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A Conceptual Design of adding VTOL capabilities to Skywalker X8

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Abstract - *This journal explores the conceptual design of incorporating Vertical Take-Off and Landing (VTOL) capabilities into the Skywalker X8, with the aim of achieving a hybrid VTOL system that meets specific performance criteria. The primary objective is to demonstrate the feasibility of developing a VTOL-enhanced version of the Skywalker X8 while adhering to stringent performance requirements.*

The proposed design focuses on achieving an All-Up Weight (AUW) of under 7 kilograms, a critical threshold for regulatory compliance and optimized payload capacity. By integrating advanced VTOL mechanisms, the modified Skywalker X8 is intended to maintain a minimum endurance of 2 hours, which is essential for applications such as aerial photography, surveillance, and mapping. This endurance is crucial for extended flight operations, enabling the aircraft to perform prolonged missions effectively.

Additionally, the design aims to ensure operational capability at altitudes up to 1000 meters Above Mean Sea Level (AMSL). This altitude flexibility is intended to enhance the aircraft's usability across diverse geographical and environmental conditions, providing adaptability to various mission profiles. The system also targets a range capability of at least 15 kilometres, thereby supporting extended missions and broader coverage areas, which is vital for comprehensive data collection and surveillance tasks.

The journal details the conceptual framework of the VTOL system, including design modifications, integration challenges, and expected performance impacts. Preliminary simulations and analysis are presented to validate the proposed design and assess its feasibility in meeting the outlined performance requirements. The findings indicate promising potential for the hybrid VTOL system, providing a foundation for future development and refinement.

1.INTRODUCTION

This document is template. The Skywalker X8 is a highly regarded unmanned aerial vehicle (UAV) known for its exceptional performance in fixed-wing flight. With its robust design, the Skywalker X8 is widely utilized for tasks such as aerial photography, surveillance, and mapping due to its endurance and stability. However, to further enhance its operational versatility, there is a growing interest in integrating Vertical Take-Off and Landing (VTOL) capabilities into the Skywalker X8's existing framework.

To achieve this goal, the design will address several key requirements. Specifically, the aircraft must be capable of take-off and operation at three distinct altitudes: 4500 meters, 5000 meters, and 5500 meters Above Mean Sea Level (AMSL). These varying altitudes present significant challenges, including reduced air density and altered aerodynamic conditions, which necessitate precise engineering and design modifications.

To accommodate these requirements, several design changes will be implemented. These include the extension of the wing and the addition of booms to integrate the VTOL propulsion system effectively. These modifications are crucial for ensuring that the aircraft can achieve the necessary lift and stability at high altitudes while maintaining operational efficiency.

In addition, the selection of an appropriate airfoil will be guided by existing research literature to ensure optimal aerodynamic performance. Following this, detailed calculations will be performed to determine the required airspeed for both fixed-wing and VTOL flight modes. Power calculations will be conducted to assess the energy needs for both flight modes, followed by battery capacity calculations to ensure that the system can meet endurance requirements.

Based on the results of these calculations, suitable components will be selected to meet the design objectives. This approach ensures that the Skywalker X8 can achieve the desired performance while integrating VTOL capabilities, thereby expanding its operational scope and enhancing its utility across various mission profiles.

1.1 Requirements

The following requirements are taken as a sample for which this conceptual design must be done. These requirements are derived from the requirements given by various government defence organizations. We have considered three different take off altitudes, three different operating altitudes. Also, along with this, the flight time is also specified for each altitude. The climb rate considered is 1m/s. And the range considered is 15 Km. The requirement of limits the overall weight of the UAV to be less than 7 Kgs. Please find them in the below table.

Mission Requirements			
	1	2	3
Take of Altitude	4500m	5000m	5500m
Operating Altitude	5500m	6000m	7000m
Total Endurance	120mins	60mins	45mins

LOS Range	15Km
Climb Rate	1m/s
All Up Weight	Less than 10kg

Table 1 - Requirement

1.2 Proposed Idea

Our Proposed Flying wing is inspired from Skywalker X8. The Skywalker X8 is a well-established and widely used conventional fixed wing unmanned aerial vehicle (UAV). It is known for its stability, payload capacity, and endurance, making it suitable for various applications in the field of unmanned aerial systems (UAS). For our specific conversion plan, the process involves modifying the Skywalker X8's airframe by extending the wing area and integrating a boom system with multiple motors. The Targeted AUW is 7000g.

