Boeing Drone Frame

Project 03

Team Hi-Jax

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Project Description

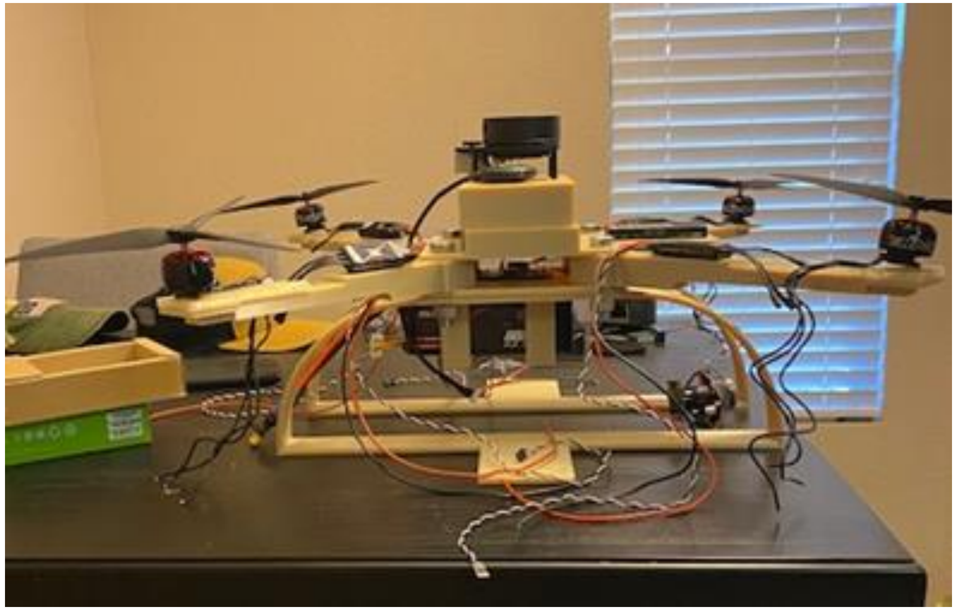
Design, analyze, and manufacture a 3D printed drone frame that minimizes weight and maximizes flight time using set commercially available components.

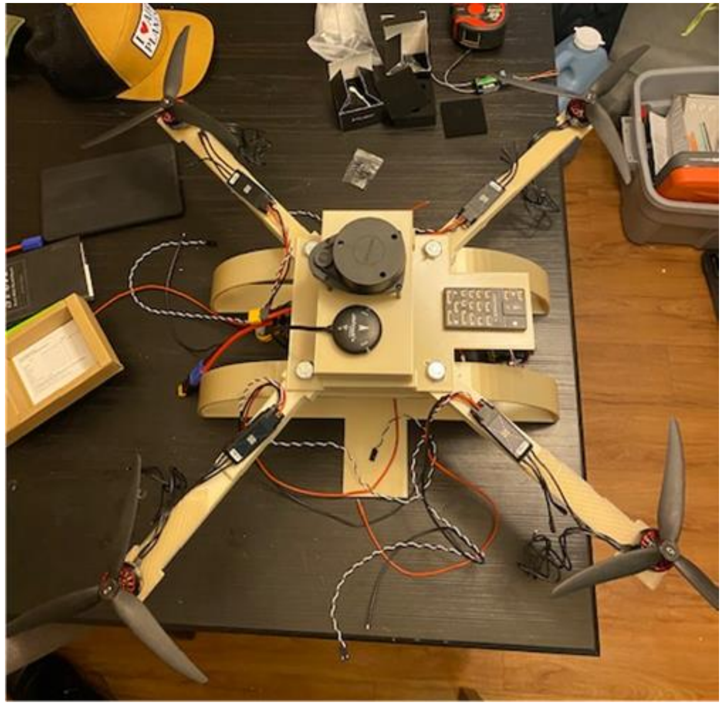
- Sponsor: Boeing
- Gain insight into team's academic processes.
- Seek innovative solutions from another perspective.

Colby Murphy

Background

Current Model:





Figures 1-2: Current assembled drone courtesy of Boeing.

Damien Brothers

Similar Device Benchmarks

DJI Phantom Series:

Figure 3: DJI Phantom 4 RTK Drone.

Yuneec Commercial Drones:

Figure 4: Yuneec Typhoon H Plus

Parrot ANAFI USA Drone:

Figure 5: Parrot ANAFI USA Drone.

