PRELIMINARY ESTIMATION OF THE PRINCIPAL DIMENSIONS OF HIGH SPEED RO-PAX ALUMINIUM CATAMARAN FERRIES BASED ON UPDATED STATISTICS

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Abstract:

The goal of a dimensional prediction model is to offer values that represent the potential full-scale vessel within acceptable tolerances.
The paper presents relations among main design parameters of the high speed ro-pax aluminium catamaran ships. The presented relations are derived from the collected data of twenty five existing high speed ro-pax aluminium catamaran ships. The paper focused on identifying design trends and relations between basic ship particulars such as: pay load, ship's overall length, waterline length, depth, beam, power output, and finally service speed. The proposed relations can be used for the preliminary estimation of the principle dimensions of the high speed ro-pax aluminium catamaran ships at the preliminary design stage or may be a basis for rational selection of the range of variation of main dimensions in high speed ro-pax aluminium catamaran ships series.
Another goal of the paper is to update the data and hence the relations that can be used to quickly predict the main dimensions of High Speed RO-PAX Catamarans in preliminary (basic/pre-contract) design stage. For this purpose, the obtained results were compared to other statistical survey made by Fragiskos Zouradkis (2005). It was found that the statistical relations slightly differs from 2005 till 2011, while the only exception was the draft where, it's noticed that recently high speed ro-pax aluminium catamaran have less draft. Finally, the obtained results were compared with previous formulae, and it was found that the obtained data are nearer to the real one.

Keywords: high speed ro-pax catamaran ships, ship design, new types of ships.

1. Introduction

High Speed ro-pax aluminium catamarans can be defined as a ship designed to carry both passengers (more than twelve passengers) and vehicles, which do not spend in the course of their voyage more than four hours at operational speed from a place of refuge [HSC Code, 2000]. The size ranges for aluminium hulls don't exceed 125 m till 2011. In the preliminary ship design two basic methodologies are used: the first based on a parent ship and the second that based on statistical data worked out from an appropriate number of ships of the same type as the ship being designed [JAN P. MICHALSKI, 1997].

The statistics based methodology is particularly useful when detailed information on the parent ship is missing.
Collecting the required data, especially in the case of non-typical ships, is often difficult due to the data being scattered over the literature or not published at all. With the high speed ro-pax aluminium catamaran ships it is even more difficult as it is a more specific new solution and relatively few ships have been built so far. The paper presents statistics based relations of the main design parameters of high speed ro-pax aluminium catamaran ships, particularly main dimensions.

2. Starting Point for design High Speed RO-PAX Catamaran Ships:

The first problem that a naval architect faces when he starts to design a ship is the selection of main dimensions meeting the entire specified requirement (dead-weight or payload, speed and dimensional limitations, etc)
The main dimensions decide many of the ship's characteristics, e.g. stability, payload, power requirements, and even transport efficiency. Therefore determining the main dimensions and form ratios represent an important phase in the overall design of a ship.
When a ship owner makes an initial enquiry, he usually gives the shipdesigner some basic specifications like type of vessel, number of passengers and number of vehicles, required service speed, route, classification society and ship's flag. [Schneekluth, 1998]. From this data and by using the proposed design charts the designer can estimate the main dimensions of the new ship.
The design charts presented here may be used in the preliminary design of high speed ro-pax aluminium catamaran ships. In devising a series of shapes e.g. for systematic testing of resistance or seagoing qualities and or can be used to assist in delineating the operational profile of a vessel for a particular trade. The user has to pick the basic ship dimensions according to the intended use of the ship with acceptable tolerances. For this reason continuous catamaran ships survey was decided. 25 existing high speed Ro-Pax aluminium catamarans designs were considered. A number of from a commercial ship database have been selected to form the basic data-set for this work.
The pay load is the summation of both passengers and vehicles weight as it can be calculated by the total number of passengers multiplied by 75 Kg. which is the passenger weight and total number of cars multiplied by 1500 kg which is the car weight [HSC Code, 2000]
It is noted that high speed catamarans use the 'Waterline length' (LWL) at the design stages, while, they operate according to the overall length (LOA) as determined by, the length of available berths, the lengths of locks that may need to be passed through, the width of harbour- or turning basins in which the ship has to maneuver, or the line of approach channels the ship has to navigate.
Beam, as determined by, the widths of approach channels, harbour entrances, and locks, the ship may have to pass through, as well as the shore-based ramp facilities available in ports of call.
Draft, as determined by, the water depth available in shallow sea areas, approaches, harbor entrances, sill heights of locks, and water depth available alongside the berths. The tidal effects, as they apply to the trading area(s) and route(s) where the vessel sails, will have to be considered.

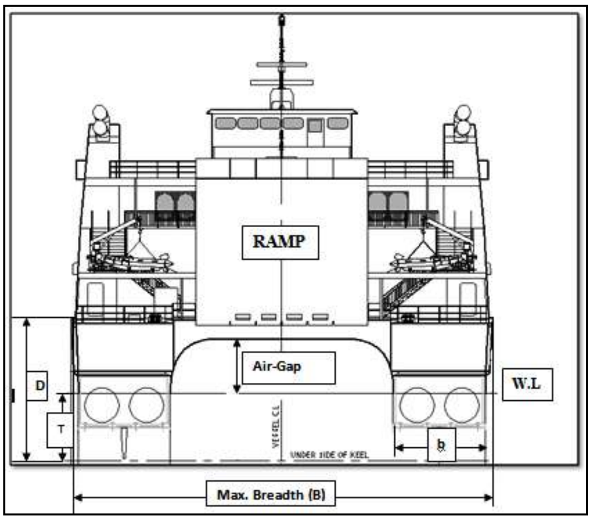

Figure (1): Basic catamaran dimensions

Figure (1) shows the basic dimensions of the catamaran ships.

