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2050 Visionary Concept: Advance Amphibious Preliminary Design

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Abstract—The creation of advance visionary aircraft designs have been stagnated in the past years due to the economical difficulties the world is facing. Aircraft design is affected in such a way, that a radical thinking is out of the question, showing no actual progress in this field of study. For this paper, a new concept will be introduced, omitting any of the actual restrictions in which a radical thinking could be compromise. This new concept will be focus on a Future 2050 Visionary Concept. This will enable the creation of "out of the box" ideas in aircraft design, in this case the design of an advance amphibious design. The preliminary design development lead to the creation of an Advance Amphibian Blended Body Wing Aircraft (AABWBA) that exceeds its water capabilities by the use of a trimaran boat hull concept, and excels the air performance due to the high results generated by the Blended Wing Body Aircraft. A new design optimization process is introduced in order to adapt the trimaran concept into the blended wing body configuration. The preliminary results show a comparison by using a trimaran concept to other types of conventional flying boat methods. The parameters of the Blended Wing Aircraft also exceed in aerodynamic results as well as flying performance and water performance.

Keywords— Seaplanes, Amphibians, 2050 Visionary Concept, Trimaran, Advance Aircraft Concepts

I. INTRODUCTION

After the years of World War II (1950), a Cold War lead by the United States (US), and the Soviet Union (USSR) initiated an expansion in many technological achievements. Rockets went into space; supercomputers made calculations faster; robotics increased the manufacturing process; among many others with no economical or social restrictions. The aeronautical industry as well got caught in this expansion of technological exploration. Researchers and scientists concentrate in the creation of "out of the box" ideas that could afford greater results. Turbofan engines were experimented and updated, jet fighters were created, and versatility of aircrafts was research. The empirical guidelines during those days were: higher, further, and faster. However, today, new guidelines have to be introduced. Due to the economical constraints the world faces today, this "out of the box" thinking is restricted to the same problems, money and social acceptance. Now, according to the European Vision 2020 guidelines [1], these have become: more affordable, safer, cleaner and quieter.

The versatility of transportation vehicles in a futuristic idea will allow an increase in a wider perspective into looking greater designs. Some examples of this futuristic vision are the creation of flying cars, water hover vehicles, among others. However, there is a design of such vehicles that had existed for decades, amphibious aircraft. Current designs are obsolete and lack an advance approach. Updates to these vehicles have been stagnated since the new guidelines do not meet the requirements into creating advance designs. The market is unreliable, and investing in such vehicles will be risky, an even if it is created a cleaner, safer, and quieter amphibian this will not be affordable. For this instance, a new vision would be created focusing in the creation of advance aircraft designs.

This new vision will be called Future Air Transport Concept Technologies for 2050 in which the new guidelines will be: safer, quieter, cleaner and efficient. An efficient concept will adopt the early guidelines (higher, further, and faster), with no restrictions in material, capital or infrastructure for planning, designing, testing, and constructing. Let us recall that this is just a radical way of thinking in order to expand the researcher's mind with no restrictions what so ever.

II. PRELIMINARY DESIGN DEVELOPMENT AND ANALYSIS

A. Introduction

In this 2050 Visionary Concept of an advance amphibious aircraft, the guidelines stated before will be taken into account in order to implement this idea into an amphibian design. However, not only the design characteristics will make a decisive change in the preliminary method, as well the computational optimization design method will take a new approach.
Some literature review approaches the design of a seaplane by first designing the floating device (i.e. the boat hull or floats) and then designing the aircraft components (wings, fuselage, empennage, etc.) [2], [3], [4]. The first steps for amphibian design is to create a boat hull or floats that will be stable, with satisfy aerodynamic and hydrodynamic properties, and will support water loads. The design of the aircraft segment depends on the properties of the hull or floats. This gives the amphibian aircraft designer a disadvantage in having an open mind on the manner on how to elaborate an advance amphibian aircraft design with an "out of the box" configuration. This approach limits the theoretical thinking into a method restricted by certain design parameters, on the contrary on what the 2050 visionary concept guidelines stand for. Nonetheless, the creativity to elaborate an advance amphibian design will push the limits into proposing a new design optimization method. This research paper will propose a new design seaplane method by designing each of the seaplane

segments ("ship vessel" and "aircraft") in a separate manner, opposing the design method proposed by the old reports. This idea will adapt, instead, to design first the "aircraft" segment and then adapting the "boat" segment into the conceptual design. There are three main advantages of adapting this conceptual design method:

1. The "aircraft" segment can be design in a separate manner, using whatever optimization method the designer will like to choose. The "boat" optimization design method will be elaborated in such a manner that will adapt which ever aircraft configuration (Conventional, Blended Wing Body, Canard, V-Tail, etc) and will optimized the desire boat hull design parameters. Therefore,
2. The conversion of an existing landplane structure into a seaplane configuration will be elaborated into this design method.
3. Simplification of this method will expand the complexity of creating an advance amphibian "boat" segment by studying a more reliable hull design and running separate trial tests.

