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Design of a Low Air Draft Passenger Boat for Inland Navigation

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ABSTRACT

Low air draft passenger boat for inland waterways navigation is a design of a boat that is suitable for navigation in the parts where there are bridges that are low enough to be navigate by regular dimensions passenger boat. Therefore for a passenger boat to navigate in Klang River from LRT Kampung Baru to LRT Tun Sambanthan for 4km long the air draft of the boat must meet the specifications of 2.0m to have a safety margin for the boat as well as 11m length for the boat to manoeuvre easily to go to and fro the route. The boat is design using Maxsurf software and the linesplan and general arrangement is design using AutoCAD. The passenger boat is able to accommodate for 54 people per trip for a speed of average 10 knots or 18.52 km/h. the boat also equip with safety that needed for the passenger to be safe during the trip as well as for their comfort is being taken into account. The economic analysis was carried out for building the boat and for operating the boat as a passenger vaessel in Klang River.

KEY WORDS: *Low Air Draf,; Passenger Boat; Maxsurf, AutoCAD.*

1.0 INTRODUCTION

Low air draft passenger boat is a boat that is design to accommodate the restricted air draft or height above the water line for inland navigation in a canal or river waterways because of the height of the bridges that already have been built across the waterways. Transport across water is economically attractive and environmentally friendly. Waterways are increasingly being used for recreational and tourism purposes. Low air draft passenger boat are an indispensable part of the waterways as they will be used for the transportation mode inside waterways that have bridges.

Nowadays in Malaysia there is many lakes, canals, rivers that have potential to make as tourism spot by putting canal boating or river cruise on it. In my project I have decided that Klang River will be my study area from LRT Kampong Baru to LRT Tun Sambanthan for 4 km long because of the existing river that flow through the city centre of Kuala Lumpur. Low air draft boat can be used as tourism or for passenger as another mode of transportations to cater the traffic congestion of land transportation.

Globally there are many rivers and canals that have use low air draft passenger boat such as Rhine River, Thames River and Osaka River to accommodate for the traffic as well as for tourism usage to cruise the river using low air draft ship to travel under the bridge but several of the bridge can be lifted to accommodate bigger ships.

For Klang River from LRT Kampong Baru to LRT Tun Sambanthan for 4 km long can be develop for the usage of passenger ships for tourism and passenger purposed because the breadth and depth of the river is good enough for inland waterways usage but there are some bridges that have really low air draft in this river for standard passenger ship navigation. This project is want to propose a design of low air draft passenger boat for inland navigations that can fit for the Klang River as well as for the others river and canals existed in this world.

River transport not utilised to the full potential for tourism in city centre and as congestion relief on road. For this project there are 2 objectives that must be conducted that are listed as following.

i. To identify a design specification of a low air draft passenger boat.
ii. To produce preliminary design needed for a boat in Klang River, General arrangement, Lines plan, Principle particulars, and Economic analysis

Waterways are any navigable a line of water. A shipping maps consist of one or several waterways. Waterways may can be include rivers, lakes, seas, oceans, and canals, there some criteria that can make the waterways to be navigable (Seddon et al., 1900):

The Classification of European Inland Waterways are a set of standards for interoperability of large navigable waterways forming part of the Trans-European Inland Waterway network within Continental Europe and Russia. It was created by the European Conference of Ministers of Transport (ECMT; French: Conférence européenne des ministres des Transports, CEMT) in 1992, (Working Party on Inland Water Transport 2004) hence the range of dimensions are also referred to as CEMT Class I–VII. The size for each waterway is limited by the dimensions of the structures including the locks and boat lifts on the route. (Working Party on Inland Water Transport 2004) In 2004, the standards were extended with four smaller sizes RA–RD covering recreational craft, which had originally been developed and proposed via PIANC. (RecCom Working Group 8 (2000) Figure 2.5 shows The Classification of European Inland Waterways standard