This was inspired from the blog https://discuss.ardupilot.org/t/skywalker-x-8-vtol-conversion-my-way/66879 where the practical flying model has been achieved.

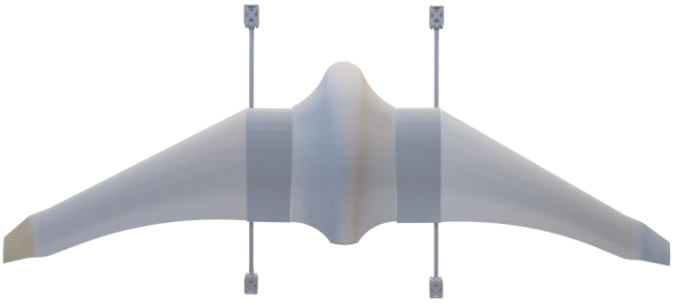
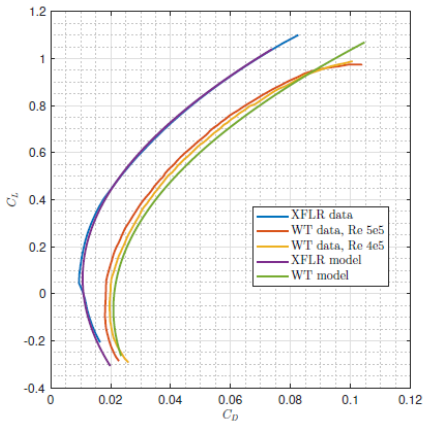


Figure 1 – Conceptual Design

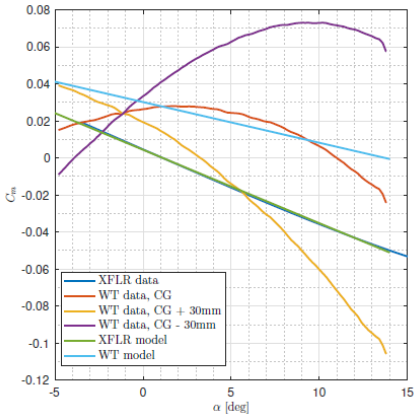
2. Aerodynamics of Skywalker X8

The Aerodynamics of Skywalker X8 is wonderful for low-speed flying. But as this a swept back wing, the Pitching moment Coefficient (Cm) plays a vital part.
With reference of the Paper "**Aerodynamic modeling of the Skywalker X8 Fixed-Wing Unmanned Aerial Vehicle**", it is found that the existing design of the Aircraft has a good pitching moment Co- Efficient.

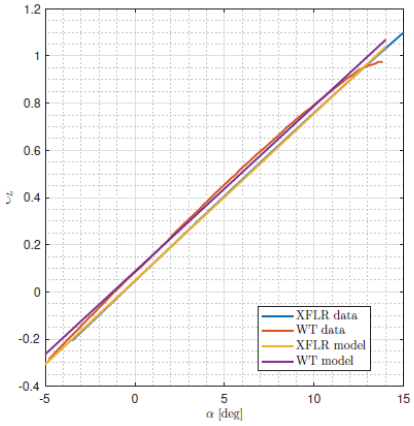
The graph is presented below: (Reynolds number considered: 4x105 and 5x105)



Graph 1 – Cl vs Cd



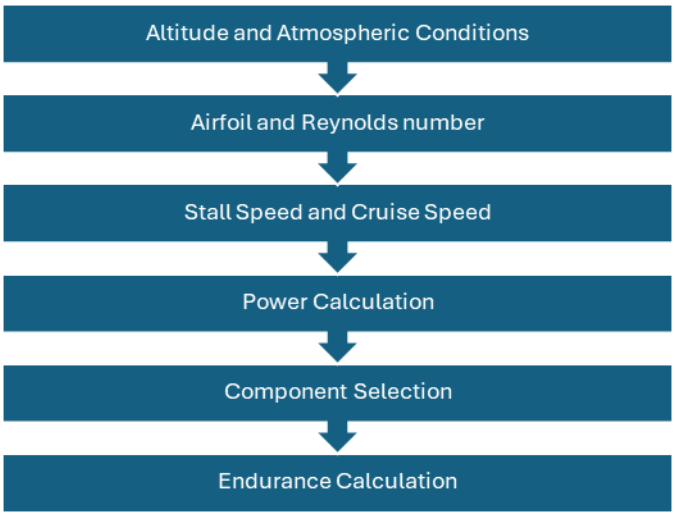
Graph 2 – Cm vs AOA



Graph 3 – Cl vs AOA

3. Process Flow

The pictorial representation below shows us the process flow that we have taken up for this journal.



