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Dual-Purpose Ro-Ro Fast Ship: Some Comments and Lower Cost Option

Professional paper

The article discusses an alternative variant to the high-speed trimaran designed as a roll-on/roll-off ship for commercial or military use that was recently published in literature (Marine Technology 42(2005)3). Initial ship performance and general plan are discussed. The alternative option to the initial ship is given with a new cargo deck arrangement for unloading time minimisation. It is shown that the proposed option with the same payload, main engine power, same speed as a minimum, and with a smaller full displacement is cheaper for building, but can ensure the same income.

Key words: *ro-ro ships, cargo handling, cost reduction, time-saving*

Dvonamjenski brzi ro-ro brod: neki komentari i jeftinija opcija

Stručni rad

Članak obrađuje alternativnu varijantu trimarana velike brzine dizajniranog kao ro-ro brod za komercijalnu ili vojnu namjenu postojećeg projekta objavljenog nedavno u literaturi (*Marine Technology* 42(2005)3). Diskutirane su glavne značajke i opći plan postojećeg broda. Alternativno rješenje u odnosu na postojeći projekt dano je s novim općim planom kojim se omogućuje minimizacija vremena iskrcaja. Pokazano je da je predloženo rješenje s istom korisnom nosivosti, snagom glavnog stroja, istom brzinom ali s manjom potrebnom istisninom jeftinije za gradnju, a omogućuje istu zaradu.

Ključne riječi: *ro-ro brodovi, rukovanje teretom, smanjenje troškova, ušteda vremena*

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Introduction

The problem of along-coast transportation of trucks is very important for a lot of industrial countries due to congestion on highways and possible higher efficiency of transportation by sea. One of the main conditions for such type of transportation is sufficiently high ship speed comparable with the average speed of a truck on a highway. Besides, the application of any ro-ro ships, especially fast vessels, is certainly efficient for the door-to-door delivery. And ship engine exhaust can be cleaned more fully and simpler, than truck engine gases. This means that transportation by fast ro-ro ships is an important and interesting issue to cargo owners and shipbuilders.

An option of a fast ro-ro ship was proposed in [1]: a triple-hull ship with a conventional central hull of high length-beam ratio and two smaller side hulls with small waterplane areas. The main dimensions and general characteristics of the proposed ship are shown in Table 1. The design demands, main dimensions and general characteristics of this previously designed ship [1] are noted as “initial data” in the text that follows.

Outer problem

Usually the problem of the selection of the pair “payload-speed” is named as “outer problem of ship designing”. Referring to the case of ships for volume cargo transportation, as ro-ro ones, the outer problem must include the needed deck area or needed volume of cargo.

Then, technical and economical decisions made in this initial design require further discussion for better solution of the problem. A required payload of this ship is the first moot point. The most common method for defining an economy-based “payload-speed” relationship is systematic variation of these parameters. Such a variation might have been carried out for this dual-purpose ship design, but these data were not shown in the article. There is also another way of payload definition: its value can be defined by the second mode of application, i.e., by selection of military payload.

The appropriate area of cargo deck (or cargo compartment volume) plays an important role in a ro-ro ship design. The specificity of the examined ship is different correlation of the payload and cargo deck area for commercial and military modes: 1.34 sq m per a ton for the first mode and 2.35 for the second. The other specificity is the need for an additional (upper) deck installation for military cargo transportation.

The previously proposed idea of added deck building does not seem to be the best option, and another solution is suggested: the ship must be designed for the largest of the two payload values and for the largest deck area. This ensures the most universal utilization of the ship without any additional installations.

General arrangement and main hull type

By the way, the shown location of helicopters in one tween deck space seems impossible: a big enough helicopter has the overall height bigger than the shown 2.5 – 3.5 m.) Besides, the added deck means that larger side hulls, outriggers, are needed to ensure higher initial lateral stability at the constant overall beam, which means too big outriggers for the one deck option. Therefore, the alternative ship should have two cargo decks initially, without changing the overall beam. A two-deck platform is also convenient for placement of helicopters.

As it becomes clear from the shown general arrangement, the payload is placed on the cargo deck(s). The inner volume of the main conventional hull is mainly empty, and that volume can be decreased without any loss of transportability. Therefore, the main hull with a small waterplane area, SWA hull, can be applied to reduce the main hull inner volume, weight and to increase vessel's seaworthiness [1]. It should be noted that the initially proposed ship would be able to sustain practically the design speed up to a Sea State of about 5, and the course changing or voluntary speed reduction, implying effective average speed reduction, is inevitable in more severe sea.

The need for the fast unloading is declared in the article [1], but this need is not ensured by some technical solutions. Specific to any multi-hull ship is the possibility of providing low roll motions, which allows proposing of an unusual solution for the wheeled cargo arrangement: not in the longitudinal, but in the lateral direction. In this case, ramps along both sides can be used for fast loading and unloading. This payload arrangement is also suitable for providing sufficient strength of multi-hull ship lateral structures.

