

# Small Water-Plane Area Corvette: Algorithm and Example of Designing

Victor A. Dubrovsky,<sup>a,\*</sup>

<sup>a)</sup> *Balt Techno Prom Ltd, St.Petersburg, Russia*

\*Corresponding author: multi-hulls@yandex.ru

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## ABSTRACT

Corvettes and patrol ships with various roles are more or less important parts of various fleets. Usually the corvettes are high-speed (21-35 knots) ships of restricted displacement (from 600 up to 3000 t). This means some essential restrictions of operability by waves. Therefore, the development of the corvette's seaworthiness is an important need of the future fleet. Ships with a small water-plane area, SWA ships, differ from all displacement ones by having the highest achievable seakeeping and by minimal losses of speed in waves. A concept of SWA corvette is designed by a special algorithm and proposed for the world market

**KEY WORDS:** *Corvette; Patrol Ship; Small Water-Plane Area Ship; Design Algorithm; Deck Area; Payload; Achievable Speed; Strength Specificity.*

## 1.0 INTRODUCTION

Corvettes and patrol ships with various roles are more or less important parts of various fleets.

There were about 200 corvettes at the beginning of 2013, up to 15 ships are being built now, and up to 20 ships are planned for order [1].

Usually the corvettes are high-speed (21-35 knots) ships of restricted displacement (from 600 up to 3000 t). This means some considerable restrictions of operability by waves. Therefore, the development of the corvette's seaworthiness is an important trend

for the fleet of the future.

The ships with a small water-plane area, SWA ships, differ from all displacement ones by having the highest achievable seakeeping and by minimal losses of speed in waves. In general, a SWA ship has seaworthiness at the level of a traditional mono-hull of considerably larger (5-15 times) displacement. This means that SWA corvettes can be very useful for use on the world market.

SWA ships differ from other types of ship in some very important details. This means that SWA ships must be designed by a specially carried out design algorithm [2].

Today some types of SWA ships are the subject of more or less research (Fig. 1). In the figure, type 1 is named a "duplus" (a twin-hulled SWA ship with one long thin strut on each underwater gondola); 2 – "trisek" (twin-hull, two struts on a gondola); 3 – "tricore" (triple-hull SWA ship); 4 – SWA main hull with two standard outriggers; 5 – standard central hull with two SWA outriggers; 6 – foiled SWA mono-hull; 7 – four-hulled SWA ship. Each SWA ship type differs from the others in specific details which must be taken into account for the type selection.

It must be noted that the examined corvettes do not have a great displacement. This means that the possible outriggers may be relatively small and not suitable for the arrangement of any apartments or even tanks. For example, for greater survivability as a battle ship, a corvette needs a divided main engine. But the parts of the main engine can be arranged only in equal hulls, not in the possible outriggers. Therefore, only SWA ships with equal hulls are suitable as corvettes.

The twin-hull SWA ship with two struts, the duplus, has the greatest initial transverse stability, while the trisek, by contrast, has minimal stability but better seaworthiness. But the too small water-plane area of the trisek creates certain problems with the arrangement of large-scale equipment, such as the main engines. This means that the duplus is the most convenient option for the twin-hull SWA ship.

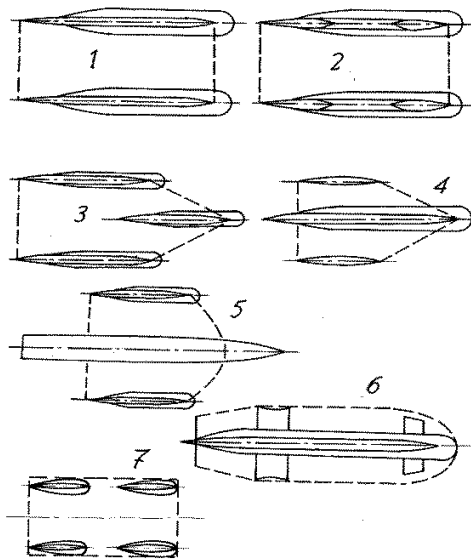


Figure 1: Types of SWA ship examined [2].

A tricore can ensure that the most favorable interaction of the wave systems is generated by the hulls. This means that the tricore can be an alternative option to a corvette, if the required speed is in the corresponding ranges of Froude numbers. The main feature of a tricore is the relatively greater (for SWA ships) role of longitudinal strength in the design process. The structure of a tricore must include two longitudinal bulkheads in the above-water platform in order to ensure a notable longitudinal bending moment (Fig. 2).

