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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 aluminum 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 aluminum 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 ship designer 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. Twenty five existing high speed ro-pax aluminium catamarans main particulars were considered to form the basic data-set for this work, See Table (2).

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.

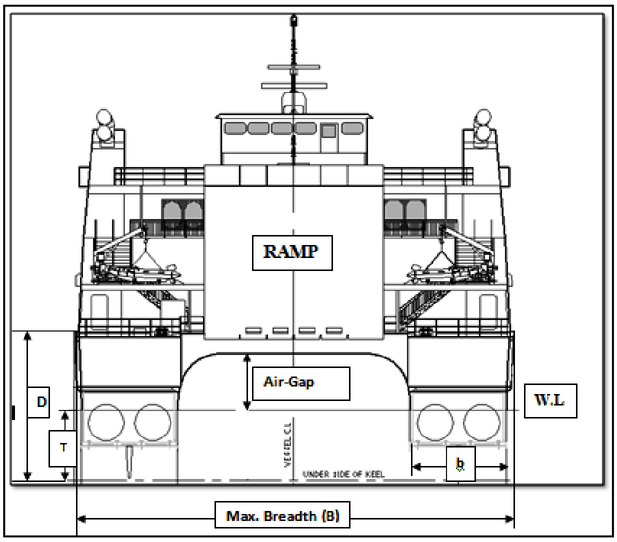

Figure (1): Basic catamaran dimensions

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 (The summation of both passenger and vehicle weights) 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):

$$LOA = 0.11\ (P.L) + 47.863 \qquad \text{.....(1)}$$

For: $40.35 \leq P.L \leq 643.125$ (Tonnes)

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].

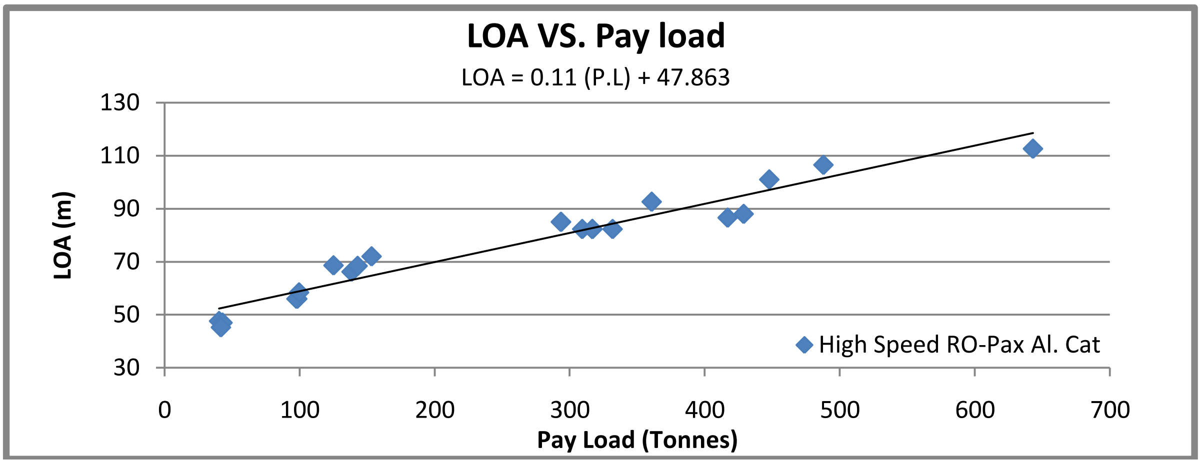

Figure (2): The relationship between LOA VS. Payload

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 (≈0.89).

