Automatic Flying Security Drone

Group 17

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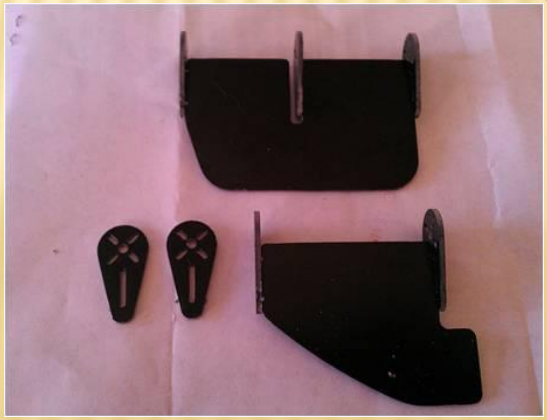
Overview

- The Automatic Flying Security Drone (AFSD) is an alternative, low-cost solution for secure monitoring of a large open area.
- The AFSD is an attempt to combine the benefits of stationary security cameras and patrol routes while limiting the drawbacks of each.
- Ideally, only one member of security personnel would be required to use the AFSD system.

Frame

- 12 inches in diameter
- Circular in shape
- Weighs 230 grams
- Made out of PVC Foam Board
- Precut slots for control surfaces and rods to be mounted.
- 4 upper control surfaces and 4 lower control surfaces.
- Interior mounting frame for electrical components, motor, etc.



TMS320F28035 Microcontroller

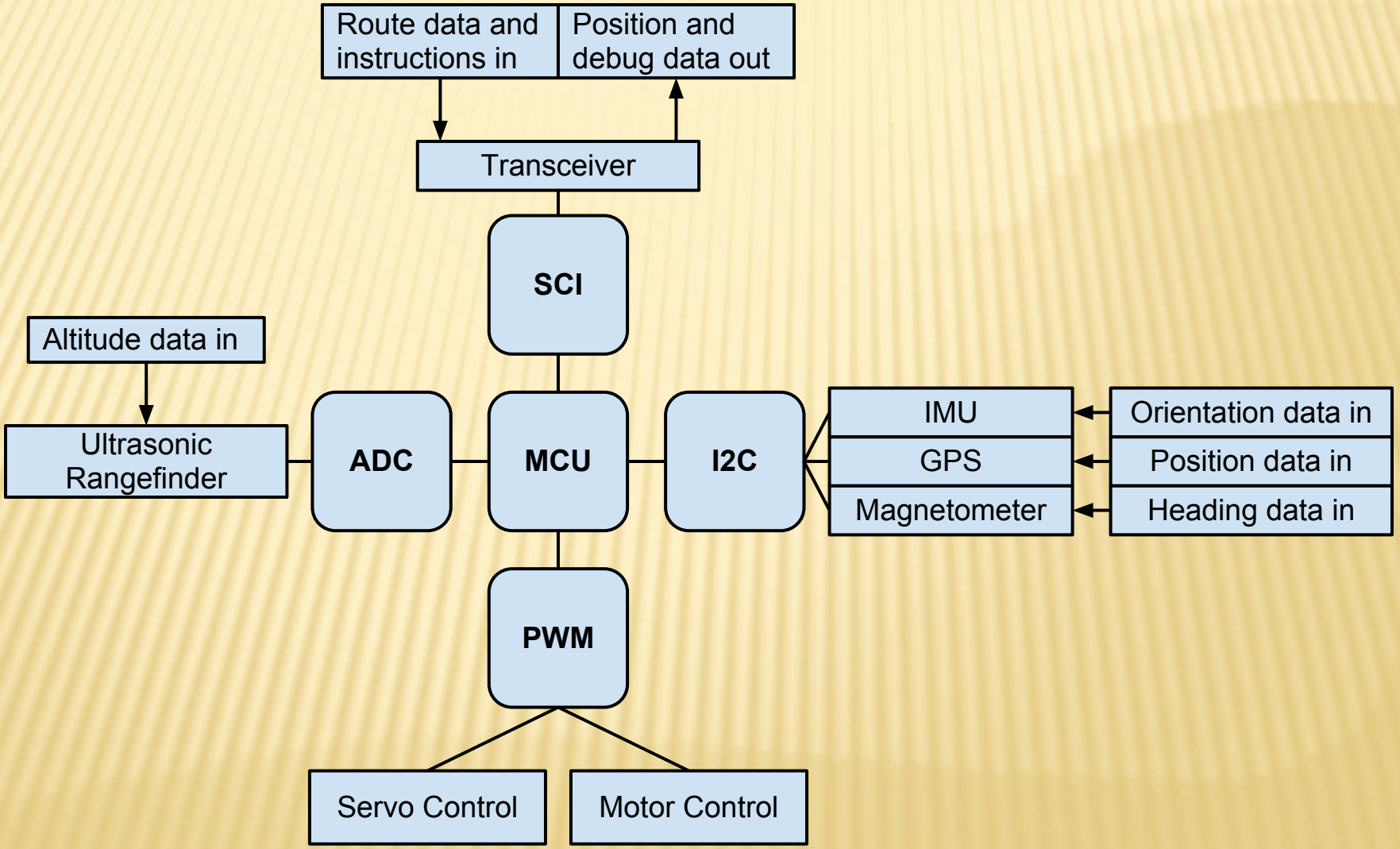
- Controls all flight logic
- Contains routines for take-off, mid-flight, and landing
- Stores the flight data in RAM
- Keeps the vehicle stable and on-course