Classification	Tonnage (t)	Length (m)	Breadth (m)	Draught (m)	Air Draft (m)	Notes
RA		5.5	2.00	0.50	2.00	"Open boat"
RB		9.5	3.00	1.00	3.25	Cabin cruiser
RC		15.0	4.00	1.50	4.00	"Motor yacht"
RD		15.0	4.00	2.10	30.00	"Sailing boat"
I	250–400	38.5	5.05	1.80–2.20	3.70	"Péniche"
II	400–650	50.0–55.0	6.60	2.50	3.70–4.70	Euro-barge
III	650–1,000	67.0–80.0	8.20	2.50	4.70	"Gustav Koenigs"
IV	1,000–1,500	80.0–85.0	9.50	2.50	4.50; 6.70	"Johann Welker"
Va	1,500–3,000	95.0–110.0	11.40	2.50–4.50	4.95; 6.70; 8.80	"Large Rhine"
Vb	3,200–6,000	172.0–185.0	11.40	2.50–4.50	4.95; 6.70; 8.80	1×2 convoy
VIa	3,200–6,000	95.0–110.0	22.80	2.50–4.50	6.70; 8.80	2×1 convoy
VIb	6,400–12,000	185.0–195.0	22.80	2.50–4.50	6.70; 8.80	2×2 convoy
VIc	9,600–18,000	270–280	22.80	2.50–4.50	8.80	2×3 convoy
	9,600–18,000	195–200	33.00–34.20	2.50–4.50	8.80	3×2 convoy
VII	14,500–27,000	285	33.00–34.20	2.50–4.50	8.80	3×3 convoy

Figure 1: The Classification of European Inland Waterways (PIANC, 1996)

Air draft (draught) is a term used to describe the distance from the top of a vessel's highest point to its waterline. Vertical clearance is the distance in excess of the air draft that allows a vessel to pass safely under a bridge or object. The consequences of failing to consider air draft and to properly calculate a vessel's vertical clearance under bridges, power lines, and other obstructions encountered during a passage can be catastrophic. (PIANC, 1996). The figure for the minimum bridge clearance includes a safety margin of 0.30 m between the highest point of the barge and the bottom of the bridge in the event of standard high water levels. This margin is intended to compensate for errors of judgment and unexpected fluctuations in the water level.

Table 1: Characteristics of reference motor cargo vessels (ECE, 2014)

CEMT class	beam (m)	length (m)	draught (m) laden	draught (m) empty	height above waterline (m)	cargo capacity (ton)	engine capacity (kW)	bow propeller (kW)
I	5.05	38.5	2.5	1.2	4.25	365	175	100
II	6.6	50 - 55	2.6	1.4	5.25	535 - 615	240 - 300	130
III	8.2	67 - 85	2.7	1.5	5.35	910 - 1250	490 - 640	160 - 210
IV	9.5	80 -105	3.0	1.6	5.55	1370 - 2040	750 - 1070	250
Va	11.4	110 - 135	3.5	1.8	6.40	2900 - 3735	1375 - 1750	435 - 705
VIa	17.0	135	4.0	2.0	8.75	6000	2400	1135

Based on the European standards The United Nations Economic Commission for Europe has drawn up recommended dimensions for a European network of waterways for recreational navigation (ECE, 2014). These values are shown in table 2.2. The sailing boat (RD) category is not found on most inland waterways.

Table 2: Reference vessel dimensions (m) according to ECE (2014)

type of craft	category	length	beam	draught	bridge height
open boat	RA	5.5	2.0	0.50	2.00
cabin cruiser	RB	9.5	3.0	1.00	3.25
motor yacht	RC	15.0	4.0	1.50	4.00
sailing boat	RD	15.0	4.0	2.10	30.00

The Klang River lies within the Klang Valley area of approximately 1,290 km square and 120km where 80km is in Selangor and 40km in Kuala Lumpur as shown in the map (JPBD Klang, 2009)

Table 3: Water level in Klang River (Sharifah, 2011)

