CONCEPTUAL DESIGN OF UTM 4-SEATER HELICOPTER

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ABSTRACT

This paper describes the conceptual design of the first UTM's 4-seater helicopter. The vehicle is in light-helicopter category and will be powered by piston engine. Parametrics study is used to identify the initial specification in order to initiate the preliminary design of the helicopter. The design process was carried-out in accordance with the FAR Part 27 standard.

Keywords*: Methodology, 4-seater helicopter, parametric study.*

1.0 INTRODUCTION

The planning to venture into this technology was started long before UTM received a 2-seater Rotorway EXEC 162F helicopter. During that time no one has any exposure on the helicopter development technology. Knowledge on the technology only restricted to the theoretical point of views such as design, performance and aerodynamic characteristics. In order to move a step forward, i.e. development phase, the Rotorway helicopter was bought. The helicopter is used as a platform for reverse engineering process. The handing over of the helicopter to UTM was held on 26th. July 2006.

Designing of a helicopter is depends on the mission and purpose of the helicopter. Helicopter can be used for observation, surveillance, military and commercial purposes. However, the control system for helicopter remained similar which is consists of 2 sticks and a paddle to functions as cyclic, collective and rudder control respectively. With these sticks and paddle, helicopter will be able to maneuver.

To design a new helicopter, some aspects must be considered such as structural layout, weight distribution and aerodynamic characterisitics. It starts with a set of specification which is defined by the requests from customers through a marketing survey or by some others means [1]. Since the helicopter is the first developed by UTM, the focus on the specification will be toward on less maintenance, less complexity of control systems as well as simple structural layout. The helicopter in this category normally is powered by piston engine with 2 main rotor blades. While maximum capacity of the helicopter is 4 passengers. The early mission for this development is to get the helicopter airborne.

2.0 DESIGN PROCESS

The tasks sequence in designing the UTM 4-seater helicopter consists of parametric study, determination of specification and configuration, weight estimation and distribution, initial sketch, conceptual design, final drawing and will end up with CFD analysis. The description for some of the tasks is as follow;

2.1 Parametric Study

The purpose of parametric study is to collect the relevant data before setting an initial specification for designated helicopter. For this, all important specification from the available 4-seater helicopter in the market has been reviewed. The information is gathered and this will provides a starting point in the design process. By using parameters such as length, width and height an early configuration of helicopter can be drawn. Five helicopters that have been referred in the parametric study were R44 Raven (2 rotor blades) [2], R44 Raven II (2 rotor blades) [2], Hummingbird (3 rotor blades) [3,4], Mil Mi-34 (4 rotor blades) [5], Mil Mi-52 (4 rotor blades) [6]. All the 4-seater helicopters are powered by piston engine.

2.2 Helicopter Specification

The final specification for the UTM's 4-seater helicopter is shown in Table 1. It is based on the parametric studies that have been carried out.

Table 1: Helicopter specifications

Type of vehicle:	Light helicopter		
Number of seat:	4		
Function:	Conventional		
<u>Helicopter Weight</u>			
Empty weight:	690kg		
Take-off weight:	1150kg		
Fuel weight:	110kg		
Payload weight:	350kg		
<u>Helicopter Dimensions</u>		<u>Helicopter Performance</u>	
Overall length:	11.60m	Cruising speed:	190km/hr
Overall height:	3.30m	Max. speed:	240km/hr
Fuselage length:	9.00m	Range:	600km
Maximum width:	1.40m	Powerplant:	260bhp
Main rotor dia.:	10.00m		
Tail rotor dia.:	1.50m		

2.3 Criteria in Helicopter Design

The criteria on FAR Part 27 [7] have been used to design the parts of the helicopter. FAR Part 27 provides important information about the limits and range of every parts of helicopter, which the designer needs to consider in order to make sure the safety and performance of the helicopter being designed. There are nine criteria need to be considered for the helicopter design, i.e. Cockpit Conceptual Design, Cabin Structure, Structural Design Criteria, Structural Floor Design, Sub Floor Design, Firewalls, Cockpit Control Panel, Crashworthy Seats and Airframe Material.