3. Proposed Formula for the Length of a New High Speed RO-PAX Aluminum Catamaran Ships:

The Pay Load of a vessel in relation to its length is illustrated in Figure (2). The following proposed formulae were obtained from analyzing the curves shown in figure (2) to estimate the length overall of new high speed RO-PAX aluminium catamaran ship (in the early design stage) as a function of the required payload (P.L):

$$LOA = -8 \times 10^{-5}(P.L)^2 + 0.1568\ (P.L) + 43.206 \qquad (1)$$

The data in this design chart can be used to estimate the length of a vessel if the cargo capacity is known from the preceding trade analysis and logistical considerations related to, or the owner requirements.

Length affects the longitudinal stability or trim of the vessel. Together with hull form and shape, length affects the seakeeping capability of the ship and thus its ability to achieve or maintain a specific schedule in adverse weather and sea conditions [Gerry Trant, 2007]. Length also affects the subdivision of the vessel into water tight compartments by means of transverse-bulkheads.

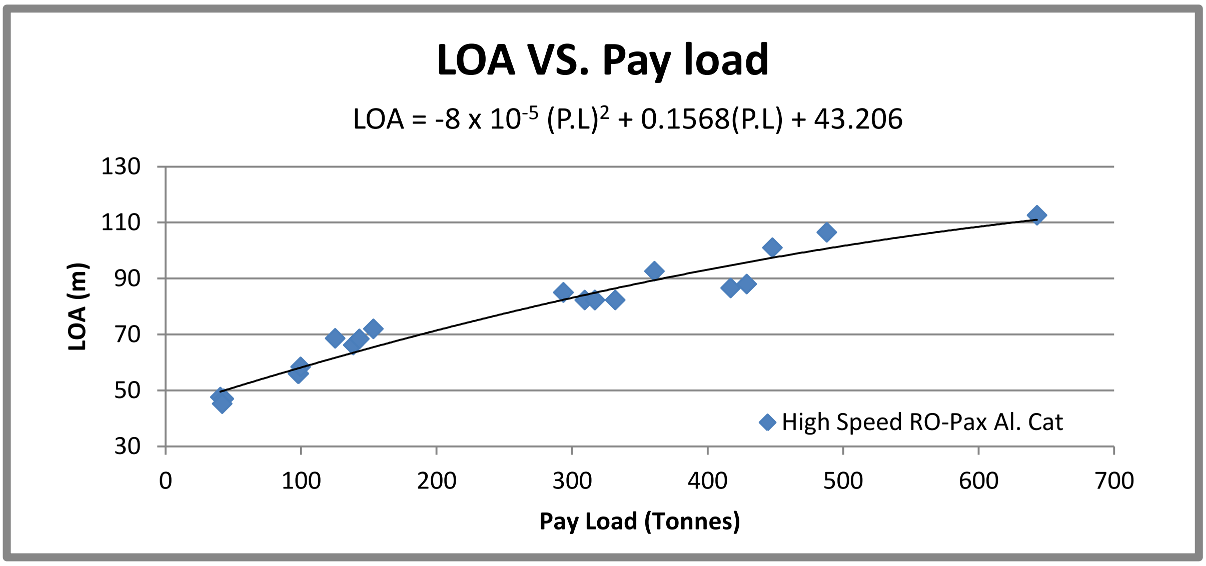

Figure (2): The relationship between LOA VS. Payload

4. Proposed Formula for the Water Line Length of a New High Speed RO-PAX Aluminum Catamaran Ships:

It has been indicated that the ship's length has a determining influence on its LWL.
By using the design chart showing the parametric relationship between LWL to LOA ratio and LOA in figure (3).
The LWL to LOA ratio appears to be fairly constant (≈0.86).