The arrangement of some of main engines in the outriggers seems a very effective solution for such a high-power ship. But the arrangement in the underwater gondolas dictates too large displacement of the outriggers, which is not needed in order to ensure transverse stability, which is the main purpose of the outriggers. The arrangement of the alternative ship main engines is the same, as in the initial ship: in the main hull and in the outriggers; but longer and inclined shafts of the outrigger engines mean the possibility of their placement in the upper parts of outriggers, i.e. smaller displacement, structural weights and own towing resistance of outriggers. The reason for a larger draught of the outriggers than that of the main hull is not explained in the examined article. The overall draught of the alternative ship is selected equal to the main hull draught of the initially designed ship; it means some added possibility of the alternative ship application in more shallow harbours, because the overall draught of the initial ship outriggers is bigger one.

Initial ship performance

It should be noted that the performance part of the examined article [1] provokes a lot of questions. For example, what is the reason for the theoretical method for the towing resistance prediction? Today there is a lot of accurate experimental data for traditional monohulls with relative length $l = L/V^{1/3} \approx 10$ (where L is the design hull length and V is the volumetric displacement). Besides, the article does not contain information on towing resistance prediction of large outriggers with a small waterplane area. (The outrigger wetted area is comparable with the area of the main hull, and the total outrigger displacement is about 35-40% of the main hull displacement. Moreover, the noted economy speed coincides with the outrigger hump Froude number of about 0.5…). Additionally, there is no information on the method predicting the interaction of the so large outriggers with the main hull and on the favourable configuration for the full and/or economy speed. Then, the values of the maximum full speed (39.5 kn) and economy speed (26 kn) estimated by the article authors seem too optimistic. Figure 1 contains the estimated initial data on the initial ship effective power definition, Figure 2 – the comparison of the initially assumed and defined values of the needed power.

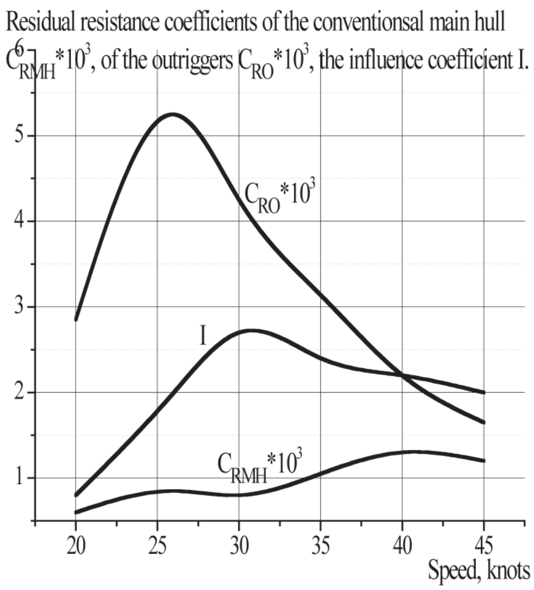
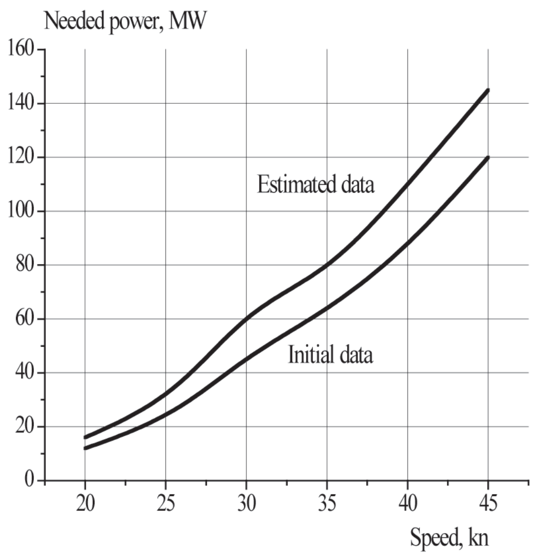


Figure 1 **Initial data of the initial option performance estimated on the basis of systematic series tests**
Slika 1 **Početni podatci o radnim značajkama početne opcije procijenjeni na temelju ispitivanja sustavnih serija**

Figure 2 **Comparison of the initial option needed power on the basis of Figure 1 data**
Slika 2 **Usporedba potrebne snage početne opcije na temelju podataka iz slike 1**



Performance of the initial ship option was estimated on the basis of some experimental data [3]; for the shown power of the initial ship, the achievable full speed was estimated to about 37 knots and the economy speed (with diesels only) to about 22 knots.

