Buoyant Drone Weight Allocation

Subsections	Part	Number of units	Mass per unit est (g)	Weight Contribution est (g)	Subsection Weight est (g)	Mass per unit (g)	Weight Contribution (g)	Subsection Weight (g)/ percent of estimate
Electronics	Pic32	1	7	7		1	1	-6
	Raspberry Pi Compute Module 3+	1	9	9		9	9	0
	SODIMM	1				3	3	3
	RC receiver	1	13	13		16	16	3
	IMU sensor	1	2.5	2.5		1	1	-1.5
	Camera (camera + breakout + antenna)	1	90.7	90.7		24	24	-66.7
	Ultrasonic sensor	4	6	24		8	32	8
	Barometeric sensor	1	1.2	1.2		1	1	-0.2
	GPS sensor	1	8.5	8.5		4	4	-4.5
	GPS antenna	1				95	95	95
	Motor	4	30	120		44	176	56
	ESC	1	25	25		24	24	-1
	Battery 1	1	640	640		637	637	-3
	Servo	4	55	220		61	244	24
	5V step down voltage regulator	1				3	3	3
	Radio telemetry	1				14	14	14
	Radio telemetry antenna	1				10	10	10
	PCB	1				30	30	30
	Total				1160.9		1324	163.1
Drone Frame	Servo connectors	4	64.76	259.04	SLDW	31	124	-135.04
	Ultasonic mount	1	141.68	141.68	SLDW	53	53	-88.68
	Motor mount block	4	13.62	54.48	SLDW	6	24	-30.48
	feet	4	1.65	6.6		1.2	4.8	-1.8
	Gondola	1	394.06	394.06	SLDW	261	261	-133.06
	Propellers	4	9.7	38.8		10	40	1.2
	Aluminum sheet	1	32.3	32.3	SLDW	45.7	45.7	13.4
	Gondola Plate	1	52.65	52.65	SLDW	50	50	-2.65
	Servo plate	4	9.2	36.8	SLDW	10	40	3.2
	Ultasonic plate	1	50.29	50.29	SLDW	25	25	-25.29
	Total				1066.7		667.5	-399.2
Payload	MagAero	1	1000	1000			1000	0
	Total				1000		1000	0
Joining elements	Carbon Steel Dshaft(temp)	4	36.5	146	SLDW	37	148	2
	Servo Shaft Coupler	4	3	12		3	12	0
	Nuts	24	3.553	85.272	SLDW	3.1	74.4	-10.872
	Washer	24	0.59	14.16	SLDW	0.7	16.8	2.64
	Screws (3D parts)	28	5.82	162.96	SLDW	5.8	162.4	-0.56
	Ultrasonic SCreews	12	0.14	1.68	SLDW	0.14	1.68	0
	Standoff screws	4	0.5	2		0.5	2	0
	Standoffs	4	0.5	2		0.5	2	0
	Motor mount	4	3	12	SLDW	3	12	0
	Motor shaft propeller attachment	4				5	20	20
	Total				438.072		451.28	13.208
Lift bag	Bag itself	1	350	350		315	315	-35
	Envelope (est)	1	500	500		696	696	196
	Lift force	1	-4050	-4050			-4050	0
				0				
	Total				-3200		-3039	161
								Change from estimate
				est Effective "weight" g	465.672	actual effective"weight" g	403.78	-61.892
				est Effective weight N	4.5635856	actual Effective weight N	3.957044	

if you add items to the weight chart add above the bottom row of each section, so calculations update								
				Mass w/o Lift	4.515672kg			
				Weight w/o Lift	44.2535856N			