Damien Brothers

Literature Review (Type: Articles)

- Drones and Possibilities of Their Usage [1]
  - The article explains the science behind the construction of drone and most important parts such as frame, propellors, engine, power, and communication system and the uses of drone.
  - The engine and wing size compatibility is very important. The larger the wing size, lowers the speed and drone volatility, and increases the aerodynamic lift, pressure, torque on engine and the vibration. To normalize everything, we must use compatible engine to the wing.
- Aeromechanical Design and Analysis of H-Drone Configuration [2]
  - This article describes the aeromechanical design and analysis of the H-Drone. The numerical simulations is performed to obtain the aerodynamic and propulsion characteristics, along with the structural design of H-Drone.

Frame configuration	Input parameters	FCU	Input parameters
	Total Weight: 4.2 kg Frame Size: 830 mm Altitude: 100 m Air Temperature: 25°C		Min. Battery Capacity 15% Takeoff Throttle 75% Tilt Limit 20° Attaches Current 0.5 A
Motor	T-MOTOR Antigravity 4006 KV380	Propellers	T-MOTOR 16*5.4CF
Esc	T-MOTOR AIR 40A	Battery	Li-Po, 6S, 11000 mAh Max. Const. C 35 C

Hovering Performance		**Max. Throttle Performance**	
Hovering Time	21.14 min.	Flight Time	8.8 min.
Throttle (in %)	66 %	Total Lift	71.2 N
ESC Current	6.51 A	ESC Current	16 A
Motor Speed	4018.4 rpm	Motor Speed	5284.7 rpm
Motor Power	94.3 W	Motor Power	214.5 W
Battery Voltage	24 V	Battery Voltage	23.7 V
Battery Current	26.5 A	Battery Current	64 A
Power Efficiency	58.6 %	Power Efficiency	55.3 %

Jay Khunt

Customer Requirements

- **Client**: Boeing
- The customer requirements are objectives that the client is looking for within the design of the project

LIGHTWEIGHT
OPTIMIZED THRUST TO WEIGHT RATIO
OPTIMIZED COMPONENT LOCATION
3D MATERIAL PROCESS
MANUFACTURED PROTOTYPE AIRFRAME
FLYING PROTOTYPE
LOW COST
MINIMAL HARDWARE

Engineering Requirements

- WEIGHT REDUCTION < 3LBS
- THRUST TO WEIGHT RATIO > 1.81
- LIDAR FIELD OF VIEW
- CAMERA FIELD OF VIEW
- CENTER OF GRAVITY
- MATERIAL STRESS ANALYSIS
- MATERIAL COST ANALYSIS
- TIME OF FLIGHT
- $5,000 Budget
- MINIMIZE HARDWARE PIECES

- QFD
  - Customer and Engineering Requirements are weighted to find the importance of each need
  - Given numerical values to objectives

#		WEIGHT REDUCTION < 3LBS	THRUST TO WEIGHT RATIO > 1.81	LIDAR FIELD OF VIEW	CAMERA FIELD OF VIEW	CENTER OF GRAVITY	MATERIAL STRESS ANALYSIS	MATERIAL COST ANALYSIS	TIME OF FLIGHT	LESS THAN $5,000
1	WEIGHT REDUCTION < 3LBS									
2	THRUST TO WEIGHT RATIO > 1.81	9								
3	LIDAR FIELD OF VIEW									
4	CAMERA FIELD OF VIEW			3						
5	CENTER OF GRAVITY	1	1	9	9					
6	MATERIAL STRESS ANALYSIS	3								
7	MATERIAL COST ANALYSIS	9	1				-9			
8	TIME OF FLIGHT	9	9			1		-3		
9	LESS THAN $5,000	3	-3				-9	9	-3	
10	MINIMIZE HARDWARE PIECES	3		1	1		-3			-1

