمة والتي كانت تعوق المرور فضلا عن حجب الرؤية عن البحر كذلك بردم أجزاء من البحر وإنشاء بعض الكباري العلوية. وقد قوبلت هذه الجهود بترحيب وتقدير من قبيل كل من قاطني الإسكندرية وزوارها علي السواء. وعلي الرغم من هذا الترحيب وحل مشكلة المرور فان المشكلة ستظهر وتتفاقم مرة أخرى في غضون سنوات قليلة من الآن مع الزيادة المضطردة في عدد السيارات وكذلك عدد السكان والزوار وعندئذ لن تفلح آية إجراءات مماثلة لما تم في السابق لحل أو التخفيف من حجم المشكلة حيث انه لم يعد هناك مبان أو شاليهات أخري لإزالتها أو مناطق بحرية لردمها دون التأثير علي البيئة البحرية وعليه فانه التفكير والبحث عن حلول أخرى غير تقليدية يصبح أمرا لا مفر منه. في هذا البحث تم تقديم مقترح بإنشاء خط ملاحي بحري يربط بين نقطتين علي ساحل المدينة ويقوم بالعمل علي هذا الخط عدد من الوحدات البحرية السريعة وقد تم دراسة أداء هذه الوحدات مع توصيف لأبعادها الرئيسية وقدراتها كما تم دراسة الأثر البيئي لمنظومة الخط البحري المقترح بما في ذلك الوحدات العاملة ومقارنة هذا الأثر مع الخطوط البرية المماثلة .

Keywords: Sea commuter, Alexandria, Sea route

1. Introduction

Alexandria is Egypt's second capital, and a main sea side resort in summertime. It is home to 40 per cent of the nation's industry and 50 per cent of the petroleum industry**.** Alexandria is also the home of quite a number of museums, monuments, harbors, terminals, airports, universities, and culture centers. Alexandria's population is around 5 millions. In summer, two million vacationers visit the city and this number is expected to increase in the coming years.

Through the seventies and the eighties of the past century, Alexandria suffered from negligence, forcing many holidaymakers to abandon the city. Streets designed to accommodate less than 100,000 cars are required to serve more than 355000 cars which means that the city has run out of roadways.

By the turn of the century, comprehensive campaign was launched for renovation, beautifying, easing traffic congestion problems in Alexandria, and putting the city once again on the international map.

The seaside boulevard was broadened. Removing the ugly old chalets that used to obstruct the sea view increased the width of the Corniche. The project turned most of the

19 km long, 14-metre-wide, two-lane road into a 21-metre-wide, six-lane avenue.

2. Short sea transportation

Currently Alexandria is served by a number of public transportation systems. These are AbouQir train, Ramel tramway, buses, microbuses, and town tramway. Two main roads serve the city. These are corniche bullevouar and Horeya Avenue; fig. 1. Recent statistics show that over 50 millions commutes annually along the coast line, that is 140000 daily [1].

A study [2] was done to improve the existing traffic system in Alexandria. Through a number of strategies to reorient the transport system, a number of measures were proposed to improve the environment quality, taking into account the growing number in cars and limited number of roads and parking lots.

Also with all efforts done to ease the traffic, no more road expansions are possible particularly in the high dense populated areas. Underground traffic system (study is already underway, being blocked by high costs and unavailable funds). Bridges also already proved to be a failure concerning cost and visual pollution.

Thus we are left with few options. Air traffic (e.g. Helicopter shuttles, small planes, telefreeks) is only suitable for a limited number of commuters besides being quite expensive. The only feasible solution is the use of short sea transportation where large masses can be moved cheaply and efficiently. This type of transportation is being employed in a number of countries [3,4].

A proposal for Commuter Sea transport system along Alexandria coast posses a number of promising advantages. It provides an addition supplementary link to existing land based transportation routes. It will also provide an attractive mean of transportation particularly for summer vacationers (over 2 millions) hence activating internal summer tourism. The weather along the coast is pleasant most of the year around. Sea routes don't involve extra or special infra structure. The proposed sea route could be expanded to cover and link other cities and villages along Egypt north coast which contributes to the development of these areas.