2.4 Weight Estimation and Center of Gravity

The center of gravity of the helicopter was performed using weight estimation series due to it accuracy [8]. The weights for every component were measured and the axis will be assumed. There are 3 axes to determine the center of gravity for helicopter, i.e. noseline station, waterline station and buttline station. For example, the noseline station (view from side of helicopter) is calculated from the sum of the static moment about some arbitrary point contributed by weight of each component. The moment of each axis is then divided by empty weight. Table 2 shows the data of center of gravity calculation for helicopter being developed.

Another approached to estimate the center of gravity location is through design software such as Catia. The advantage of Catia is the centre of gravity for a design can be shown straight forward in the drawing. However, all the drawing and design must be done with actual scale.

According to Prouty [9] the best position for the center of gravity on a single-rotor helicopter is slightly ahead of the main rotor shaft. The noseline position of center of gravity for helicopter being developed is 2.25 meter as shown in Figure 1, which is slightly ahead of main rotor shaft. The center of gravity could be rearranged by moving certain components such as battery, seats or by putting additional weight to function as a ballast.

Table 2 Value for Center Of Gravity

COMPONENTS WEIGHT	WEIGHT		NOSELINE	MOMENTS	BUTTLINE STATION	MOMENTS	WATERLINE STATION	MOMENTS
	(lb)	(kilogram)	STATION(meter)	(kg.m)	(meter)	(kg.m)	(meter)	(kg.m)
Blade mass	75.92	34.44	2.30	79.21	0.00	0.00	3.60	123.97
Hub and hinge	37.05	16.81	2.30	38.65	0.00	0.00	2.80	47.06
Horizontal stabilizer	18.24	8.27	8.20	67.84	1.50	12.41	1.90	15.72
Vertical stabilizer	36.01	16.33	8.20	133.94	0.00	0.00	2.40	39.20
Tail rotor	45.12	20.47	8.20	167.82	1.60	32.75	2.10	42.98
Fuselage	342.92	155.55	2.10	326.65	0.00	0.00	1.80	279.99
Landing gear	144.96	65.75	2.20	144.66	0.00	0.00	0.50	32.88
Engine installation	120.00	54.43	2.60	141.52	0.00	0.00	1.20	65.32
Propulsion subsystem	33.71	15.29	2.80	42.81	0.00	0.00	1.50	22.94
Fuel system	8.74	3.96	2.50	9.91	0.00	0.00	1.10	4.36
Cockpit control	15.87	7.20	2.60	18.72	0.00	0.00	1.50	10.80
System control	12.80	5.81	1.10	6.39	0.00	0.00	1.10	6.39
Instruments	9.96	4.52	0.60	2.71	0.00	0.00	1.30	5.87
Hydraulics	89.17	40.45	1.80	72.81	0.00	0.00	0.90	36.40
Electrical	90.78	41.18	0.60	24.71	0.00	0.00	0.80	32.94
Furnishing and equipment	36.99	16.78	1.90	31.88	0.00	0.00	1.00	16.78
Manufacturing variation	8.94	4.06	2.30	9.33	0.00	0.00	1.10	4.46
Empty weight	1127.18	511.29	2.25	1150.40	3.10	45.16	26.60	788.05

Points center of gravity (Noseline)

