LODEÁ

Low Altitude Observation Delta-wing Electric Aircraft

Technion
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Introduction

Nowadays a wide range of weight options exists when talking of unmanned air vehicles – starting at low Weight and growing up to dozens of tons. Technology has evolved over the years in both the aviation and construction of aviation, in the field of optics and much more. The developments can now obtain and display capabilities inconceivable in aviation field. Electric propulsion, minor UAVs and noise reduction are now the pinnacle of research and development in this field.

Requirements

- Man-portable UAV
- Over the hill / Urban surveillance
- Fast field deployment
- Endurance: 30 min.
- Fully automated flight (including take-off and landing)
- Simple to operated by one man
- Quiet
- Portable Ground Control System (PGCS)
- Real time video camera

Preliminary Design Review

- E.O Sensor chosen – MicroCam (99 gr)
- Estimated weight: 4.5 KG
- Configuration : Combination of **Flying wing** and vertical take off & landing
- Inspiration was- The Raytheon KillerBee and the IAI Panther.
- Electric motors selection with limitations:
  - Propeller's diameter: 10inch
  - 3 motors with 2.2 Kgf each
  - Hacker A30-14L Motor for vertical takeoff or landing
  - Hacker A50 14-L Motor for horizontal flight
- Using 3 Blades Propeller – reduced the power & sustains, increased flight speed & Thrust
- Using Lipo Battery – Thunder Power RC G6 Pro lite 2700mAh 4S –
  - Provided low weight and high capacity.
- Flying Wing – Enough space for vertical propellers & No need of tail
- Using Reflex Profile stabilized the wing by creating a Negative moment for a positive angle of attack – The Chosen airfoil- EPPLER E340 airfoil with 11.9% t/c

MicroCam sensor

Hacker A30-14L

2700mAh Battery

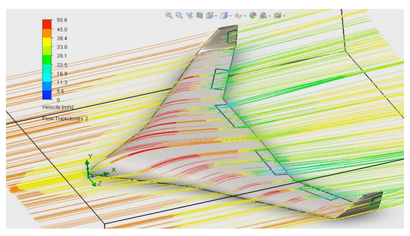
Propeller Thrust test

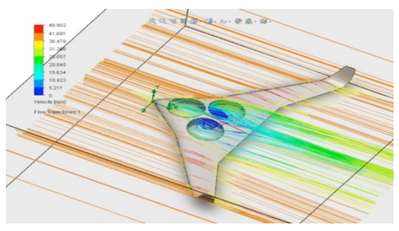
The motor and propeller were connected to a weight that represented the UAVs approximate weight. When compared to the prediction, the test showed that less thrust was received. Overall, the results were within the required limits of more than 1.5Kg per one of the three motors.

Propeller [Diameter X Pitch]	Throttle [%]	Thrust [Kg]
APC 9X3.8	50	
	75	0.9
	100	1.05
APC 9X7.5	50	0.5
	75	1.05
	100	1.09
APC 10X4.7	50	0.77
	75	1.55
	100	1.59

Preliminary Performance Analysis

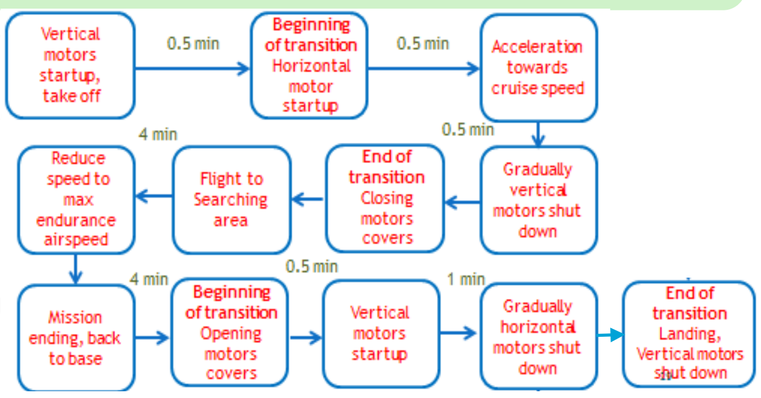
A CFD analysis was carried out on the UAV using the CFD option of the SolidWorks program.
The results showed reasonable flow on the model, and turbulence flow on the cavities.
It was concluded that the cavities of the aircraft led to turbulence and therefore, great loses in performances. The option of closing the cavities was then investigated.





Control System- Flight Pattern

The UAV's control system requires – Linear and angular accelerometers & Air Data, Sensors & Optic sensors, GPS, etc.



Flight pattern for the UAV, showing approximated times for each step

Critical Design Review

Detailed Design of The Outer Wing

The wing structure was based on leading edge spars, trailing edge spars, ribs and mid-fuselage reinforcement .

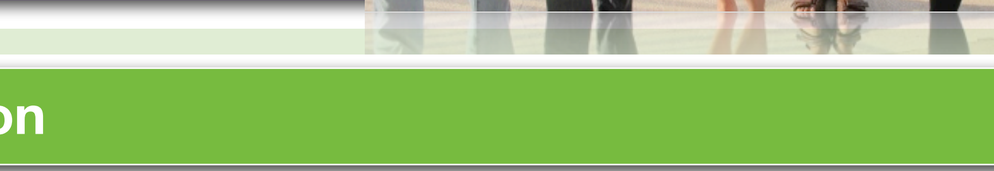
On top of the spars and reinforcement was placed a thin Kevlar skin

The wing was designed to work under bending load.