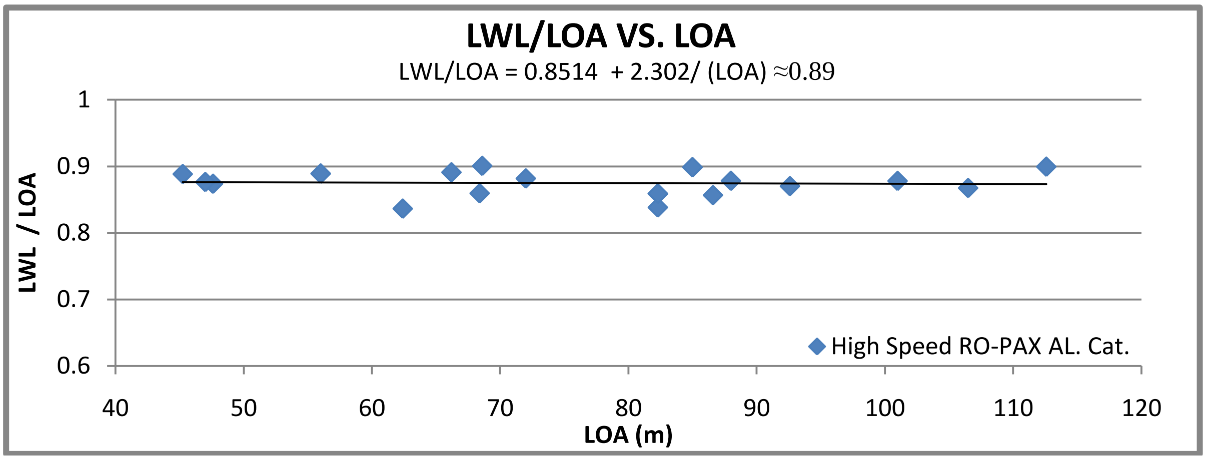

Figure (3): The relationship between LWL/LOA VS. LOA

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:

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

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

$$T = 0.0355(LOA) + 0.1825 \quad (4)$$

For: $44 \leq LOA \leq 112.6$ (m)

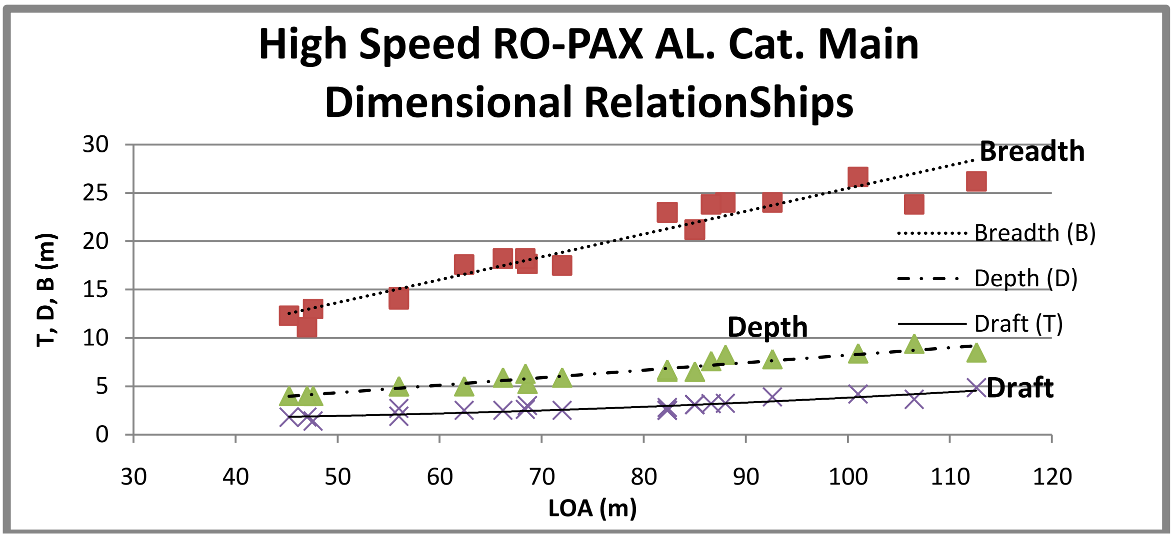

Figure (4): Breadth, Depth, Draught and Length overall relationships

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.