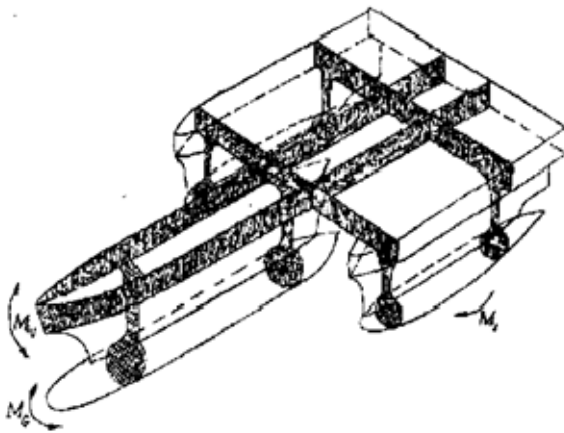


Figure 2: Hull structure of a tricore [2].

It seems evident, if the ship is not very big, and if an inner hangar is needed, that the longitudinal bulkheads in the platform must be cut for arrangement of the hangar. This means that a rational structure cannot be ensured. Therefore, a tricore cannot be a viable option for a small SWA ship such as a corvette

## 2.0 DESIGN ALGORITHM.

A general characteristic of all multi-hull ships, including SWA ships, is the relatively large area of the decks, both the inner and the upper one. And all contemporary surface battle ships are designed for the required deck area. The same area defines the overall dimensions and hull structure mass. This is the reason for the very important role of the deck area in the algorithm for the design of multi-hull ships (Fig. 3).

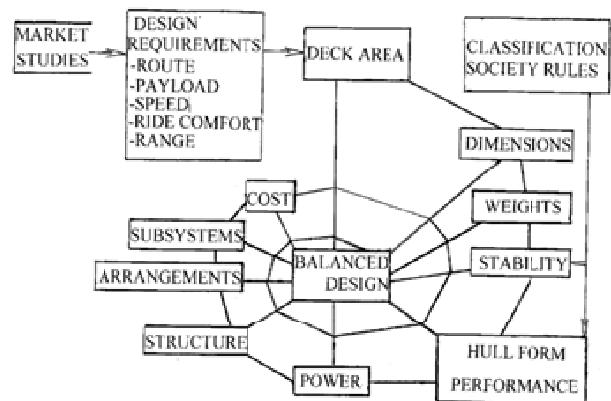


Figure 3: The design algorithm [2].

The minimal initial data needed for SWA ship design are:

- the examined number of hulls; as noted before, a twin-hull ship, duplex, is selected for designing;
- the required payload and useful inner deck area; a payload of 200 t and a required deck area of 2000 m<sup>2</sup> are assumed;
- the number of inner decks and the height between decks in the above-water platform; one inner deck and 2.5 m height are assumed;
- full (and economy, if needed) speeds; the zero approximation of full speed is assumed to be 25 knots, but a wider value range can be examined at the design stage, for example, for selection of the main engines; the economy speed of 15 knots is assumed;
- range for pre-arranged speed, economy or full; a range of 5000 nm at 15 kn is assumed;
- design sea state and corresponding standards; Sea State 5 is selected as the design value for full operability;
- standard of non-sinkability (number of water-tight apartments, which can be flooded without the ship sinking); the standard of 3 apartments is adopted; the possibility of an apartment being filled in with floatable foam can be decided in the later design stages.

Some possible initial restrictions of the SWA ship dimensions can be included in the design process: - overall length and/or beam (depending on the dimensions of the building and/or repair location); - design draft at full displacement (depending on the harbor and/or dock depth); - depth of shallow water (for selection of design speed). A maximal design draft of 4.5 m is assumed, as for some of the existing mono-hull corvettes.

Some preliminary added assumptions are selected in accordance with Chapter 7 of [2]. The overall dimensions of the above-water platform are defined with variation of the platform

beam relative to the platform length. The vertical distance between the wet deck and the design water-plane is selected on the basis of existing statistical data (Fig. 4). A vertical clearance of about 4 m is selected for the duplus.