Version 5.2						State Based Current(mA)				Time in State(hrs/day)								
Name	Description	Quantity	Nominal Voltage(	Input V Regulation(VIH)	Output V Variation(VOH)	High Expected	High Measured	Low Expected	Low Measured	High	Low	Total Consumption/Cycle(mA*hrs)	Total Energy/Cycle (mW*hrs)	Power%	Datasheet link	Comments	Versioning	Power
LiPo Battery Charger	Charger	1	11.1	100-240V AC (From outlet)		.1-10A adjustable							100000 (when using AC input)		https://www.maxa	With current battery, should take 61 minutes to fully charge from 83% depleted while auto-balancing cell 100W charging power max	-Redid motor test and power with new ESC	Microcontroller, Microproccesor, and Oscillators
LIPO 11.1V 3S 11000mAh	Battery	1	11.1		9.6-12.6V							-9166.66	101750		https://www.maxa	83% of 11000mAh discharge for max current 40C discharge rating, 440A max discharge current 5C charge rating, 48.5A max charge current 3.2 per cell cutoff voltage(9.6V total) 4.2 per cell max voltage(12.6V total)	-Verified IMU, Altimeter, RC receiv GPS, and Microcontroler power	Sensors
uC32	Microcontroller	1	5	(VDD) 2.3-3.6V (Cannot go lower than 1.75V, unless it will lose RAM data) (I/O) 2.64-3.6V VIH 0-.66V VIL	2.4 - 3.6V VOH 0-.4V VOL	75.5	60	0	0	1	0	60	300	0.29%	https://drive.goog	60mA current tested running servo code	- Added column for tested and verified current for each part	Actuators
Raspberry Pi 3B+	Microprocessor (VBAT)	1	5	2.5-5.25V	N/A	1200	500	0	0	1	0	500	2500	2.46%	https://www.raspl	Using 5V 1.2A maximum current draw specifications datasheet		
AKK KC03	Camera/Transmitter	1	11.1	7-20V	Supplies 5V Vout for Camera	340	312	0	0	1	0	312	3463.2	3.40%	**https://www.am**	Supply current for transmitter too		
FS-iA6B Receive	RC Receiver	1	5	4-6.5V	N/A	20	34	0	0	1	0	34	170	0.17%	https://www.ama	Tested receiving 30mA current constant for receiving		
Serial Telemetry Transmitter	Data Transmitter	1	5	5V	N/A	100	100	0	0	1	0	100	500	0.49%	https://www.spar	100mA current needed for transmitting at 20dBm		
MPL3115A2	Pressure/Temperature Sensor	1	3.3	(VDD)1.95-3.6V (VDDIO)1.62-3.6V (I/O) 2.475-3.3V VIH 0-.99V VIL	2.97-3.3V VOH 0-.33V VOL	0.2	0.16	0	0	1	0	0.16	0.528	0.00%	https://drive.goog	Typical current needed during Acquisition/Conversio of data in high resolution mode		
HC-SR04	Ultrasonic	4	5	(VDD) 5V (Trigger)2-5V	2-5V	15	2	0	0	1	0	8	40.844	0.04%	https://drive.goog	Current needed for each 4 sensors running for whole cycle, added power for PWM usage by sensors to re data at 16hz (.844mW)		
MTK 3339	GPS Module	1	3.3	(VDD)3-4.3V (VDDBackup)2-4.3V (I/O) 2-3.3V VIH 0-.8V VIL	2.4-2.8V VOH 0-.4V VOL	25	25	20	20	0.01	0.99	20.05	66.1759	0.07%	https://drive.goog	25mA(Tested) Acquisition of GPS Signal takes 30s r 20mA supply current for Tracking, adds 1.09mW for continuous UART power usage		
ICM-20948	IMU 9DoF IC	1	3.3	(VDD)1.71-3.6V (VDDIO) 1.71-1.95V (I/O) 1.35-2.3V VIH 0-.54V VIL	1.62-1.8V VOH 0-.18V VOL	3	3	0	0	1	0	3	9.9	0.01%	https://drive.goog	Typical current during data acquisition in 9-axis mod		
MPRLS0001 PG00001C	Pressure sensor	1	3.3	(VDD)1.8-3.6V (I/O) 0-.66V VIL 2.64-3.3V VIH	0-.66V VOL 2.64-3.3V VOH	4	4	0	0	1	0	4	13.2	0.01%	https://sensing.h	Tested to receive 3mA max while on		
2600Kv	Motor	4	11.1	6.4-12.6V	N/A	4086	4086	1787	1787	1	0	16344	181418.4	178.30%	B08KRRWM7F?r	Depends on how much time drone is rising, 2x hove at full throttle, .125g of thrust per motor to hover Also took into account 85% motor efficiency(Brushle See motor Power section		
RC Sail Winch Servo	Servo	4	5	4.8-6V	N/A	350	350	3	1	0	1	12	60	0.06%	https://www.ebay	Depends on how much time drone is turning, Current ranges from 3-350mA, depending on how m the drone is turning		
			11.1			Total Difference	742.54					17397.21	188542.2479					
			Max Voltage									Total mAh	Total mWh					

Power Rails	Items	Voltage(V)	Average)ropout Voltage(V	Max Current(mA)	Max Regulated Current(mA)	Max at Dissipation(mW)ue to Regulators Time Dependent)	Max Heat Dissipation(mW)	Comments
Rail 1	3	11.1 Nominal (Ranges from 12.6-9.6V)	0	12906	N/A	661	661	Heat comes from 7.5ft wires to and from each motor 1.588 ohms per 1000 feet 14AWG at 4.342A max
Rail 2	1	5	6.1	1400	5000	11	1235	5V switching regulator for servos, 85% minimum efficiency
Rail 3	5	3.3	1.7	41	800	70	70	3.3V Regulator used on microcontroller
Rail 6	5	5	6.1	750	5000	662	662	Same 5V Switching Regulator used for every other 5V part 85% efficient
						1403		
						Maximum Total Power lost to Heat(mWh)		

Insert Flight Time Here(Hours)	1
Insert Percentage of time at high throttle here(0-1)	1
Insert Turning time percentage here(0-1)	0

Final Battery Calculation	Results	
Total Energy Needed(mWh)	189,945.53	
Battery 83% discharge limit(mWh)	101750	
Battery Condition	Out of Battery	
Power Used by Motors(mWh)	181,418	95.51%
Power Used by Servos(mWh)	60	0.03%
Power Used by Everything Else(mWh)	7064	3.72%
Power Lost to Heat Else(mWh)	1,403	0.74%