60 MHz clock speed
32-bit architecture
128 kB of flash memory
6 PWM Channels
I2C, SCI, ADC interfaces

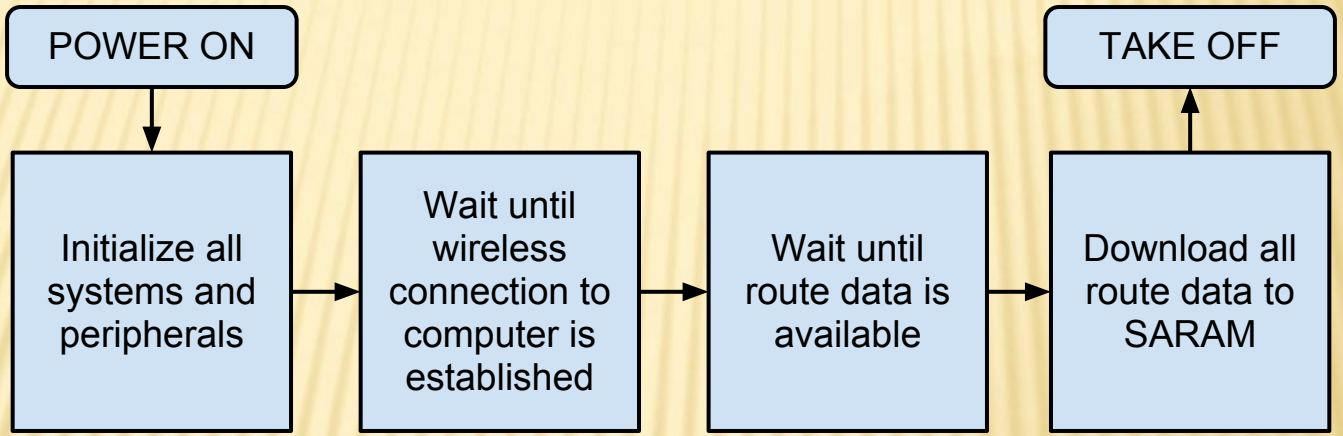
MCU Selection

- Decisions:
  - Texas Instruments for familiarity
  - C2000 for development kits
  - Piccolo family for flexibility in decision
  - 28035 because it was the best of the family that most suited our application
    - most flash storage
    - most RAM
    - no nominal drawbacks for capitalizing on better hardware