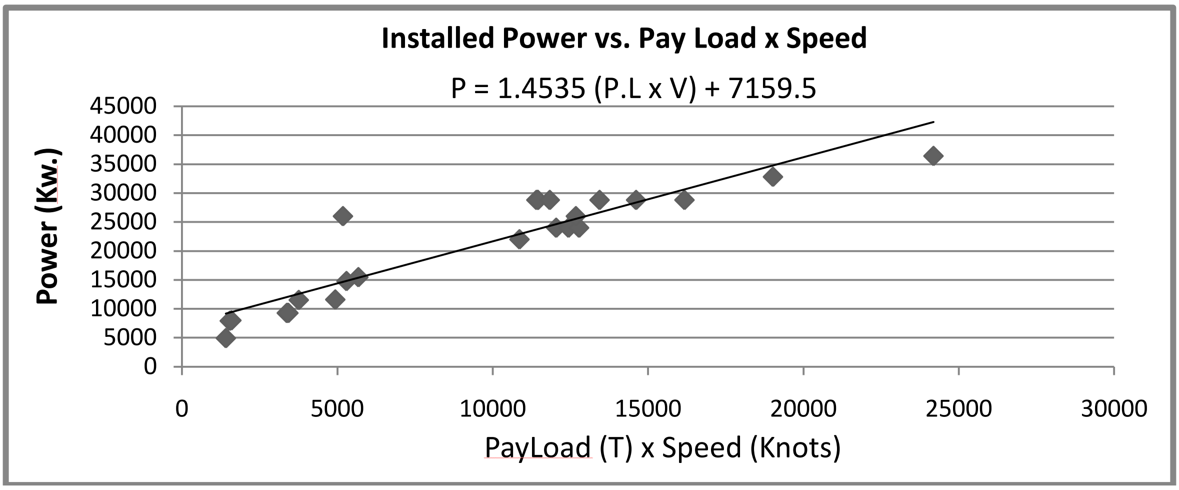

Figure (7): The relationship between Power VS. Payload x Speed

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 F.Zouridakis [Fragiskos Zouradkis, 2005), are shown in Figures (8, 9, 10, 11 and 12).

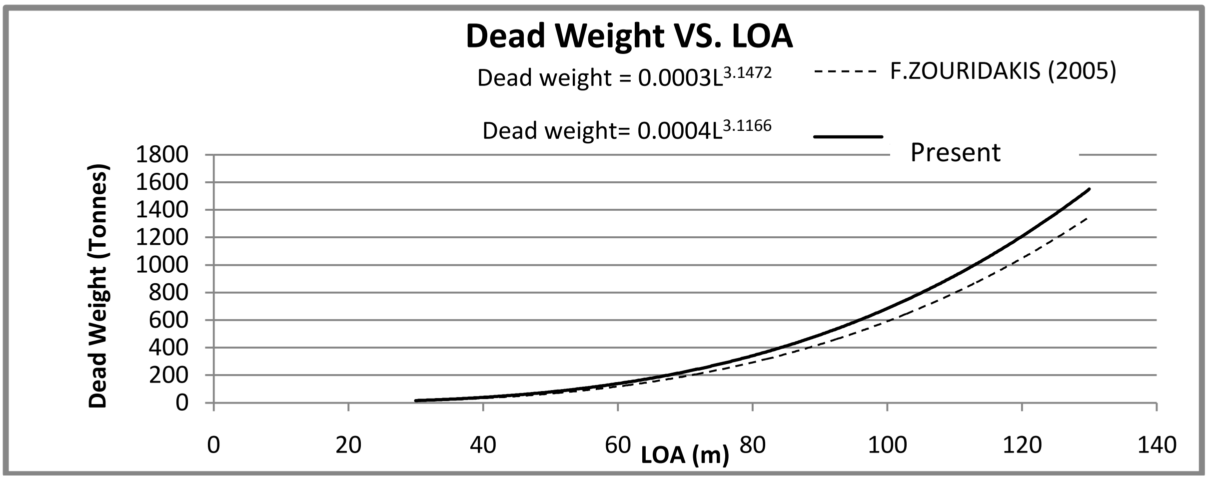

Figure (8): Comparison between ships's DWT VS. LOA

Figure (8) shows that the new trends (in the proposed formula) indicate higher deadweight at the same LOA. The reason may be attributed to heavier light ship weight when steel is used, as in F.Zouridakis data base.