Name	Description	Designator	Quantity	Manufacturer	Supplier	Total mass[g]	Total Price [$]	CAD file	EagleCAD library	Shop link	Ordered	Recieved
LiPo Battery Charger	Charger	CHA	1	Hitec	MaxAmps	0	$119.99	☐	☐	https://www.maxamps.com/lipo-battery-charger-hitec-x2-ac-plus-black-edition-ac-	☑	☑
11.1V 3S 11000mAh LiPo battery	Battery	BAT1	1	MaxAmps	MaxAmps	640	$249.99	☑	☐	https://www.maxamps.com/lipo-11000-3s-11-1v-battery-pack	☑	☑
PRT 10474	XT60 connectors male/female pair		1		Digikey		$1.50	☐	☑	https://www.digikey.com/en/products/detail/PRT-10474/1568-1816-ND/8258064?i	☑	☑
AC0805JR-07680RL	680 ohm resistor SMD 0805		1		Digikey		$0.10	☐	☑	https://www.digikey.com/en/products/detail/AC0805JR-07680RL/YAG3800CT-ND	☑	☐
ERA-6APB471V	470 ohm resistor SMD 0805		1		Digikey		$0.70	☐	☑	https://www.digikey.com/en/products/detail/panasonic-electronic-components/ER/	☑	☐
RC0805FR-0710KL	10K ohm resistor SMD 0805		9		Digikey		$0.42	☐	☑	ey.com/en/products/detail/RC0805FR-0710KL/311-10.0KCRCT-ND/730482?item	☑	☐
C0805X103K5RAC7210	0.01uF capacitor SMD 0805		1		Digikey		$0.35	☐	☑	products/detail/C0805X103K5RAC7210/399-C0805X103K5RAC7210CT-ND/1356	☑	☐
LD053C104KAB2A	0.1uF capacitor SMD 0805		12		Digikey		$5.32	☐	☑	n/en/products/detail/LD053C104KAB2A/478-LD053C104KAB2ACT-ND/12153435	☑	☐
GRM21BC81C106ME15L	10uF capacitor SMD0805		8	Murata Electroni	Digikey		$2.00	☐	☑	https://www.digikey.com/en/products/detail/GRM21BC81C106ME15L/490-10499-	☑	☐
LD1117DT18CTR	1.8V Voltage Regulator		1	STMicroelectroni	Digikey		$0.60	☐	☑	https://www.digikey.com/en/products/detail/stmicroelectronics/LD1117DT18CTR/1	☑	☐
LD1117DT33CTR	3.3V Voltage Regulator		1	STMicroelectroni	Digikey		$0.51	☐	☑	https://www.digikey.com/en/products/detail/LD1117DT33CTR/497-1235-1-ND/586	☑	☐
LD1117DT50CTR	5.0V Voltage Regulator Linear		1	STMicroelectroni	Digikey		$0.54	☐	☑	https://www.digikey.com/en/products/detail/LD1117DT50TR/497-1238-1-ND/5862	☑	☐
D24V50F5	5.0V Voltage Regulator Switching		1	Pololu	Pololu	3	$16.95	☐	☐	https://www.pololu.com/product/2851	☑	☐
PIC32MX340F512H-80V	Microcontroller	M1	1	Microchip Technology	Digikey	2.3	$6.77	☐	☑	https://www.digikey.com/en/products/detail/PIC32MX340F512H-80V%2fPT/PIC32	☑	☐
FT232RQ-REEL	USB to UART FTDI IC		1		Newark		$4.95	☐	☑	https://www.newark.com/webapp/wcs/stores/servlet/EnhancedCheckoutConfirma	☑	☐
FT232RQ-REEL	USB to UART FTDI IC		1		Digikey		$4.60	☐	☑	https://www.digikey.com/en/products/detail/FT232RQ-REEL/768-1008-1-ND/1836	☑	☐
BCM2837B0	Raspberry Pi Compute Module M3+ 8GB (Microprocessor)	M2	1	Raspberry Pi	Digikey	9	$30.00	☑	☑	https://www.digikey.com/en/products/detail/CM3%2b%2f8GB/1690-1030-ND/986	☑	☐
DX07S016JA1R1500	USB-C header	J2	2	JAE Electronics	Mouser		$3.02	☑	☑	https://www.mouser.com/ProductDetail/JAE-Electronics/DX07S016JA1R1500?qs	☑	☐
MicroSD Socket	SD card socket for Raspberry Pi		1		Adafruit		$1.95	☐	☑	https://www.adafruit.com/product/1660	☑	☐
Sandisk 16GB Ultra MicroSD Card	MicroSD Card for Raspberry Pi	MSD	1	SanDisk	Amazon	9.92	$6.18	☐	☐	https://www.amazon.com/dp/B073K14CVB/	☑	☑
10033854-052FSLF	DDR2 SODIM slot (Raspberry Pi Compute Module)		1	Amphenol ICC	Digikey		$6.40	☑	☑	https://www.digikey.com/en/products/detail/amphenol-icc-fci/10033854-052FSLF/	☑	☐
CB3LV-3C-8M-000000 80MHz crystal o	80MHz crystal oscillator		1		Digikey		$1.35	☐	☑	https://www.digikey.com/en/products/detail/cts-frequency-controls/CB3LV-3C-8M	☑	☐
ASDK-32.768kHz-LRT	32.768kHz crystal oscillator (smaller footprint)		1		Digikey		$2.73	☐	☑	https://www.digikey.com/en/products/detail/abracon-llc/ASDK1-32.768KHZ-LRT/2	☑	☐
ASEK-32.768kHz-LRT	32.768kHz crystal oscillator (reference footprint)		1		Digikey		$1.33	☐	☑	https://www.digikey.com/en/products/detail/abracon-llc/ASEK-32-768KHZ-LRT/20	☑	☐
MPL3115A2	Pressure/Temperature Sensor IC	BAR	1	NXP USA	Mouser	1.9	$5.46	☑	☑	https://www.mouser.com/ProductDetail/841-MPL3115A2R1	☑	☐
MTK 3339	GPS Module	GPS	1	Mediatek	Adafruit	4	$29.95	☐	☑	https://www.adafruit.com/product/790	☑	☐
ANT-LTE-RPC-UFL	GPS Antenna	GPSANT	1	Adafruit	ChangHong		$14.95	☐	☑	https://www.adafruit.com/product/960	☑	☐
SMA to u.FL cable adapter	GPS u.FL to SMA adapter		1	Adafruit	Adafruit		$3.95	☐	☑	https://www.digikey.com/en/products/detail/adafruit-industries-llc/851/6051775?s=	☑	☐
HC-SR04	Ultrasonic	SON	3	Sparkfun	Sparkfun	25.5	$12.00	☑	☑	https://www.sparkfun.com/products/15569	☑	☐
ICM-20948	IMU 9DoF IC	IMU	1	TDK InvenSense	Digikey	13	$10.47	☐	☑	https://www.digikey.com/en/products/detail/tdk-invensense/ICM-20948/6623535	☑	☐