StationID (Photo)	Station Name (Cross-section)	District	River Basin (Trend)	Last Update Time	River Level (Graph)	Normal level	Alert Level	Warning Level	Danger Level
3015432	Sg.Kelang di Tmn Sri Muda 1	Petaling	Sg.Kelang	21/09/2016 - 22:00	1.88	2.80	4.40	4.58	5.00
3015490	Sg.Damansara di TTDI Jaya	Petaling	Sg.Kelang	21/09/2016 - 23:30	3.27	3.50	7.30	7.80	8.30
3115402	Sg.Buloh di Paya Jaras	Petaling	Sg.Buloh	21/09/2016 - 23:00	-99.99	22.00	23.70	24.45	25.20
3015435	Sg.Damansara di Batu 3	Petaling	Sg.Kelang	21/09/2016 - 23:15	2.33	2.70	4.50	5.25	6.00
3115404	Sg.Damansara di Kg.Melayu Subang	Petaling	Sg.Damansara	21/09/2016 - 21:00	14.66	14.60	16.40	16.70	17.40
3115403	Sg.Damansara di Taman Mayang	Petaling	Sg.Damansara	21/09/2016 - 23:30	14.55	14.50	17.00	17.30	18.00
3015436	Sg.Kelang di Puchong Drop	Petaling	Sg.Kelang	21/09/2016 - 23:00	4.87	7.50	9.00	9.30	10.00
3016402	Sg.Penchala di Jalan 222	Petaling	Sg.Kelang	21/09/2016 - 23:15	17.04	18.00	21.00	21.30	22.00
3016480	Sg.Penchala di Kg.Gandhi	Petaling	Sg.Kelang	21/09/2016 - 22:45	10.40	9.30	13.00	14.00	15.00
3017445	Sg.Kuyoh di Seri Kembangan	Petaling	Sg.Kelang	21/09/2016 - 23:00	37.09	36.50	38.50	39.25	40.00
3014401	Sg.Kelang di Bandar Klang	Kelang	Sg.Kelang	21/09/2016 - 22:45	2.17	2.20	2.40	2.58	3.00
3015482	Sg.Kelang di Tugu Keris	Klang	Sg Klang	21/09/2016 - 18:15	2.27	1.70	3.30	3.48	3.90
3015481	Sg.Kelang di Kg Jawa	Klang	Sg Klang	21/09/2016 - 23:00	-99.99	3.00	4.20	4.50	5.20
3315401	Sg.Rawang di Tmn.Tun Teja	Gombak	Sg.Selangor	21/09/2016 - 23:00	32.56	32.80	34.30	34.60	35.30
3216467	Sungai Batu di Sg Selayang	Gombak	Sg. Selayang	21/09/2016 - 22:45	48.93	48.90	51.00	51.30	52.00

2.0 METHODOLOGIES

Case study – Klang River

The profile and data of Klang River is obtained from the Department of Irrigation and Drainage Selangor to know the

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draft, air draft, depth, breadth, and height of bridges and the length of the river. The area of the river from LRT Tun Sambanthan to LRT Kampung Baru have been decided as the case study area for the length of the river is 4.036km the average depth of the river is 2.5m the breadth and air draft are show on the table below. Figure below represent the view of the bridges that have been built along the river.

Departure: LRT Kampung Baru
Water depth: 2.5m (average)
Air draft: 2.5m (average)

Arrivals: LRT Tun Sambanthan
Water depth: 2.5m (average)
Air draft: 2.5m (average)

Table 4: Component along Klang River at site location.

No.	Type	Height (meter)	Lebar (meter)	Draft (meter)	Jarak (meter)
1	Terminal LRT Kampung Baru	-	13	2.5	0
2	Jalan Sultan Ismail bridge	4	13	2.5	540
3	Pedestrian bridge	6	13	2.5	542
4	LRT Crossing Bridge	4	11	2.5	544
5	Pedestrian Bridge	6	14	2.5	744
6	Jalan Dang Wangi Bridge	4	14.8	2.5	925
7	Jalan Capstone Bridge	4	15	2.5	1208
8	3 Lane Bridge	4	14	2.5	1299
9	Jalan Munshi Abdullah Bridge	4	13	2.5	1378
10	Pedestrian bridge	6	13	2.5	1516
11	Pedestrian bridge	6	13	2.5	1748
12	Terminal LRT Masjid Jamek	4	11.5 7(250)	2.5	1822
13	Lebuh Pasar Besar Bridge	4	17	2.5	2131
14	Pedestrian bridge	4	18	2.5	2345
15	Jalan Tun Sambathan Bridge	4	19	2.5	2503
16	Pasar Seni Pedestrian Bridge	9	18	2.5	2578
17	Jalan Kinabalu Bridge	5	10	2.5	2867
18	LRT Crossing Bridge	12	16	2.5	2968
19	Electrical Crossing bridge	4	15	2.5	3052
20	Jalan Sultan Sulaiman Bridge	4	19	2.5	3132
21	LRT Crossing Bridge	12	18	2.5	3320
22	Piping	4	16	2.5	3363
23	Jalan Damansara Bridge	6	18	2.5	3443
24	Pedestrian bridge LRT Tun Sambanthan	6	19	2.5	4036

Figure 2: Site map of Klang River

Preliminary Design A Low Air Draft Passenger Boat Specific For The Case Study of Klang River.