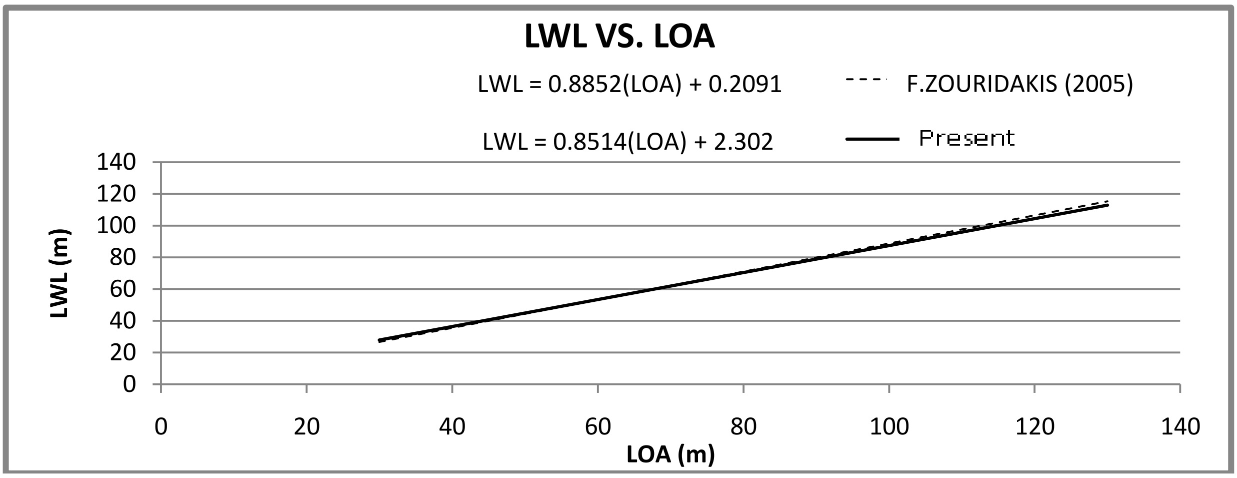

Figure (9): Comparison between ships's LWL VS. LOA

Figure (9) shows a slight (nearly no) difference happened, in the relationship between LWL VS. LOA.