BSS138	Logic Level FET 1.8V to 3.3V vice versa for IMU & PIC32MX340F512H I2C communication wire		5	ON Semiconduct	Mouser		$2.00			https://www.mouser.com/ProductDetail/863-BSS138-G	☑	☐
MPRLS0001PG00001C	Pressure sensor IC	MPR	1	Honeywell	Digikey	1.1	$6.44	☐	☐	https://www.digikey.com/en/products/detail/honeywell-sensing-and-productivity-so	☑	☐
Flysky FS-i6X 6-10(Default 6)CH 2.4GH	RC transmitter and transceiver		1	Flysky	Amazon		$55.99			https://www.amazon.com/gp/product/B0744DPPL8/ref=as_li_tl?ie=UTF8&tag=rc-	☑	☐
Serial Telemetry Radio Kit - 915MHz, 10	Transmitter		1		Sparksfun		$39.99			https://www.sparkfun.com/products/15007	☑	☐
Racerstar RS20A BLheli_S 4-in-1 ESC	ESC/ Motor Telemetry	ESC	1	Racerstar	getfpv	25	$28.00	☐	☐	https://www.getfpv.com/racerstar-rs20a-blheli-s-4-in-1-esc.html	☑	☑
SK3 2822-1275kv	Motor	MOT	4	Turnigy	Hobbyking	120	$78.12	☑	☐	https://hobbyking.com/en_us/turnigy-aerodrive-sk3-2822-1275kv-brushless-outru	☑	☑
AKK KC03	**Camera and Transmitter**	**CAM+CAMTX**	**1**	**AKK**	**Amazon**	**67.76?**	**$27.99**	☐	☐	**https://www.amazon.com/AKK-Degree-800TVL-Switchable-Transmitter/dp/B**	☑	☑
FPV Receiver 5.8G 150CH OTG Receiver	Camera Receiver	CAMRX	1	SKYDROID	Amazon	50	$27.99	☐	☐	https://www.amazon.com/Receiver-Female-Plastic-Android-Monitor/dp/B07Q5MF	☑	☑
RC Sail Winch Servo 25T	Servo, 10.6kg / 0.9sec	SRVO	4	Corona	Ebay	60	$64.00	☐	☐	https://www.ebay.com/itm/254648162225?chn=ps&mkevt=1&mkcid=28	☑	☑
Master Airscrew 9 x 4.5 Multi Rotor Propeller Set White	Propeller	PROP	2	Master Airscrew	Hobbyking	19.4	$11.78	☐	☐	https://hobbyking.com/en_us/master-airscrew-9-x-4-5-multi-rotor-propeller-set-wh	☑	☐
1.0 oz HyperD	Fabric to be used for envolope	ENV	18	HyperD	Rip stop by the rol	500	$85.00	☐	☐	https://ripstopbytheroll.com/collections/ultralight-nylon-fabric/products/1-0-oz-hyp	☑	☑
Multipurpose 6061 Aluminum Sheet	Aluminum sheet	Al	1	McMaster-Carr	McMaster-Carr	32	$4.68	☑	☐	https://www.mcmaster.com/89015K116/	☑	☑
Passivated 18-8 Stainless Steel Pan Head Phillips Screw	Screew for envlope attachment	SCREW1	50	McMaster-Carr	McMaster-Carr	TBD	$11.90	☑	☐	https://www.mcmaster.com/91772A530/	☑	☑
Medium-Strength Steel Hex Nut	nut for envope attachment	NUT	100	McMaster-Carr	McMaster-Carr	TBD	$4.88	☑	☐	https://www.mcmaster.com/95462A029/	☑	☑
Steel Pan Head Phillips Screw	Ultrasonic screws	USCREW	25	McMaster-Carr	McMaster-Carr	TBD	$8.41	☑	☐	https://www.mcmaster.com/92005A006/	☑	☑
Steel Pan Head Phillips Screw	washers on inside of envelope of external part connections	WASH	30	McMaster-Carr	McMaster-Carr	TBD	$9.24	☑	☐	https://www.mcmaster.com/90131A101/	☑	☑
Carbon Fiber Filament - 1.75mm	3D Printer Filament	FIL	1	NylonX	Matterhackers	TBD	$58.00	☐	☐	https://www.matterhackers.com/store/l/nylonx-carbon-fiber-nylon-filament-1.75mm	☐	☐
8238 Weather Balloon	Helium Lift Bag	LFTB	1	Hwoyee	scientific sales	200	$35.00	☐	☐	https://www.scientificsales.com/8238-Weather-Balloon-350-Grams-Natural-p/823	☑	☑
60ft3 Al He Cylinder W/ CGA580 Valve	Helium	He	1	Varies	Praxair	N/A	$248.00	☐	☐	https://www.praxairusa.com/	☐	☐
OSH Park PCB	PCB printing	PCB	1	OSH Park	OSH Park	TBD	$260.10	☐	☐	https://oshpark.com/	☑	☐
Servo to Shaft Clamping Coupler 0.250-	Servo connector	CUPLR	4		ServoCity	12	$28.00	☑	☐	https://www.servocity.com/0-250-24-tooth-c1-spline-servo-to-shaft-clamping-coup	☑	☑
D-Profile Ends, 1045 Carbon Steel, 1/4"	D-Profile Rotary Shaft	SHAFT	4	McMaster-Carr	McMaster-Carr	120	$27.16	☑	☐	https://www.mcmaster.com/8632T132/	☑	☑
970120244	Votage Regulator Standoff	VR STAND	10		Digikey		$6.27	☑	☐	https://www.digikey.com/en/products/detail/w%C3%BCrth-elektronik/970120244/	☑	☐
MPMS 002 0005 PH	Voltage Regulator Screew	VR SCREW	100		Digikey		$7.47	☑	☐	https://www.digikey.com/en/products/detail/b-f-fastener-supply/MPMS-002-0005-	☑	☐
2057-440-AL-6	Hex Standoff	PCB STAND	4		Digikey		$3.04	☑	☐	://www.digikey.com/en/products/detail/raf-electronic-hardware/2057-440-AL-6/768	☑	☐
9900	Philips screw	PCB SCREW	4		Digikey		$0.44	☑	☐	https://www.digikey.com/en/products/detail/9900/36-9900-ND/317321?itemSeq=3	☑	☐
U.FL-R-SMT-1	Coaxial surface mount antenna plug	ANT1	1	Hirose Electric	Digikey		$1.19	☑	☐	https://www.digikey.com/en/products/detail/hirose-electric-co-ltd/U-FL-R-SMT-1-8	☑	☐
36 pin male header	0.1" break away male headers		1		Adafruit		$4.95	☐	☐	https://www.adafruit.com/product/392	☑	☐
BK-868	CR1220 3V button battery holder SMD		1		Digikey		$0.54			https://www.digikey.com/en/products/detail/BK-868/BK-868-ND/2242597?itemSe	☑	☐
						Total Price:	$1,691.60					