4. Selection of Aero foil

The selection of aero foil is crucial in designing a flying wing, as it significantly influences the aircraft's stability and efficiency. A flying wing lacks traditional tail section, relying heavily on the airfoil shape to maintain control and lift.

4.1 Reynolds Number

For analyzing air foil characteristics at 7000m AMSL, a typical operating Reynolds number is required

$$V_{stall}@7000\ m\ AMSL = \sqrt{\frac{2\times MTOW\times 9.81}{\rho\times S_{ref}\times CL_{max3D}}} = 14..54\ m/s$$

[M =7 kg, C_{Lmax3D} = 1.0]

V_{cruise} = 1.2 x V_{stall} = 17.4 m/s

$$Re = \frac{\rho\times V_{cruise}\times mean\ aerodynamic\ chord}{dynamic\ viscosity} = 1.9\times 10^5 = \sim 0.2\ Million$$

For analyzing air foil characteristics at 5500m AMSL, a typical operating Reynolds number is required.

$$V_{stall}@5500\ m\ AMSL = \sqrt{\frac{2\times MTOW\times 9.81}{\rho\times S_{ref}\times CL_{max3D}}} = 13.44\ m/s$$

[M =7 kg, C_{Lmax3D} = 1.0]

V_{cruise} = 1.2 x V_{stall} = 16.12 m/s

$$Re = \frac{\rho\times V_{cruise}\times mean\ aerodynamic\ chord}{dynamic\ viscosity} = 2.1\times 10^5 = \sim 0.2\ Million$$

Airfoil characteristics have been analyzed for 0.2 million Reynolds Number

4.2 Airfoil

The Actual airfoil of Skywalker X8 is not disclosed by the Manufacturer, but it closely resembles S5010, so we had considered this as the Airfoil.

Similarly, from the reference article:" **Airfoil Selection Procedure, Wind Tunnel Experimentation and Implementation of 6DOF Modeling on a Flying Wing Micro Aerial Vehicle**", in this paper, they have considered 10 different airfoils, and found that E387 more apt for a flying wing configuration, so we have taken these two airfoils for our Skywalker X8 remodeling

Airfoil	ClCdmax	Clmax	αstall	Clα	Cd0	Cmα
E184	44.04	0.88	9	0.0856	0.014	0.0058
E186	45.76	0.98	10.5	0.0960	0.021	0.0034
E387	60.90	1.35	11.75	0.1028	0.015	0.0043
FX69H083	53.07	1.05	9.5	0.0439	0.015	0.0022
M5	46.73	1.03	10	0.0928	0.013	0.0039
M6	45.56	1.23	13.5	0.0906	0.017	0.0058
S5010	45.07	1.25	12	0.0951	0.014	0.0025
S5020	46.08	1.21	11	0.1005	0.014	0.0021
MH60	45	1.20	10.5	0.099	0.015	0.0031
HS-522	44.5	1.19	11	0.091	0.012	0.0025