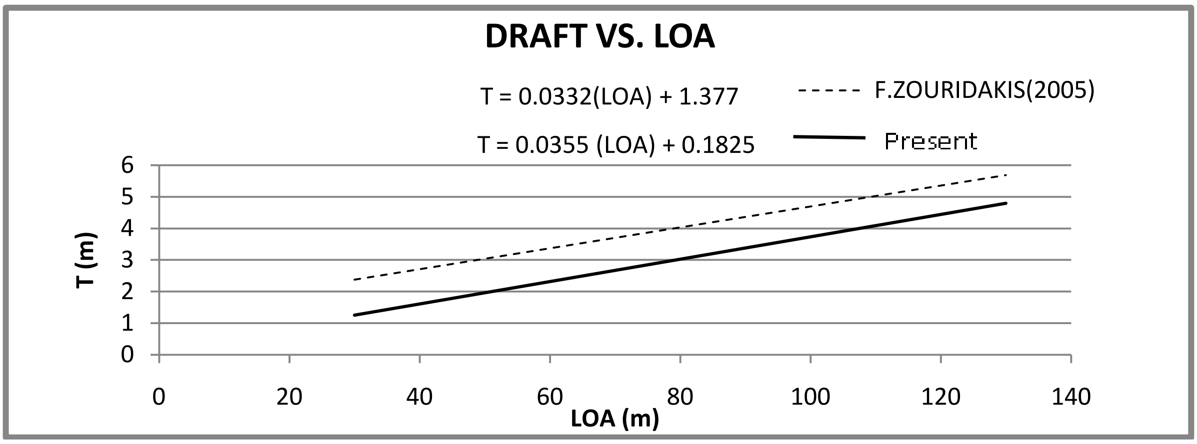

Figure (10): Comparison between ships's T VS. LOA

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

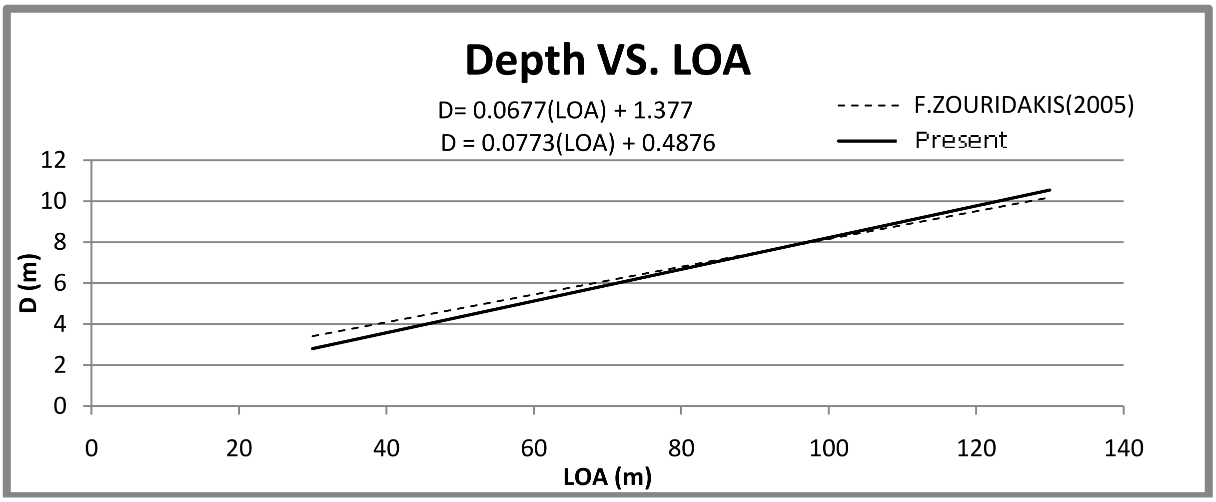

Figure (11): Comparison between ships's D VS. LOA

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

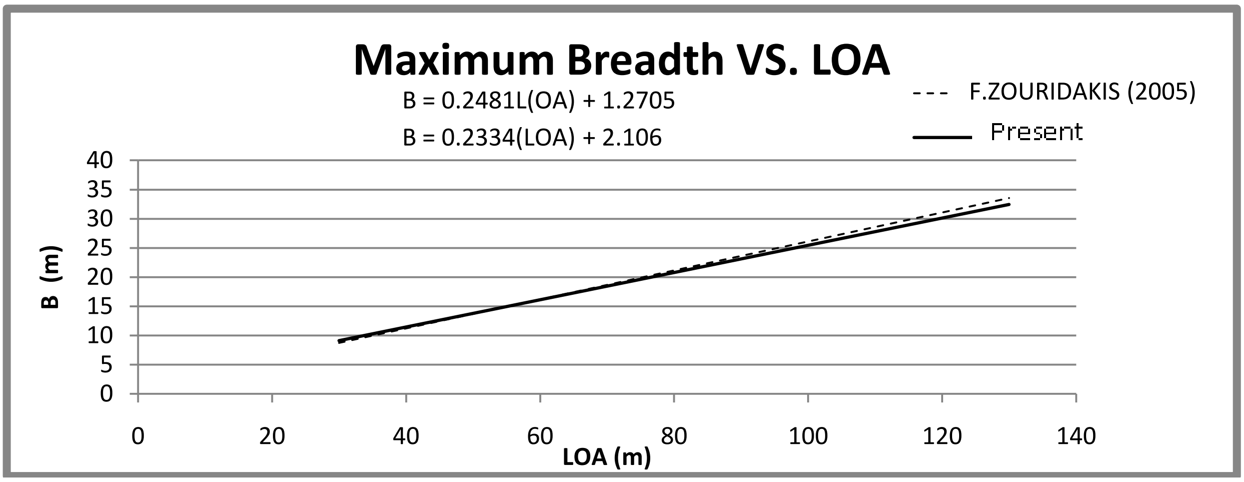

Figure (12): Comparison between ships's B VS. LOA

8. Verification of proposed formulae

Two test cases are selected [www.damen.nl, 2011] to compare results as estimated by proposed & F.Zouridakis formulae for determining breadth, depth and draft based on LOA. Calculated results as obtained by F.Zouridakis and proposed method are shown in Table (1). Analysis of results shows that proposed formulae give more accurate results.

Table (1): Values of the predicted main dimensions for both formulae:

Ship Name	**Main Dimensions (m)**	**INPUT** (m)	**F.Zouridakis method**	**Proposed method**
			Value (m)	**Value (m)**
Fast Ferry 6016	B=16.2	LOA=60	16.156	16.11
	D=5		5.439	5.12
	T=2		3.369	2.3
WPC 5214	B=13.8	LOA=52	14.167	14.2
	D=4.6		4.897	4.5
	T=1.8		3.1	2

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.