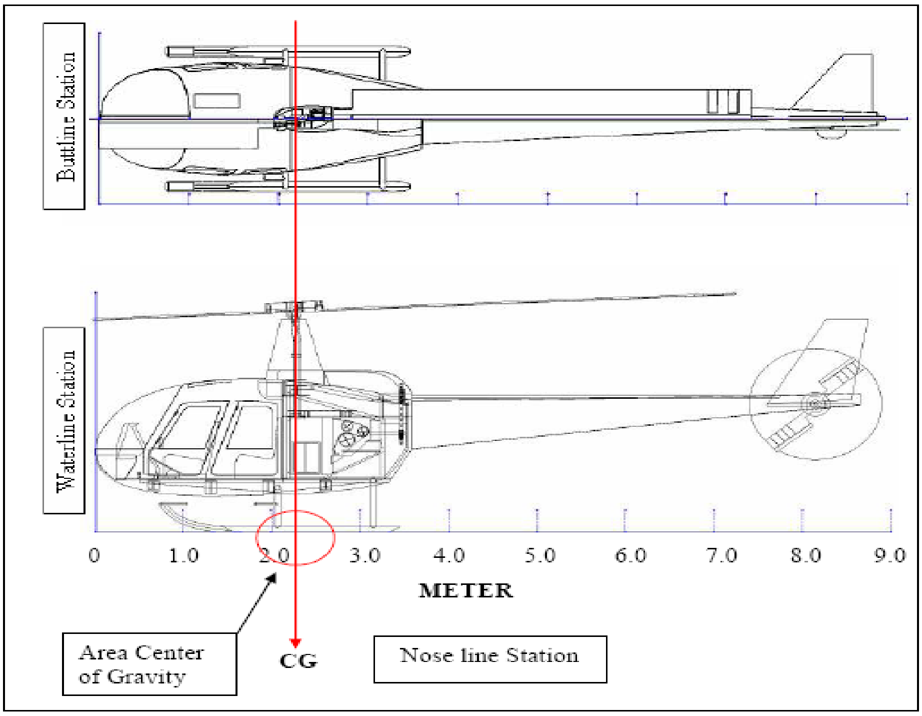

Figure 1: Determination of center of gravity

2.5 Fuselage Shape

The conceptual stage of the helicopter fuselage was design after going through a series of initial sketches. Major changes on the fuselage shape were done to avoid similarities between helicopters being referred. However, the size and contour of the fuselage still confined to the dimensions of the referred helicopters. There are 11 major plane cross-sections constructed in order to remain the aerodynamically shape on the fuselage. By dividing fuselage into upper and lower parts (side view) as shown in Figure 2, the coordinates for each point can be determined as shown in Table 3.

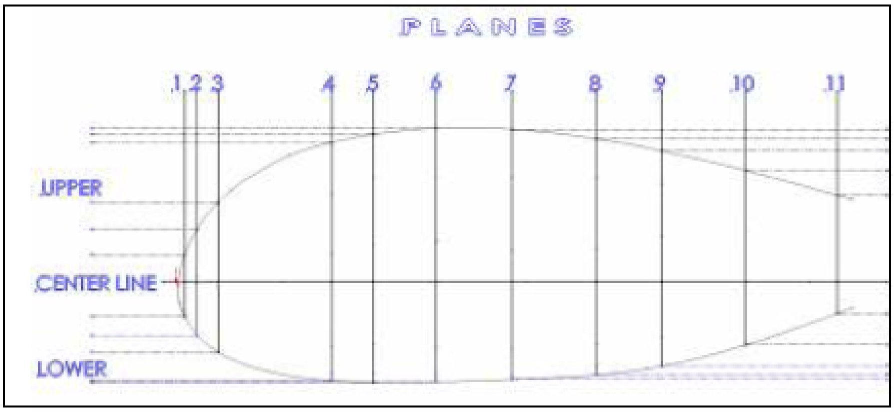

Figure 2: Upper and lower part from side view

Table 3: Distance on each plane (Side view)

Planes	Distance from origin (meter)	Lower (meter)	Upper (meter)
1	0.053	-0.211	0.316
2	0.132	-0.342	0.342
3	0.263	-0.447	0.499
4	0.999	-0.629	0.894
5	1.262	-0.631	0.947
6	1.657	-0.628	0.999
7	2.131	-0.627	0.999
8	2.683	-0.605	0.921
9	3.077	-0.527	0.842
10	3.629	-0.395	0.71
11	4.208	-0.211	0.552

To determine the coordinates, which is represents the width of the fuselage, the drawing must be viewed from top as shown in Figure 3. With the use of central exist across the fuselage the coordinates can be determined. The curve profiles for fuselage is identical on the left and right when view from top. The coordinates for fuselage width is shown in Table 4. The point of origin is referred to the utmost front of the helicopter fuselage.