Table 2 - Airfoil Comparison

4.2 Airfoil Comparison

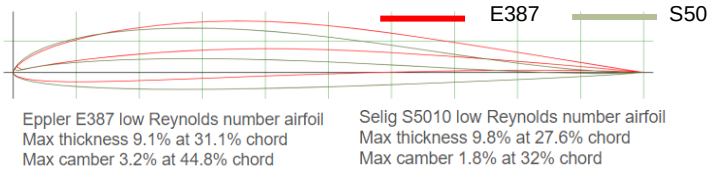
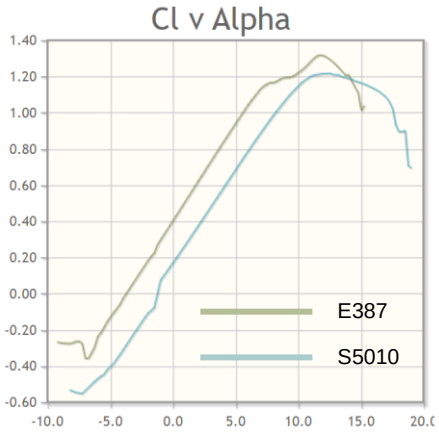
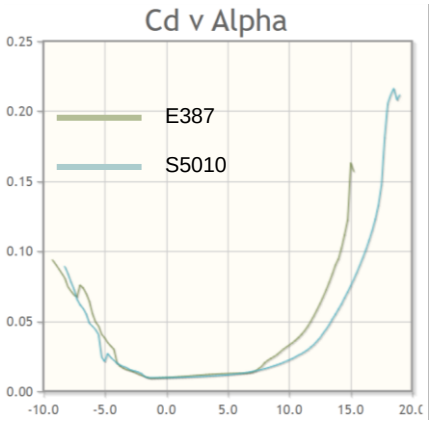


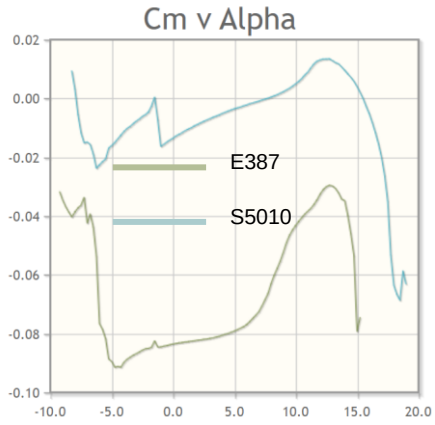
Figure 2 – E387 & S5010 Comparison



Graph 4



Graph 5



Graph 6

Although we don't know the actual aerofoil of the Sky walker X8, we had done reverse engineering and with a 3D scanned model, we could find that the E387 Airfoil is the closest resemblance to Skywalker X8, For Our Project, We have Selected E387 Airfoil and carried out our calculations.

4. Calculations

The calculations below are conceptual assumptions.

4.1 FW Power Calculation

(Considering $C_{D0} = 0.065$, $V_{Cruise}@7000m\ AMSL = 17.4$)

(Considering $C_{D0} = 0.065$, $V_{Cruise}@5500m\ AMSL = 16.1$)

$$Power_{Ideal} = \text{Drag} * V_{Cruise}$$

The Estimated Drag = 9.719N

The Estimated Drag = 10N

$$Power_{electrical} = \frac{Power_{Ideal}}{\eta_{Prop} * \eta_{motor}}$$

FW Power	7000m AMSL	5500m AMSL
The $Power_{Ideal}$	169.65W	165.2W
The $Power_{electrical}$	362.8W	353.71W

(Assumed $\eta_{Prop} = 0.55$ $\eta_{motor} = 0.85$)

Table 3 - FW Power

4.2 VTOL Power Calculation

When the UAV is in hover, momentum theory alone can be used to calculate the hover power.

$$P_h = \frac{(mg)^{3/2}}{FoM\sqrt{2\rho\pi N_r r_{prop}}}$$

$r_{prop} = Propeller\ Radius\ in\ m$, **considered** $= 0.2286$

$N_r = No.\ Of\ Rotors$, ***cosidered*** $= 4$

$\rho = 0.69\ kg/m^3$ **@ 5500m AMSL**

$\rho = 0.77\ kg/m^3$ **@ 4500m AMSL**

where FoM is the figure of merit. Typical propellers achieve a figure of merit between 0.5 – 0.7. A value of 0.6 is used. The geometric pitch of the propeller is not considered by momentum theory . This is confirmed by experimental data indicating that the power to produce a given thrust at hover does not depend on the propeller pitch.