Power/Passive Components	
Controllers, Processors and Oscillators	
Actuators and Receivers/ Transmitters	
Sensors	
External Hadrware (Not Powered)	
Plug Accessories	

Version 5.3						State Based Current(mA)				Time in State(hrs/day)								
Name	Description	Quantity	Nominal Voltage(	Input V Regulation(VIH)	Output V Variation(VOH)	High Expected	High Measured	Low Expected	Low Measured	High	Low	Total Consumption/Cycle(mA*hrs)	Total Energy/Cycle (mW*hrs)	Power%	Datasheet link	Comments	Versioning	Power
LiPo Battery Charger	Charger	1	11.1	100-240V AC (From outlet)		.1-10A adjustable							100000 (when using AC input)		https://www.maxa	With current battery, should take 61 minutes to fully charge from 83% depleted while auto-balancing cell 100W charging power max	-Same as V5.2, but with the origina motors included instead of the replacements	Microcontroller, Microproccesor, and Oscillators
LIPO 11.1V 3S 11000mAh	Battery	1	11.1		9.6-12.6V							-9166.66	-101750	-28.10%	https://www.maxa	83% of 11000mAh discharge for max current 40C discharge rating, 440A max discharge current 5C charge rating, 48.5A max charge current 3.2 per cell cutoff voltage(9.6V total) 4.2 per cell max voltage(12.6V total)		Sensors
uC32	Microcontroller	1	5	(VDD) 2.3-3.6V (Cannot go lower than 1.75V, unless it will lose RAM data) (I/O) 2.64-3.6V VIH 0-.66V VIL	2.4 - 3.6V VOH 0-.4V VOL	75	60	0	0	1	0	60	300	0.08%	https://drive.goog	60mA current tested running servo code		Actuators
Raspberry Pi 3B+	Microprocessor (VBAT)	1	5	2.5-5.25V	N/A	1200	500	0	0	1	0	500	2500	0.69%	https://drive.goog	Using 5V 1.2A maximum current draw specifications datasheet		
AKK KC03	Camera/Transmitter	1	11.1	7-20V	Supplies 5V Vout for Camera	340	305	0	0	1	0	305	3385.5	0.93%	**https://www.am**	Supply current for transmitter too		
FS-iA6B Receive	RC Receiver	1	5	4-6.5V	N/A	20	34	0	0	1	0	34	170	0.05%	https://www.ama	Tested receiving 30mA current constant for receiving		
Serial Telemetry Transmitter	Data Transmitter	1	5	5V	N/A	100	100	0	0	1	0	100	500	0.14%	https://www.spar	100mA current needed for transmitting at 20dBm		
MPL3115A2	Pressure/Temperature Sensor	1	3.3	(VDD)1.95-3.6V (VDDIO)1.62-3.6V (I/O) 2.475-3.3V VIH 0-.99V VIL	2.97-3.3V VOH 0-.33V VOL	0.265	0.16	0	0	1	0	0.16	0.528	0.00%	https://drive.goog	Typical current needed during Acquisition/Conversio of data in high resolution mode		
HC-SR04	Ultrasonic	4	5	(VDD) 5V (Trigger)2-5V	2-5V	15	2	0	0	1	0	8	40.844	0.01%	https://drive.goog	Current needed for each 4 sensors running for whole cycle, added power for PWM usage by sensors to re data at 16hz (.844mW)		
MTK 3339	GPS Module	1	3.3	(VDD)3-4.3V (VDDBackup)2-4.3V (I/O) 2-3.3V VIH 0-.8V VIL	2.4-2.8V VOH 0-.4V VOL	25	25	20	22	0.01	0.99	22.03	72.7099	0.02%	https://drive.goog	25mA(Tested) Acquisition of GPS Signal takes 30s r 20mA supply current for Tracking, adds 1.09mW for continuous UART power usage		
ICM-20948	IMU 9DoF IC	1	3.3	(VDD)1.71-3.6V (VDDIO) 1.71-1.95V (I/O) 1.35-2.3V VIH 0-.54V VIL	1.62-1.8V VOH 0-.18V VOL	3	3	0	0	1	0	3	9.9	0.00%	https://drive.goog	Typical current during data acquisition in 9-axis mod		
MPRLS0001 PG00001C	Pressure sensor	1	3.3	(VDD)1.8-3.6V (I/O) 0-.66V VIL 2.64-3.3V VIH	0-.66V VOL 2.64-3.3V VOH	4	4	0	0	1	0	4	13.2	0.00%	https://sensing.h	Tested to receive 3mA max while on		
1275kV	Motor	4	11.1	6.4-12.6V	N/A	3900	7840	1900	6550	1	0	31360	348096	96.14%	runner-motor.htm	Depends on how much time drone is rising, 2x hove at full throttle, .125g of thrust per motor to hover Also took into account 85% motor efficiency(Brushle See motor Power section		
RC Sail Winch Servo	Servo	4	5	4.8-6V	N/A	350	350	3	1	1	0	1400	7000	1.93%	https://www.ebay	Depends on how much time drone is turning, Current ranges from 3-350mA, depending on how m the drone is turning		
			11.1			Total Difference	-3190.895					33796.19	362088.6819					
			Max Voltage				3044		1144			Total mAh	Total mWh					