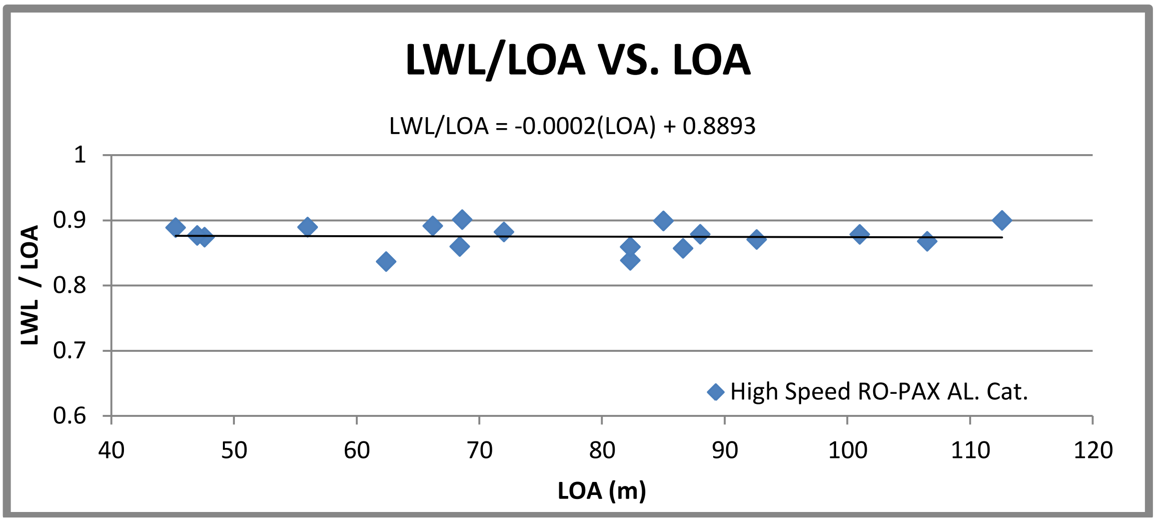

Figure (3): The relationship between LWL/LOA VS. LOA

5. Proposed formula for other main dimensions of high speed RO-PAX aluminium catamaran ships:

The following proposed formulae were obtained from the curves shown in figure (4) to estimate the breadth, depth and draft respectively in meters of new high speed RO-PAX aluminium catamaran Ships (in the early design stage) as function of the required LOA:

$$B = 0.2334(LOA) + 2.106 \quad (2)$$

$$D = 0.0773(LOA) + 0.4876 \quad (3)$$

$$T = 0.0004(LOA)^2 - 0.0285(LOA) + 2.3425 \quad (4)$$

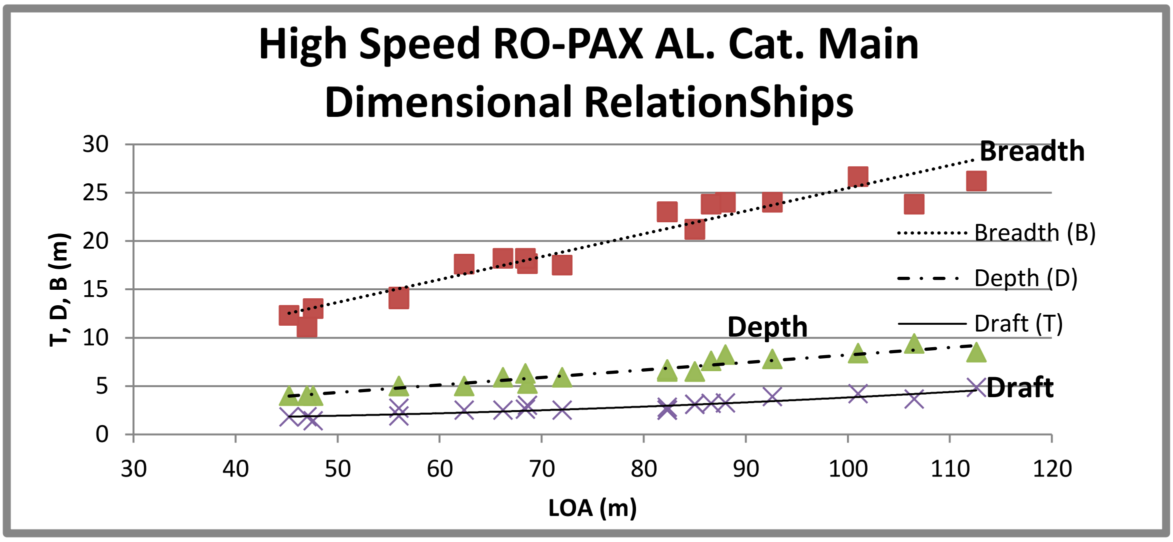

Figure (4): Breadth, Depth, Draught and Length overall relationships

The L/B ratio is an important parameter both for classical ships and for catamarans (it influences stability, resistance, cubic capacity). But in Catamarans the value of this ratio is chosen mainly due to functional reasons – the required cargo deck arrangement. A separate question is the breadth of underwater body, i.e. the distance between demi-hulls based on stability requirements [JAN P. MICHALSKI, 1997]. The design chart presented in Figure (4) shows the range of practically used values of B/L ratio which fits into a narrow range of 0.22: 0.28.