VTOL Power	5500m AMSL	4500m AMSL
Total $Power_{Hover}$	485W	459W
$Power_{Hover}$ per motor	121W	115W

Table 4 – VTOL Power

4.3 VTOL Battery Capacity estimation

VTOL capacity: (Assumed Time for Take-off: 2mins, Landing: 2 mins)

Battery capacity for takeoff = $Power_{Hover}$* $T_{Takeoff}$/(4 *6) in Ah

(During Take-off, Voltage Considered: 4V per cell)

Battery capacity for landing = $Power_{Hover}$* $T_{Landing}$ /(3.3 *6) in Ah

(During Landing, Voltage Considered: 3.3V per cell)

The total Battery Capacity required for 4 mins is mentioned in the table, the battery considered is 6S 1P battery

VTOL Batt Capacity required	5500m AMSL	4500m AMSL
Battery capacity for takeoff - 2mins	0.606Ah	0.573Ah
Battery capacity for landing -2mins	0.808Ah	0.765Ah
Total Battery capacity for VTOL	1.414Ah	1.338Ah

Table 5 - Battery Capacity required for VTOL

4.4 FW Climb Power Calculation and Battery capacity estimation

The Fixed Wing climb power calculations are done as per the formula below

$Power_{Climb}$ = ($Power_{Ideal}$ + (weight * rate of climb))/(η_{Prop} * η_{motor})

Rate of climb(ROC) = 1m/s **(From Mission Requirements)**

FW Climb Power	**7000m AMSL**	**5500m AMSL**
$Power_{Climb}$	509.2W	500.2W

Table 6 - FW Climb Power

For 1500m AGL, T_{Climb} at ROC = 1 m/s = 1500/1 = 1500 s = 25 min = 0.41 h

For 1000m AGL, T_{Climb} at ROC = 1 m/s = 1000/1 = 1000 s = 16 min = 0.277 h

Battery capacity for FW Climb = $Power_{Climb}$ * T_{Climb}/(3.7 * 6)

FW Climb Batt Capacity required	**7000m AMSL**	**5500m AMSL**
Total Battery capacity for FW Climb	9.4Ah	6.24Ah

(Assuming voltage per cell to be 3.7)

Table 7 - FW Climb Batt Capacity

4.5 FW Cruise Battery capacity estimation

FW Cruise Power:

FW Power	**7000m AMSL**	**5500m AMSL**
The $Power_{ideal}$	362.8W	353.71W

Table 8 - FW Cruise Power

Battery Capacity Required = $Power_{ideal}$* T_{Cruise}/(3.7 * 6) in Ah

Altitude	Duration	FW Cruise Batt Capacity required
Cruise@7000m AMSL	**16mins**	4.65Ah
Cruise@7000m AMSL	**100mins**	15.93Ah

(Assuming voltage per cell to be 3.7)

Table 9 - Batt Required for Cruise Power

4.5 Total Battery capacity estimation

Assuming avionics power is 60 Wh, then the battery capacity required for Avionics is

Battery required for avionics = 60/ (3.7*6) = 2.702Ah

(Assuming voltage per cell to be 3.7)

Total Power consumed	7000AMSL	5500AMSL
Battery Power required for Avionics	2.702Ah	2.702Ah
Battery Power required for VTOL	1.41Ah	1.33Ah
Battery Power required for Climb	9.4Ah	6.24Ah
Battery power required for Cruise	4.65Ah	15.93Ah
Total Battery Power required	18.162Ah	26.202Ah

Table 10 - Total Battery Required

5. Components Selection

Based on the above power calculations and battery capacity estimation, we have selected the following Motors, ESCs, Battery and Propellers.

5.1 Fixed Wing Motor

The motor has been chosen based on the Climb power required at Altitude 7000AMSL

AT4130-450 kV motor

The motor's design and construction make it suitable for demanding applications and provide excellent performance characteristics.

Figure 3 – Fixed Wing Motor

Motor	Propeller	Throttle	Voltage (V)	Current(A)	Power(W)	RPM	Thrust(g)
AT4130 Long Shaft KV450	APC 17X10	50%	22.16	14.22	315.17	4285	2182
		55%	22.08	18.77	414.61	4705	2671
		60%	22.01	23.17	510.03	5078	3124
		65%	21.92	28.6	627	5418	3610
		70%	21.82	34.25	747.18	5733	4039
		75%	21.72	40.63	882.51	6090	4486
		80%	21.57	49.2	1061.39	6405	5113
		90%	21.31	65.24	1390.48	6926	6091
		100%	21.16	74.27	1571.68	7167	6534

Table 11 – Specifications of AT4130 KV450 Motor

5.1.1 Pitch Speed

The fixed-wing propeller selection is dependent on the operating speed regime as the propeller thrust tends to go zero at a particular speed for a given propeller pitch and rpm known as pitch speed. The propeller recommended for the chosen FW engine by OEM is 17-inch x 10-inch