Power Rails	Items	Voltage(V)	Average Dropout Voltage(V	Max Current(mA)	Max Regulated Current(mA)	Max at Dissipation(mW Due to Regulators (Time Dependent)	Max Heat Dissipation(mW)	Comments
Rail 1	3	11.1 Nominal (Ranges from 12.6-9.6V)	0	12906	N/A	471	471	Heat comes from 4ft wires to and from each motor 1.588 ohms per 1000 feet 14AWG at 3.044A max
Rail 2	1	5	6.1	1400	5000	1235	1235	5V switching regulator for servos, 85% minimum efficiency
Rail 3	5	3.3	1.7	41	800	70	70	3.3V Regulator used on microcontroller
Rail 6	5	5	6.1	750	5000	662	662	Same 5V Switching Regulator used for every other 5V part 85% efficient
						2438		
						Maximum Total Power lost to Heat(mWh)		

Insert Flight Time Here(Hours)	1
Insert Percentage of time at high throttle here(0-1)	1
Insert Turning time percentage here(0-1)	1

Final Battery Calculation	Results	
Total Energy Needed(mWh)	364,526.38	
Battery 83% discharge limit(mWh)	101750	
Battery Condition	Out of Battery	
Power Used by Motors(mWh)	348,096	95.49%
Power Used by Servos(mWh)	7,000	1.92%
Power Used by Everything Else(mWh)	6993	1.92%
Power Lost to Heat Else(mWh)	2,438	0.67%

System Technical Requirements V.5

Requirement Number	Hierarchy			Description		
	System	Subsystem	Component	Type	Requirement	Verification
1.0.0	Drone Flight Time			Performance	Shall fly for at least 30 minutes with magnetometer payload during normal autopilot flight. May fly for one hour as a reach goal.	Simulation - Test flights in simulations will model battery levels and estimate total obtainable flight time Physical Testing - The drone will be flown and have its flight time measured, as well as winds speeds and other factors.
1.1.0		Power Usage		Performance	Component power should be optimized in part selection, design, and usage	Design - Power budget will be created to assist in the design of the drone to select parts. Simulation - Current draw will be monitored in flight simulation to ensure power budget was accurate Physical Testing - Battery voltage will be monitored during flight to estimate power usage
1.1.1			Hardware	Functional	Shall consume power within the power budget 11.4kW	Simulation - Test power usage within simulator Physical Testing - Power draw measured using multimeter
1.1.2			Battery	Functional	Battery shall be capable of supplying all components listed in subsystem 1.1.1 for the amount of time listed in 1.0.0	Design - Power budget shall decide battery size Simulation - Battery levels will be monitored during simulated flights Physical Testing - The drone will have its flight time and battery levels measured
1.2.0		Drone Effective Weight		Functional	The drone shall have an effective weight of between 0 and 5 N. This requirement must be balanced with 1.1.0, since the effective weight will affect power usage.	Design - Use solidworks to determine mass of drone, and use offset of estimated bouyancy of lift bag at STP to determine effective weight Testing - Weigh the drone after full construction and inflation to determine effective weight
1.2.1			Drone Body	Functional	The weight of the drone body and components shall be less then 15 N. The payload weighs 9.8N. The estimated lifting force of the bag specified in 2.2.0 is 19.6N. Weight should be minimized to assist on requirement 1.1.0, since effective mass is not affected.	Design - Weight budget will be used to estimate the weight of the final drone Physical Testing - The drone body will be weighed on its own.
1.2.2			Lift Bag	Functional	The drone shall have a lift bag capable of counteracting drone mass, resulting in effective weight of < 5N. Currently specified at 4.07 cubic meter nominal volume, but might change based on requirements 1.1.0 and 2.1.0	Design - The drone mass and required lift force will be calculated and adjusted to meet requirements Physical Testing - Will test effective weight
1.3.0		Control System Optimization		Performace	System design may implement a throttle control in autopilot to remain in optimal efficiency range of motors where possible, but shall not conflict with 1.2.0	Design - See if this is a possible solution when motor choices and force analysis are finalized. Will use travel speed, not wind speed for optimization Simulation - Test flight to see if there is a worthwhile difference Physical Testing - Monitor throttle outputs during autopilot flight and battery voltage to estimate efficiency range of motors
2.0.0	Minimal Drone Speed			Performance	Drone shall be able to fly at least 5mph in winds up to 15mph	Design - All forces will be calculated, including drag, to estimate proper motor size Simulation - Flight Simulations will test flight speed under different conditions Physical Testing - The drone will use its GPS to measure the flight speed of the drone
3.0.0	RC Control			Performance	RC Control: Drone shall respond to user commands with pitch and roll angles within ±0.1 radians and a height of 1±0.15m.	Simulation - Flight simulation will model responses to user input Physical Testing - Motor angles will be tracked and used to confirm accuracy of RC response, and flight response in air will also be monitored
3.1.0		System Response		Performance	The drone shall respond to user input in < 0.5 seconds	Physical Testing - Time response time. Easiest test is from floating position to a hard acceleration.
3.1.1			RC Controller	Functional	A controller should be chosen that is capable of providing all neccesary commands (Foward, turn, ascend, descend and others if deemed necessary) as well as relaying information to the user as specified in requirement 3.2.0	Physical Testing - The drone responds to the user's inputs, including forward, turn, ascend, and descend
3.1.2			Software	Functional	The software shall be fast enough to respond quickly to all user commands and error handling.	Simulation - Software speed will be measured in simulation tests. Physical Testing - Responses will be measured for different situations in both normal flight and lab conditions (since we want to model a crash not actually crash)
3.1.3			Autonomous Functions	Functional/Performace	Some autonomous functions should be called while in the RC control state to assist the user, such as terrain tracking 4.2.0 and auto landing 4.5.0	Simulation - Responses in simulation will be tested, with simulated terrain, simulated landing and other needed functions Physical Testing - Using and switching between autonomous and RC FUNCTIONS will be tested for safety and reliability.
3.2.0		Data Feedback		Functional	The drone shall be able to send feedback to the user so the user can respond	Design - The software will be designed to send back drone data Physical Testing - Data will be monitored; this also assists with confirming other system requirements
3.2.1			Camera	Functional	The drone shall send camera feedback to assist in user controlled flight	Physical Testing - The camera feed will be monitored and any cutouts or issues will be recorded
3.2.2			Crash Detection	Functional	The drone shall alert the user if it is determined to have crashed	Simulation - Crashes will be simulated and output will be monitored Physical Testing - A crash will be simulated in a lab setting to test drone response
3.2.3			Low Battery	Functional	The drone shall alert the user when the battery runs low, and autoland specified in requirement 4.5.0 if critically low. Specific values to be determined.	Simulation - Voltage levels will be simulated and fed to the system and response of the simulation will be recorded Physical Testing - The drone will be flown until it has a low battery, then pushed until it autolands. Tested away from users in case of crash
3.3.0		Switch from Autonomous Control to RC		Performance	The drone should be able to switch from autonomous control to remote control but may need to move into a safe position first, and have preset settings, to prevent a crash. Component level will be determined as we find potential problems	Design - Can switch control modes from remote controller Physical Testing - The drone will be switched to RC control from autonomous in both safe and unsafe conditions to measure effectiveness Simulation - Switching between RC and autonomous in the simulation will be tested
3.4.0		Closed-Loop RC		Functional	The system should be able to maintain pitch and roll angles within 0.1 radians of zero and a height of 1+-0.15 m	
4.0.0	Autonomous Control			Performance/Environmental	Autonomous Control: Drone shall maintain stable pitch/roll/height and follow a path.	Design - A feedback control system will be used to ensure the drone succesfully flies on its own Simulation - Paths and environments will be generated to test autonomous responses Physical Testing - Plan a path and test the drones ability to follow it accurately using GPS data and monitor height with ultrasonics
4.1.0		Path Following		Performance/Environmental	The drone shall be able to follow a path specified by the user in up to 15mph wind with a positional accuracy of 5m	Simulation - Drone position will be kept track of in a simulated environment with wind Physical Testing - GPS data will be used to confirm drone position compared to the preplanned path.
4.1.1			GPS Sensor	Functional	The sensor shall be accurate to within 5m of its location with sampling of at least 3Hz	Design - Check sensor data sheet for rated values Physical Testing - Test GPS location data compared with actual sensor position