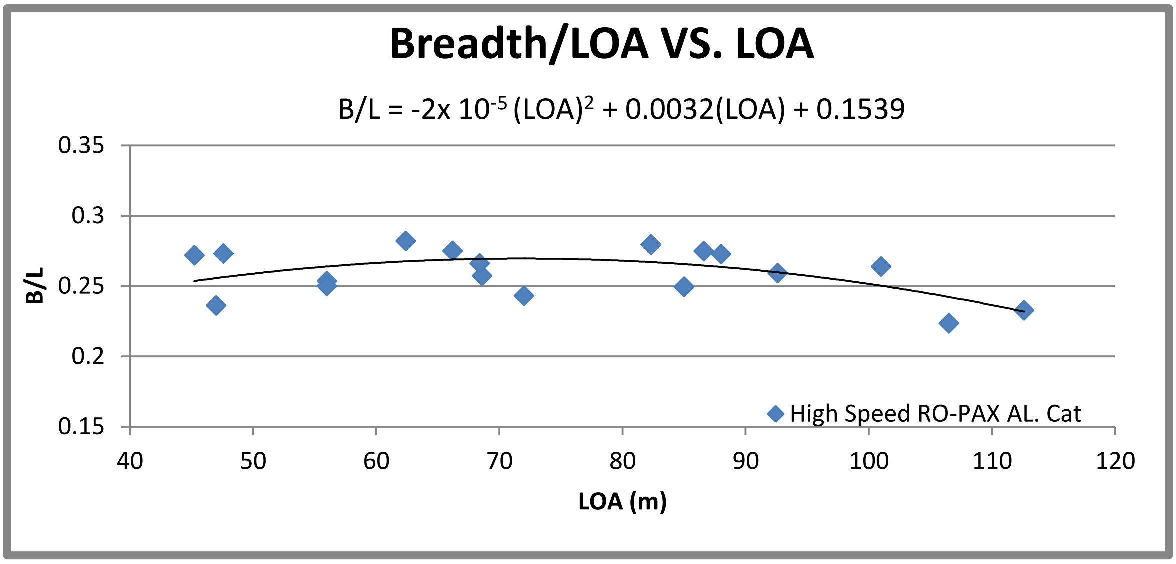

Figure (5): The relationship between B/LOA VS. LOA

The relationship between beam and draught affects transverse stability, resistance and seakeeping. Draft is affected by trim (the difference between the draught at bow and stern), and heel (the difference between draft at port- and starboard side). Both trim and heel may cause problems in shallow water operations and particularly alongside a quay during loading and discharging, where a specific trim may be required to reduce the ramp angle in order to increase the speed at which vehicles can enter and leave the ship. Whilst length and beam are permanently fixed, draft is constantly varying during the operation of the vessel. The amount of cargo, fuel, and fresh water, as well as their individual and combined distribution throughout the vessel affects draft. The draft of high speed Ro-Pax aluminium catamarans is assisted by the design chart in Figure (6), showing the parametric relationship between draft and beam.

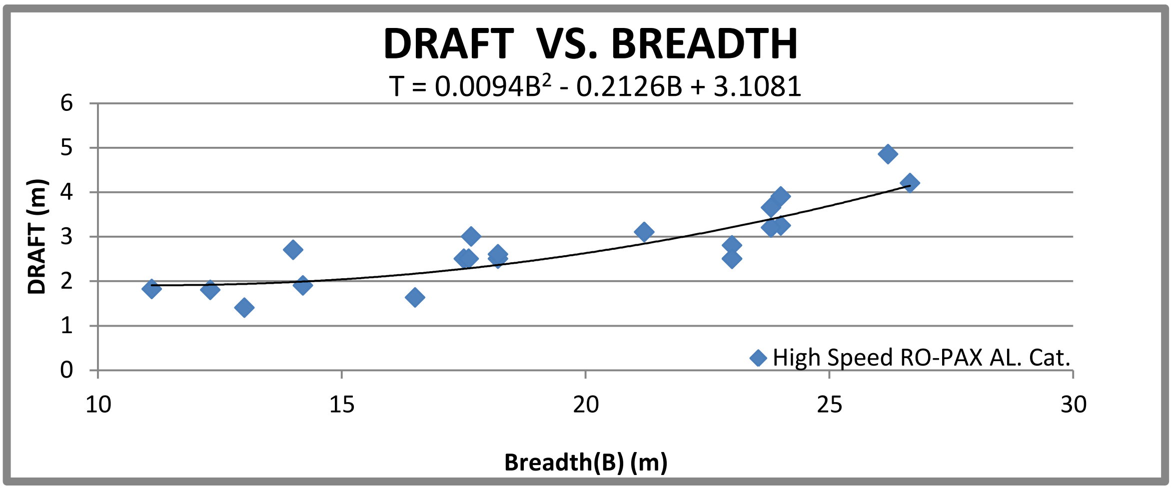

Figure (6): The Relationship between Draft and Breadth

6. Proposed formula for Power output of High Speed RO-PAX Aluminium Catamaran Ships:

The power needed to propel a vessel depends upon its size and its speed. In the case of high speed Ro-Pax catamarans, ship size is generally expressed by the payload. The power required for each operating speed needs to be estimated and the main engines need to be selected and arranged accordingly. Figure (7) shows the relation of installed power and the payload of the collected catamaran database.