Wing Parameters:

- Wing area is $0.09\,m^2$
- The 0.45m span wing is subject to 2.25kgf.
- Wing load is $25\,{}^{Kg}/_{m^2}$.
- Under 3.8g (Normal category) wing load is $95\,{}^{Kg}/_{m^2}$.

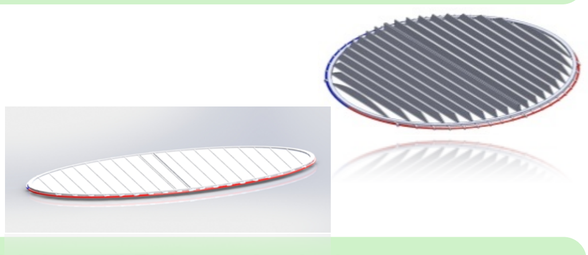
- The wing has 2 Spars and 2 ribs: One main spar and one trailing edge spar, tip and root ribs. U beam can produce better performance as easier manufacturing:



Cavities Closing Mechanism

The option of closing the cavities of the rotors was examined in order to maintain satisfying performances of the UAV .

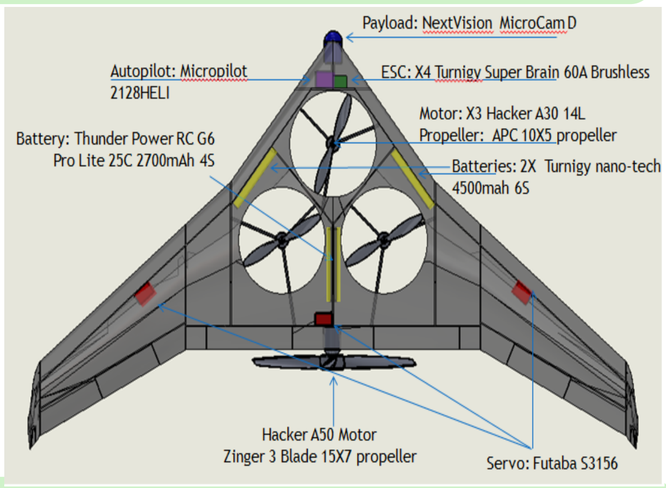
The chosen mechanism was The shutter cover due to its simplicity and the UAV geometry limitations.



Components Location and Weight and Balance Analysis

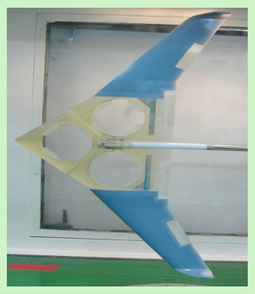
Distance from reference datum [mm]	Location
390mm	Center of mass
391.5mm	Aerodynamic center

MTOW 4.5Kg
CG @ 390mm
Stability margin 0.3%

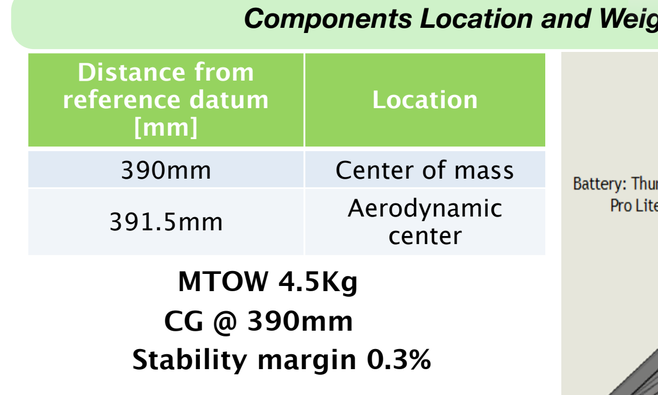


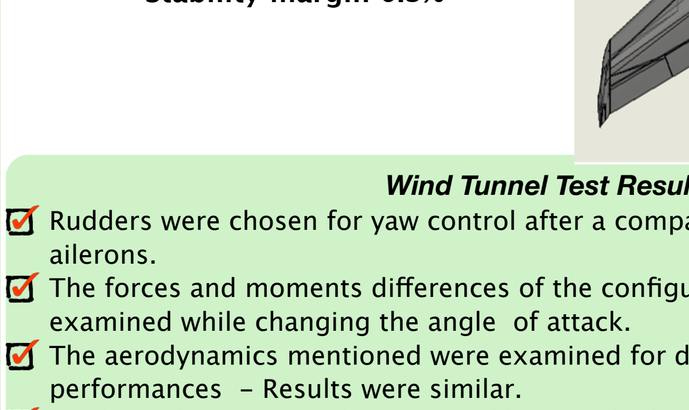
Wind Tunnel Test Results Evaluation

- ☑ Rudders were chosen for yaw control after a comparison to the splitter ailerons.
- ☑ The forces and moments differences of the configurations were examined while changing the angle of attack.
- ☑ The aerodynamics mentioned were examined for different maneuvering performances – Results were similar.
- ☑ Final conclusion was- the option of leaving the bottom of the cavities open is possible.



Configuration performances comparison:





Final results:		Analysis results	Experimental Results- All Shutters Closed	Experimental Results- Bottom Shutters Open
Stalling Speed	[Kts]	34.95	27.55	28.02
Minimum Drag	[Kgf]	2.17	2.97	3.86
At Speed Of	[Kts]	48.46	41.35	36.3
Minimum Required Power	[Watt]	465.24	545.2	621.05
At Speed Of	[Kts]	36.82	31.42	27.58
Maximum Cruise Range	[Km]	22.7	19.4	18.5 @30kts