4.2.0		Terrain Tracking		Performance/Environmental	The drone shall maintain a constant height above the ground, approximately 1m, and adjust height as needed. < 15% overshoot	Simulation - A terrain will be generated and the drone's height will be monitored, as well as its altitude Physical Testing - The drone will be given a preplanned path over flat and rough terrain and its flight while ultrasonic data will be used to confirm actual height
4.2.1			Ultrasonic Sensors	Functional	The sensors shall be able to monitor area in front of the drone in order to maintain constant height of 1 m. Physical location and sensor sensitivity affects effectiveness	Simulation - The field of view and ability of the sensors to update the system in time will be simulated Physical Testing - The range of the sensors, distance, and angle will be confirmed and adjusted for
4.2.2			Barometric Sensor	Functional	The sensor shall be able to monitor altitudes above 4m for drone altitude awareness.	Physical Testing - Measurements in real-time will be confirmed and adjusted for
4.3.0		Error Handling		Performance/Environmental	The drone should be able to detect flight errors and compensate accordingly, specified in component section	Simulation - Errors will be simulated and responses recorded Physical Testing - Errors will be performed in a lab setting and responses will be recorded
4.3.1			IMU Sensor	Functional	The IMU should be able to detect crashes and abnormal situations and feed the data back into the system	Simulation - Sensor reading will be simulated and fed into error handling functions to test functionality Physical Test - The data will be tested in flight and in a laboratory setting to ensure proper system response
4.3.2			Error Detection	Functional	Follows same requirements as 3.2.2 and 3.2.3	Same tests as in 3.2.2 and 3.2.3
4.3.3			Popped balloon	Functional	The drone should be able to detect a popped balloon with a pressure sensor and by calculating the force needed to stay afloat. Will make emergency landing if popped	Simulation - The bouyancy of the drone will be quickly changed in a simulated flight and the drone response recorded Physical Test - The drone response will be tested with a sudden change in drone mass (attaching a weight) and pressure sensor manipulated to simulate deflation, and result will be recored. Test done in lab setting
4.4.0		Data Feedback		Functional	The drone shall send required data back to the user, as well as any errors specified in requirement 4.3.0	Simulation - Data will be fed to the simulator during simulated flights Physical Testing - Data will be tracked during flight and laboratory tests
4.5.0		Autolanding		Performance/Environmental	The drone should be able to safely land without damage to itself, the environment, or users.	Simulation - Simulated landing on several types of surfaces and wind conditions Physical Testing - The drone will be be autolanded throughout tests
4.6.0		Calculate New Path		Performance	If there is a system failure as specified in 4.3.0 that requires landing, the drone shall take the nearest path to a landing zone in <5s	Simulation - Partial system failure will be tested and the drone's ability to make it to a landing zone will be tested Physical Testing - TBD Need to plan safe way to test
4.7.0		Switch from RC to Autonomous Control		Performance	The drone should be able to switch from remote control to autonomous control but may need to move into a safe position first, and have preset settings to prevent a crash. Specifics will be determined as we find potential problems	Design - Can switch modes from remote controller Physical Testing - The drone will be switched to autonomous control from remote control in both safe and unsafe conditions to measure effectiveness Simulation - Switching between RC and autonomous in the simulation will be tested
4.8.0		State Estimation		Functional	The drone should be able to determine its pitch, yaw, roll, and NED states, as well as their derivatives to use in the autonomous functionality and error detection systems	Design- Returns pitch, yaw, row, and state of microprocessor. Physical Testing - Drone must stabalize itself after a while.
5.0.0	Cost			Functional	The drone shall cost less than $10,000. Reach-The drone may cost less than $6,000	Bill of materials will be recorded and manufactuing costs will be estimated
6.0.0	Magnetometer Interference			Performance	The magnetometer interference shall be less than 10 nT	Physical Testing - The magnetometer will record magnetic field with the drone on and off and the difference will be compared
6.1.0		Motor Generated Interference		Functional	The interference from the motors will be calculated and shall be less than requirement 6.0.0	Design -The magnetic contributions from motor locations will be added and summed together to estimate net interference
6.1.1			Outputted Interference	Functional	The interference should be calculated for each motor, and balanced with 6.1.2	Design - Magnetic Fields will be calculated for each motor Physical Testing - Will use a magnetometer to record actual magnetic fields with the motor on
6.1.2			Physical Location	Functional	The physical location of motors on the drone shall be decided with magnetic field outputs of motors in 6.1.1 in order to meet 6.0.0	Design - The positions will be calculated based off motor outputs in 6.1.1 Physical Testing - The total field will be measured at the point of the magnetometer
7.0.0	Drone Safety			Performance/Functional/Safety	The drone, its usage, and build should be safe to all individuals involved	Test for each factor will be designed, tests listed in subsystems
7.1.0		Collision Considerations		Performance	The drone should be designed to cause minimal damage to the user and environment in the event of a crash	Physical Testing - Since this is a safety test, we will need to find a safe way to test this. Specific test TBD
7.1.1			Body Design	Functional/Safety	The body of the drone should have no protruding or sharp componets that can hurt the user	Physical Testing - Since this is a safety test, we will need to find a safe way to test this. Specific test TBD
7.1.2			Propellers	Functional/Safety	The propellers should be safe if the user comes in close contact. May be enforced with propeller guards, propeller material, and other methods that will be determined.	Physical Testing - Since this is a safety test, we will need to find a safe way to test this. Specific test TBD
7.2.0		Electrical Safeguards		Functional/Safety	The drone should have features to protect the drone and user from electrical malfunctions	Physical Testing - Since this is a safety test, we will need to find a safe way to test this. Specific test TBD
7.2.1			Protected Electronics	Functional/Safety	The electronics and wires should be protected and securely mounted to prevent shorts, dropping components, etc	Physical Testing - Since this is a safety test, we will need to find a safe way to test this. Specific test TBD
7.2.2			(Fuses, Other safeguards?)	Functional/Safety	Some electrical components may be implemented to protect electronics	Physical Testing - Since this is a safety test, we will need to find a safe way to test this. Specific test TBD
7.3.0		Helium		Safety	A method of handling shall be adopted or developed by the team to ensure the helium and helium tank are handled safely.	A procedure will be written up in team documentation and followed by all people handling helium
8.0.0	Helium Leakage			Environmental/Functional	The lift bag shall maintain 90% of its buoyancy over a one week period	The drone will be weighed on a scale, then weighed again a week later. Helium loss will be calculated at the end of the week.
8.1.0		Detect Helium Leakage		Enviromental/Functional	Pressure sensor shall send out an error message when pressure sensor is decreasing during flight	Physical Testing - Will test a slowly leaking balloon with the pressure sensor mounted. Can be tested with normal air
8.1.1			Pressure Sensor	Environmental/Functional	Sensor should detect volume drop of helium balloon	In software, check if error message is being received
9.0.0	Leagal Compliance			Legal/Functional	The drone and team shall abide by all applicable laws for drone flight.	