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.

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NO	Ship Name	Year	Calss	L.O.A (m)	L.W.L (m)	B (m)	D (m)	T (m)	DWT (tonne)	Power (KW)	Speed (knots)	Passangers& crews (No.)	Passangers& crews (No.*0.075 tonne)	Vehicles (No.)	Vehicles (No.* 1.5 tonne)	Pay Load (Tonnes)
1	hawaii superferry	2007	GL	106.5	92.4	23.8	9.4	3.65	800	28800	40	800	60	150	225	285
2	Bocayna Express	2003	DNV	66.2	59	18.2	5.9	2.5	315	11600	35.6	466	34.95	69	103.5	138.45
3	Aremiti 5	2004	GL	56	49.8	14.2	5	1.9	122	9280	34.8	710	53.25	30	45	98.25
4	AUTO EXPRESS 82	1997	DNV	82.3	70.7	23	6.7	2.5	346	24000	38	724	54.3	175	262.5	316.8
5	delphin	1996	GL	82.3	69	23	6.5	2.5	346	24000	40.2	624	46.8	175	262.5	309.3
6	Euroferrys Pacifica	2001	GL	101	88.7	26.65	8.4	4.2	750	28800	30	951	71.325	251	376.5	447.825
7	FARASAN & Jazan	2009	GL	68.6	61.8	17.65	5.25	3	258	11520	30	668	50.1	50	75	125.1
8	FARES AL SALAM	2002	GL	56	49.8	14	5	2.7	130	9280	34.5	442	33.15	43	64.5	97.65
9	HIGHSPEED 2	2000	GL	72	63.5	17.5	5.9	2.5	280	15464	37	644	48.3	70	105	153.3
10	Highspeed 4	2000	GL	92.6	80.6	24	7.8	3.9	470	28800	40.5	1050	78.75	188	282	360.75
11	highspeed 5	2005	GL	85	76.4	21.2	6.5	3.1	470	28800	39	834	62.55	154	231	293.55
12	JADE EXPRESS	1998	BV	47.6	41.6	13	4	1.4	54	7920	38	338	25.35	10	15	40.35
13	highspeed 5	2005	GL	85	76.4	21.2	6.5	3.1	470	28800	39	834	62.55	154	231	293.55
14	AUTO EXPRESS 47	2011	BV	47	41.2	11.1	4	1.82	63.3	4930	32.8	372	27.9	10	15	42.9
15	LAKE EXPRESS	2004	GL	62.4	52.2	17.6	5	2.5	148	9280	34	408	30.6	46	69	99.6
16	LEONORA ChRISTINA	2011	DNV	112.6	101.3	26.2	8.5	4.85	1000	36400	37.6	1435	107.625	357	535.5	643.125
17	maria dolores	2006	DNV	68.4	58.8	18.2	6.3	2.6	260	14790	37	606	45.45	65	97.5	142.95
18	Carmen Ernestina	2008	GL	88	77.3	24	8.25	3.246	550	28800	37.7	1218	91.35	225	337.5	428.85
19	SHINAS & Hormuz	2008	DNV	44	39.6	16.5	6.2	1.63	70	26000	51.5	220	16.5	56	84	100.5
20	silver express	2005	BV	45.24	40.2	12.3	4	1.8	67	8000	38	356	26.7	10	15	41.7
21	superstar express	1997	DNV	82.3	70.7	23	6.7	2.5	340	24000	38.5	924	69.3	175	262.5	331.8
22	SPIRIT OF ONTARIO 1	2004	GL	86.6	74.2	23.8	7.6	3.2	470	32800	45.6	800	60	238	357	417
23	Catlink iii	1996	DNV	78.6	71	20.8	7.2	2.7	460	22000	37.5	600	45	163	244.5	289.5
24	JEAN DE LA VALETTE	2010	GL	106.5	92.4	23.8	9.4	4.9	850	28800	40	824	61.8	156	234	295.8
25	BOOMERANG	1998	DNV	82.3	70.7	23	6.7	2.8	346	26000	40	724	54.3	175	262.5	316.8

Table (2): Existing high speed RO-PAX aluminium catamarans main particular