

Assessment of the Stability of Passenger Ships in Coastal Navigation in Case of Lacking Ship Geometry Data

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Ships should ensure safe navigation by meeting the stability norms defined by the International Maritime Organization (IMO) and determined by national maritime administrations. The fulfillment of these norms is becoming increasingly important, especially for passenger ships used for tourist excursions. Recently, the development of maritime tourism has greatly increased the demand for these ships most of which are converted fishing vessels. The situation described in this paper pertains to Albania and most probably differs in other countries in the region and the wider area. Ships rarely have adequate technical documentation. The Albanian Register of Shipping requires the performance of stability tests, the results of which are entered in the amended stability book to ensure the vessels' compliance with the norms following modifications undergone and guarantee safe navigation for tourists. An examination of a variety of ship design papers helped us identify various methods and methodologies for determining approximate geometric ship elements with an acceptable degree of reliability. However, their use should be limited and reliability proven by calculating

KEY WORDS

- ~ Ship geometry measurements
- ~ MaxSurf software
- ~ Ship stability
- ~ Ship's VCG
- ~ GM
- ~ Inclining experiment

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parameters such as lightship VCG, number of passengers per m², assessing the possible range and area of navigation and weather conditions (mainly wind speed and wave forces). The calculations based on stability testing and the use of highly reliable software such as MaxSurf - Integrated Naval Architecture Software, Napa - Naval Architectural Package, Autoship - Systems Operation, Orca3D - Naval Architecture Software delivered fast and reliable stability assessment results and verified conformance with the norms prescribed by the Albanian Register of Shipping.

1. INTRODUCTION

Recently, maritime tourism in the bay of Vlora saw rapid development and the consequently increasing demand for passenger ships, especially those suitable for one day excursions (Rexhepaj, 2019).

Field observations and contacts with the Albanian port authorities and maritime administration suggest that these ships have major safety standard and service issues.

Tourist boats operate mainly in the bays of Vlora and Saranda, at short distances (1-2 hours) and inland, such as on Koman and Vau i Dejes lakes on the Drin River or artificial lakes such as Belsh lake in Elbasan. The problems faced by the owners of these ships are associated with the coastal infrastructure required for periodic and instantaneous technical repair and maintenance. The only repair shipyard is the Pashaliman Shipyard, which is still under the jurisdiction of the Ministry of Defense, but lacks the tools and specialists needed to meet all ship repair, maintenance and construction requirements. In these conditions, lacking the required safety-related technical data, these ships fail to meet the safety standards applicable at sea and geometric and stability calculations are not made. As the Albanian Register of Shipping

Table 1.

Number and transport capacity of ships in the bay of Vlora.

Year	2016	2017	2018	2019
Number of ships	3	4	10	15
Daily transport capacity	295	342	1198	1350
Number of pax	9150	14546	30843	51815

(ARS) (AMA, 2009) set a series of safety norms that must be taken into consideration, we attempted to conduct an in-depth analysis of IMO norms and requirements implemented by other European registers having similar coastal conditions with respect to tourist services, mainly of the Croatian Register of Shipping (Shipping, 2002).

We consulted several bibliographies because:

- these ships are rather old and have been in operation for a great number of years;
- these ships underwent structural modifications, in the course of which they were examined for potential damage that may have occurred during the provision of technical support;
- some ships have undergone structural modifications without the supervision of a specialist or an engineer.

Most ships have been completely repurposed and converted from service ships into one-day passenger transport ships. Thus, to meet the prescribed requirements and norms, these ships must first meet some other preconditions.

As almost no ship has the requisite documentation, such as technical documentation, general layout and structural drawings, the development of a ship lines plan requires their size and respective structural elements to be physically measured.

2. THE TRIM AND STABILITY BOOKLET

All relevant calculations for ships in lightweight and other loading conditions should be made both at departure and upon arrival to determine their displacement and coordinates of their center of gravity. Hydrostatic data facilitate the identification of the vertical center of the metacenter, KM. Hydrostatic and dynamic stability curves are then calculated and designed by drawing up stability booklets (Biran, Ship Hydrostatic and Stability, Stability booklet, 2003), (IMO, Resolution MSC.267(85) - International Code on Intact Stability, 2008) containing calculations and stability curves for anticipated loading conditions.