9.1.0		FAA Compliance		Legal/Functional	The drone and team shall abide by all applicable laws for drone flight	Get confirmation from someone who knows drone laws (TBD) so we abide by all rules
9.1.1			Follow FAA part 107 (flying small drones < 30kg)	Legal/Functional	Drone shall be less than 30kg when in flight outdoors.	Get confirmation from someone who knows drone laws (TBD) so we abide by all rules
9.1.2			Statutory provision (PL 115-254, Section 350)	Legal/Functional	Drone shall follow PL 115-254, Section 350. 'Use of Unmanned Aircraft Systems at Institutions of Higher Education.'	Get confirmation from someone who knows drone laws (TBD) so we abide by all rules
9.1.3			Registered Drone with FAA	Legal/Functional	We shall create an FAADroneZone account with email and password and register the drone through the account.	Receive Registration confirmation
10.0.0	Noise Level			Performance	The drone should be quieter than 65dB	Physical Testing - Measure noise level of drone from 5 ft away
11.0.0	Manufacturability			Functional	The drone should be able to be manufactured with equipment within our access, further decomposed in subsystem requirements	Can be manufactured
11.1.0		3D Printing		Functional	All 3d printed components should fit within dimensions of the Lulbot Taz4 or Lulzbot Mini printer beds	Can be printed
11.2.0		Soldering		Functional	All components must be able to be soldered with Soldering Iron and team member skill level	
11.3.0		Envelope		Funtional	The envelope must be able to be cut with standard scissors and sewed with sewing machine Dylan owns, for dimensions to be within 5% of design when inflated.	
11.4.0		PCB		Functional	The PCB design must fit within manufacturing manufacturing abilities of OSHAPark	

*All edits within a section, add at the bottom of that section, since interpendencies refer to specific numbers. If a new system requirements, add to the bottom of list

1/13/2021	V.1	Created
1/28/2020	V.2	Cleaned up shall statements to make requirements more clear. Finalized for submission.
2/4/2021	V.3	Completed reformatted and new requirements added, and broken down. In part due to new things we have learned and to better align with instructor requirements in the request for a resubmission. Due to scale of changes, the original file is in original tab for records
2/8/2021	V.4	Updated shall should and may statements to make more concrete and finalize for submission. 30min Flight time shall, and 60 moved to may, but it is highly preferable.
6/7/2021	V.5	Updated techincail requirmets to their final state, some where move around, and varification methods