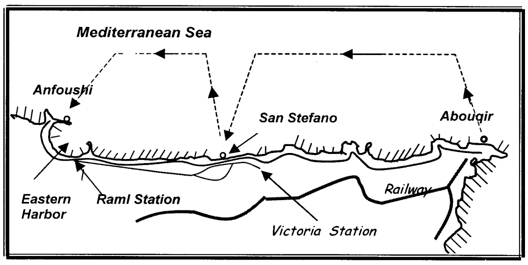

Fig. 1. Proposed maritime route and exisiting transport means (railway, tramway, and high way) between AbouQir and Anfoushi.

Case study: A New, maritime passenger short sea route to improve mobility and relieve congestion is suggested to be employed along the northeast Alexandria coast. The maritime route considered is planned to connect two main focal points of AbouQir and Qaitebay. Fig. 1. The distance by sea is about 25 km, to be covered in less than 30 minutes to be competitive with other existing transport systems. The choice of maritime route was based on the available data on existing land routes, available data on commuter origin / destination matrix between city districts / centers, and finally on environmental assessment of the proposed routes and comparison with presently used means of transport.

3. Proposed vehicles requirements

Marine vehicles to operate on the selected maritime route should fulfill a number of requirements. Referring to land based transportation means, the time of trip by sea should not be more than 30 minutes. Accordingly, the vessel speed will be around 50 km/hr (27 knots).

Considering the number of passengers per trip and how they will be seated (number of decks, seats per row, number of rows, number of isles; the seating configuration of the vessel), a preliminary estimate for the vehicle main dimensions is obtained as:

The number of required rows N_{rows} on the main deck is given as

$$N_{ROWS} = k\frac{N_{PASSENGERS}}{N_{seats/row}}. \quad (1)$$

Where number of seats per row $N_{seats/row}$ varies from 8 in a narrow form to 14 in a wide form vehicle. The factor k accounts for the number of levels to accommodate the passengers on the vehicle. k=1 for a single level vehicle and 0.6667 (or 2 thirds) for a two-level vehicle. This was based on having two thirds of the passengers on the main deck if two deck vehicle is employed.

The length L_s and B_s width of the seating area on the main vehicle deck is obtained from:

$$L_S = 1.35\, N_{ROWS}$$
$$B_S = 0.6 N_{seats/row} + 1 * N_{Isles}. \quad (2)$$

The formula allows for seat standard dimensions, inter seat spacing and ergonomic aspects for the passengers safety and comfort. Number of isles N_{isles} varies from 2 in narrow forms (mono hulls) to 3 in wide forms (catamarans). See fig. 2.

Having decided upon the main dimension of the seating area, the total length L and breadth B of the vehicle is

$$L = 1.5 L_S$$
$$B = B_S. \quad (3)$$

Again, the vehicle length is 50% longer to provide for lobby and service areas on the deck. Once the length and speed are known, the vehicle operating draft can be checked to ensure the type of vehicle best suited for the route under study. This is dictated by the vehicle speed length ratio or her Froude number Fn.

For the particular route under current study a high speed craft would be the most suitable candidate.

Using speed and length one can check the Froude number value to ensure a High Speed craft (HSC) vehicle. According to the IMO Code of Safety for dynamically supported craft 1977 [5] Froude's number should be greater or equal to 0.9. Hence