The following ship stability rules have been set in accordance with the safe navigation norms (Biran, Ship Hydrostatic and Stability, Stability booklet, 2003), (IMO, Resolution MSC.267(85) - International Code on Intact Stability, 2008):

- ship name, number in the register, harbor of registry, gross/net tonnage, ship dimensions, number of passengers and draft must be indicated;
- general layout with all compartments, tanks, storage, crew and passenger accommodation and amidships positions must be available;
- capacity and center of gravity (longitudinal and particularly vertical) of each load such as fuel, stores, fresh or ballast water, vertical center of gravity of vehicles must be calculated;
- weight of passengers and crew, their effects and centers of gravity must be calculated. The hydrostatic data of the ship, the heights of the transverse metacenter and the time to change the trim by one centimeter;
- the effect of free surfaces on the stability of tanks containing liquids must be determined;
- a diagram of cross curves of stability indicating the height of the assumed axis from which the righting levers are measured and the trim assumed must be drawn up;
- superstructures, deckhouses, hatchway structures on or above the freeboard deck may be taken into account in the curves;
- the diagram and statements are required to be provided separately for the light, ballast and service loaded conditions at departure and upon arrival, provided that consumables are reduced to 10% of their capacity. A statement indicating lightweight, deadweight, displacement, their center of gravity, metacenter and metacentric height (GM). The curve of Righting Levers (GZ). These are corrected for a liquid free surface.
- The inclining test and appropriate lightship calculations must be made.

3. SHIP HULL 3D-CAD MODELLING

The physically measured point coordinates were used to obtain hull lines and surfaces. Then, the faired model of the hull was developed by interpolation and optimization processes. The hull was reconstructed using the Maxsurf software. All surfaces were checked to ensure the observance of the geometric boundary conditions and recreate surfaces belonging to any of the three main groups: the bow, the stern and the central regions (C, 2006).

The following steps need to be taken to reconstruct a 3D ship hull model based on physically measured point coordinates (al X. B., 2008):

- Necessary measurements of keel line, extreme parts of the hull and its sections were taken. Based on the condition of a particular ship and international guidelines, we intended to measure as many sections as we could. Although it is generally recommended to measure physical frames every 50 cm, that depends on the length of a given ship. In this case, ship length was sixteen (16) meters. A total of 20 measurements were taken.

- Surfaces were built individually for each part of the hull (bow, stern, central body).
- Individual surfaces were assembled and the hull assumed its preliminary form.
- The hull was double checked. Initially based on previously designed geometric data and subsequently on physical measurement. This approach was adopted to avoid systematic and chance errors.
- The surface of the CAD model was smoothed until the required level of compliance with hydrostatic characteristics was achieved.
- The drawing of the CAD model of the modelled hull was carried out. (al K. L., 2016)

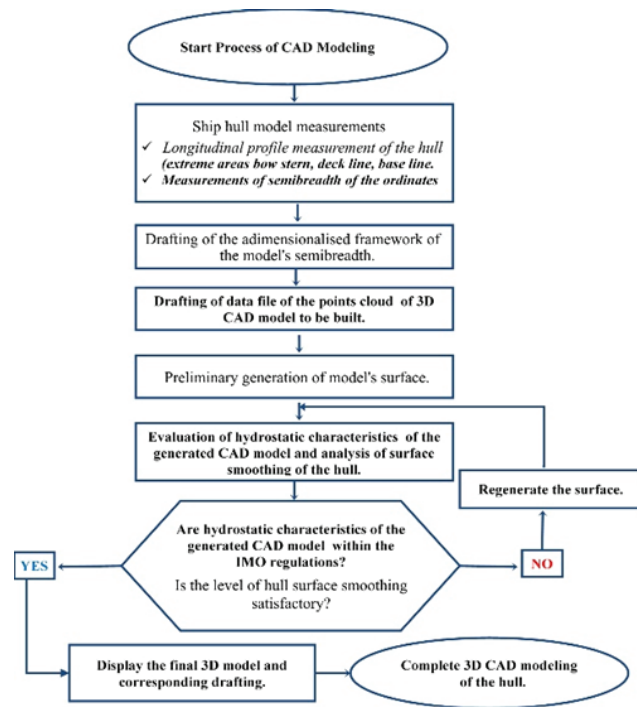


Figure 1. General flow chart of the hull recreation process.