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By using the criteria and all the principal theories and parameters needed to be considered on designing the low air draft passenger boat that suits the profile of Klang River. Preliminary design for the craft is based on the previous craft that have been designed for other canal and waterways but must be according to Klang River profile. The preliminary design must include the general arrangement, lines plan, and rule dimensions. Rule dimension of the Low Air Draft Passenger Boat L= 10m, B=3.5m, T=1 m, Hv=2m

Material selected for this project is composites of fibre glass that have the most resistance for slow water usage. The usage of composite as the hull of the boat is the best because by using composites only 1 mould is needed for 40 vessels going to build. This have reduced the energy and amount of time needed for completing the low air draft passenger boat.

3.0 RESULTS AND DISCUSSION

Design Concept

In designing the low air draft passenger boats deals with the selection of the boat size geometric parameters such as length beam, depth, draft and the form coefficients in which they are to comply with the observed boundary limitations of speed, stability. seakeeping, strength and environment. Some of the typical examples are past design available state of art in the various fields existing rules or ones that likely to come into force which a country complies, restrictions of the size rivers ports water depth and slip ways. The classification of inland waterways, locks, air draft, minimum channel dimensions, hydraulic parameters, straight sections of waterway for navigation, bends, and bridges and number of passengers.

Economic analysis imposed on the freedom in designing or building a boat in which turns out to have a larger production cost than the capital of the owners. some of the typical examples are cashflow, reduction in manpower on the ship where this help to reduce manning cost minimizing building time maintenance load required at the boat, time in refit and time in port, economic climate and exact manner in which money is funded.

Design Characteristic and Specifications

For building and design the low air draft passenger boat there is some design characteristic and specifications that have been list down about the feature needed for the design produced to be the safest and most suitable dimensions for the use of Klang River. The specification plays an important role as a guideline and limit of the design so that the final design will be inside a safe margin. The characteristics and specifications of the design is shown in Table 5.

Table 5: Characteristics and Specifications for Low Air

Criteria	Details
Waterway Class	Iv
Lock	No Locks
Depth Of River	2.5m
Height Of Bridges From Waterline	2.5m
Minimum Bend	120m Radius
Maximum River Width	20m
Minimum River Width	7.5m
Length Overall Allowed	12m
Safety Margin For Navigation	1m Both Side
Allowable Air Draft Hb	2m

Determining the Safe Air Draft Required For Klang River Navigation

For the Klang River the safe air draft required for klang river navigation is determined by using formula to ensure the boat can be navigate without being restricted by the height of the bridges for the trip.

$$S = 0.5\,H_B \tag{1}$$

H_B is the bridges height from water surface and for Klang River the lowest bridges have the height of 2.5m located at almost all the bridges therefore the safety margin for the bridges height is 0.5m ad this means that the headroom maximum height can only be 2m. the design is required to be in less than 2m height to satisfy the safety margin needed for Klang River

Designing a Low Air Draft Passenger Boat

For the designing a low air draft passenger boat that is to design the hull form of the vessel based on the characteristics and specification for a safe air draft, depth and length. The dimensions will only be decided after a few calculations and consideration in the design steps. Hull form design is to create and design the lines plan of the vessel based on the preliminary main dimensions by using the using the Maxusrf's sample design. A few of the calculations and adjustments on the dimensions are done to make sure that the dimension of the low air draft passenger boat for Klang River are within a reasonable margin for the required height, length, breadth, and depth.

Hull Form Design

In designing the hull using Maxsurf software, we either can start from scratch or just edit the ship that already build in maxsurf. For this project we just edit the sample that already in the maxsurf. Result from the main dimensions calculation we obtained length, breadth, depth, draft and block coefficient CB of

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the ship, by editing the sample design in maxsurf to fit our ship we obtained our hull form.

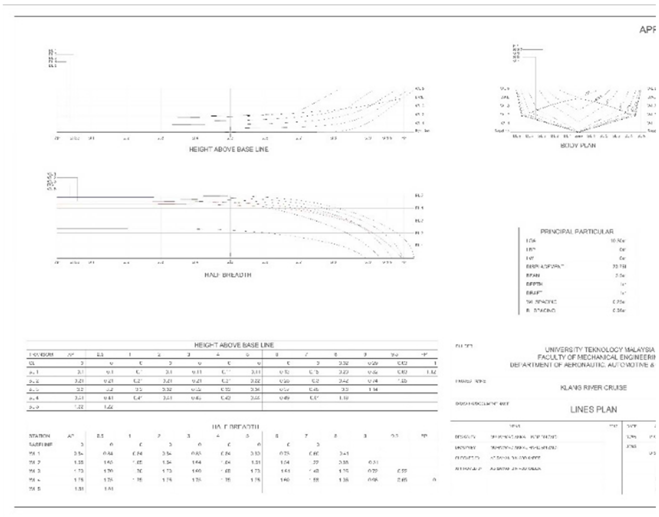

Figure 3: Hull form design lines plan

Hydrostatic Particulars Result

Table 6 is the hydrostatic particulars result of the low air draft passenger boat generated from the Maxsurf programme. The low air draft passenger boat is design to accommodate the Klang River from LRT Kampung Baru to LRT Tun Sambanthan. The ship is equipped with all necessary facilities for 2 crews. The speed of the ship is approximately 10 knots

