red hexacopter tail,

CPSLO NSBE 25-26
Technical Project #1

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Mission Objectives

1. Create an interdisciplinary technical project to engage members and develop engineering skills. (eg. iterative design, testing, and presenting).
2. Project must have potential to be built upon and continued in future years

1. Requirements

Requirements

ID	Requirement	Rationale
1	The Hexacopter shall have a thrust-to-weight ratio greater than 2:1 at maximum takeoff weight	Need at least 1:1 to hover. Because this hexacopter is not for high speed or high maneuver applications it does not have to be very high (eg. 3:1)
2	Must be able to carry multiple different payloads without permanent modification to air frame	Modular payload capability enables flexibility and reuse of the platform in the future
2.1	The hexacopter shall be able to support payloads up to 3.0 Kg	Gives ample headroom for a variety of potential payloads
2.2	All payloads shall include independent PSU's	Reduces complexity, compartmentalization further support modularity
3	The Hexacopter shall achieve a minimum nominal flight time of 30 minutes without payload	A 30-minute nominal flight endurance ensures meaningful operational in realistic mission conditions (climb, cruise, maneuvering, descent).
3.1	The minimum flight time requirement shall be met without discharging the battery beyond 80% depth of discharge	Limiting battery discharge preserves battery health and gives ample time for drone to return and land post mission

Requirements Cont.

ID	Requirement	Rationale
4	The Hexacopter shall support both manual and autonomous control, including waypoint navigation and autonomous return to home	Ability for both control methods provides flexibility for testing as well as safety in redundancy
5	The Hexacopter shall maintain safe operation following loss of a single propulsion unit	This requirement leverages the inherent redundancy of hexacopters
5.1	Shall sustain controlled flight in the case of a single motor failure	Validates parent requirement
5.2	Shall perform safe landing in the case of a single motor failure	Validates parent requirement
6	The Hexacopter shall support GPS-based navigation using an onboard receiver that provides positional accuracy of ±2 meters under nominal operating conditions.	GPS navigation enables the autonomous flight mode, tracking and mission repeatability, all necessary for qualification and good data

2. Hardware

Main Hardware

	Component	Rationale
Frame	TAROT FY690S	Affordable frame large enough to support our mission profile,
Motors	SunnySky V3508 700kv	Designed for long flight time while working at high efficiency. With max propeller size limited by the frame, these motors give us the necessary thrust for our mission profile.
Propellers	TAROT Carbon Fiber 1355	High quality, durable and able to withstand
ESC	Skywalker V2 ESC	Data sheet for the selected motors demand 40-amp speed controllers. Skywalkers are a known brand and reliable.
Flight Controller	Pixhawk 6C w/ PM07	Reasonable price and works with the Flight Control Firmware chosen, also provides versatility for future payloads
Battery	Zeee 4S Lipo 10000mAh 14.8V 120C	Most cost effective, weight efficient for our purposes. Using two to reach desired 30-minute flight time.
GPS	M9N GPS	Fast navigation updating, accurate positioning, built-in safety features, powerful antenna, low power consumption, light-weight.

3. Software

Software

	Software Components	Rationale
Flight Control Firmware	Ardupilot	- Selected for its reliable autonomous flight control, advanced GPS and sensor fusion, and is compatible with Pixhawk hardware. - Very versatile, supports a lot of different vehicle types, superior FC Firmware for agricultural drones
Control Interface	QGroundControl	- Works with Ardupilot, provides mission planning for autonomous flight, and flight map display. - Runs on macOS and Windows, compatible with Pixhawk hardware.

4. Compatibility and Verification

Online Drone Calculators

To verify that all selected components would function together and get predictions for key metrics such as flight time, T:W ratio, and payload capacity online drone calculators were used.