Since measurements are highly important and have a significant effect on the viewing of ship stability assessment results, they deserve special attention.

Traditional measuring requires simple measuring tools such as: plumb line, measuring tape and digital meter, batten, 90 degree measuring tool, spirit level, marker, and tensioned rope. Using the data obtained, the lines were initially modeled in AutoCAD, potential measurement errors were corrected and the lines plan for the ship drawn up.

There are two problems:

- The ship is on the ground. In this case the positioning of the ship against the horizontal and diametric plane must be well-

controlled, and some corrections may be required.

- The ship is in the water. In this case the measurements should be made directly on and inside the ship, beginning with the physical frames and proceeding to the lines plan.
- Other digital methods using 3D scanning of the hull surface are not applicable, as they take longer and do not have very high measurement accuracy requirements.

The following example illustrates traditional vessel positioning and measurement:

- putting the vessel in the right position, just as it would be free in the water;
- positioning two horizontal tensioned ropes to determine the middle line plane;
- determining the main dimensions of the vessel (LOA and BOA);
- choosing an external reference system for the vessel;
- choosing half-breadth along which the transverse sections (De_Ruyter, 2012) will be drawn.

4. THE NUMBER OF PASSENGERS PERMITTED AND THEIR ACCOMMODATION

Ship owners seek to increase the number of passengers onboard tourist vessels operating in Albanian bays, sometimes even beyond the norms or requirements of the International Convention for the Safety of Life at Sea (SOLAS, 1974/1980), which is detrimental to vessel stability and passenger safety. We have issued some recommendations in response to the norms (Shipping, 2002):

For passenger ships not engaged on international voyages

Passenger cabins must not be located in front of the fore nor behind the aft collision bulkhead, nor where clear headroom is less than 2.0 m;

4.1. Permitted Number of Passengers on Exposed Parts of the Deck

In case of day trips, the number of passengers allowed to stay on the exposed deck during transportation is determined by dividing the free space available to passengers by 0.7. In no case should the number of passengers exceed the number of the seats provided.

4.2. Seats Dimensions Should Be as Follows

The seats should be at least 0.45 m wide, seats on the deck should be 400-480 mm high. Rear seat backrest must be at least 400 mm high. When the seats are grouped in transverse or longitudinal rows, the crossings between these groups must be at least 0.75 m wide. The distance between two adjacent rows must not be less than 0.80 m.

5. PRELIMINARY DETERMINATION OF LIGHTSHIP AND VCG

Lightship (Biran, Ship Hydrostatic and Stability, Stability booklet, 2003) is the weight of an empty ship (hull, outfit, and weights of machinery including liquids in various systems). The concept of marginal weight, which should be slightly higher, is used to identify inaccuracies in lightship assessment in naval architecture. R – reserve (tolerance/margin of uncertainty) is 2–3% (up to 6% according to Schneekluth) to compensate for potentially inaccurate weight group estimates.

Lightship weight (WL) approximately corresponds to the weight of the ship upon its delivery from the shipyard to the ship owner.

It is defined as:

$$W_L = W_H + W_M + R \quad (1)$$

where:

W_H – weight of hull

$W_H = W_{ST} + W_{OT}$

W_{ST} – weight of steel structure

W_{OT} – weight of outfitting

W_M – weight of machinery

$W_M = W_{MM} + W_{MS} + W_{MR}$

W_{MM} – weight of main machinery

W_{MS} – weight of shaft and propeller

W_{MR} – weight of remaining machinery

R – reserve (tolerance/margin of uncertainty) is 2–3% (up to 6% according to Schneekluth) to compensate for potentially inaccurate weight group estimates.

As for the initial estimation of the VCG of a fully loaded ship, the relationship between KG and depth D is illustrated as:

$$KG = C \cdot D_s \quad (2)$$

where modified depth D_s is defined as:

$$D_s = D + \nabla_{SS} / (L_{PP} \cdot B) \quad (3)$$

and ∇_{SS} – volume of superstructures and deckhouses.