Table 6: Hydrostatic Particulars

Displacement	20.76	t
Volume (displaced)	20.76	m^3
Draft Amidships	1	m
Immersed depth	1	m
WL Length	10	m
Beam max extents on WL	3.5	m
Wetted Area	39.671	m^2
Max sect. area	2.555	m^2
Waterpl. Area	30.728	m^2
Prismatic coeff. (Cp)	0.813	
Block coeff. (Cb)	0.593	
Max Sect. area coeff. (Cm)	0.73	
Waterpl. area coeff. (Cwp)	0.878	
BMt	1.333	m
BML	10.42	m
GMt corrected	1.959	m
GML	11.046	m
KMt	1.959	m
KML	11.046	m
Immersion (TPc)	0.307	tonne/cm
MTc	0.229	tonne.m
RM at 1deg = GMt.Disp.sin(1)	0.71	tonne.m
Length:Beam ratio	2.857	
Beam:Draft ratio	3.499	
Length:Vol^0.333 ratio	3.639	

Hydrostatic Graph

Figure 4 shows the hydrostatic graph generated from the Maxsurf software based on the low air draft passenger boat design specifically for Klang River.

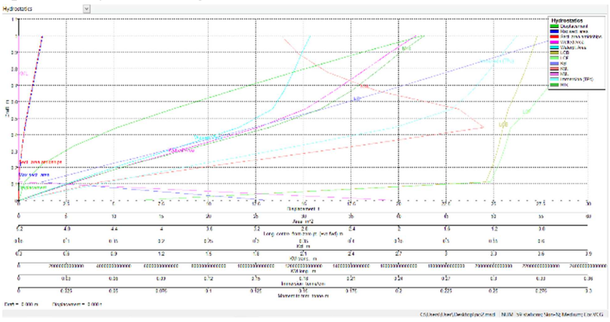

Figure 4: Hydrostatic Graph Generated

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Curves of form

Figure 5 shows the curve of form generated from the Maxsurf software based on the low air draft passenger boat design specifically for Klang River.

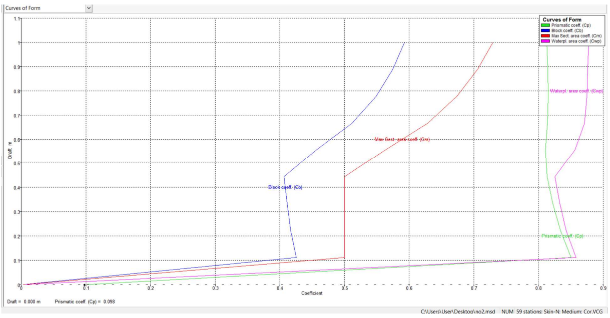

Figure 5: Curve Of Form Generated

Curves of Area

Figure 6 shows the curve of area generated from the Maxsurf software based on the low air draft passenger boat design specifically for Klang River

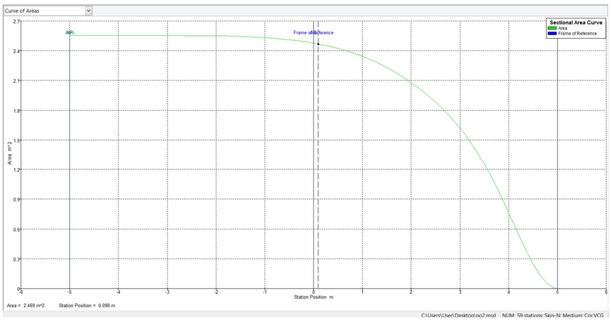

Figure 6: Curve of Area Generated

Bonjean Curve

Figure 7 shows the Bonjean curve generated from the Maxsurf software based on the low air draft passenger boat design specifically for Klang River