- Mass estimate from summing listed masses of all components: 3.0784 kg

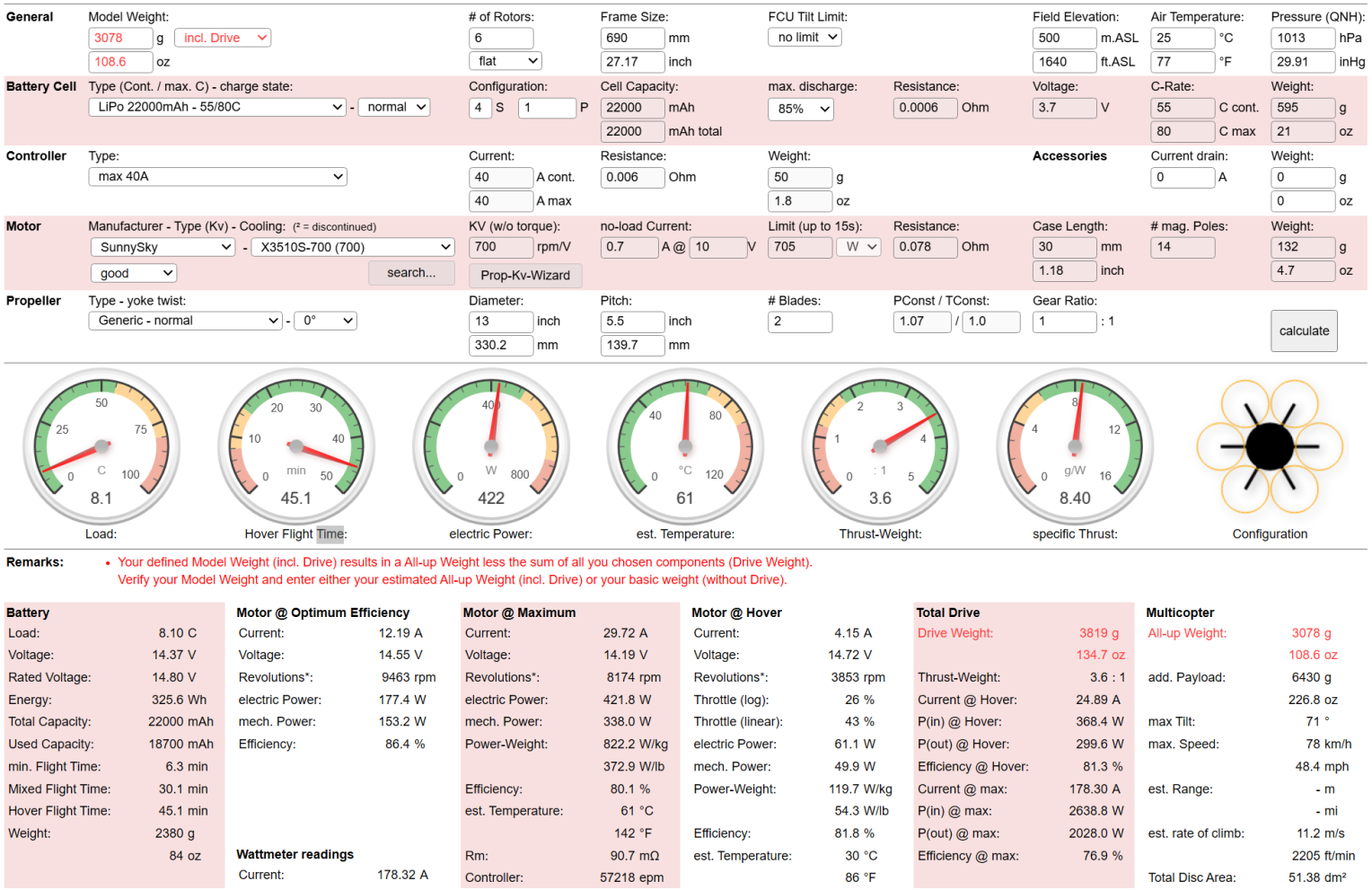
1. https://www.ecalc.ch/xcoptercalc.php
   - Restricted free trial: use analogous battery and motors
2. https://www.flyeval.com/

eCalc Results

Flight Time: 30min-45min

TWR: 3.6

Additional Payload: >5 kg



General	Model Weight:	# of Rotors:	Frame Size:	FCU Tilt Limit:		Field Elevation:	Air Temperature:	Pressure (QNH):
	3078 g incl. Drive	6	690 mm	no limit		500 m.ASL	25 °C	1013 hPa
	108.6 oz	flat	27.17 inch			1640 ft.ASL	77 °F	29.91 inHg
Battery Cell	Type (Cont. / max. C) - charge state:	Configuration:	Cell Capacity:	max. discharge:	Resistance:	Voltage:	C-Rate:	Weight:
	LiPo 22000mAh - 55/80C - normal	4 S 1 P	22000 mAh	85%	0.0006 Ohm	3.7 V	55 C cont.	595 g
			22000 mAh total				80 C max	21 oz
Controller	Type:	Current:	Resistance:	Weight:		**Accessories**	Current drain:	Weight:
	max 40A	40 A cont.	0.006 Ohm	50 g			0 A	0 g
		40 A max		1.8 oz				0 oz
Motor	Manufacturer - Type (Kv) - Cooling: (² = discontinued)	KV (w/o torque):	no-load Current:	Limit (up to 15s):	Resistance:	Case Length:	# mag. Poles:	Weight:
	SunnySky - X3510S-700 (700)	700 rpm/V	0.7 A @ 10 V	705 W	0.078 Ohm	30 mm	14	132 g
	good search...	Prop-Kv-Wizard				1.18 inch		4.7 oz
Propeller	Type - yoke twist:	Diameter:	Pitch:	# Blades:	PConst / TConst:	Gear Ratio:		
	Generic - normal - 0°	13 inch	5.5 inch	2	1.07 / 1.0	1 : 1		calculate
		330.2 mm	139.7 mm					