Finally, the main goals that should be attained to acquire the desire design will be focused on the following:

1. The seaplane should acquire an outstanding hydrostatic stability in order to excel during the water taxing operations.
2. The advance design will have the capability to operate in rough, high wave waters, giving the seaplane more water options in which to operate, hence a greater hydrodynamic capability.
3. The increase in aerodynamic drag caused by the extra components should not compromise the flight performance of the seaplane.
4. Water Performance and Air Performance should be comparable to that of a speed boat and a speed aircraft, in order to attain the best of both designs.
5. Finally, all structural components would be analyzed thoroughly in order to meet all requirements.

B. Aircraft Design Development

In the design of an aircraft vehicle, there are many proposed methods that are utilized to optimize the desire design. Raymer [5] uses a proposed design method mainly used in a Class I sizing process based largely on empirical methods. Many other design methods are involved and introduced depending on the aircraft configuration (canard, Blended Wing Body, Flying Wing). For the purpose of this research paper, it will be assumed that the designer will choose whatever design method that will be most suitable and comfortable to work with the advance aircraft configuration. The aircraft will be design in a separate manner from the ship vessel, and when the two designs are elaborated, a new design method will be introduced in order to blend the aircraft and vessel into an amphibian configuration.

C. Water Operation Geometry Calculations

The design method of an amphibious aircraft implemented will be using a wide variety of methods in order to compare and maximize the desire results fulfil from the 5 points in the Introduction section. Since this amphibian aircraft must excel in both hydrostatic and hydrodynamic, it will be first calculated the use of a conventional boat hull with stabilizers and compare with a more advance design method that could exceed the water characteristics. Retracting the extra components of the floats or stabilizers will reduce the aerodynamic drag. The floats will form a single component embodied to the hull and fuselage when retracted. This will reduce the drag form interference factor added by the floats and boat hull [5], hence decreasing the aerodynamic drag. The design optimization method is set up to work with a number of different aircraft configurations which would be converted into an amphibian configuration. The sizing method will be elaborated in a fashion where the main inputs will focus the existing landplane parameters (Gross Weight, Wing Characteristics, Power plants, Aircraft Geometry). When given the known input parameters, the sizing process outputs all major "boat" component geometries, hydrostatic estimation, component drag estimates, water and air performance characteristics. Finally, when the boat geometry is given, this will be blended to the newly created landplane aircraft to create the advance amphibian design, where new hydrostatic estimations, component drag estimates, water and air performance characteristics will be given to show the parameters of the amphibian design.

1) Boat Hull Calculations: The primary functions of any hull is to give the amphibious aircraft buoyancy, and to provide longitudinal and transverse stability on the water and when underway to takeoff speeds. The float or hull must provide reasonable resistance while in the water so that the aircraft is capable of taking-off with the power it has available. It must also be designed in such a way so as to hold landing impact pressures to reasonable levels. All of these factors can drastically change the form of the hull.

First, in order to find the necessary calculations for the geometry of a boat hull, fundamentals of Archimedes Principle must be understood. The volume (V) required for the seaplane to stay afloat on water will be calculated based on the displacement weight (Δ_0), as shown in eq. (1).

$$V = \frac{\Delta_0}{w} \tag{1}$$

Where (w) is the density of the fluid. Calculation of the total volume of the trimaran should take into account an extra 100% of the total displacement, which represents the "reserve of buoyancy" [4]. Based on the literature review, generally the beam is established as the design reference parameter of seaplane floats and hull [6]. The beam is the widest section of the float as shown in Fig. 1.

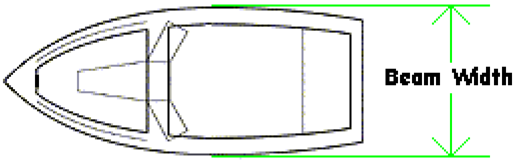

Fig. 1: Beam Width of a Conventional Boat [9]

From fluid dynamics, Tomaszewski came with an empirical formula on how to calculate the beam (b) of a hull based on a beam load coefficient (C_{Δ_0}) [6]:

$$b_{hull} = \sqrt[3]{\frac{\Delta_0}{C_{\Delta_0} w}} \quad (2)$$

The length of the boat hull is calculated using eq. (3).

$$L_{hull} = \frac{R_{LB}\Delta_0}{b_{hull}^2} \quad (3)$$

where R_{LB} is the length-to-beam ratio. The length of the boat hull is then compared to the minimum fuselage length set by the designer. To calculate the height of the hull, it is simply multiply the beam of the hull times 0.65.

2) Wing Tip Float Calculations: Most amphibious aircraft that use a boat hull as their primary water operation method must augment their transverse stability through auxiliary means. To properly understand the reason for this lack of transverse stability, it is necessary to explain the concept of the transverse metacenter. The transverse metacentric height (*BM*) is the distance between the center of gravity and the transverse metacenter (*GM*).