Pitch Speed = (RPM of motor X Propeller Pitch / 60) X 0.025

RPM	Pitch Speed (m/s)
1000	4.16
2000	8.33
3000	12.5
4000	16.6
5000	20.83
6000	25
7000	29.16

Table 12 -Pitch Speed – 17x10

The cruise-regime of 16 m/s to 18 m/s for the airfoil chosen, the rpm range is around 4000 – 5000. Which is considerably higher

If we chose a propeller of size 17-inch x 12-inch, following is the pitch speed that we get.

RPM	Pitch Speed (m/s)
1000	5
2000	10
3000	15
4000	20
5000	25
6000	30
7000	35

Table 13 - Pitch speed - 17x12 Prop

The cruise-regime of 16 m/s to 18 m/s for the airfoil chosen, the rpm range is around 3000 – 4000. which in acceptable range for the chosen FW Motor.

5.2 FW Propeller

With the findings in the motor data, the 3 closest electric propellers available are chosen and are to be run on thrust bench to get the propeller performance data.

We are going to choose APC Propellers; These propellers provide high performance and low noise.

In this, we have chosen 3 propellers

- APC 17x10E
- APC 17x12E
- APC 18x10E

Figure 4 – ACP Propeller

5.3 Electronic Speed Controller – FW

To maintain control and stability during flight, we have chosen the AT-75A 6S T-Motor ESC (Electronic Speed Controller)

The ESC will provide precise control of the motor speed, ensuring the continuous current flow with minimal heating. Features:

- Input Voltage Abnormal protection
- Low Battery protection
- Overheat protection
- Throttle Signal Loss protection

Figure 5 - AT-75A ESC

Model	Continuous Current	Burst Current(<10s)	BEC Mode	BEC Output
AT-75A 6S	75Amps	95Amps	Switch	5V/5A

Table 14 - ESC Specifications

5.4 VTOL MOTOR

The considered motor Thrust is to weight ratio for this aircraft is 2:1

Weight of the Aircraft: 7000g
Thrust required is 2 times of 7000g which is 14000g

The motor KDE4215XF-465kV has been considered based on the requirement

MOTOR	PROPELLER	THROTTLE	AMPERAGE	POWER	EST. THRUST AT SEA LEVEL		RPM
		[%]	[A]	[W]	[g]	[N]	[rev/min]
KDE4215 XF-465kV	18.5" X 6.3 DUAL-EDN	25.00%	3.7	94	1052	10.32	2850
		37.50%	8.2	205	1784	17.51	3810
		50.00%	15.4	388	2726	26.74	4730
		62.50%	25.1	633	3702	36.31	5530
		75.00%	36.9	930	4661	45.72	6220
		87.50%	49.6	1249	5516	54.11	6840
		100.00%	62.6	1576	6150	60.33	7230

Table 15 – Specifications of KDE4215XF – 465kV Motor

5.4.1 VTOL Motor Test data Correction

With altitude, electrical power is assumed to remain same even though it is expected to reduce due to thin air.

With reduction in voltage, thrust and power drop is modelled whereas current is assumed to remain same

$$\text{Altitude Correction} = \left[\frac{\rho_{4500m\ AMSL}}{\rho_{Test\ Data}}\right]^{0.55}$$

Low Voltage Correction:

- Test voltage (Max) = 4.35 V/cell
- Take-off voltage = 4 V/cell
- Landing voltage = 3.3 V/cell
- Take-off voltage ratio = 0.919
- Landing voltage ratio = 0.758

$$\text{Corrected } Thrust_{Hover} \text{ after Density Correction} = Thrust_{Hover} * \text{Altitude Correction}$$

$$\text{Corrected } Thrust_{Hover} \text{ after Low Voltage Correction} = (Thrust_{Hover} \text{ after Density Correction}) * \text{Voltage Correction}$$

Power Corrected = Power from test data x corrected voltage

5.4.2 VTOL Motor Test data Correction during takeoff

With the above voltage and voltage ratio and the formulas we have tabulated the corrected test data