Coefficient C is taken from Dudzszus and Danckwardt (1982) as in the following table.

Table 2.

C coefficient for KG estimation (Bertram, 1998).

Passengers ships	0.67-0.72
Fishing vessels	0.66-0.75

Based on the Estimation of Ship Weights study, page 177 Papanikolaou, A. (2014), Ship Design (pp. 268, 262-263), the vertical position of the weight center of R was assumed to be located 20% higher than the estimated KG of the vessel.

5.1. Evaluation of Vertical Center of Gravity

In our case study, based on the above recommendations, the vertical center of gravity of the ship with 30 passengers on main deck and 50 passengers on upper deck was calculated as shown in Table 4 based on the following assumptions:

- that the maximum number of crew was 3 people on board. The average weight of each individual was estimated at 75 kg,
- that the center of gravity of a seated passenger was 0.3 m above the seat and the center of gravity of a standing passenger 1 m,
- that the lightweight is determined based on real measurement of the draft. The measured draft of the vessel was 1.10 m and the hydrostatic data indicated that the ship's lightweight was 32 tons,
- the vertical center of "Other" group weight was taken $[0,5 \cdot (\text{Depth of Ship})]$.

Table 3.

Weights on the vessel.

Nr	Weight Items	Weight (t)	VCG of weights Zi (m)
1	Lightship	32,00	1,27
2	Passenger and crew members Main deck (33 = 30+3)	2,64	3,30
3	Passenger on upper deck (50)	4,00	5,30
4	Fuel	5,00	0,35
5	Water	2,00	0,35
6	Other	3,00	1,35
Total Weight		48,64	1,58

The vessel's vertical center of gravity:

$$KG = \frac{\sum_2}{\sum_1} = \frac{76,89}{48,64} = 1,58 \text{ m} \quad (4)$$

6. TYPICAL METACENTRIC HEIGHT VALUES

The evaluation of the initial stability of the vessel in the preliminary design stage usually only requires the comparison of the obtained GM value with values typical for similar ship types, as shown in the following table (Papanikolaou, Typical Values of Metacentric Height, 2014):

Table 4.

Typical GM values per passenger ship upon departure and in fully loaded condition.

Passengers ships (oceangoing)	1.0-2.5 m
Passengers ships (limited waters)	0.5-1.5 m
Passengers ships CATAMARAN	> 10m

High GM values paired with the sufficient range of positive restoring arm curves ensure satisfactory stability and safety of the ship against capsizing at high inclination angles.

High GM values trigger intense rolling motion and transverse acceleration on the ship's deck, in view of the relationship (Papanikolaou, Typical Values of Metacentric Height, 2014):

$$T_{ROLL} \propto B / (GM)^{1/2} \quad (5)$$

where T_{ROLL} – natural roll period of the ship.

$GM \geq 0.30\text{--}0.35$ m is recommended upon departure and in design loading condition. (Papanikolaou, Typical Values of Metacentric Height, 2014).

7. SPECIAL CRITERIA FOR THE CROWDING OF PASSENGERS ON ONE SIDE AND DURING THE TURNING MANEUVER

The angle of heel during the crowding of passengers on one side and the turning maneuver, must not exceed 10° (Papanikolaou, Special Criteria for Certain Types of Ships, 2014):

$$M_R = 0.200 \cdot \frac{V_o^2}{L_{WL}} \cdot \Delta \cdot \left(KG - \frac{d}{2} \right) \quad (6)$$

where:

M_R = heeling moment (kN·m)

V_o = service speed (m/s)

L_{WL} = waterline length (m)

Δ = displacement (t)

D = mean draught (m)

KG = height of center of gravity above baseline (m).

8. SPECIAL FREEBOARD CRITERIA

Large freeboard provides large reserve buoyancy, increases a ship's survivability in case of hull damage and additionally improves ship stability at large inclination angles. Sufficient freeboard improves the ship's behavior in seaways. According to the data in the following figure, small ship ($L \leq 65$ m) freeboard is less than/equal to 1% L, while the corresponding required height of ships with approximate $L \geq 120$ m is more than 1.5% L (Papanikolaou, Freeboard, 2014).