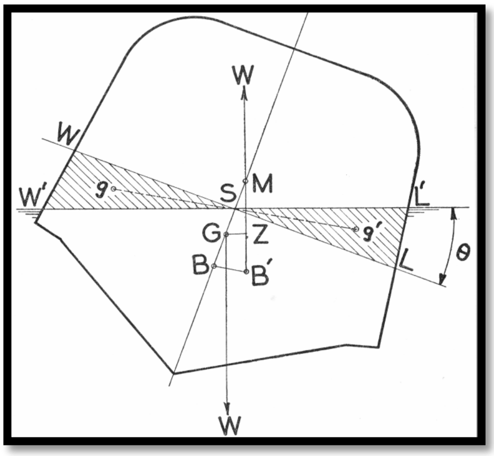

Fig. 2: Transverse Metacentric Height [2]

Fig. 2 shows the center of gravity of the hull is located at point G. The center of buoyancy is located at point B. If the metacenter is above the center of gravity, the aircraft is stable. If the metacenter coincides with the CG, the aircraft is in neutral stability. If the metacenter is below the CG, the aircraft is unstable.

A method used to increase the transverse stability of a boat plane without the drastic measure of greatly increasing the beam is the used outboard wing-tip floats mounted on either side of the fuselage (Fig. 3) or even in the mid section of the wing.

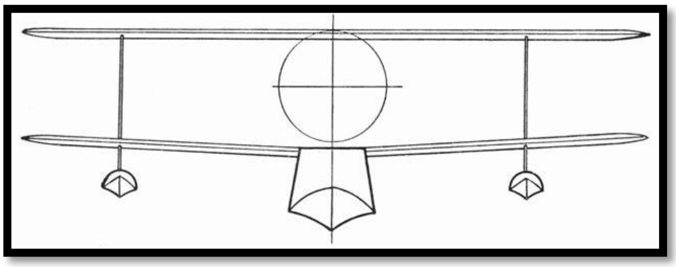

Fig. 3: Wing Tip Floats [2]

The Federal Aviation Administration [7] has specified a required buoyancy for any lateral stabilizing floats by mandating that the righting moment provided by a float when fully submerged be greater than shown in eq. (4) [2],

$$M = R\Delta_0\left(h + \sqrt[3]{\Delta_0}\right)\sin\theta \quad (4)$$

where M is the moment of the lateral float in lb-ft/kg-m, R is a coefficient based on the weight of the aircraft, h is the negative metacentric height of the hull and θ is the angle of heel required to completely submerge a lateral float.
The derived formula for the reduction in metacentric height (*BM*) on water is [3]:

$$BM = \frac{I}{V} \tag{5}$$

where (*I)* is the Moment of Inertia of the vessel. The metacentric height is an approximation of the vessel stability for small angle (0-15 degrees) of heel. Beyond that, the stability of the vessel is dominated by what is known as a righting moment (*RM*), eq. (6):

$$RM = \Delta_0 GM sin\theta \tag{6}$$

The buoyancy required is found by dividing the righting moment by the distance from the center of gravity of the lateral stabilizing float to the center of the fuselage. Then, the breadth or beam of the stabilizing floats, b_{stabs}, is calculated using eq. (6)

$$b_{stabs} = \sqrt[3]{\frac{\Delta_{stabs}}{2}} \tag{7}$$

where Δ_{stabs} is the displacement of one stabilizing float. The ratios for the length and depth to the breadth are given by Langley [2], with the length being 4 times the breadth and the depth being 0.5 times the breadth.

3) Trimaran Hull Calculations: A trimaran is a multihulled boat consisting of a main hull and a two smaller outrigger hulls, attached to the main hull with lateral struts, as shown in Fig. 4.

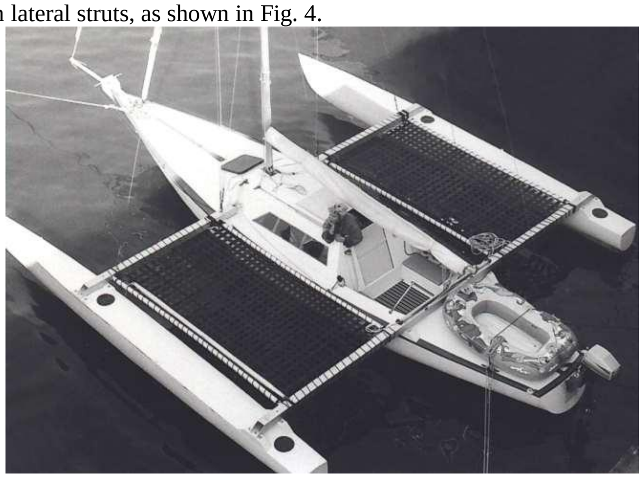

Fig. 4: Trimaran Example [8]

Few studies on the design of trimaran dimensions have been conducted and the empirical formulas given before are well adapted to conventional floats and boat hulls, but not for a trimaran concept. A new approach must then be manipulated in order to find suitable formulas for the design process of the trimaran device. The key characteristic connection between floats and boat hulls is the slenderness ratio of a trimaran (*SLR*) shown in eq. (8 **)**.

$$SLR = \frac{L}{b} \tag{8}$$

The slenderness ratio takes values depending upon the functional utility of the vessel in question. The standard values of slenderness ratio are shown in Fig. 5.