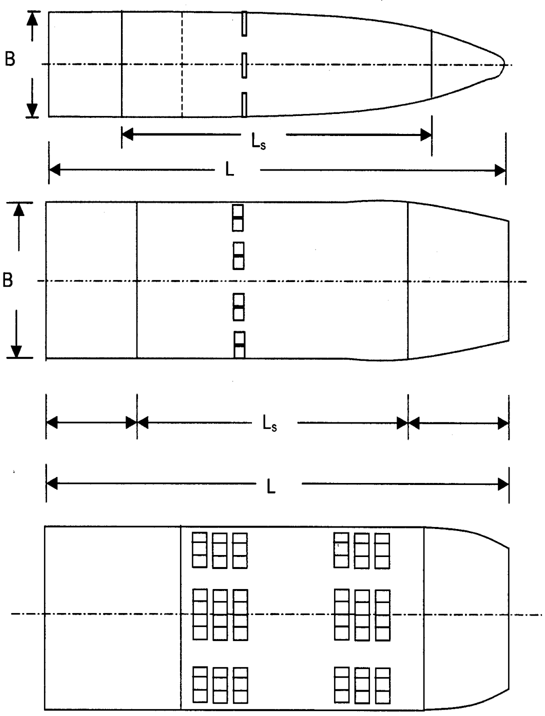

Fig. 2. Seating configurations.

$$F_n = \frac{V}{\sqrt{gL}} \geq 0.9\,. \quad (4)$$

A High Speed Craft (HSC) is also defined by having a construction coefficient C_{cc} not greater than 0.04 [6] where:

$$C_{cc} \equiv \frac{Displacement(ton)}{(LB)^{1.5}}. \quad (5)$$

Hence, the upper limit for the vehicle weight in tones is

$$W = 0.04(LB)^{1.5} \quad (6)$$

where Length L and breadth B are in meters

Volumetric Froude number $F_{n\nabla}$ is also used to categorize fast or HSC. According to IMO regulations F_{nv} should be not less than 1.181. This means that,

$$F_{n\nabla} = \frac{V}{\sqrt{g\nabla^{1/3}}} \geq 1.181, \quad (7)$$

which in turn means that the ship should have a speed in m/s not less than

$$V \geq 3.7 * \nabla^{0.1667}, \quad (8)$$

where ∇ is the volume of displacement in m^3.

An estimate for the power can be made at this stage making use of the main dimensions and speed. Approximate formulas for the installed power required exist in the literature. The formulas after Refs. [7] and [8] are proved to yield close results.

$$P = \frac{0.75V^2W}{(.517 + 0.121L)^2}, \quad (9)$$

or

$$P = \frac{0.219V^2W}{B}, \quad (10)$$

where P is brake power in kW, V ship speed in knots, W weight in tons, and L, and B are length and breadth in meter.

Flow chart in fig. 3 summarizes the above procedure.

Applying the above scheme for the case under consideration, table 1 below gives preliminary dimensions for two proposed vehicles.

From the resulting geometrical ratios and speed length ratio, the first proposal indicates a monohull configuration while the second proposal fits a catamaran (twin hull) category. See table 2 which is derived from published data for existing ships e.g. [9].

3.1. Environmental impact study

Ships are considered as a source of emissions to ground, air and water of a magnitude beyond what is wanted. Fig. 4 shows the different types of emissions from a typical cruise ship.

The environmental impacts have been subdivided in two situations, ship under normal operation and ship in case of an accident. The impacts during normal operation are negligible because the construction, installation and managing criteria, enforced by both national and international regulations to prevent any kind of sea pollution. For the natural configuration of the proposed route, there is no interaction between the vessel and other navigation or marine environment. The coastal area of Alexandria is free of coral reef or protected areas, therefore no special cautions required.

In case of an accident (e.g. collision), the oil spilled into the sea can be removed by a number of recovery methods (e.g. oil skimmers). Hence, for the small quantity of oil spilled from ship full fuel tank, in order to preserve shorelines, it is sufficient to determine a minimum distance from the coast that the vessel has to sail in order to give a sufficient time to recover the oil pollution before reaching to coast.

For limited quantities and medium fuel oil, the minimum distance of the vessel from the shorelines can be approximately estimated by:

$$r_{min} = \sqrt{10^5 . \nabla^{0.75} / \pi}, \quad (11)$$

where ∇ is the volume of oil spilled.

Factors such as wind speed, wave height and the delay between spill and response are not considered in the above formula. For the two proposals suggested earlier, 10 m^3 fuel tank capacity would be sufficient for operation during a day period. Such quantity would be spread over a 423 m radius. The formula used on eq. (11) is good for preliminary estimate for route distance from shoreline. Commercial codes are avaialble for more accurate prediction of oil spill spread for a given site, wind and current characteristics.