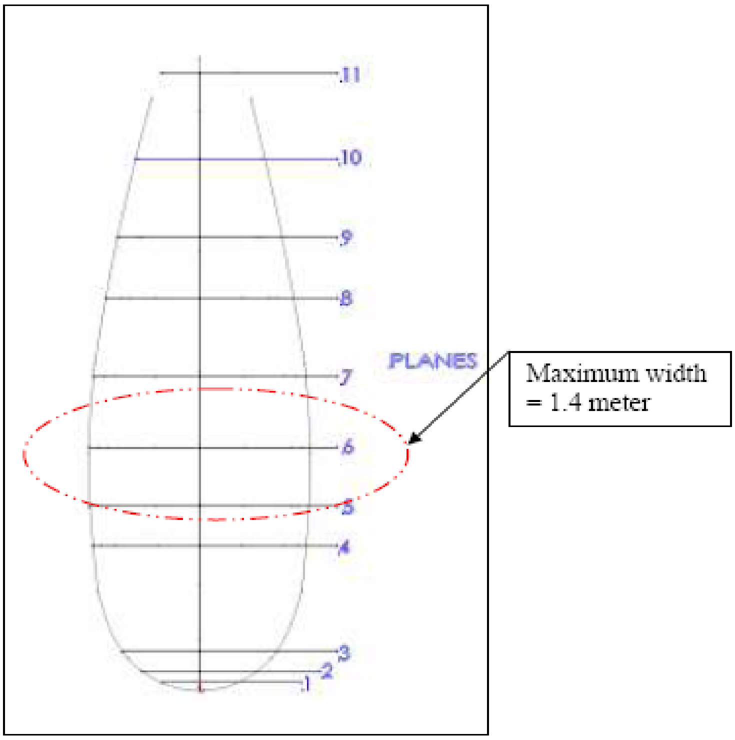

Figure 3: Curve profile of UTM helicopter viewed from top

Table 4: Distance on each plane (Top view)

Planes	Distance from origin (meter)	Right (meter)	Left (meter)
1	0.053	-0.209	0.209
2	0.132	-0.349	0.349
3	0.263	-0.489	0.489
4	0.999	-0.676	0.676
5	1.262	-0.700	0.700
6	1.657	-0.698	0.698
7	2.131	-0.676	0.676
8	2.683	-0.606	0.606
9	3.077	-0.513	0.513
10	3.629	-0.279	0.279
11	4.208	-0.233	0.233

Figure 4 shows the cross section curves when viewed from front. The maximum height for helicopter fuselage is 1.57 meter.

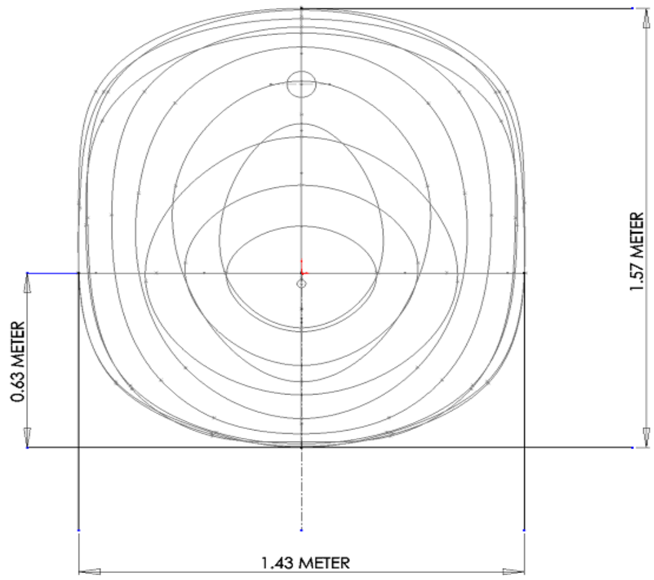

Figure 4: Cross section curves at different planes (Front View)

The center part of the fuselage is in rectangular shape to accommodate control systems, seats, avionics panel, and other instruments. Figure 5 shows the combination of side plane, top plane and cross section curves on each plane. With the use of advanced computer drawing software, the combination of the planes from different angles can be translated into 3-D image illustration. Example of the illustration is as shown in Figure 6, which is soon to be the shape of UTM 4-seater helicopter.