SLR	8-10: 1	For slow cruising vessels
	12-14: 1	For performance cruisers
	20: 1	For extreme racers

Fig. 5: Slenderness Ratio [9]

An important component of designing a hull or float is the forebody length. The size of the forebody represents compromising between flight requirements and seaworthiness at low speeds on water. If the length and the beam are too great, the structural weight and the aerodynamic drag limit the performance of the whole seaplane. On the other hand, if the length and the beam are too short, the spray characteristics become a limitation in gross weight and increase the hazards of operation in rough water [10]. The forebody length (l_f) in for a given beam load coefficient is [6]:

$$l_f = b\sqrt{\frac{C_{\Delta_0}}{k}} \tag{9}$$

From hydrodynamic point of view, the afterbody (l_a) assists getting over the hump and to provide buoyancy at rest. A relation between the length of the forebody and the afterbody is shown in eq. (10 **)** [11]:

$$l_a = (110\%\ to\ 115\%)l_f \qquad (10)$$

Since the total length (L) of the hull or float is as follows:

$$L = l_f + l_a \qquad (11)$$

Rearranging eqs. (8)- (11 ***)***, and choosing 111% of forebody to afterbody length, the following formulas are obtained:

$$\frac{l_f}{b} = \frac{SLR}{2.11} \qquad (12)$$

$$C_{\Delta_0} = k\left(\frac{l_f}{b}\right)^2 \qquad (13)$$

The only two unknown variables are spray coefficient (k) and slenderness ratio (SLR). Spray coefficient can be selected depending on the mission characteristics shown in Table 1.

Table 1: Spray Coefficient Factors

k = 0.0525	Very Light Spray
k = 0.0675	Satisfactory Spray
k = 0.0825	Heavy but acceptable Spray
k = 0.0975	Excessive Spray

Selecting the appropriate spray coefficient (k) and slenderness ratio (SLR), the beam of the hull (b) can be calculated from eq. (2). With the slenderness ratio (SLR) selected and the beam hull calculated, the total length of the boat hull (L) is calculated using eq. (8 **)**. However, there is a constraint in calculating the hull length. The hull length should not exceed the length of the landplane fuselage. With the beam hull other characteristics of the hull can be calculated (Bow Height, Forebody Deadrise Angle, Step Height, etc.). In order to maximize the efficiency of the trimaran concept, the outriggers (floats) should be half the length of the main hull [9]. Therefore, with the spray coefficient (k) and slenderness ratio (SLR) selected, the beam of the outriggers can be calculated from eq. (8). The same approach as the main hull will apply to calculate the rest of the outrigger characteristics.

III. PRELIMINARY TESTING AND RESULTS

A. Preliminary Testing

In order to analyze an optimum design for the advance amphibian, the sizing design process method will be tested by the use of a conventional flying boat configuration. First, a conventional high wing, T-tail landplane will be design. The landplane will have the characteristics of a short haul, subsonic aircraft. Using the sizing method proposed by Raymer [5], the following data was obtained, in Table 2. A CAD (Computer Aided Design) Model is shown in Fig. 6.

Using the initial Gross Weight (GW) of the aircraft, the weight of the boat hull and floats will be calculated using Langley's experimental testing. Calculation of Float Weight (W_f) was elaborated using a comparative curve of area and streamline form [2], in which the following equation was derived:

$$W_f = GW0.0365 + 43.5 \qquad (14)$$

Langley calculates the weight of the boat hull based on statistics using materials from 1935; he calculated that the weight of the boat hull is around 12% the total gross weight of the aircraft.

Table 2: Typical Aircraft Parameters

Gross Weight [kg]	6,500
Empty Weight [kg]	3,900
Max Fuel [kg]	1,300
Fuselage Length [m]	14.47
Fuselage Diameter [m]	1.92
Wing Area [m^2]	34.86
Wing Span [m]	19.08
C_{Lmax}	1.63
Flat Plate Drag Area [m^2]	1.109
Max Speed [km/hr]	380
Thrust Available [N]	30,500

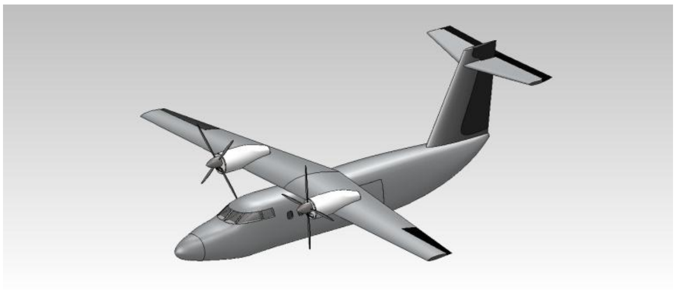

Fig. 6: 3-D CAD Model of Conventional Landplane Aircraft

With the introduction of new materials such as composites, the weight parameters of the floating device could be reduced. Most composite materials have a density of around 1.60 g/m^3, as compared to most aluminum alloys 2.8 g/m^3. It can be safely assumed that the weight of the material can be reduced by 50%. A comparison of the weight increase due to the hull and floats is shown in Table 3.

Table 3 shows the extra empty weight generated by the boat hull and floats added to the amphibian. For that instance, the operating weight decreases, and the maximum fuel and payload carried by the craft will be compromised. However, the extra floats, that will be an aiding device for the hydrostatic stability, could also be employed as an extra fuel tank, hence the extra maximum fuel shown in Table 3.