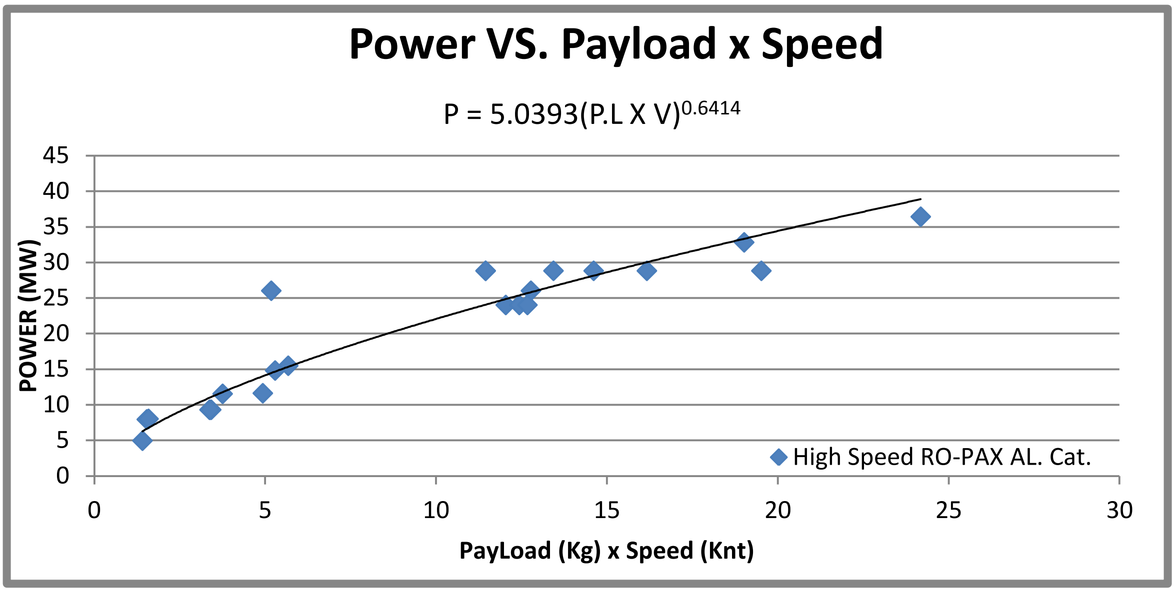

Figure (7): The relationship between Power VS. Payload x Speed

It must be noticed that the above obtained main particulars are preliminary values and should be rechecked through detailed calculations regarding buoyancy, stability, flooding, economic operation … etc.

7. Comparative Parametric Relationships Study:

In this section comparisons of some estimated relationships with those made by Fragiskos Zouridakis (2005), are shown on Figures (8, 9, 10, 11 and 12).

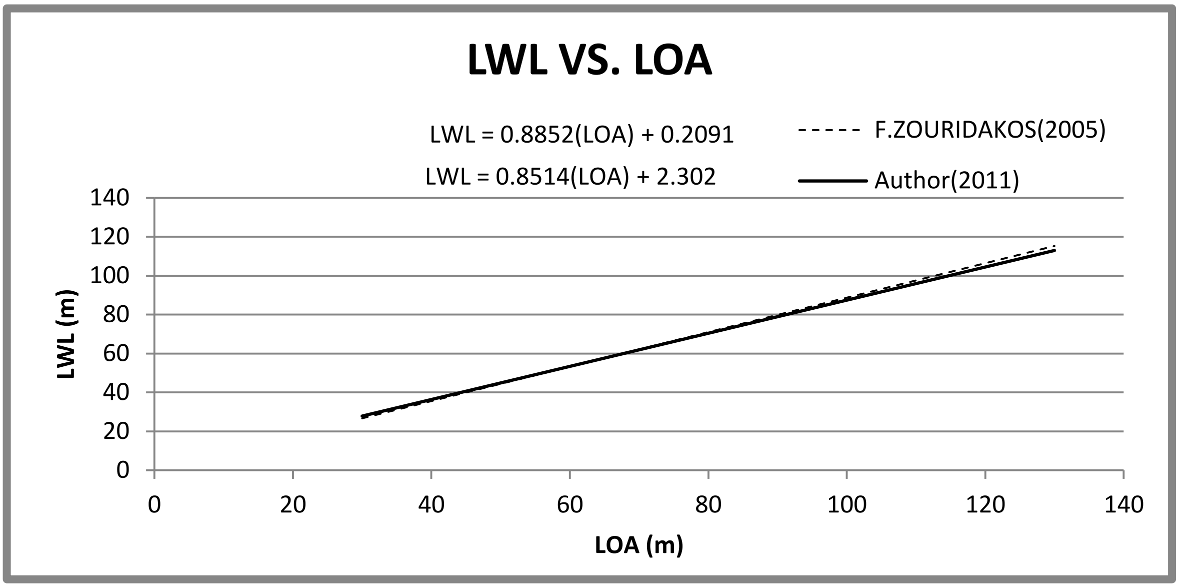

Figure (8): Comparison between ships's LWL VS. LOA

Figure (8) shows a slight (nearly no) difference happened in the relationship between LWL VS. LOA.