3.1.1. Impacts on air

The parameters to be taken into consideration are mass flow rate and composition of the exhaust gases. The exhaust flow rate is dependent on the engine power and type. For each engine it varies according to the operating conditions. The gas composition depends essentially on the engine type, the fuel used, the engine age and maintenance degree. In order to quantify the impact of the

Table 1
Preliminary dimension for two proposed vehicles

Parameter	Narrow (proposal 1)	Wide (proposal 2)
Length L (m)	33.750	24.107
Breadth B (m)	8.000	11.400
Weight W (ton)	177.462	182.237
Vol of disp (m3)	173.134	177.792
Speed V (knots)	27.000	27.000
Trip duration (hr)	0.50	0.500
Installed power estimate (kw)	3531.302	2544.780
Fuel consumption per trip (ton)	0.343	0.247
L/B	4.219	2.115
Length froude number	0.763	0.902
V/(L)∧0.5	2.564	3.033
Volumetric froude number	1.877	1.869

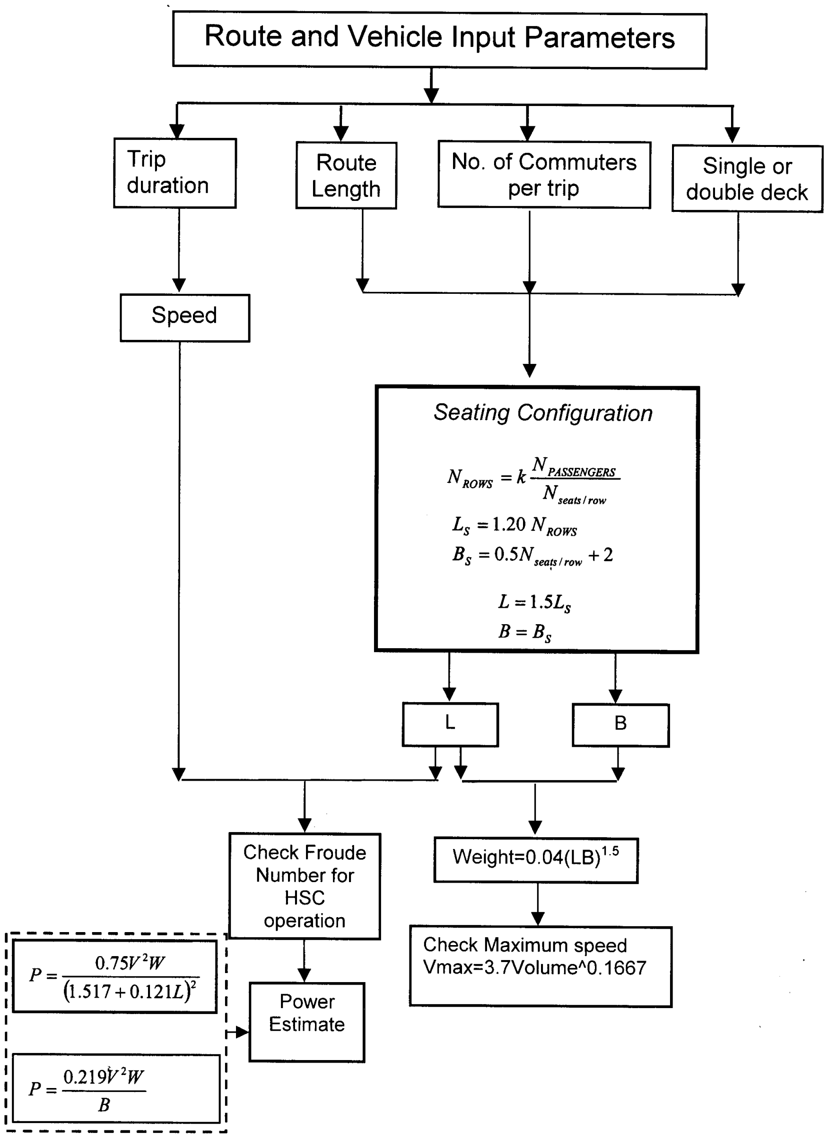

Fig. 3. Flow Chart for estimating vehicle main dimensions and installed power.