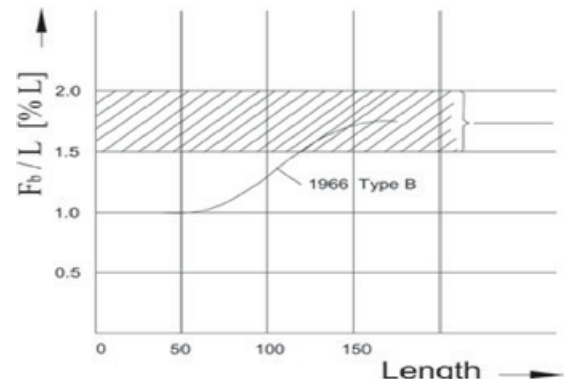


Figure 2.

Basic ship freeboard relative to their length, according to ICLL 1966.

9. CASE STUDY - EVALUATION OF STABILITY OF VESSEL "ESPERANZA"

As required by the Albanian Register of Shipping, calculations have been made to verify the stability of tourist ships that operate in the Vlora and Saranda bays, as well as in inland waters such as Koman and Vau i Dejes lakes.

The methods of calculation presented in this paper have been used. Most of the ships lack the necessary technical documentation, some are very old and have undergone structural modifications to be repurposed and converted into tourist ships (Albanian Shipping Register, 2019).

Table 5.

Data on ships for tourist transport in Albania.

Name	Year of construction/reconstruction	Built in	GT	NT
DRAGOBIA, Koman	1982/2013	Durres	24	15
BERISHA 01, Koman	N/A/2015	Koman	57	18
BERISHA 03, Koman	N/A/2015	Koman	64	19
TEUTA	1976/2015	Italy	9	3
Black Pearl	2012/2015	Marmaris, Turkey	99	53
Teuta I	1980/2018	Italy	9	6
SARDA, Vau i Dejes	N/A	N/A	NA	NA
JULKA UNIQUE	2018/N/A	Vlore	142	64
TINA TOURIST	1984/2018	Greece	44	26
ESPERANZA	1990/2018	SCILLA RC, Italy	43	13
ROZAFI	N/A/2018	N/A	42	23
AQUAMARINE	1997/N/A	Marmaris, Turkey	N/A	N/A
DELFINI 23	1980/N/A	Kalymnos, Greece	15	9
LIBURNA	1963/2019	Greece	77	34
SEASTAR	2017/N/A	Italy	7	2.1
AVVENTURA II	1991/N/A	Peschici FG, Italy	7.27	4.94
ANNA ST	1984/2019	Durres, Alb	13	6
MOGILA	1955/2002/2019	Montenegro	132	40
PADAJ	1989/2020	Bellaria, Italy	8	3

Name	Number of passengers	Lightship	VCG Lightship	VCG Fully loaded	LOA	B	D	T
DRAGOBIA, Koman	46 pax	22.40	1.27	1.45	12.90	4.50	1.85	1.25
BERISHA 01, Koman	80 pax + 10 cars	32.8	1.20	1.588	24.60	6.40		0.55
BERISHA 03, Koman	100 pax + 12 cars	49.81	1.20	1.55	29.80	7.40	1.30	0.65
TEUTA	30 pax	8.99	0.88	1.175	12.75	3.70	1.90	1.20
Black Pearl	180 pax	91.31	1.75	2.088	21.35	6.90	2.75	1.43
Teuta I	50 pax	9.58	0.82	1.31	13.60	3.80	1.50	0.92
SARDA, Vau i Dejes	40 pax	N/A	N/A	0.96	14.50	4.00	1.60	1.00
JULKA UNIQUE	200 pax	31	2.66	3.12	24.00	9.00	1.65	0.98
TINA TOURIST	150 pax	30.5	1.49	1.648	22.50	4.80	2.85	1.255
ESPERANZA	80 pax	32	1.27	1.58	16.60	4.60	2.45	1.46
ROZAFI	30 pax + 10 cars	29.6	0.99	1.7	20.40	7.40	1.80	1.33
AQUAMARINE	225 pax	127.8	1.67	2.09	30.50	8.00	3.50	2.10
DELFINI 23	48 pax	12.19	1.54	1.52	11.90	3.30	1.28	0.79
LIBURNA	120 pax	145.74	2.06	2.21	23.75	6.25	3.40	2.40
SEASTAR	50 pax	2.97	1.13	1.67	12.00	5.00	1.70	0.40
AVVENTURA II	45 pax	11.45	1.2	1.3	11.96	2.72	2.00	0.95
ANNA ST	33 pax	18	1.056	1.30	13.22	3.58	1.90	1.26
MOGILA	286 pax	159.7	1.69	1.79	25.50	13.70	2.15	1.142
PADAJ	20 pax	12.35	0.82	1.02	11.00	2.82	1.50	1.00