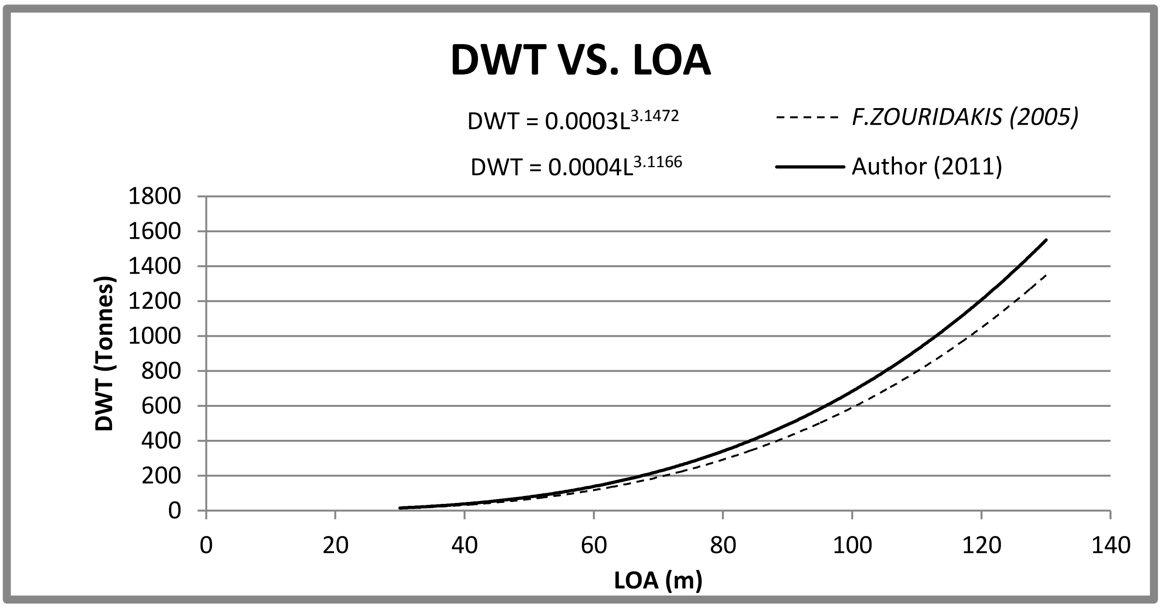

Figure (9): Comparison between ships's DWT VS. LOA

Figure (9) shows that the new trends (in the proposed formula) indicate higher DWT at the same LOA. The reason may be attributed to heavier light ship weight when steel is used, as in F.Zouridakis data base.

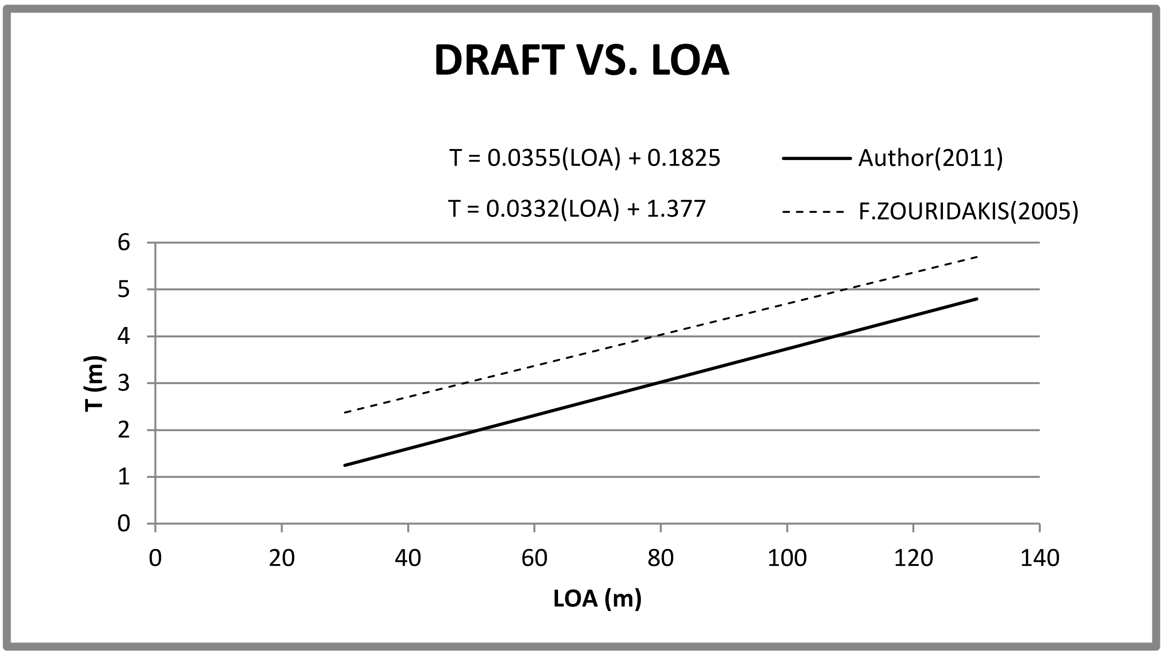

Figure (10): Comparison between ships's T VS. LOA

Figure (10) shows lower draft at the same LOA. This difference could be attributed to improved hull design and lighter materials selected.