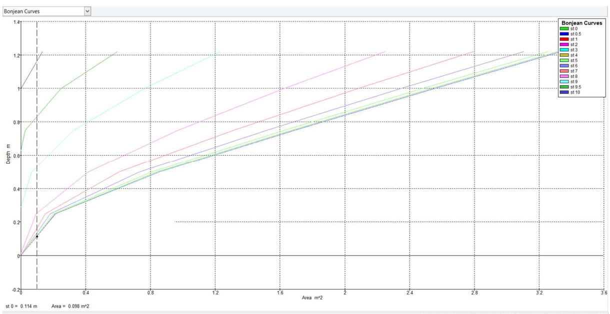

Figure 7: Bonjean Curve Generated

KN Curves

Figure 8 shows the KN curve generated from the Maxsurf software based on the low air draft passenger boat design specifically for Klang River

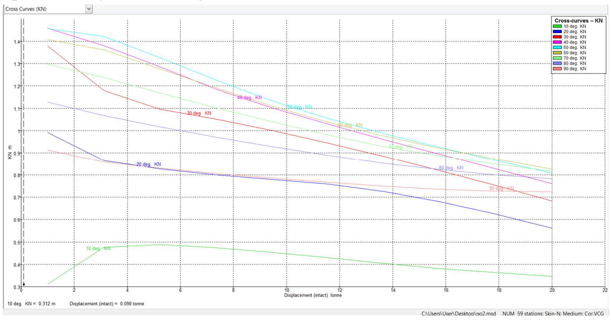

Figure 8: KN Curve Generated

General Arrangement

In the shipbuilding process, a general arrangement of the ship is drawn or created in order to demonstrate how the ship architect has addressed the expressed needs of the owner or operator of the ship. These drawings give naval architects, builders and the owner a clear view of the overall arrangement of the ship.

The general arrangement must have all the arrangement of facilities and machineries for all spaces inside the ship. A good general arrangement must follow the rules and regulations in the design process as it ensures the safety for every crews and cargo. Determination of various safety aspects such as position of collision bulkhead, watertight bulkheads and double bottom are very important for the ship to survive if occurs any damage to the hull.

Thus, the general arrangement design is a process that has to keep revised with the production sites until both the owner and classification society are satisfied with the results. Corrections have to be made based on the feedback from onsite engineers regarding the feasibility of the arrangement of system. Therefore, general arrangement is the final and the most important step in this project.

Determination of Crew Numbers and Ranking

The crew numbers are determined based on the reference ship. The accommodation spaces are designed based on the crew numbers and the ranking. Table 7 Shows the positions and number of crew for low air draft passenger boat.

Table 7: Crews Number and Ranking

Position	Number of person	Jobs description
Pilot	1	Driving the vessel
Crew	1	Arranging the customers inside the vessel

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Determination of Engine Rooms

Based on the design requirement, the speed of the ship is 10knots. The power prediction needs to be done in order to determine the size of the engine and other machinery. Figure 9 shows the specifications and dimensions of the engine uses

0.395m x 4 = 1.58m for the breadth of the engine
0.677m for the length of the engine

DF150/175 SPECIFICATIONS

MODEL	DF150	DF175
ENGINE TYPE	Four-Stroke DOHC 16 Valve	
FUEL DELIVERY SYSTEM	Multi Point Sequential Electronic Fuel Injection	
TRANSOM HEIGHT mm (in.)	L: 508 (20) X: 635 (25)	
STARTING SYSTEM	Electric	
WEIGHT kg (lbs.) *Dry-weight, not including propeller	L: 211 (465.2) X: 215 (474.0)	
NO. OF CYLINDERS	4	
PISTON DISPLACEMENT cm^3 (cu.in.)	2,867 (174.9)	
BORE × STROKE m/m (in.)	97 × 97 (3.81 × 3.81)	
MAXIMUM OUTPUT kW (PS)	110 (150)	129 (175)
FULL THROTTLE OPERATING RANGE rpm	5000-6000	5500-6100
STEERING	Remote	
OIL PAN CAPACITY ℓ (U.S. / Imp. qt.)	8.0 (8.5/7.0)	
IGNITION SYSTEM	Fully-transistorized	
ALTERNATOR	12V 44A	
ENGINE MOUNTING	Shear Mount	
TRIM METHOD	Power Trim and Tilt	
GEAR RATIO	2.50 : 1 (Two-stage Reduction Gear)	
GEAR SHIFT	F.N.R	
EXHAUST	Through Prop Hub Exhaust	
DRIVE PROTECTION	Rubber Hub	
PROPELLER SIZE (in.) OPTIONAL	15-1/2 × 17 15-1/4 × 19 14-3/4 × 21 14-3/4 × 23 14-1/2 × 25 14-1/2 × 27	