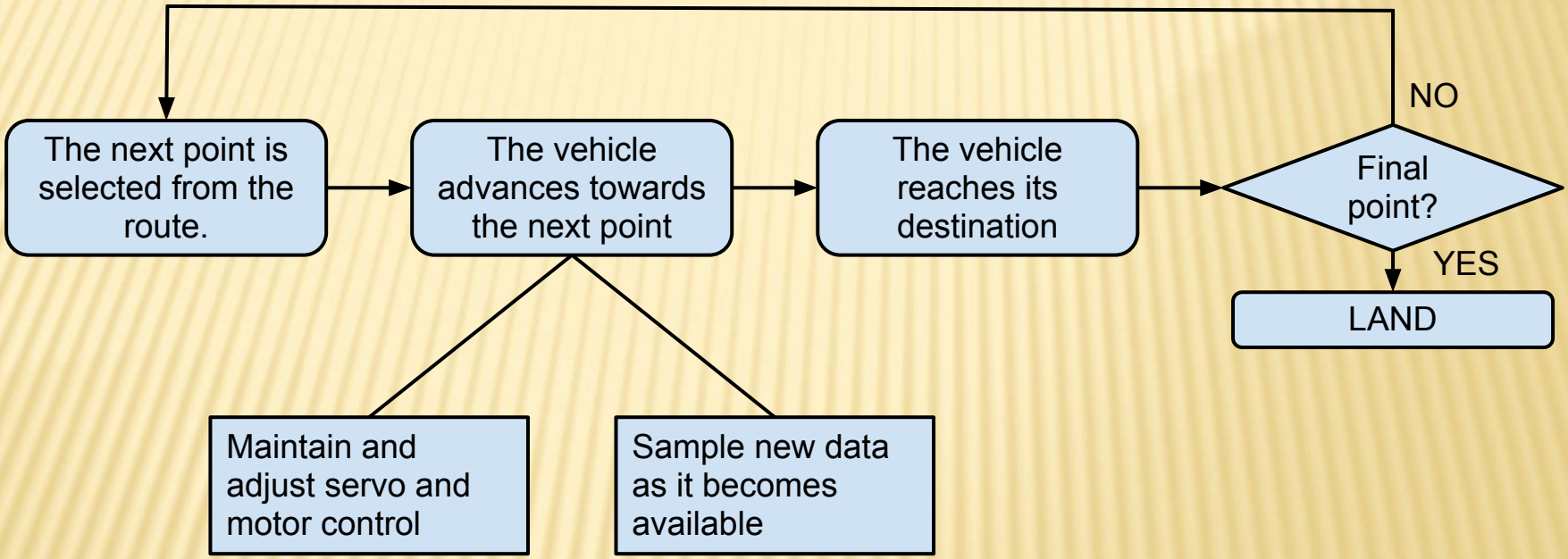
MCU I/O Diagram



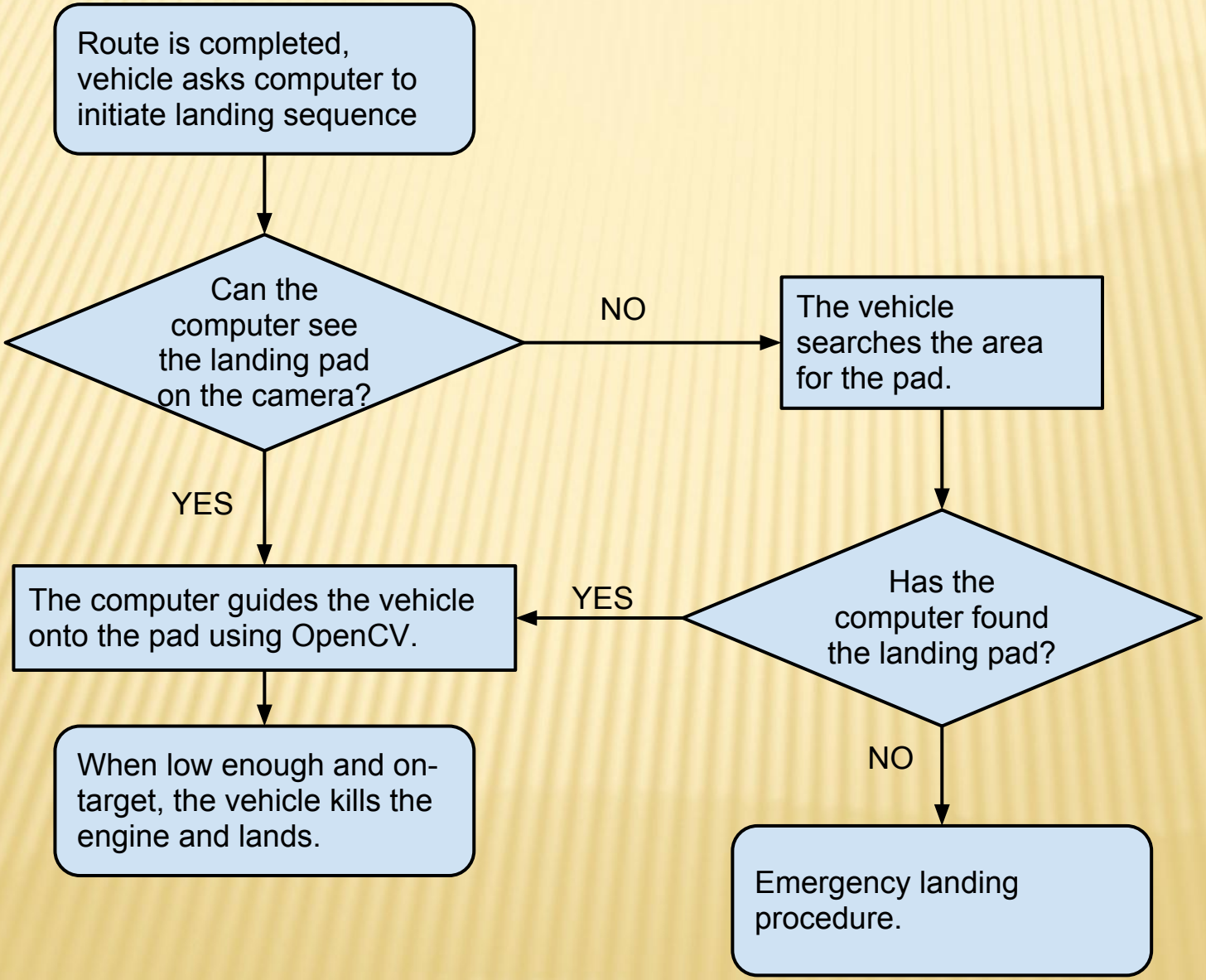
Navigation: Initialization and Takeoff



Navigation: Main Flight Loop



Navigation: Landing



Servos

- Futaba S3117 used to rotate all control surfaces
  - Weight: 6g
  - Torque: 23.6 oz-in
- Controlled by a 50 Hz repeating pulse that is generated by the MCU's PWM peripheral
- By adjusting the duty cycle of the pulse wave, the angle of the servo can be adjusted in a range of 180 degrees.

Motor

- Park 400 Outrunner Motor
- Controlled by a specialized motor controller which is in turn controlled by a pulse wave from the MCU's PWM.