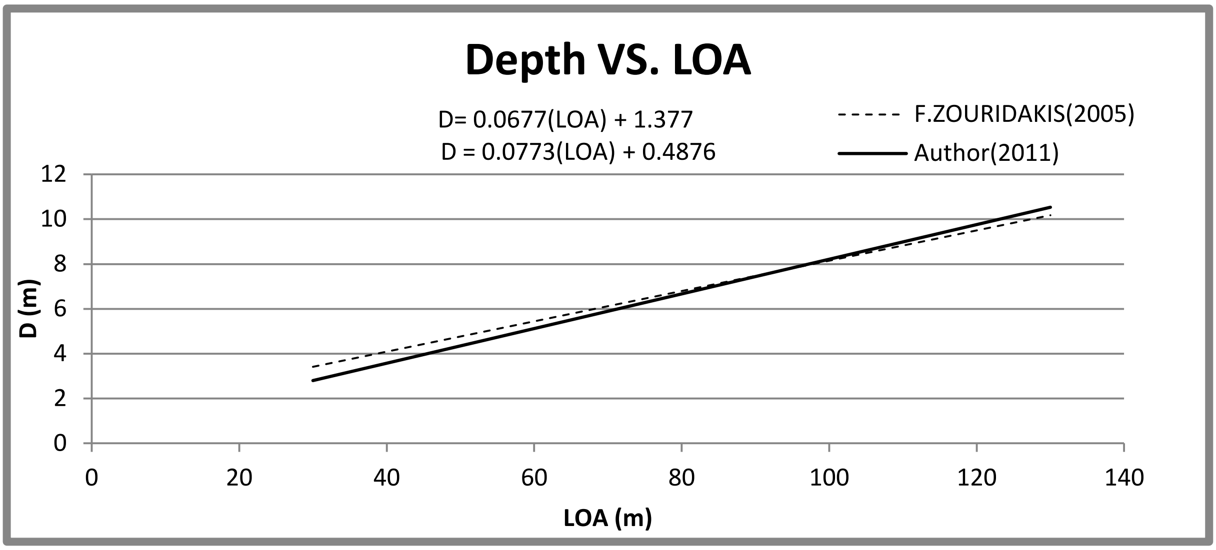

Figure (11): Comparison between ships's D VS. LOA

Both depth and beam relation with LOA exhibit slight difference between the two data base set as shown in Figure (11) & (12).

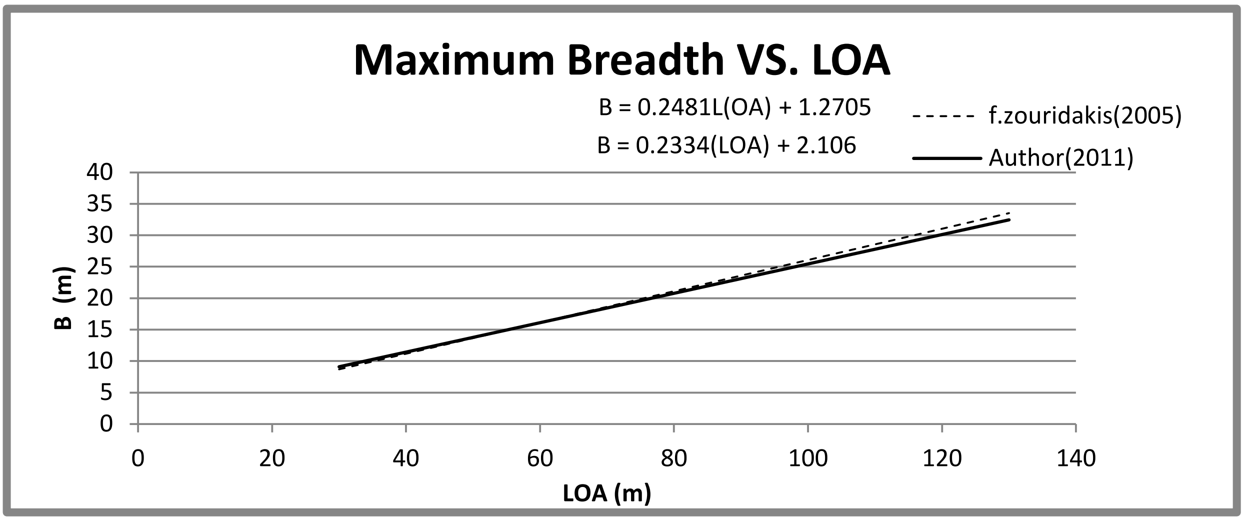

Figure (12): Comparison between ships's B VS. LOA

8. Case Study:

Two test case study is selected to compare results as estimated by proposed & F.Zouridakis Formulae for Determining Breadth, Depth and Draft. Main dimensions of these two cases are given in (Table 1).

Table (1): Existing ships main dimensions [http://www.damen.nl, 2011]:

Ship name	LOA (m)	Max.B (m)	D (m)	T (m)
Fast Ferry 6016	60	16.2	5	2
WPC 5214	52	13.8	4.6	1.8

Prediction results as obtained by F.Zouridakis and proposed methods are shown on table (2).

Table (2): Values and Errors percentages for both formulae:

Ship Name	Main Dimensions	F.Zouridakis Formula		Proposed Formula	
		Value (m)	Error (%)	Value (m)	Error (%)
Fast Ferry 6016	B	16.156	- 0.26	16.11	- 0.55
	D	5.439	8.07	5.12	1.96
	T	3.369	40.635	2.132	6.1
TOTAL ERRORS			**48.96**		**8.61**
WPC 5214	B	14.167	2.58	14.2	3
	D	4.897	6	4.5	- 2
	T	3.1	42	2	10
TOTAL ERRORS			**50.58**		**15**

Table (2) shows that by using the estimated relations among beam, depth and draft to LOA exhibit slight errors to the actual values, while results obtained by F.Zouridakis exhibit higher draft at the same LOA causing higher total errors.

9. Conclusions:

A quick and simple method based on statistical analysis of the data of 25 existing high speed ro-pax aluminium catamarans of different sizes (LOA range from 45.24: 112 m) has been proposed and presented in simple formulae and design charts ready for use to estimate overall length, waterline length, breadth, depth, draught and power, in preliminary design stage for high speed aluminium ro-pax catamarans. The proposed formulas for preliminary estimation of basic dimensions were compared by other survey information made on different 52 high speed ro-pax aluminium catamaran ships by Fragiskos Zouridakis (2005) and the results which were obtained were close.