9.1. Basic Steps to Model the Ship Hull of the “Esperanza”

The development of a 3D-CAD model of a real ship requires the obtainment of vessel hull dimensions. The main dimensions of the vessel are shown in Table 2 and general layout in Figure 2. The measurement process was carried out on physical bulkheads and on 10 or 20 theoretical ordinates of the ship. Following measurement completion and the obtainment of ordinates, profile line and extreme parts required to draw up a database in MS Excel, the set up of the half-breadths of the model to be build was created (al X. B., 2008).

Table 6.

Main dimensions of the ship “Esperanza”.

Length overall	LOA = 16.60 m
Length between perpendiculars	LBP = 15.60 m
Breadth overall	BOA = 4.60 m
Depth	D = 2.45 m
Draft	T = 1.46 m
Passengers + Crew	80+3
Main engine:	2x177 HP
Construction material:	Wood
Year of reconstruction:	1990
Place of construction:	Italy

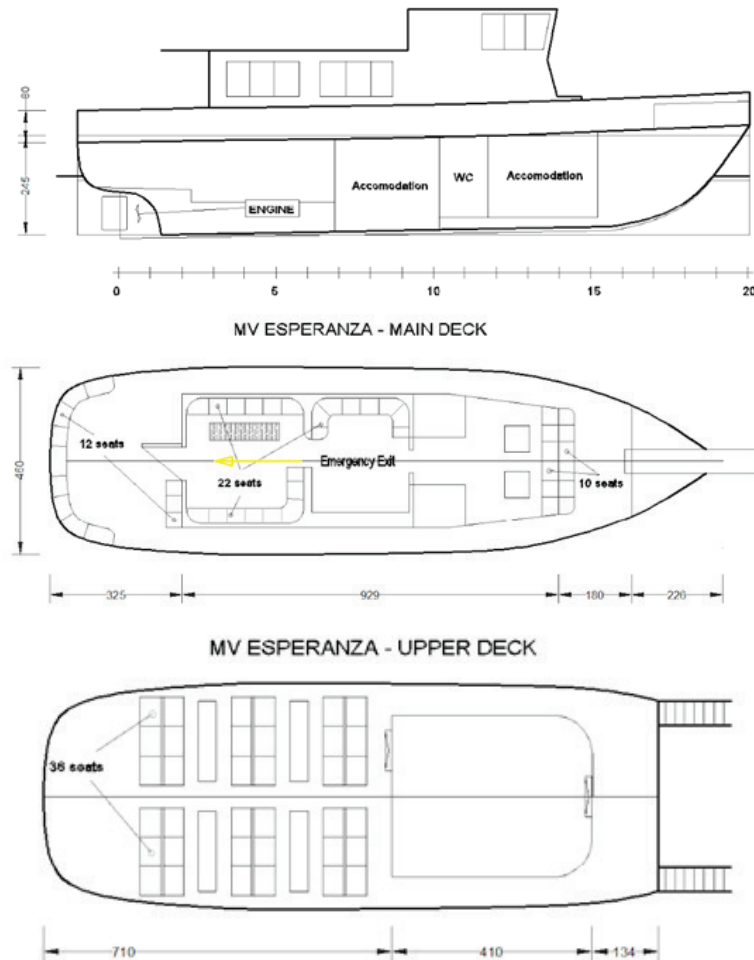


Figure 3.
General layout of tourist ship “ESPERANZA”.

After database creation in MS Excel, the 3D model of the vessel was created using the MaxSurf software.