Table 2
Published data for existing ships [9]

Type	*L/B*	*B/T*	*V/(L)*^0.5
Mono	4-6	3-7.5	1.8-3.8
Cat	2.5-4.5	3.5-10	2-3.8

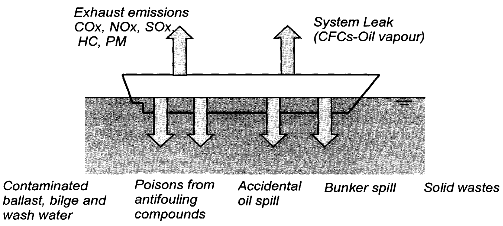

Fig. 4. Possible emissions from cruisers.

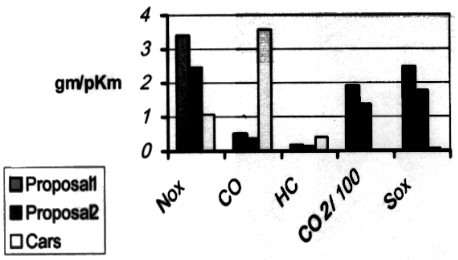

Fig. 5. Relative impacts (gm/pass km).

emissions on the environment, two gas dispersion conditions should be considered, first for normal seagoing operation and second for the condition of maneuvering in ports.

During seagoing at high velocity the mass flow rate is greater but the gas composition is generally better, since the engine is optimized for this condition. Also, during seagoing at high speed the gas dispersion is more efficient and the emission is produced far from centers of population. In case of maneuvering at port, the gas composition is generally worse (presence of unburned products) and the emission is discharged close to the centers of population. Therefore, the maneuvering condition is the worst and critical with regard to the air pollution.

The principal pollutants associated with the exhaust gas emission are NOx, CO, HC, CO_2, SOx. The emission rates of CO_2 and SOx do not depend on the engine load, whereas those of NOx, CO and HC depend on the load. In more details the quantity of NOx increases with engine load, while the emission rate of CO decreases with it and that of HC is near constant. The emission rates of NOx are greater for low-speed diesel engines, while those of HC and CO are near the same for both low and high-speed diesels.

For the quantification of the emissions in a particular trip, the data given by Lloyd's Register, [10] which refers to fuel consumption are used. These are based on average data collected from in service ships. tables 3 , and 4 give the emission rates for normal seagoing condition (*N*), for maneuvering (*M*) and for the whole trip (*T*) for the two proposals. The coefficient (*e*) represents the specific steady state emission, while the coefficient (*a)* is the ratio between the maneuvering and steady state emissions.

The relative impact of a transport system is the ratio between the absolute value of the impact and the number of passengers multiplied by the length of the trip. It can be measured in grams of pollutant/passenger. Km. This definition depends mainly on the occupancy rate of the vessel. See fig. 5.

3.1.2. Noise impact

The radiated noise is mainly due to the propulsion and auxiliary machinery. For noise impact assessment the measured level for high speed vessel in sea going condition [3] is about 70 dBA at a distance of 30 m which is compared to that emitted by cars, and trains in fig. 6.

4. Comparison and impact assessment of existing and proposed transport systems

The main particulars of any proposed study are determined at a preliminary stage, according to the economical and practical considerations. The annual operating cost of any vehicles consists of the sum of the total annualized capital investment and the annual fuel costs, additional to the labors and maintenance costs. Generally, the annual fuel cost is contributed about 50 to 70 percentage of the total annual operating cost.

In the preliminary stage of the present investigation, none of the economic evaluations, maintenance, labors, and capital costs is considered. Since, the fuel cost is considered the main part of the annual operating cost of any vehicles, only the fuel cost and

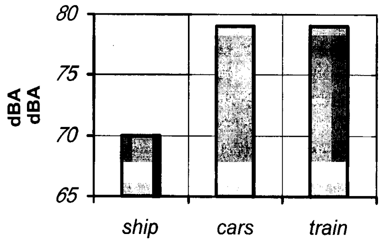

Fig. 6. Noise impacts (dB).