One of the main goals of this research is to create a modern seaplane that has improved water capabilities. In order to excel in its hydrodynamics, the amphibian must obtain the most suitable design characteristics both in strength and performance. As explained in the design development and using eqs. (2) - (**13)**, and selecting the desire spray coefficient (*k*) and slenderness ratio (*SLR)* the following dimensions were obtained, shown in Table 4.

Table 3: Weight Component Breakdown

Weights [kg]	***Landplane***	***Amphibian***
MTOW	6,500	6,500
Boat Hull	0	350
Floats	0	250
Empty Weight	3,900	4,500
Operating Weight	2,600	2,000
Max Fuel	1,000	1,300

Table 4: Floating Device Dimensions

	Main Hull	**Outrigger**	**Stabilizer**	**Wing Tip Float**
Slenderness Ratio	7	14	-	-
Spray Coefficient	0.0975	0.08	-	-
Beam [m]	2.03	0.59	0.95	0.65
Length [m]	14.47	7.13	3.82	2.60
Forebody [m]	6.99	3.38	1.81	1.23
Afterbody [m]	7.48	3.75	2.01	1.37
Bow Height [m]	1.32	0.53	0.48	0.32
Step Height [m]	0.18	0.05	0.09	0.06
Forebody Angle	30^o	45^o	15^o	15^o
Afterbody Angle	22^o	40^o	20^o	15^o
Keel Angle	7^o	7^o	7^o	7^o
Volume [m^3]	19.33	1.51	1.74	0.55
Y displacement [m]	-	1.74	3.00	9.54

With the dimensions of the Main Hull, the Outrigger, the Stabilizer and the Wing tip Floats calculated, the new floating device will be added to the landplane aircraft to create the amphibian. The following pictures show the 3 different configurations of the amphibian.

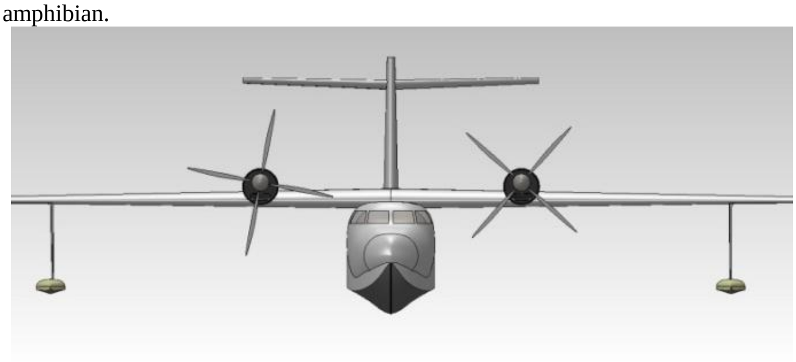

Fig. 7: CAD Model of Amphibian with Wing Tip Floats

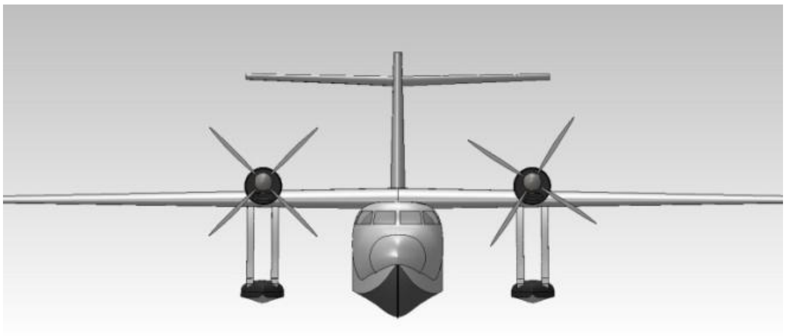

Fig. 8: CAD Model of Amphibian with Nacelle Support Stabilizers

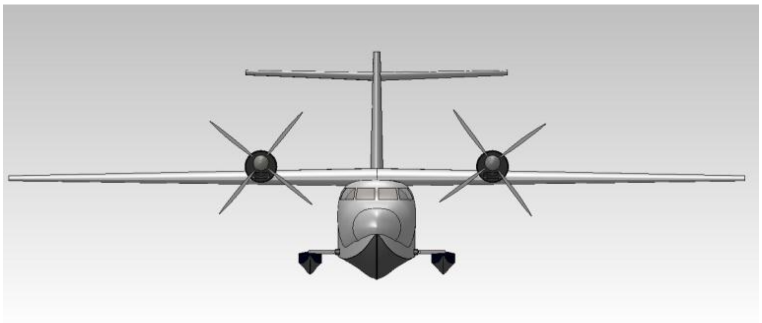

Fig. 9: CAD Model of Amphibian with Trimaran Concept

Since the 3 methods provide the necessary buoyancy for the amphibian to float on water, a hydrostatic, hydrodynamic, structural support, and other parameters will be analyzed in order to decide which method will be the most advance, giving an efficient aircraft with the most optimum characteristics.

The first step is to calculate the hydrostatic stability. Using the approach from eq. (5), the metacentric height can be calculated. The center of gravity, center of buoyancy, metacentre and metacentric height are shown in Table 5.