Load: 8.1 C

Hover Flight Time: 45.1 min

electric Power: 422 W

est. Temperature: 61 °C

Thrust-Weight: 3.6 : 1

specific Thrust: 8.40 g/W

Configuration

Remarks:

- Your defined Model Weight (incl. Drive) results in a All-up Weight less the sum of all you chosen components (Drive Weight). Verify your Model Weight and enter either your estimated All-up Weight (incl. Drive) or your basic weight (without Drive).

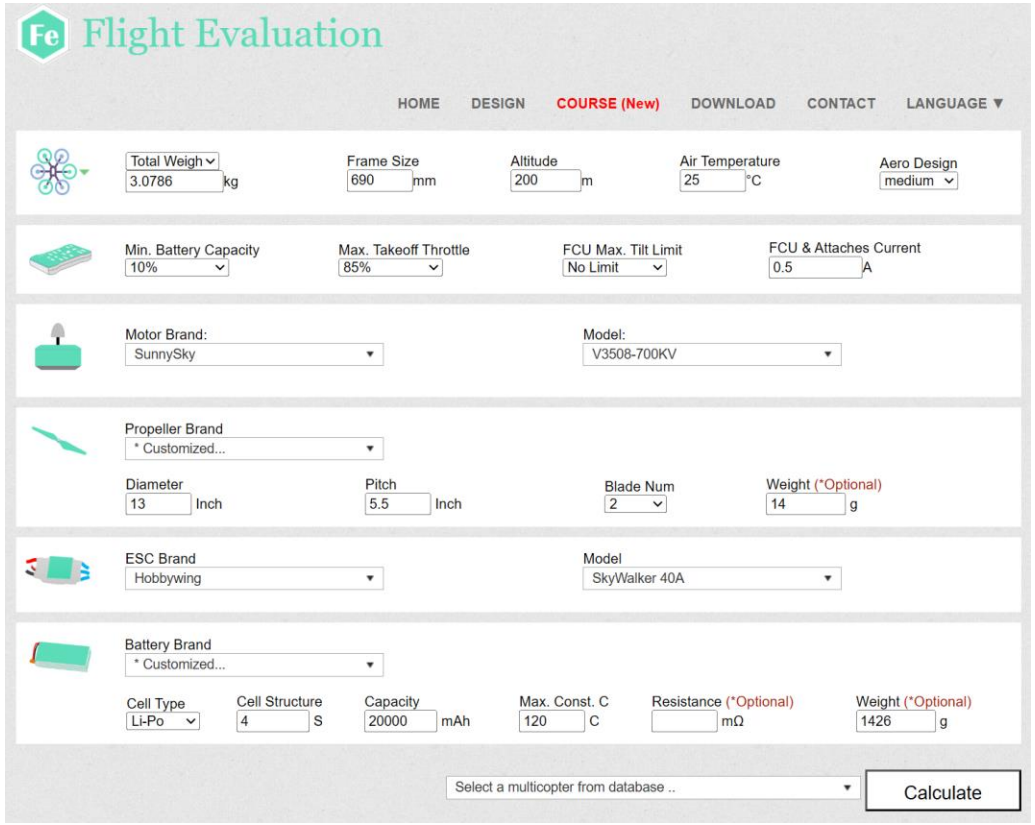
Battery		**Motor @ Optimum Efficiency**		**Motor @ Maximum**		**Motor @ Hover**		**Total Drive**		**Multicopter**	
Load:	8.10 C	Current:	12.19 A	Current:	29.72 A	Current:	4.15 A	Drive Weight:	3819 g	All-up Weight:	3078 g
Voltage:	14.37 V	Voltage:	14.55 V	Voltage:	14.19 V	Voltage:	14.72 V		134.7 oz		108.6 oz
Rated Voltage:	14.80 V	Revolutions*:	9463 rpm	Revolutions*:	8174 rpm	Revolutions*:	3853 rpm	Thrust-Weight:	3.6 : 1	add. Payload:	6430 g
Energy:	325.6 Wh	electric Power:	177.4 W	electric Power:	421.8 W	Throttle (log):	26 %	Current @ Hover:	24.89 A		226.8 oz
Total Capacity:	22000 mAh	mech. Power:	153.2 W	mech. Power:	338.0 W	Throttle (linear):	43 %	P(in) @ Hover:	368.4 W	max Tilt:	71 °
Used Capacity:	18700 mAh	Efficiency:	86.4 %	Power-Weight:	822.2 W/kg	electric Power:	61.1 W	P(out) @ Hover:	299.6 W	max. Speed:	78 km/h
min. Flight Time:	6.3 min				372.9 W/lb	mech. Power:	49.9 W	Efficiency @ Hover:	81.3 %		48.4 mph
Mixed Flight Time:	30.1 min			Efficiency:	80.1 %	Power-Weight:	119.7 W/kg	Current @ max:	178.30 A	est. Range:	- m
Hover Flight Time:	45.1 min			est. Temperature:	61 °C		54.3 W/lb	P(in) @ max:	2638.8 W		- mi
Weight:	2380 g				142 °F	Efficiency:	81.8 %	P(out) @ max:	2028.0 W	est. rate of climb:	11.2 m/s
	84 oz	**Wattmeter readings**		Rm:	90.7 mΩ	est. Temperature:	30 °C	Efficiency @ max:	76.9 %		2205 ft/min
		Current:	178.32 A	Controller:	57218 epm		86 °F			Total Disc Area:	51.38 dm²