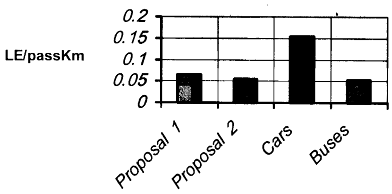

Fig. 7. Fuel cost per pass km.

fuel consumption are reported. The fuel consumption and cost for any vehicles per trip are calculated based on the available data regarding the public buses and private cars running along the cornice bullevouar. The number of stops, crossing points and allowable speed through the distance of proposed route are considered. On the base of public transport services data, an occupancy rate of 60% has been used. Assuming that all the vehicles are running at normal conditions without any traffic problems, the operating fuel cost for proposed units and public buses with private cars are calculated and summarized in table 5. Results are also displayed in fig. 7. The results tabulated in the table indicated that the fuel cost per passenger per trip is good for public bus where as it is approximately same for both marine vehicles but it is very high in case of private cars. Also, the traffic time impact for marine vehicles is much better than public buses and approximately twice the private cars. The proposal 2 is more convenient than the proposal 1 from the economical point of view.

5. Conclusions

- The sea constitutes a promising highway means of transport for countries like Egypt with two long coasts (1000 km long) to ease traffic congestion and double or triple its traffic network.

Table 3
Emission rates for proposal 1

Proposal (1)	e (kg/ton)	A	N(kg)	M (kg)	T(kg)	Impact (gm/pass km)
Nox	59	0.055	20.210	1.112	21.321	3.411
CO	8	0.17	2.740	0.466	3.206	0.513
HC	2.7	0.1	0.925	0.092	1.017	0.163
CO2/100	3250	0.07	1113.243	77.927	1191.170	1.906
Sox	42	0.07	14.387	1.007	15.394	2.463

Table 4
Emission rates for proposal 2

Proposal (2)	e (kg/ton)	A	N(kg)	M (kg)	T(kg)	Impact (gm/pass km)
Nox	59	0.055	14.564	0.801	15.365	2.458
CO	8	0.17	1.975	0.336	2.310	0.370
HC	2.7	0.1	0.666	0.067	0.733	0.117
CO2/100	3250	0.07	80.2242	56.157	858.399	1.373
Sox	42	0.07	10.367	0.726	11.093	1.775

Table 5
Marine trans port compared to land transport

Items	Marine transport		Land transport	
	Proposal 1	Proposal 2	Private cars	Public buses
A verage speed (km/h)	50	50	50	40
No. of stops	1	1	0	15
No. of passengers	250	250	2	50
Equivalent unit	1	1	75	5
Maneuvering and stops time (min)	20	20	10	42.5
Total time per trip (min)	50	50	40	80
Power per unit (kw)	3531	2545	100	184
SFC. (gm/kw.hr)	205	205	200	245
FC/trip. Unit (kg)	603.213	434.771	13.333	60.107
Total FC/trip (kg)	603.213	434.771	1000.000	300.533
Fuel cost/trip (LE)	301.606	217.385	1333.333	150.267
Fuel cost /trip. Passenger, (LE)	2.011	1.449	8.889	1.002
Fuel cost / km. passenger, (LE)	0.080	0.035	0.0356	0.040
Time duration impact	0.625	0.625	0.500	1.000
Fuel cost impact	0.226	0.163	1.000	0.113
Traffic time impact	0.471	0.471	0.235	1.000

- Short sea transport can greatly contribute to reducing traffic congestion on the roads with major benefits for human safety and for the environment
- Sustainable development for Egypt north coast and linking of new resort area on the north coast requires good and multi mode transport means.
- Global environmental impacts of a proposed marine route and operating high speed vehicles is evaluated and compared with that of shore vehicles. The results are quite promising and comparisons show that favorable environmental performances of the sea transport with respect to shore ones even though more detailed study of some related aspects is needed in order to confirm the feasibility for fast passenger transportation and its favorable impact on the environment
- Further and detailed study should also be carried out concerning type of vessels, economics, terminal facilities, integration with other traffic networks …etc.

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