Weight	56 g
RPM/Volt	920 RPM/V
Diameter	1.1 inch
Length	1.15 inch
Idle Current	.7 A
Continuous Current	10 A
Max Burst Current	13 A
Internal Resistance	0.1 ohm
Voltage	7.2-12 V

IMU

IMU	AdruIMU V3	ADXL345 & IMU3000
Price	$49.99	$59.99
Accelerometer Range	+/-2g, 4g, 8g, 16g	+/-2g, 4g, 8g, 16g
Gyroscope Range	±250, 500, 1000, 2000°/s	±250, 500, 1000, 2000°/s
Interface	Serial	I2C
Accelerometer Axes	3	3
Gyroscope Axes	3	3
Power	6-12 VDC	2.1-3.6V DC
Magnetometer	No	No
Self-Test	Yes	No

MAGNETOMETER

- Triple Axis Magnetometer Breakout
- MAG3110

Voltage	1.95-3.6 V
Range	±1000 microT
Sensitivity	0.1 microT
Output Data Rate	80 Hz
Interface	I2C
Number of Axis	3-axis

GPS

GPS Module	MediaTek MT3329	Fastrax UP430	Parallax RXM-SG
Price	$37.99	$32.35	$39.99
Antenna	Built-in Patch	Built-in Patch	External
Position Accuracy	< 3 m	2.5 m	5 m
Interface	Serial (SPI)	I2C	I2C
Tracking Sensitivity	-148 dBm	-163 dBm	-148 dBm
Update Rate	up to 10 Hz	up to 5 Hz	1 Hz
Baud Rate	9600 bps	4800 bps	9600 bps
Power Supply	3.3V-5V	1.8 V	3.3V-5V
Power Consumption	48 mA@5V	90 mA @ 1.8V	50 mA@5V
Size	38x38x7.8 mm	22x22x8 mm	1.7x1.6x0.6 in

- For better signal a ANN-MS active antenna will be used.

Wireless

Functional Requirement:

- 1 mile range
- transmit GPS
- video
- UAV commands
- outdoor operation

Free space loss = C + 20*log(D)+20*log(F)

Wireless - FCC

- ISM restriction
- minimizing frequency and maximizing bandwidth
- free space loss = -110 dBm

ILLEGAL :
US 30dBm = 1 W

transmit power > 16 dBm

Frequency range		Bandwidth	Center frequency	Availability
6.765 MHz	6.795 MHz	30 kHz	6.780 MHz	Subject to local acceptance
13.553 MHz	13.567 MHz	14 kHz	13.560 MHz	
26.957 MHz	27.283 MHz	326 kHz	27.120 MHz	
40.660 MHz	40.700 MHz	40 kHz	40.680 MHz	
433.050 MHz	434.790 MHz	1.84 MHz	433.920 MHz	Region 1 only and subject to local acceptance
902.000 MHz	928.000 MHz	26 MHz	915.000 MHz	Region 2 only
2.400 GHz	2.500 GHz	100 MHz	2.450 GHz	
5.725 GHz	5.875 GHz	150 MHz	5.800 GHz	
24.000 GHz	24.250 GHz	250 MHz	24.125 GHz	
61.000 GHz	61.500 GHz	500 MHz	61.250 GHz	Subject to local acceptance
122.000 GHz	123.000 GHz	1 GHz	122.500 GHz	Subject to local acceptance
244.000 GHz	246.000 GHz	2 GHz	245.000 GHz	Subject to local acceptance