Overall beam, depth and draft show linear upward sloping trends with length. The LWL to LOA ratio appears to be fairly constant in the area of 0.85-0.9. The draft to the same LOA show high differences between both relationships, if any, are due to the advanced technology in shipbuilding in recent years also market needed to decrease draft. Also DWT shows an increase with LOA (in new trends).

Another comparison between proposed & F.Zouridakis Formulae for estimating breadth, depth and draught of two existing high speed ro-pax aluminium catamarans and actual values of the same ships were done, and the total results which were obtained from the proposed formula were fair enough and compatible with actual values than those were obtained by F.Zouridakis design formula.

Finally, it has to be noted that these charts and equations need to be updated from time to time to cope with the continuous developments in the industry of high speed catamarans.

References:

High Speed Craft Code (HSC), (2000) International Maritime Organization (IMO).

Fragiskos Zouradkis, (2005) A Preliminary Design Tool for Resistance and Powering Prediction of Catamaran Vessels. Massachusetts Institute of Technology.

Gerry Trant, Felix Schmidt & Mary Gallagher, (2007) FEASIBILITY OF NEW RORO / ROPAX SERVICES BETWEEN IRELAND AND CONTINENTAL EUROPE.

JAN P. MICHALSKI, (1997) Statistical data of hull main parameters useful for preliminary design of SWATH ships. Polish Naval University.

Nadiya Bukhanevych, (2010) Key Configurations for Design and Fabrication of High Speed Offshore Vessels. University of Stavanger.

Dominick Cimino & David Tellet, (2007), Marine Vehicle Weight Engineering. Copyright ©2007 by the Society of Allied Weight Engineers (SAWE Inc.)

William L.Hagan, (2008) A Practical Application of concept selection methods for high speed marine vehicle design. Massachusetts Institute of Technology.

Collected data from internet sites:

Nigel Gee, (2002) FUTURE TRENDS IN HIGH SPEED VESSELS. from: http://media.bmt.org/bmt_media/resources/29/Paper12.pdf "Accessed 06-2011"

Nigel Gee, (2006) High Speed Marine Transport.from:http://media.bmt.org/bmt_media/resources/29/Paper47-HighSpeedMarineTransport.pdf "Accessed 08-2011"

Available from:

http://www.austal.com/ar/ "Accessed 08-2011"

BARRAS, (2004) Ship Design and Performance for Master and Mates. Amsterdam: ELSIVER.

http://www.damen.nl/products/DAMEN_FAST_FERRIES.aspx?mId=8618 "Accessed 08-2011"

	Ship Name	Year	L.O.A (m)	L.W.L (m)	B (m)	D (m)	T (m)	DWT (tonne)	Power (KW)	Speed (knots)	Pay Load (Tonnes)
1	El-RIYADH	2008	88	77.3	24	8.25	3.246	550	28800	37.7	587.7
2	Jazan	2008	68.6	61.8	17.65	5.25	3	258	11520	30	288
3	Aremiti 5	2004	56	49.8	14.2	5	1.9	122	9280	34.8	156.8
4	AUTO EXPRESS 47	2011	47	41.2	11.1	4	1.82	63.3	4930	32.8	96.1
5	AUTO EXPRESS 82	1997	82.3	70.7	23	6.7	2.5	346	24000	38	384
6	Bocayna Express	2003	66.2	59	18.2	5.9	2.5	315	11600	35.6	350.6
7	BOOMERANG	1997	82.3	70.7	23	6.7	2.5	346	24000	40	386
8	delphin	1996	82.3	69	23	6.5	2.5	346	24000	40.2	386.2
9	El-Kahera	2009	88	77.3	24	8.25	3.246	550	28800	37.7	587.7
10	Euroferrys Pacifica	2001	101	88.7	26.65	8.4	4.2	750	28800	30	780
11	FARASAN	2009	68.6	61.8	17.65	5.25	3	258	11520	30	288
12	FARES AL SALAM	2002	56	49.8	14	5	2.7	130	9280	34.5	164.5
13	hawaii superferry	2007	106.5	92.4	23.8	9.4	3.65	800	28800	40	840
14	HIGHSPEED 2	2000	72	63.5	17.5	5.9	2.5	280	15464	37	317
15	Highspeed 4	2000	92.6	80.6	24	7.8	3.9	470	28800	40.5	510.5
16	highspeed 5	2005	85	76.4	21.2	6.5	3.1	470	28800	39	509
17	highspeed 5	2005	85	76.4	21.2	6.5	3.1	470	28800	39	509
18	JADE EXPRESS	1998	47.6	41.6	13	4	1.4	54	7920	38	92
19	LAKE EXPRESS	2004	62.4	52.2	17.6	5	2.5	148	9280	34	182
20	LEONORA ChRISTINA	2011	112.6	101.3	26.2	8.5	4.85	1000	36400	37.6	1037.6
21	maria dolores	2006	68.4	58.8	18.2	6.3	2.6	260	14790	37	297
22	SHINAS & Hormuz	2008	67	57.62	16.5	6.2	1.63	70	26000	51.5	121.5
23	silver express	2005	45.24	40.2	12.3	4	1.8	67	8000	38	105
24	SPIRIT OF ONTARIO 1	2004	86.6	74.2	23.8	7.6	3.2	470	32800	45.6	515.6
25	superstar express	1997	82.3	70.7	23	6.7	2.8	340	26000	38.5	378.5