Flyeval Results

Flight Time: 39 min

TWR: 3.2

Additional Payload: 4.73 kg



5. Test Plan

Test Plans

1. Fight Test upon Build Completion
   - Validates nominal endurance, battery discharge, manual/automatic control, waypoint navigation and return to home capability.
2. Flight Test with Dummy Payload – 3 kg of water
   - Proves payload capacity, take off weight, and T:W ratio
3. Simulated Motor Failure Flight Test
   - Validates controlled flight and landing under motor failure
4. GPS Navigation & Performance Test
   - Validates GPS system works and can provide data within accuracy requirements

Testing / V&V

ID	Verification Method	Verification Details
1	Analysis	
2	Demonstration	
2.1	Test	Flight test with dummy load of water
2.2	Inspection	
3	Test	Flight test without payload
3.1	Analysis	Use calculators to predict battery depletion
4	Test	Flight test upon build completion

Testing / V&V

ID	Verification Method	Verification Details
4	Test	Flight test upon build completion
5	Test	Flight test with simulated motor failure
5.1	Test	Flight test with simulated motor failure
5.2	Test	Flight test with simulated motor failure
6	Inspection	Simple test of gps and flight controler systems to determine if functional

6. Budget

Component	Price per	Quantity	Price Total	Link
SunnySky V3508 700kV	$42.99	6	$257.94	https://sunnyskyusa.com/products/sunnysky-v3508-motor?variant=45705642191
Pixhawk 6C with PM07	$184.99	1	$184.99	https://holybro.com/products/pixhawk-6c?variant=45417248391357
Skywalker V2 ESC	$20.00	6	$120.00	https://www.hobbywingdirect.com/products/skywalker-esc?variant=40777942007923
Tarot 1355 Propellers	$45.00	1	$45.00	https://www.amazon.com/TAROT-Carbon-Propeller-TL2829-Multicopter/dp/B0895TSC7R?th=1
TAROT FY690S	$170.86	1	$170.86	https://www.amazon.com/Tarot-Aircraft-Folding-Hexacopter-TL68C01/dp/B01D0ZDHUG
Zeee 4S Lipo Battery	$215.00	1	$215.00	https://zeeebattery.com/products/zeee-4s-lipo-battery-10000mah-14-8v-120c-ec5?variant=43954068947251&country=US&currency=USD
M9N GPS	$55.00	1	$55.00	https://holybro.com/products/m9n-gps
ec5 to xt60 Connectors	$8.99	1	$8.99	https://www.amazon.com/LINSYRC-2Pairs-Adapter-Connector-Battery/dp/B0CNGHYGM6/
Shrink Wrap	$13.99	1	$13.99	https://www.amazon.com/Eventronic-Heat-Shrink-Tubing-Kit-3/dp/B0BVVMCY86/
ToolkitRC Battery Charger	$65.99	1	$65.99	https://www.motionrc.com/products/toolkitrc-m6ac-300w-6-cell-6s-lipo-ac-dc-multifunction-battery-charger-tk13800
12 Guage Wire	$11.99	1	$11.99	https://www.amazon.com/Electrical-Durable-Flexible-Various-Applications/dp/B0D6VH4M42?th=1
Bullet Connectors	$6.99	1	$6.99	https://www.amazon.com/Connectors-Terminal-12-10AWG-Insulated-Connector/dp/B0CP55CLZH/
		Total:	$1156.74	

Next Steps

- Applications
- LiDAR
- Autonomous Flight
  - Potentially collision avoidance
- Flight License

- Build
- Test
- Profit