Table 5: Hydrostatic Stability

Distance from Keel [m]	**Trimaran**	**Stabilizer**	**Wing Tip Float**
Draft Line	0.48	0.48	0.53
Center of Bouyancy	0.26	0.26	0.29
Center of Gravity	1.82	1.82	1.79
Metacentre	1.61	4.13	17.09
Metacentric Height	0.06	2.57	15.59

Using eq. (6), the following plot was obtained by graphing the Righting Moment (*RM*) as a function of angle of heel θ, shown in Fig. 10, with the data obtained from *Table 5* and the required displacement of each component

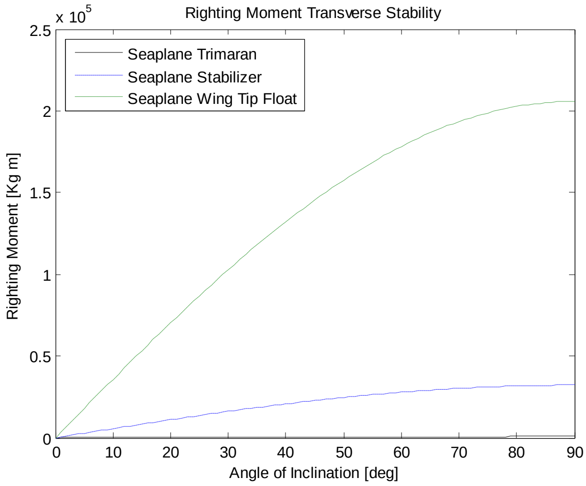

Fig. 10: Righting Moment Graph

Table 5 and Fig. 10 show the trimaran as the most unstable method. Still, if the righting moment remains positive, the vessel is statically stable. The question is if this positive metacentric height will be enough to withstand high waves or moving waters.

To show an example on the location of the metacentre (GM), the center of buoyancy (CB), and the centre of gravity (CG), a model of the trimaran seaplane was elaborated shown in Fig. 11.

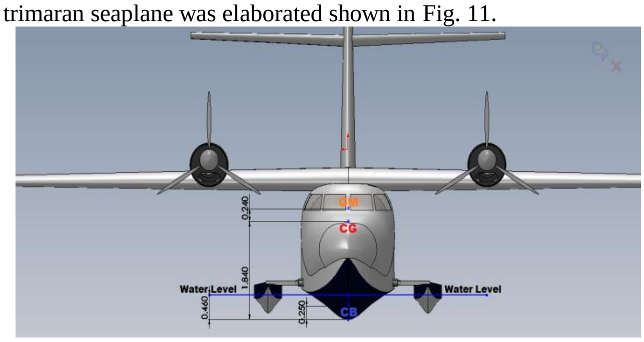

Fig. 11: CAD Model of Trimaran Seaplane at Transverse showing Metacentre, Centre of Gravity, and Buoyancy

Next step will be to compare the hydrodynamic characteristics of the amphibian by calculating the water resistance of the 3 different floating devices. To calculate the water resistance (R_w) the following equation is used:

$$R_w = 0.5 C_{R_w} w A U^2 \qquad (15)$$

where C_{R_w} is the coefficient of water resistance, A is the area of load water plane, and U is the velocity of the amphibian. The coefficient of water resistance is divided into wave coefficient and coefficient of viscous resistance. Wave coefficient is the resistance of water to the movement of the body across the formation of waves. Viscous resistance is the resistance caused by the friction between the fluid and the object, in this case the floating device, in which factors such as velocity, geometry, and dynamic viscosity are taken into account. Then using eq. (15) and plotting water resistance (R_w) as a function of Velocity the following graph was obtained.

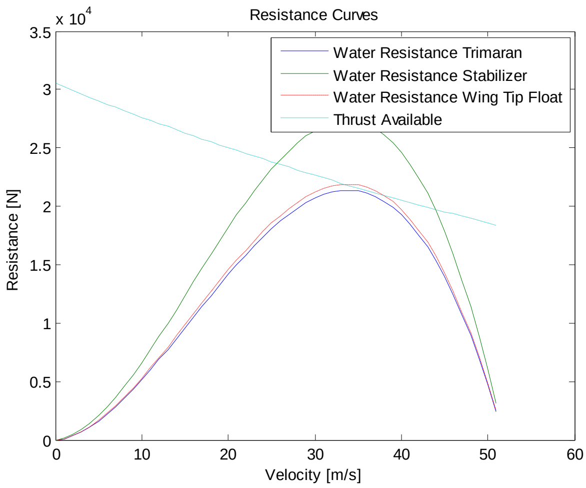

Fig. 12: Water Resistance Curves and Thrust Available

The following graph, Fig. 12, shows the water resistance curves of the 3 amphibian methods, and the available thrust generated by the engines. The water curves form a hump at its maximum peak. This peak is the point where the amphibian starts to separate from the water, therefore, if the engines do no generate enough thrust, the aircraft will not be able to take off from water. Clearly from the graph, the trimaran and wing tip float methods do not exceed the thrust available curve, and therefore, be able to takeoff. Past studies conducted on trimaran shows that wave resistance of trimarans is significantly lower compared to an equivalent catamaran [13]. For this instance, in theory, trimaran has superior seagoing performance.