DIMENSIONS

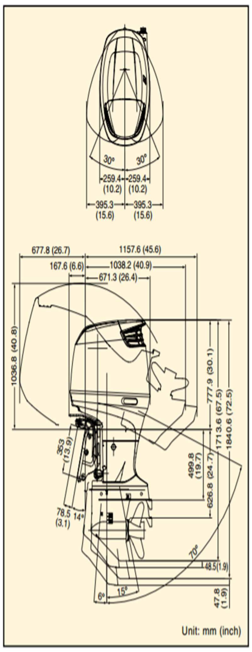

Figure 9: Shows the specifications and dimensions of the engine uses

Passenger Space on Board

The space for each passenger on board of this boat can be calculated as follows

Area of service deck
= 3 x 6.3
= 18.9 m²

Area of each passenger
= Area of service deck/number of passenger
= 18.9/54
= 0.35m²

As stated in the regulations by Sarawak Marine Department, the minimum space required for a passenger, representing crowded situation, is to be 0.25 m². Therefore it can be said that the space provided by the boat is justified and also be classified as comfortable situation.

Boarding Ladder

Made with fiberglass length and width about 0.45m respectively with small long blocks as staircase.No hand rails and no supporting equipment holding the ladder. Angle of inclination is about 40˚.

Wheelhouse

The wheelhouse shall have room enough for at least two seated crew members, together with controls, gauges and alarms and radio equipment. Protection against rain shall be adequate. Toughened glass shall be used for all wheelhouse windows, Wipers or clear view screen shall be fitted. At least one door and one other exit shall, be fitted. Visibility therefrom shall not be impaired by excessively oblique window panels. Head room in the wheelhouse shall be at least 1.9m. Wheelhouse deck shall not be lower than the gunwale.

Number of pilot : 1 (seated)
Equipment : Control Panel
Gauges
Radio

Freeboard

The freeboard shall be no less than consistent with the number of passenger and crew permitted at the departure condition. The freeboard to the gunwale shall be at least 0.38m.

Engine and Engine Room

i. Passenger compartments shall be separated from the engine compartment by a gas tight bulkhead integral to the ship hull.

ii. The propulsion engine(s) of a passenger vessel shall be able to be stopped instantly from switch or through mechanical means. Such emergency stopping device should be protected from accidental application.

iii. All engines of passenger express boats shall be fitted with proper silencers. The maximum level of sound which may be emitted by passenger express boats should be not more than 100 db. when measured at a distance of not more than 0.5 metre from the orifice of the engine exhaust pipe during fair weather condition.

iv. The engine room wall may be lagged with suitable fire resisting sound proofing material reduce the noise level emitted from the engine room Double doors may be fitted to entrances to engine

Passenger Accommodations

i. The number of passengers permitted marked conspicuously in red in letters at least 150mm high near all entrances used by passenger. The number of passengers permitted in compartment shall be

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conspicuously marked in red in letters at least 75 min high.

ii. Head room shall be at least 1.9m. Headroom be reduced to 1.7m in way of passenger seats.

iii. Passenger seat shall be fixed in a permanent manner; loose chairs etc. shall not be used. No luggage shall be stored above the passenger seat.

iv. Each seat shall be at least 400mm wide and 320mm deep spaced 700mm apart from back to back.

v. 4.8.8.5 An approved seating arrangement plan shall be displayed in all passenger compartments.

vi. Aisles shall be at least 500mm in width.

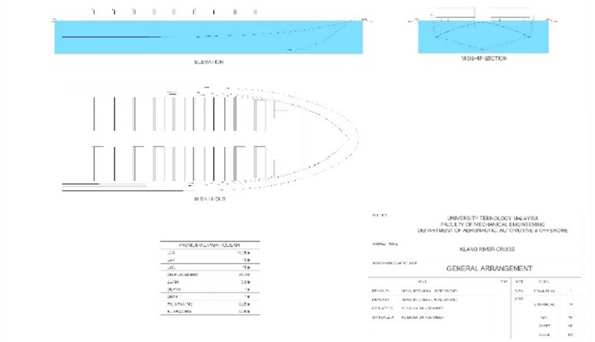

Figure 10: General arrangement

Economic Analysis

Based on the last scope of the project which is economic analysis there are 9 things that have been considered important and need to be focus for the design of a low air draft passenger boat for inland navigation in Klang River. Thus the economic analysis should be conducted to determine the costs required in the construction as follows:

Boat First Cost

The cost of the boat is break down in to the price shown below

i Hull cost - Fiberglass cost
RM 2.90/kg x 20760kg = RM 60.204.00

ii Work cost per kg of fiberglass
RM 2.10/kg x 20760kg = RM 43,596.00

iii Machinery cost
Engine SUZUKI DF150
= RM 76 431.61 x 2
= RM 152,862.00

iv Total cost
Hull cost + work cost + machinery cost
= RM 256,662.00

Total Service Hour per Annum

The number of trips made per annum can be calculated as below

Service Hour = 8am-11pm = 15 Hours/Day

Maintenance Hour = 336 Hours (Two Weeks For The Whole Year

Total Service Hour per Annum = (365 – 14) X 15 = 5265 Hours Per Year

Fuel Consumption

From collected data of Suzuki

Service hour = 15 hours per day
Service speed = 10 knots
Machine fuel consumption 22 l/hr
Conversion 1 knots = 0.515 m/s
After conversion
Service speed = 10knots x 0.515 = 2.06 m/s
Machine fuel consumption per day =22 x 15 = 330 litres (per 15 hours)

Fuel Cost per Year

Fuel cost = RM 2.12 per litre
Total fuel consume per year = 22 x 5625 = 123,750 litre
Total fuel cost = 123,750 x 2.12 = RM 262,350.00
Passengers Carried and Charges per Year

From the observation the estimated passengers adults and children who will occupied the seat in terms of percentage are given as below

Adults passengers = 60% of full capacity
Children passengers = 15% of full capacity

Note that not all seats are seated for every trips. However it may be full sometimes, depending on the season when there are holiday or festivals more people will be using the tour boat. The percentage indicated based on daily average passengers.

Total passengers per trip = 75% of full capacity 54
= 0.75 x 54
= 40.5
= 41 passengers

The price will be quoted as the same as Melaka River Cruise which is RM10.00 per passenger per trip. Children is RM5.00 per trip. While for infant below 2 years old is free. Time taken for each trip is 45 minutes, it is able to make 15 trips per day.

Ticket charges = 10.00 x 0.60 x 54 x 15 + 5.00 x 0.15 x54 x 15 = RM 5535 per day

RM5535.00 x 351 = RM 1,942,785.00 per year

Crew Cost

One captain employ on board when the boat is in services and is paid RM2500 One crew employ on board when the boat is in services and is paid RM1500 monthly. Therefore annual crew wages is as below

RM 2500 x 12 = RM 30,000
RM1500 x 12 = RM 18,000
Total = RM 48,000

Maintenance and Repair Cost

The maintenance and repair cost per boat per year is estimated to be RM10000. With all the above calculation parameters, the boat

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operating cost, voyage cost, revenues can be determined. The element that made up operating cost are :

- **i.** Crew wages
- **ii.** Maintenance and repair
- **iii.** Overhead cost

The details obtained for the elements are as below

Table 8: Operating Cost

A) Crew Wages	RM18,000
B) Maintenance And Repair	RM10,000
C) Insurance	RM6,000
D) Overhead	RM10,000
Total Operating Cost P.A	RM44,000

Annual Boat Revenue

The parameters that made up as revenue for the boats are passenger charges. From calculation, the values of these parameters are

Passenger charges = RM 1,942,785.00

Total revenues = RM 1,942,785.00

Interest

Assume a building period of 2 years from order to delivery.

Assume interest rate is 4% for 20 years of loan

Capital cost x % =RM 1,192,009 x 4%

= RM 47680.36

Annual payment = RM 47680.36/20

= RM 2384.02

For 2 years = RM 4768.04

4.0 CONCLUSION

It can be concluding that this project has accomplished all of the objectives. A Low air draft passenger boat is a boat that is design to accommodate the restricted air draft or height above the water line for inland navigation in a canal or river waterways because of the height of the bridges that already have been built across the waterways. A design specification has been produce, and the preliminary design needed for a boat in Klang River is produced with these certain parameter

- **i.** General arrangement
- **ii.** Lines plan
- **iii.** Principal particulars
- **iv.** Economic analysis

The Klang River from LRT Kampong Baru to LRT Tun Sambanthan for 4 km long can be develop for the usage of passenger ships for tourism and passenger purposed because the breadth and depth of the river is good enough for inland waterways usage because of it is at the centre of the Kuala Lumpur. And it can be used to relieve the road congestion.

The economic analysis of building and using this boat in Klang River are also very good and promising good revenue for the municipality to apply this low air draft passenger boat here.

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