Alternative option initial data

The design requirements and characteristics of the alternative ship option are as follows:

- payload 2.000 t and payload area 4.000 sq. m;
- overall beam 32 m and design draught 6 m;
- two-floor platform with watertight transverse bulkheads on the lower deck; transverse placement of wheeled cargo; two ramps on each board in each watertight compartment; the upper deck of the cargo space can have non-watertight lateral frames and stern ramps for longitudinal transit of wheeled cargo;
- a pair of elevators for helicopters in each watertight compartment of the above-water platform and the upper deck with three landing places for heavy helicopters;
- as the examined prototype, the alternative ship option will have main engine power of 104 MW, consisting of two gas turbines (2x36 MW) and two diesels (2x16 MW);
- gas turbines will be installed on the main hull and diesels in the above-water part of the outriggers;
- design quantity of fuel will be 500 t and the maximum possible supply 1500 t;
- the main hull will have small waterplane area and a flat-shaped gondola.

Designing steps

From these design requirements, the following design steps result in the main dimensions of the alternative ship:

a. The minimum length of the cargo space can be defined as 62.5 m; but slightly longer length, 75 m, is chosen because of convenient arrangement of the three landing places for helicopters along the cargo space length. The height of the cargo on each deck is selected as 3.5 m for wheeled cargo or container placement, and helicopter transportation on the platform lower deck. The distance between lower and wet decks is 1 m.

b. The vertical clearance on the alternative ship is 4 m, like in the prototype, because of the stern placement of the platform and sufficiently small motions of the SWA main hull that ensure low probability of the wet-deck slamming of the alternative ship in comparison with the initial ship. Hence, the main hull height is 18 m.

c. The average height of the main hull gondola is 4 m, but this can be increased at the main engine room. An additional advantage of all SWA ships is the possibility of minimal design draught: it can be equal to the gondola height at full displacement. The ship can operate at such draught in harbours and in still water. In waves, with a small quantity of water ballast the draught can be increased for better seaworthiness (smaller waterplane area means small quantity of water ballast). However, such decision means higher design displacement of the ship and structural weight, higher towing resistance, etc. The design draught of the presented option is 6 m.

d. The ship is designed for near-coast sailing. Therefore, a speed independence of water depth is highly desirable. As was shown previously [2], this independence is provided if the hull-length design Froude number is at least 0.6. This results in the main hull length of 120 m. A sketch of the deck arrangement is shown in Figure 3.

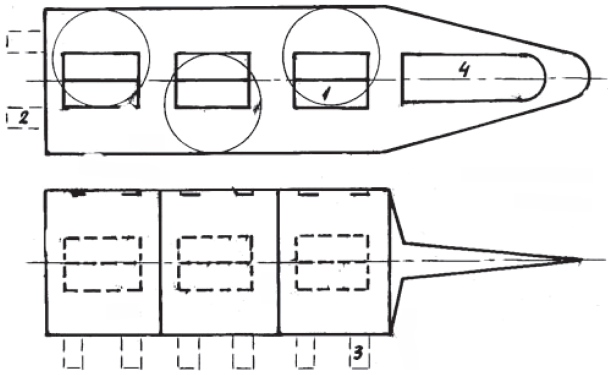


Figure 3 **Cargo deck general arrangement of the alternative Ro-Ro ship proposed for unloading time minimisation (1- helicopter elevator, 2- stern ramps for longitudinal loading / unloading from the intermediate deck, 3- ramps for lower deck, 4- superstructure)**

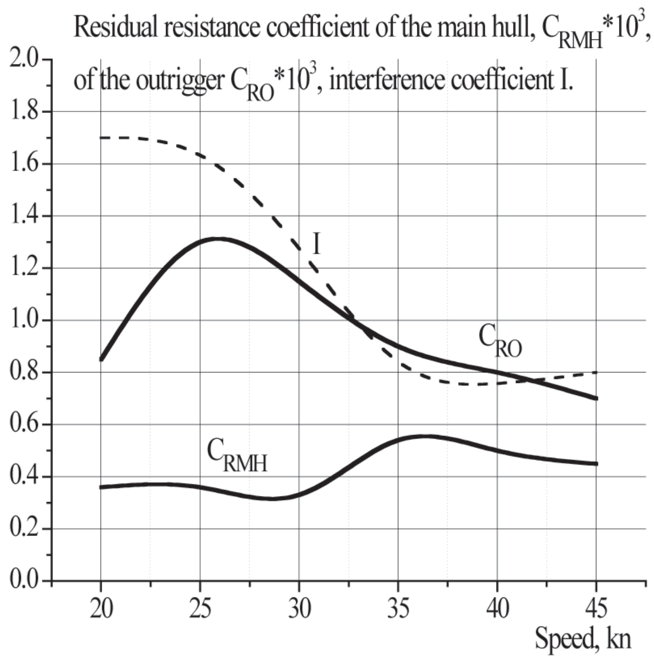
Slika 3 **Prijedlog općeg plana palube tereta alternativnog Ro-Ro broda kojim se omogućuje minimizacija vremena iskrcaja (1 – dizalo helikoptera, 2 – krmene rampe za uzdužno ukrcavanje / iskrcavanje s međupalube, 3 – rampe za donju palubu, 4 - nadgrađe)**