Now it is essential to think in techniques to reduce the aerodynamic drag caused by the outriggers, stabilizers, or wing tip floats. A useful technique is to retract the floats into a position where the floats will create a single body shape, either to the wing or the fuselage. It is explained when an odd shape component is being calculated, an increase in drag form interference factor must be added to the actual value [5]. It is also explained: "The form factor is a measure of how "streamlined" the component is; it is a function of the component thickness-to-length ratio" [12]. In this case, the form interference factor (*F*) from of a flying boat hull must increase by a 50%, and for floats from 75%-300%, depending on the shape. It was then assumed that the interference factor for the boat hull had an increase of 10%, rather than 50% increased, due to the perfect aerodynamic shape mounted of the hull will be with respect to the fuselage. The following images show how the floats were being retracted.

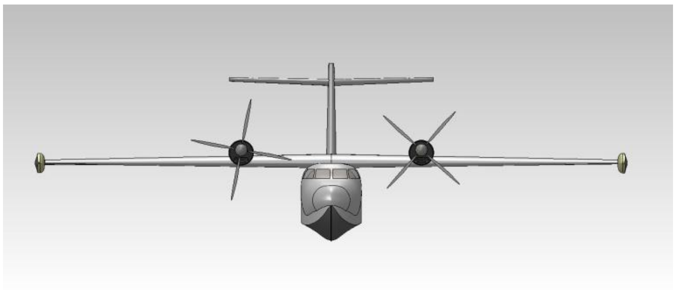

Fig. 13: Wing Tip Floats Retracted into the Wing Tips

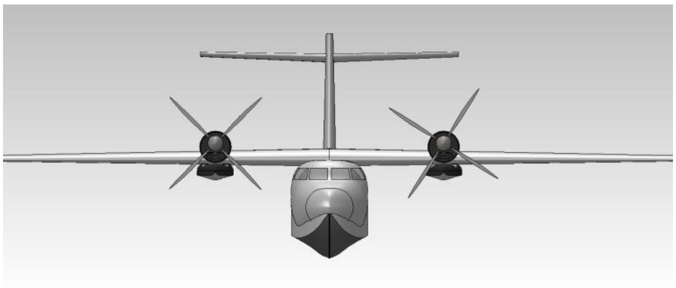

Fig. 14: Nacelle Wing Stabilizers Retracted

The strutting on the wing tip floats and stabilizers will compromise some the wing structural support, and will require a complex retracting system, therefore strong and heavy material will be required. This will also compromise an extra in weight, reducing the useful weight the aircraft will be able to carry. In the case of the trimaran, the strutting will be support through the boat hull, in which the boat hull will be built through the entire fuselage of the aircraft, reducing the need for strong material used for the strutting. The outriggers will be retracted into the boat hull, creating a "smoother" body that will result in less aerodynamic drag, as shown in Fig. 15 [14].

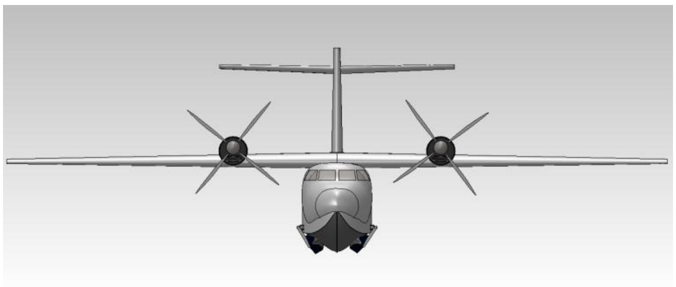

Fig. 15: Trimaran Outriggers Retracted unto the Boat Hull

B. Advance Amphibian Preliminary Results

The preliminary testing gave an idea unto which method will give the desire results that were given in the points from the 2050 visionary concept. First, instead of using turboprop engines, this amphibian aircraft will be replaced with modern and more powerful turbofan engines that will generate more thrust. A trimaran method will give the amphibian less stability on water, but the water speed will be greater, the retracting system will decrease structural support, hence decreasing the extra weight, and the retracting system will decrease significantly the aerodynamic drag at flight. In such case, a new technique could be introduced. Instead of retracting the outriggers and forming a single body with the boat hull, a final solution is to place the floats inside the boat hull, as shown in Fig. 16.

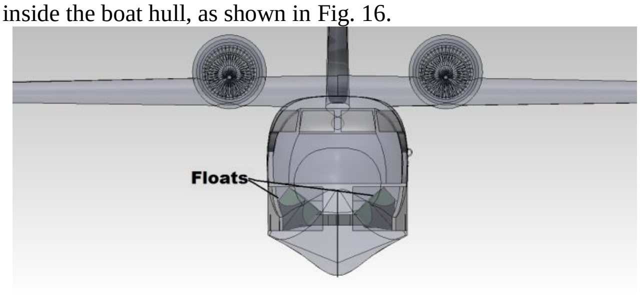

Fig. 16: Example CAD Model with undercarriage Floats

The floats will be retracted inside the boat hull, the same way the landing gear is retracted undercarriage. The only drawback will be the added structural support required, compromising an increase in weight of the strutting.

In a 2050 Visionary concept, the aircraft must achieve a more technical update, thus a new landplane aircraft was design using the same sizing technique as for the conventional aircraft. The result is the creation of a Blended Wing Body (BWB) aircraft. The BWB has the same initial characteristics as the conventional high wing, T-tail aircraft, but the results are higher, showing an advance in the aircraft structure. The following *Table 6* shows the parameters of the BWB, as well an image in Fig. 17 shows the configuration of this Blended Wing Body Aircraft (BWB).