Test Data available with 18.5" x 6.3 Dual Blade Propeller

- Voltage = 26.1 V (max)
- Temperature = 295 K
- Pressure = 102600 Pa
- Density (estimated) = 1.2117 kg/m3

Throttle (%)	Current (A)	Power (W)	Thrust (grams)
25	3.7	94	1052
37.5	8.2	205	1784
50	15.4	388	2726
62.5	25.1	633	3702
75	36.9	930	4661
87.5	49.6	1249	5516
100	62.6	1576	6150

Table 16 – Actual Thrust data

Thrust Data with Altitude Correction

- Density at 5500m AMSL = 0.697 kg/m3
- Electrical Power is assumed to remain the same even though it is expected to reduce due to thin air

$$\text{Density Correction} = \left[\frac{\rho_{5500m\ AMSL}}{\rho_{Test\ Location}}\right]^{0.55}$$

Throttle (%)	Current (A)	Power (W)	Thrust (grams)
25	3.7	94	775.9488
37.5	8.2	205	1315.868
50	15.4	388	2010.681
62.5	25.1	633	2730.573
75	36.9	930	3437.925
87.5	49.6	1249	4068.568
100	62.6	1576	4536.202

Table 17 – Thrust data Altitude Correction

Thrust Data with Voltage Correction

- Test Data Voltage = 26.1 V
- Takeoff Voltage Condition = 26 V
- Takeoff Voltage ratio = 0.919
- Assumed that the current remains same, while power and thrust drops

Throttle (%)	Current (A)	Power (W)	Thrust (grams)
25	3.7	88.8	713.0969
37.5	8.2	196.8	1209.282
50	15.4	369.6	1847.816
62.5	25.1	602.4	2509.396
75	36.9	885.6	3159.453
87.5	49.6	1190.4	3739.014
100	62.6	1502.4	4168.77

Table 18 – Thrust data Voltage Correction

RESULT

Hover Thrust per motor = 3-3.5 kg,
This thrust can be achieved at 75 % throttle
Total Hover Current = 23.7x4=94.8A (75 % throttle)

5.4.3 VTOL Motor Test data Correction during landing

Thrust Data with Altitude Correction

- Density at 5500m AMSL = 0.697 kg/m3
- Electrical Power is assumed to remain the same even though it is expected to reduce due to thin air

$$\text{Density Correction} = \left[\frac{\rho_{5500m\ AMSL}}{\rho_{Test\ Location}}\right]^{0.55}$$

Throttle (%)	Current (A)	Power (W)	Thrust (grams)
25	3.2	94	775.9488
37.5	5.6	205	1315.868
50	9.5	388	2010.681
62.5	15.3	633	2730.573
75	23.7	930	3437.925
87.5	34.9	1249	4068.568
100	44.9	1576	4536.202

Table 19 - Thrust data Altitude Correction

Thrust Data with Low Voltage Correction

- Test Data Voltage = 26.1 V
- Takeoff Voltage Condition = 19.3 V
- Takeoff Voltage ratio = 0.758
- Assumed that the current remains same, while power and thrust drops

Throttle (%)	Current (A)	Power (W)	Thrust (grams)
25	3.2	73.26	588.169
37.5	5.6	162.36	997.427
50	9.5	304.92	1524.0
62.5	15.3	496.98	2069.77
75	23.7	730.62	2605.947
87.5	34.9	982.08	3083.974
100	44.9	1239.48	3438.44

Table 20 – Thrust data Low Voltage Correction

RESULT

Hover Thrust per motor = 3-3.5 kg,
This thrust can be achieved at 88 % throttle
Total Hover Current = 35 x4=94.8A (88 % throttle)

5.5 VTOL Propeller

With the findings in the motor data, the 3 closest propellers available are chosen and are to be run on thrust bench to get the propeller performance data.

We are going to choose KDE and T-Motor Propellers; These propellers provide high performance and low noise.