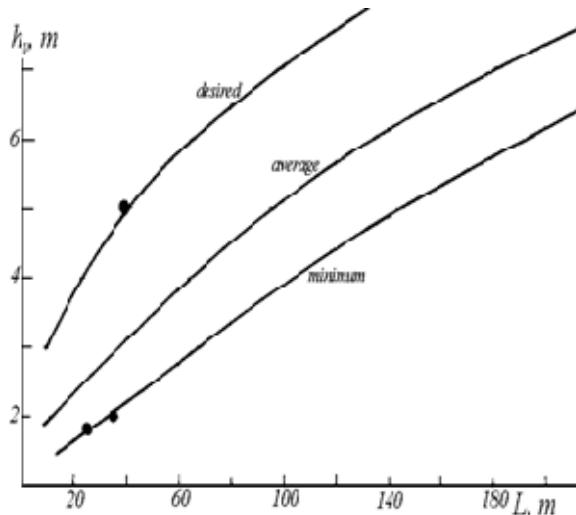


Figure 4: Recommended values of SWA ship vertical clearance [3].

### 3.0. STRENGTH SPECIFITY AND HULL STRUCTURE MASS.

The main feature of the strength of all multi-hulls is the relatively greater role of the transverse strength, and the relatively smaller role of the longitudinal strength.

At zero approximation, the transverse strength of the examined SWA ships is defined by the transverse general loads (Fig. 5).

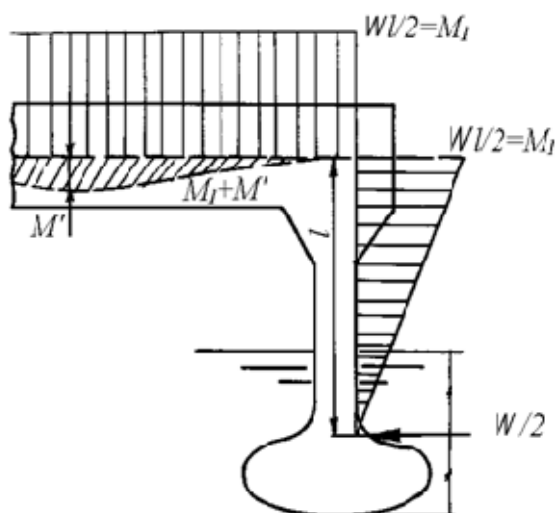


Figure 5: Main transverse loads [3].

The most heavily loaded section of the transverse bulkheads, which are the main frames ensuring strength, is the section near the strut widening. Some systematic calculations of the required thickness of plates at the section are the basis of the approximate selection of the minimal plating thickness (Fig. 6).

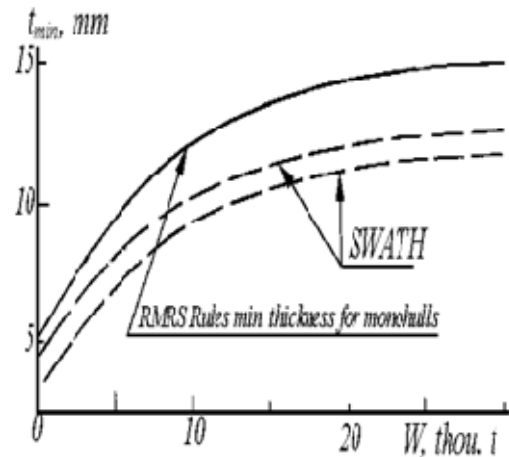


Figure 6: Minimal thickness of the strut plating [3].

The shown thickness of the most loaded cut is assumed for the hull structures of the examined SWA ships. It allows the estimation of the structure mass of the platform at zero approximation (for varied correlation of the overall beam and overall length).

### 4.0 TRANSVERSE STABILTY AND ITS STANDARD.

Statistical data allows the estimation of full displacement on the basis of the mass of the above-water platform (including the payload). This allows the estimation of the hull dimensions (the volume of the under-water gondolas and the approximate beam of the struts).

It is supposed that the initial transverse metacentric height must ensure a heel of no more than 10 degrees, at a side wind of speed 100 knots (zero ship speed).

This condition is the basis of the definition of the required area of the strut water-plane at zero approximation

### 5.0 ZERO APPROXIMATION DIMENSIONS

The shown selected initial data and solutions allow definition of the main dimensions, referring to the variation tables from [2]. The dimensions allow definition of the technical and tactical characteristics of the examined corvette.