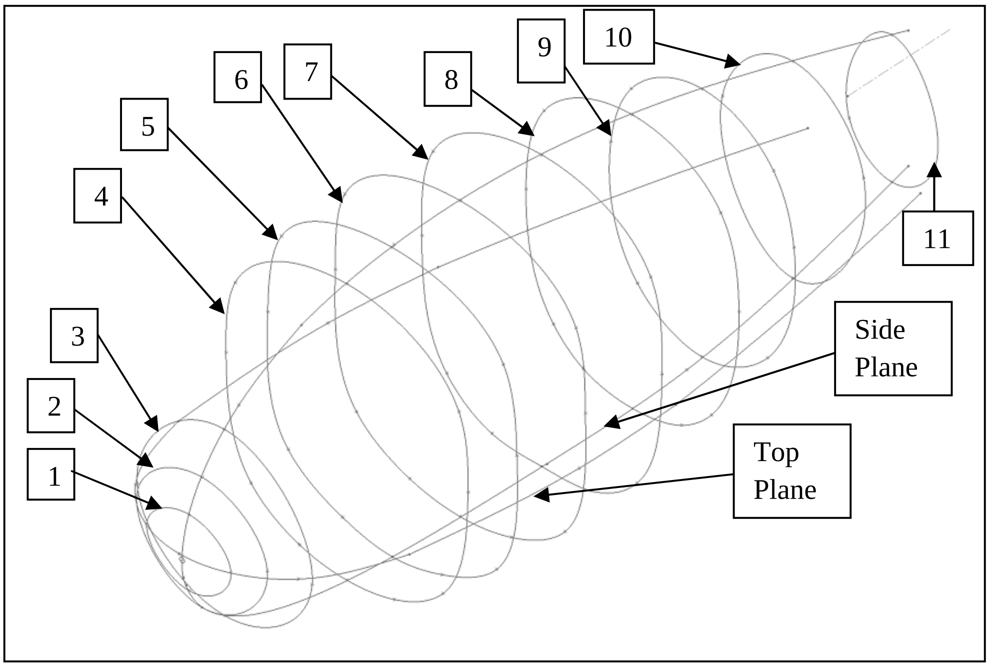

Figure 5: Isometric view of 3 combination curves

Figure 6: Shape of UTM's 4-seater helicopter

3.0 Conclusion

Parametric study is a process of collecting important data to quest for the similarities among helicopters being reviewed. The data will allowed for a preliminary design such as helicopter main dimensions and specifications. Aparts from that, rules must be abided for certification application purposed from the relevant governing body. For the rotary wing aircraft the rules is provided in FAR Part 27.

For helicopter to steadily hover and fly, the weight distribution of every component plays an important role. The weight distribution will determine the location of center of gravity of a helicopter. The best position for the center of gravity on a single-rotor helicopter is slightly ahead of the main rotor shaft. There are several methods to measure the center of gravity of a helicopter. The simplest way is by hanging the helicopter through crane or by others means. Weight ballast could be used to move the center of gravity to the balance condition.

The next task is to determine the shape of helicopter. Aerodynamically shape of fuselage will contribute to a better performance of specifications. Thinner body shape will results in less frontal area drag and this type of helicopter is suitable for military purposes due to quick responces with any input given by the pilot. However, for civillian use a wide cabin is preferred in order to provide comfort to the passengers. With the emergence of advanced software and super computer nowadays as well as composite materials, the time taken to develop a new helicopter is no longer difficult as before.

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