Legend	
A	DJI PHANTOM 4 RTK DRONE
B	YUNEEC TYPHOON H PLUS
C	PARROT ANAFI USA DRONE

#	Customer Needs	Customer Weights	Technical Requirements: WEIGHT REDUCTION < 3LBS	THRUST TO WEIGHT RATIO > 1.81	LIDAR FIELD OF VIEW	CAMERA FIELD OF VIEW	CENTER OF GRAVITY	MATERIAL STRESS ANALYSIS	MATERIAL COST ANALYSIS	TIME OF FLIGHT	LESS THAN $5,000	MINIMIZE HARDWARE PIECES	Customer Opinion Survey: 1 *Poor*	2	3 *Acceptable*	4	5 *Excellent*
1	LIGHTWEIGHT	5	9	9			3	3	3	9	1	3		B		A	C
2	OPTIMIZED THRUST TO WEIGHT RATIO	4.5	9	9			1			9					B	AC	
3	OPTIMIZED COMPONENT LOCATION	3.5			9	9	9	1				3		C		AB	
4	3D MATERIAL PROCESS	4	9	9			9	9	9		9	3		B	A	C	
5	MANUFACTURED PROTOTYPE AIRFRAME	5	9	3	9	9	1	9	9	3	9		B		C	A	
6	FLYING PROTOTYPE	2	9	9	9	9				3	3				AC	B	
7	LOW COST	1.5	9					1	9		9	3	A	C	B		
8	MINIMAL HARDWARE	3	9				1	3	3		3	9	B			C	A
	Technical Requirement Units		LBS	N/A	DEGREES	DEGREES	INCHES	PSI	$	MINUTES	$$	#					
	Technical Requirement Targets		2.8	2	180	360	0	2000	150	30	1500	24					
	Absolute Technical Importance		225	154.5	94.5	94.5	95	110	118.5	106.5	114.5	69					
	Relative Technical Importance		1	2	7	7	7	5	3	6	4	10					

Dante Faria

Schedule

Week	Week Starts	Agenda	Individual Assignments	Team Assignments
1	29-Aug	Lecture: Introduction to Capstone	**Project Sign up**	
2	5-Sep	Staff/Team Meetings	**SW Review**	**Team Charter**
3*	14-Sep	Lecture: Presentation guidelines, Report guidelines, etc.		
4	21-Sep	**Presentation 1: CNs/ERs and Background**	**Peer Eval 1**	
5	28-Sep	Staff/Team Meetings		
6	5-Oct	Staff/Team Meetings	**Self Learning**	
7	12-Oct	**Presentation 2: Concept Gen and Eval**	**Peer Eval 2**	
8	19-Oct	Staff/Team Meetings		**Preliminary Report**
9	26-Oct	Staff/Team Meetings		**Website Check**
10	2-Nov	Lecture: Analytical Analysis Discussions		**Individual Analytical Memo**
11	9-Nov	**Presentation 3: Final Presentation**	**Peer Eval 3**	
12	16-Nov	Staff/Team Meetings		**Final Report**
13	23-Nov	Staff/Team Meetings		**Final CAD/BOM**
14*	30-Nov	Staff/Team Meetings	**Indiv. Analytical Report**	
15	7-Dec	**Prototype Demo**		**Final Prototype**
Finals	12-Dec		**Final Peer Eval**	**Website check**

- 9/26 @ 2pm – Tag-up to review Capstone Schedule and Help Needed
- 10/26 @ 2pm – Review Prelim Report, website, and Help needed in prep for Analytical Memo
- 11/7 @ 2pm – NAU share Preliminary Final Presentation and Final report with Boeing
- General – Familiarize ourselves with ANSYS

* Project is on time however we are still waiting on CAD files from Boeing

Thomas Schreiber

Budget

- Boeing has granted the team $5,000 to complete the task at hand
- We estimate that we will only use about $3,000 of the budget
- All required parts needed for manual flight will cost the team $581. If you include all parts of the design, it will cost $1,100.
- Only minimal hardware is needed to test the airframe on a manual flight.
- Printing Air Frame in NAU MakerLab will be around $340 to make with 1,300 grams of filament (3 lbs or lighter)

Components on Example Drone	Quantity
Hobbytown 40A ESC	4
Gemfan 9045 3-Blade Prop	4
Battery Charger	1
Battery Connector	1
Socokin 6S Lipo Battery	1
Slamtec RPLIDAR	1
iFlight XING 2814 880KV Motor	4
Arducam PTZ Camera	1
2-Axis Brushless Gimbal	1
Flysky FS-i6X 2.4GHz RC Trans/Receiver	1
NVIDIA Jetson Nano GPU	1

Color Coding Key
Required Component for Footprint on Design, cannot be altered (not required to purchase)
Required for Manual Flight, can be altered with similar component if unavailable

Colby Murphy

Thank You!

Questions?

References

1. Kardasz, P., Doskocz, J., Hejduk, M., Wiejkut, P., & Zarzycki, H. (2016). Drones and possibilities of their using. *J. Civ. Environ. Eng*, *6*(3), 1-7.

2. Dwarakanathan, D., Raja, S., Shanmugam, P., Shashank, D., Rohan, M., Selvam, C., ... & Saha, S.K. (2022, May). Aeromechanical Design and Analysis of H-Drone Configuration. In *2022 13th Asian Control Conference (ASCC)* (pp. 2223-2228). IEEE. https://ieeexplore.ieee.org/abstract/document/9828119