The same approach done to the conventional aircraft to calculate the floating device of the BWB aircraft will be done, thus only using a trimaran concept since it was proved that it will give this amphibian an excellent result in water performance. Fig. 18 shows the Advance Amphibian Blended Wing Body Aircraft (AABWBA).

Table 6: Blended Wing Body Input Parameters

Gross Weight [kg]	7,600
Empty Weight [kg]	4,600
Max Fuel [kg]	2,000
Fuselage Length [m]	13.7
Fuselage Diameter [m]	4.5
Wing Area [m^2]	39.09
Wing Span [m]	23.47
C_{Lmax}	1.3
Flat Plate Drag Area [m^2]	0.445
Max Speed [km/hr]	740
Thrust Available [N]	40,500

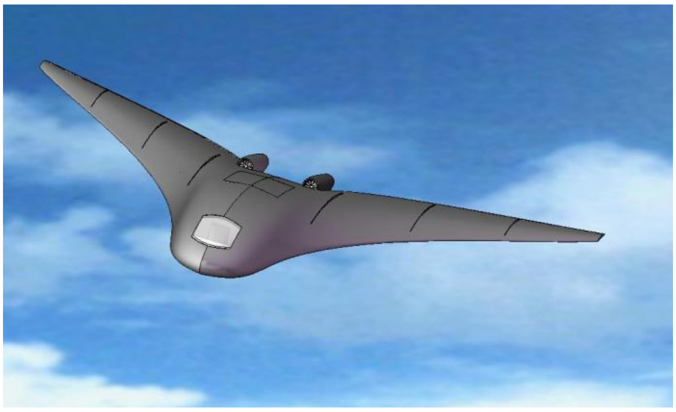

Fig. 17: Blended Wing Body Aircraft

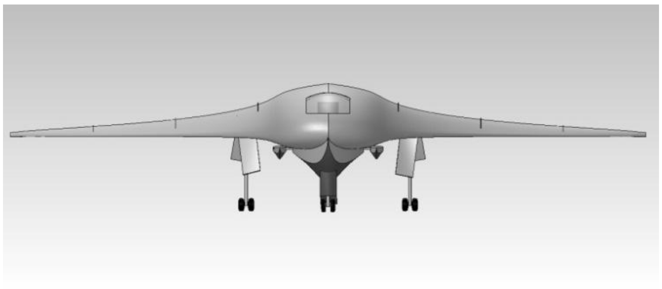

Fig. 18: Advance Amphibian Blended Wing Body Aircraft

IV. CONCLUSIONS

The preliminary results show some of the advantages of using the trimaran concept into a seaplane design, and the increase in flight performance when the floats are retracted. The design excels in hydrostatic stability as shown from *Table 5* and Fig. 10. The metacentric height of this design has a positive value in the transversal stability. The water speed that a trimaran shows is also significant, in which water resistance is less compared when using the wing tip floats or stabilizers as explained by the graph in Fig. 12.

For the flight performance, mounting the floats inside the undercarriage decreases significantly the drag as compared to an extended position. The flight performance of the seaplane increases the rate of climb, range, and endurance.

The aim of this research is to design an “out of the box” idea that will stand out not only because of its improved performance, as well as its unique design idea. On a long term basis, suitable infrastructure (seaports) can be constructed in order to increase seaplane market and operations.

The creation of the Blended Wing Body Aircraft creates a more efficient landplane than a conventional configuration. Combining the advance trimaran concept to the blended wing body design, an advance amphibian aircraft emerges, exceeding both water performance and air performance on any kind of amphibian aircraft of its type. The theoretical design exceeds the “out of the box” thinking, as well as the aesthetic design. The advance amphibian blended wing body aircraft gets a futuristic design that will attract the attention of investors, and will get a high social acceptance.

Finally, with the aid of Computer Aided Design (CAD) software, SOLIDWORKS, a model was elaborated to show a futuristic picture of this advance amphibian design shown in Fig. 19, Fig 20, Fig. 21 and Fig. 22.

Fig. 19: Futuristic 3-D CAD Model of Amphibians at Takeoff from a Modern Sea Port

Fig 20: Futuristic CAD Model of a Turboprop Seaplane

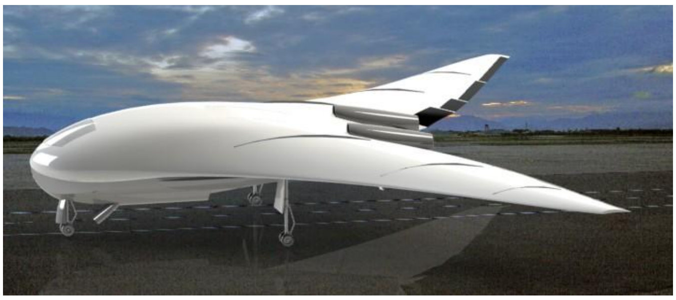

Fig. 21: Futuristic 3-D CAD Model of BWB Trimaran Amphibian

Fig. 22: Futuristic Models of a Turboprop seaplane and a BWB Amphibian

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