In this, we have chosen 3 propellers

- 18.5 x 6.3 DUAL-EDN (KDE)
- P18 x 6.1 T-Motor
- MF1806 T-Motor

Figure 6 – VTOL Propellers

5.6 Electronic Speed Controller – VTOL

To maintain control and stability during flight, the XROTOR 4IN1 ESC- MICRO 60A has been chosen

Features:

- High-performance 32-bit microprocessor with a running frequency of up to 48MHz for an excellent performance.
- The code supports regular 1-2ms pulse width input, as well as Oneshot125 (125-250us), Oneshot42 (41.7-83.3us) and Multi shot (5-25us).
- The code also supports a beacon functionality, where the ESC will start beeping after a given time of zero throttles. This can be very useful for finding lost crafts

Figure 7 – VTOL ESC

Model	Continuous Current	Burst Current(<10s)	BEC Mode	BEC Output
Micro 60A	60Amps	80Amps	NA	Not Avaliable

Table 21 – ESC Specifications

5.6 Battery – Compatibility

Compatibility check for VTOL propulsion(During Takeoff & Landing):

- Hover current at during Takeoff 5500 m AMSL = 94.8 A
- Discharge Rating at Hover = 94.8/30 = 3.16 C
- Hover current at during Landing 5500 m AMSL = 140 A
- Discharge Rating at Hover = 80/30 = 4.66 C

Considering current at 100% throttle
Total current drawn = 44.9 x 4 = 250.4 A
Discharge Rating = 250.4/30 = 8.33 C

Both above-mentioned discharge rate conditions are within maximum continuous discharge rate characteristic of the battery pack

5.6.1 Selection of Battery

For both FW Flight and VTOL conversion, we are using one solid-state Li-ion battery as the power source.
Specifically, we have plans to use a 30000mAh 5C solid-state Li-ion battery, which offers high energy density and capacity. The Total Battery Ah estimation required for our complete mission is 26.202 Ah. We will be using only 90% of the battery, so 90% of 30Ah is 27Ah.

Figure 8 – Solid state Li-ion Battery

5.7 Airframe Material

Expanded polypropylene material has been chosen to be used as material for airframe. Polypropylene (PP) is a kind of hemi crystalline thermoplastic plastics. Most commercial polypropylenes are isotactic and has an intermediate level of crystallinity between that of low-density polyethylene and high-density polyethylene. EPP is a recyclable closed cell molded foam with an impressive set of properties that you would struggle to find in another material

Figure 9 – Airframe made with EPP Foam

5.8 Weight Estimation

Category	Description	Quantity	Unit Weight(grams)	Total Weight (Grams)
ESC - VTOL	Tekko32 F4 Metal 4in1 65A ESC (65A)	1	15.8	15.8
Motor- VTOL	KDE4215XF-465kv	4	200	800
Propeller - VTOL	KDE-CF155-DP (15.5X5.3)	1 Set	120	120
ESC - FW	AT 75A 6S	1	63	63
Motor- FW	AT4130 Long Shaft - 450kV	1	350	350
Propeller - FW	APC 17x12E	1	64	64
Battery	YANGDA THUNDER STONE SOLID STATE LI-ION BATTERY - 30000mAh	1	2570	2570
Autopilot	Pixhawk Cube Orange with mini carrier	1	55	55
GPS	Here 3 GPS	2	49	98
UBEC	KDEXF-UBEC22	1	24	24
Gimbal	NH 2 UZ	1	560	560
Tracker	NH Trip 5	1		
Servo	Hitec D-145SW	2	27	54
Radio	SOL8SDR2x1W-P	1	120	120
Airspeed sensor	CUAV SKYE airspeed sensor	1	22	22
Frame	Skywalker X8(With Wing Extension)	1	900	900
Boom	0.75" X 0.88" X 66" LONG CARBON FIBER(with Landing gear extension)	2	322	644
Harness	To be Measured			
Total				**6459 grams**

Table 22 – Total Weight Estimation without Harness

6. Conclusion

In conclusion, the development of a compact and agile Flying Wing Hybrid VTOL offers a viable solution to the limitations commonly associated with conventional fixed-wing UAVs and larger VTOL systems.

Also with our Conceptual design we are able to prove the theoretical capabilities of our model achieving the requirements of the mission.

This project is divided into multiple phases wherein the following are identification of BOM, Avionics Architecture, Procurement of materials, Sub system testing and validation, System integration with design modifications, Bench testing and Flight testing and data gathering

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BIOGRAPHIES

I am Karthik Rajendran an Aeronatical **Engineer** with **6+ years of experience** in **UAV System Engineering, Integration, and Testing**. I have worked in multiple Defence Projects for various companies in my Career. I also bring my expertise in UAV Designing from Conceptual design to final product.