The main dimensions and general characteristics are shown in Table 1. A scheme of the general arrangement and transverse bulkhead placement is shown in Figure.7. An artist's view of the corvette is shown in Figure. 8

Table 1: The main dimensions and general characteristics of the proposed corvette at zero approximation.

|                                                                |            |
|----------------------------------------------------------------|------------|
| Overall dimensions, L*B*H, m                                   | 60x20x13.5 |
| Full displacement, t, w/out water ballast                      | Abt. 1100  |
| Light displacement, t                                          | Abt. 850   |
| Full displacement, with ballast, t                             | Abt. 1200  |
| Draft, at 1200 t, m                                            | 4.5        |
| Draft, at 1100 t, m                                            | 3.5        |
| Draft, at 850 t, m                                             | Abt. 2.5   |
| Power for speed 20 knots, full displacement w/out ballast, MW  | 2 x 2.5    |
| Power for speed 25 knots, full displacement, w/out ballast, MW | 2 x 6.5    |
| Power for speed 30 knots, full displacement w/out ballast, MW  | 2 x 10.5   |
| Deadweight, w/out ballast, t                                   | 250        |
| Deadweight, with ballast, t                                    | 350        |
| Design Sea State for full operability                          | 5          |

## 6.0 CONCLUSION AND RECOMMENDATION

The presented data show the possibility of designing and building a small water-plane corvette with full operability (full speed, any heading, permissible characteristics of motions) at Sea State 5, i.e. operating for double the time per year of existing mono-hulls having the same roles.

The corvette shown can have a design draft of about 2.5 m, i.e. it can serve in many shallow-water harbors.

It is recommended that the proposed corvette should be designed and built for the world market.

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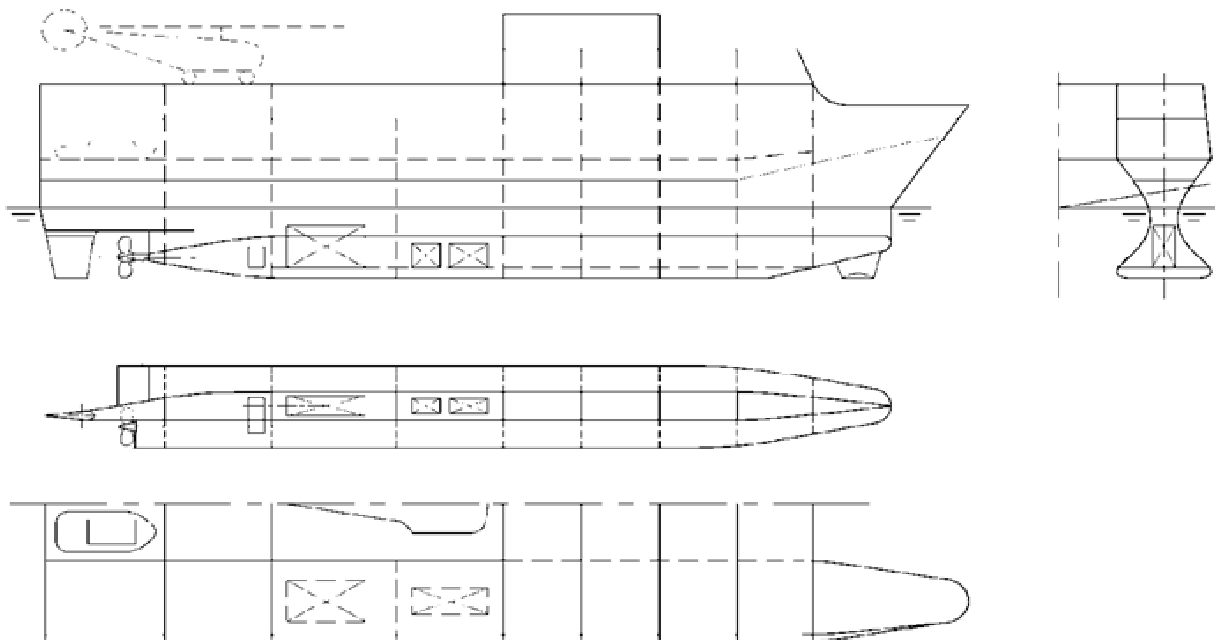


Figure 7: Scheme of general arrangement of a duplex as a corvette.



Figure 8: Possible external view of a duplus as a corvette