Alternative ship dimensions and performance

After selection of overall dimensions the structural weight of the hull can be estimated. With reference to the previously

Figure 4 **The initial data for the alternative ship performance estimation predicted on the basis of systematic series tests**

Slika 4 **Početni podatci za procjenu radnih značajki alternativnog broda predviđeni na temelju ispitivanja sustavnih serija**



defined average thickness of the SWA hull plating [2], the weight of the equipped hull is about 2500 t. This means that the total displacement, including payload and 5% supply of displacement, is about 6,000 t.

Assuming the main demand to the transverse stability is needed for the 100-kn beam wind at zero speed, the waterplane area of outriggers can be determined as 2 x 150 sq. m. Thus, all overall dimensions of the alternative ship design are defined, and the achievable speed can be estimated.

The experimental data [3] applied to performance estimation of the alternative ship are shown in Figure 4, and the required power in Figure 5.

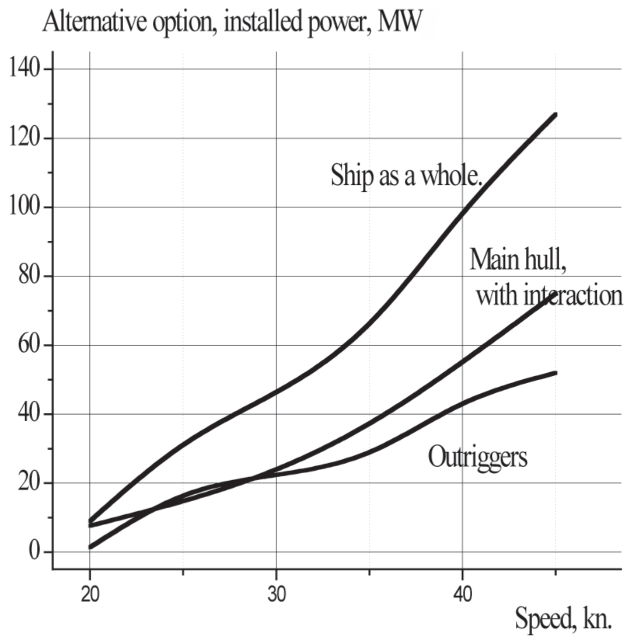


Figure 5 **Power required for the alternative ship**
Slika 5 **Potrebna snaga alternativnog broda**

For the propulsion coefficient at full speed of about 0.7 (possible for optimal diameters of propulsors), the experimental data from [3] allow us to estimate the full speed of about 39 knots and the speed with diesels of about 24 knots.

All SWA ships have excellent seakeeping characteristics and minimal losses of full speed in severe seas. This means that even lower speed of the alternative ship in still water can be permissible, if practical absence of speed losses is taken into account. The average speed in sea will be higher, like the speed of the examined initial option of the ship.

Further, a sufficiently flat gondola of the SWA main hull allows application of a novel technology of an artificial gas cavity for viscous resistance reduction. Referring to the share of the bottom area in the main hull wetted area, about 25%, the main hull towing resistance can be realistically decreased by about 12% [4].

This means that this alternative ro-ro ship can have approximately the same speed in still water as it was supposed previously for the initial ship. However, a SWA ship has always a higher achievable average speed in a seaway. The alternative ship will be supercritical from the water depth consideration, i.e. it will have practically the same speed at any reasonable water depth.

Conclusion

The alternative option of a fast ro-ro ship can be more effective for both commercial and military cargo transportation.

Table 1 **Main dimensions and general characteristics of the compared fast Ro-Ro ships**
Tablica 1 **Glavne izmjere i opće značajke uspoređivanih brzih Ro-Ro brodova**

Characteristic	Initial ship	Alternative ship
Overall length, m	182	125
Overall beam, m	32.2	
Overall design draught, m	8	6
Full displacement, t	8700	6000
Total installed power, MW	104	
Total payload, t	Commercial mode 2000/ Military mode 1640	2000
Total cargo area, sq. m	Commercial mode 2860/ Military mode 3850	4000
Full speed, still water, kn	Optimistic 39.5, more realistic 37	With air cavity 40.5, without 39
Economy speed, by diesels, kn	Optimistic 26, more realistic 22	With air cavity 26, without 25
Fuel supply, t	500 for commercial mode/1500 for military mode	
Operability coefficient in Northern Atlantic, %	About 75	About 98

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