The hull surface design process was conducted in three stages:

1. Modelling of initial hull curves
2. Building of the hull surface
3. Smoothing of the hull surface

After visualization, potential errors occurring during coordinate insertion were corrected, appropriate modifications were made and record file containing all coordinates of the points needed to generate the hull were created (Systems, 2009).

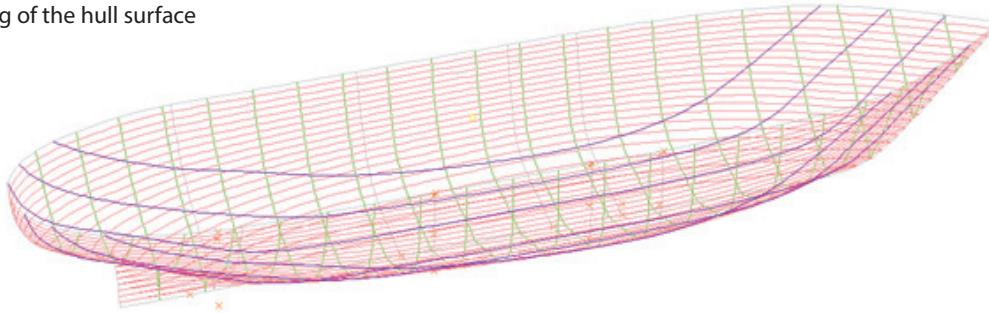


Figure 4.
Model - final form of the hull after consecutive encore. 3D Lines Plan of 'ESPERANZA'.

9.2. Generation of Hydrostatic Curves

Hydrostatic curves were calculated (Biran, Ship Hydrostatic and Stability, Stability booklet, 2003) (Figure 3) using the Hydromax Software. Table 2 presents data for the fully loaded vessel, corresponding to waterline DWL=1.46m.

Table 7.

Hydrostatic DATA of vessel "ESPERANZA".

Draft Amidsh. M	DWL=1.46	Block Coeff.	0.53
Displacement tonne	48.5	Midship Area Coeff.	0.78
Draft at FP m	1.46	Waterpl. Area Coeff.	0.82
Draft at AP m	1.46	LCB from zero pt. (+ve fwd) m	8.36
Draft at LCF m	1.46	LCF from zero pt. (+ve fwd) m	7.95
WL Length m	15.6	KB m	0.90
WL Beam m	4.20	BMt m	1.23
AWL (m ²)	51	Immersion (TPC) tonne/cm	0.515
Prismatic Coeff.	0.68	MTc tonne.m	0.51

9.3. Stability Data Calculations

Stability data were calculated using the MAXSURF Naval Architecture Software (Hydromax).

The following diagram shows the static stability curve of the vessel.

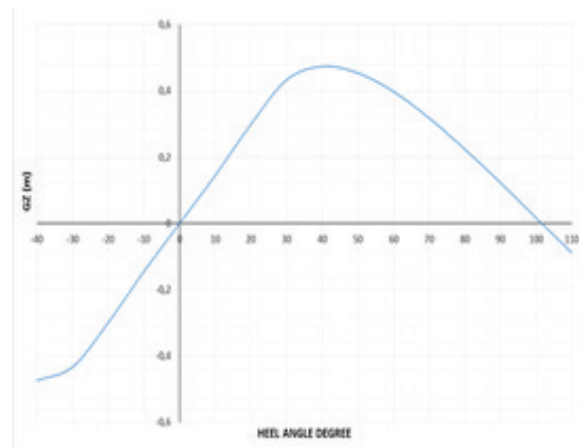


Figure 5.
GZ diagram vs heeling angle.

Table 8.

Stability data according to Hydromax Software calculations.

Heel to starboard (degrees)	10	20	30	40	50	60	70	80	90
GZ (m)	0,15	0,30	0,43	0,47	0,45	0,40	0,32	0,22	0,12
Displacement (mt)	48,40	48,40	48,40	48,40	48,40	48,40	48,40	48,40	48,40
Wetted area (m ²)	69,58	70,38	74,50	77,60	79,47	80,68	81,47	81,81	81,39
Water plane area (m ²)	51,36	53,05	47,91	41,27	36,93	34,23	32,80	32,49	32,23
Prismatic coefficient	0,68	0,68	0,70	0,71	0,72	0,73	0,74	0,75	0,75
Block coefficient	0,53	0,50	0,53	0,59	0,63	0,66	0,68	0,68	0,63

9.4. Criteria for Righting Lever Curve Properties

The assessment of the level to which the IMO stability criteria (IMO resolution A.167) (IMO, IMO stability Criteria (IMO

resolution A.167)) have been met is conducted using the stability curve for the main loading condition/s in respect of the vessel's operation.

Table 9.

Verification of IMO stability criteria.

Code	Criteria	Value	Units	Actual	Status
A.749(18) Ch3 - Design criteria applicable to all vessels	3.1.2.1: Area 00 to 300	3.151	m.rad	6.65	Pass
	3.1.2.1: Area 00 to 400	5.157	m.rad	11.25	Pass
	3.1.2.1: Area 300 to 400	1.719	m.rad	4.60	Pass
	3.1.2.2: Max GZ at 300 or greater	0.200	m	0.47	Pass
	3.1.2.3: Angle of maximum GZ	25	degree	40.9	Pass
	3.1.2.4: Initial GMt	0.150	m	0.82	Pass

9.5. Weather Criteria (Wind and Rolling Criterion)

The ability of a vessel to withstand the combined effects of beam wind and rolling was demonstrated by reference to Figure 9 (al L. k., 2005).

Under these circumstances, area b is equal to or greater than area a, as indicated in the following table.

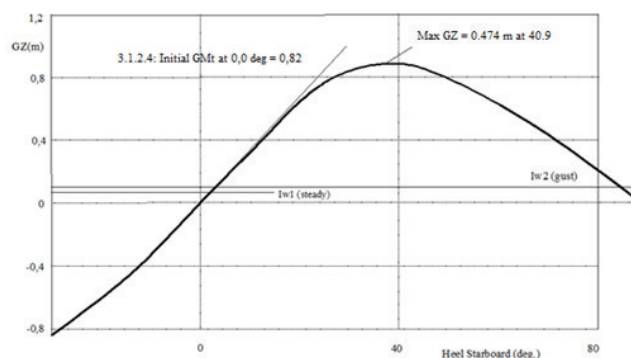


Figure 5.
Severe wind and rolling.

Table 10.

Verification of weather criteria.

Criteria	Value	Units	Actual	Status	Margin%
A.749(18) Ch3 - 3.2.2: Severe wind and rolling					
Angle of steady heel is not greater than	16.0	deg	4.6	Pass	+60
Angle of steady heel / Deck edge immersion angle is not greater than	80.000	%	28.59	Pass	+64
Area1 (b) / Area2(a) is not less than	100.000	%	231.14	Pass	+131
Area1 (under GZ), from 6.2 to 50.0 deg.		m.deg	15,28		
Area1 (under HA), from 6.2 to 50.0 deg.		m.deg	5,55		
Area1(b), from 6.2 to 50.0 deg.		m.deg	9,73		
Area2 (under GZ), from -16.4 to 9.5 deg.		m.deg	-0,91		
Area2 (under HA), from -16.4 to 6.2 deg.		m.deg	3,31		
Area2(a), from -16.4 to 6.2 deg.		m.deg	4,21		

10. CONCLUSIONS

The purpose of this study was to present the necessary stability procedure required by the Albanian Register of Shipping, which is of paramount importance for the safety of short distance passenger transport activities.

Consulting various authors and literature on ship design, methods and methodologies for preliminary determination or empirical formulas for calculating various technical elements of vessels, such as vertical center of gravity for lightship, minimum values for metacentric heights GM or others parameters, helped us create an excellent inventory to be used in ship calculations required to fill out the trim and stability booklet as described above.

Some technical recommendations with respect to the maximum number of passengers allowed were given to ensure safe navigation. The application of these recommendations to ship stability assessment required by the Albanian Register of Shipping was described. The procedure followed by actual measurement is helpful for 3D modelling of ship hulls and useful for creating models in similar cases.

The use of the naval computer package significantly contributed to the obtainment of improved hull surface and facilitated extremely tedious manual work.

The fulfillment of the stability criteria was verified in accordance with the criteria stipulated in the IMO stability code and the norms prescribed by Resolution MSC.267 (85).

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