transmit power - free space loss - misc loss > receiver sensitivity

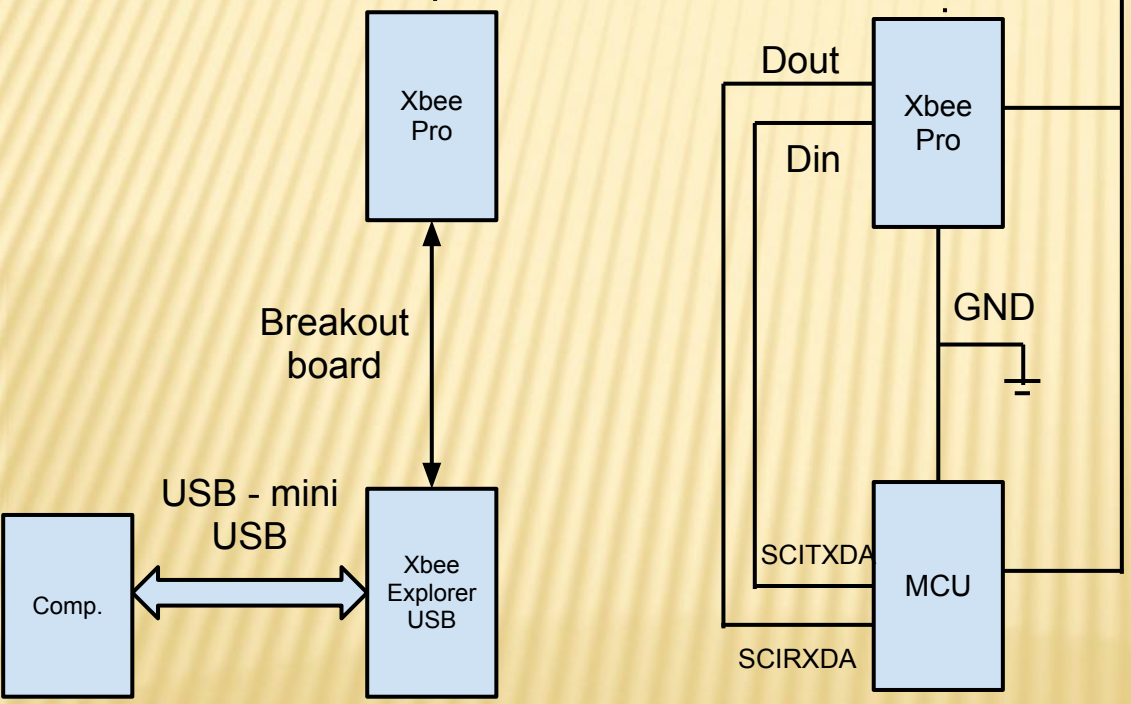
Networking , PHY & MAC layers

- PHY&MAC - IEEE 802.15.4
  - 902-928 MHz
  - lightweight overhead - max 46 bytes
  - WPAN architecture
- Networking - Zigbee or 6LoWPAN
  - uses 802.15.4 stack
  - popularity
  - non-commercial use

Wireless - XBee Pro

915MHz 802.15.4
full duplex

max: 250kbps - 1 mile range



Operation Voltage	3.3V
Average current	215mA
Transmission Power	60mW output (+18dBm)
Range	1 mile (1500m) range
Antenna	Built-in antenna Fully FCC certified
ADC input pins	6 (10-bit)
digital IO pins	8
Encryption	128-bit
Configuration	Local or over-air
command set	AT or API
Max data rate	250kbps

Camera - Determining Factors

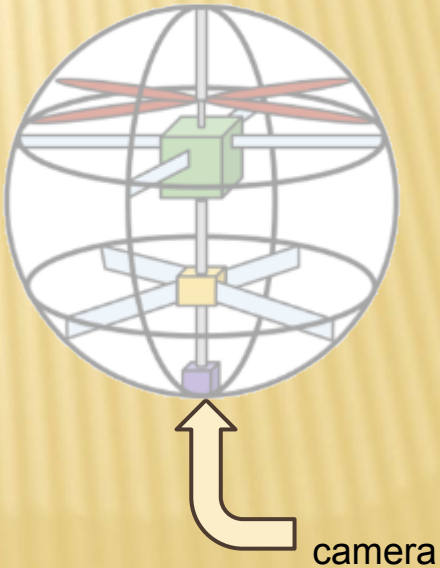
Sensor type: CCD vs CMOS

Color Encoding: PAL vs NTSC

Image Scanning techniques: Progressive vs interlaced

Bandwidth:

$$352 * 240 * \underset{\text{color depth(bits)}}{8} * \underset{\text{RGB}}{3} * \underset{\text{FPS}}{10} \approx 2 \text{ Mbps}$$



Camera + Receiver

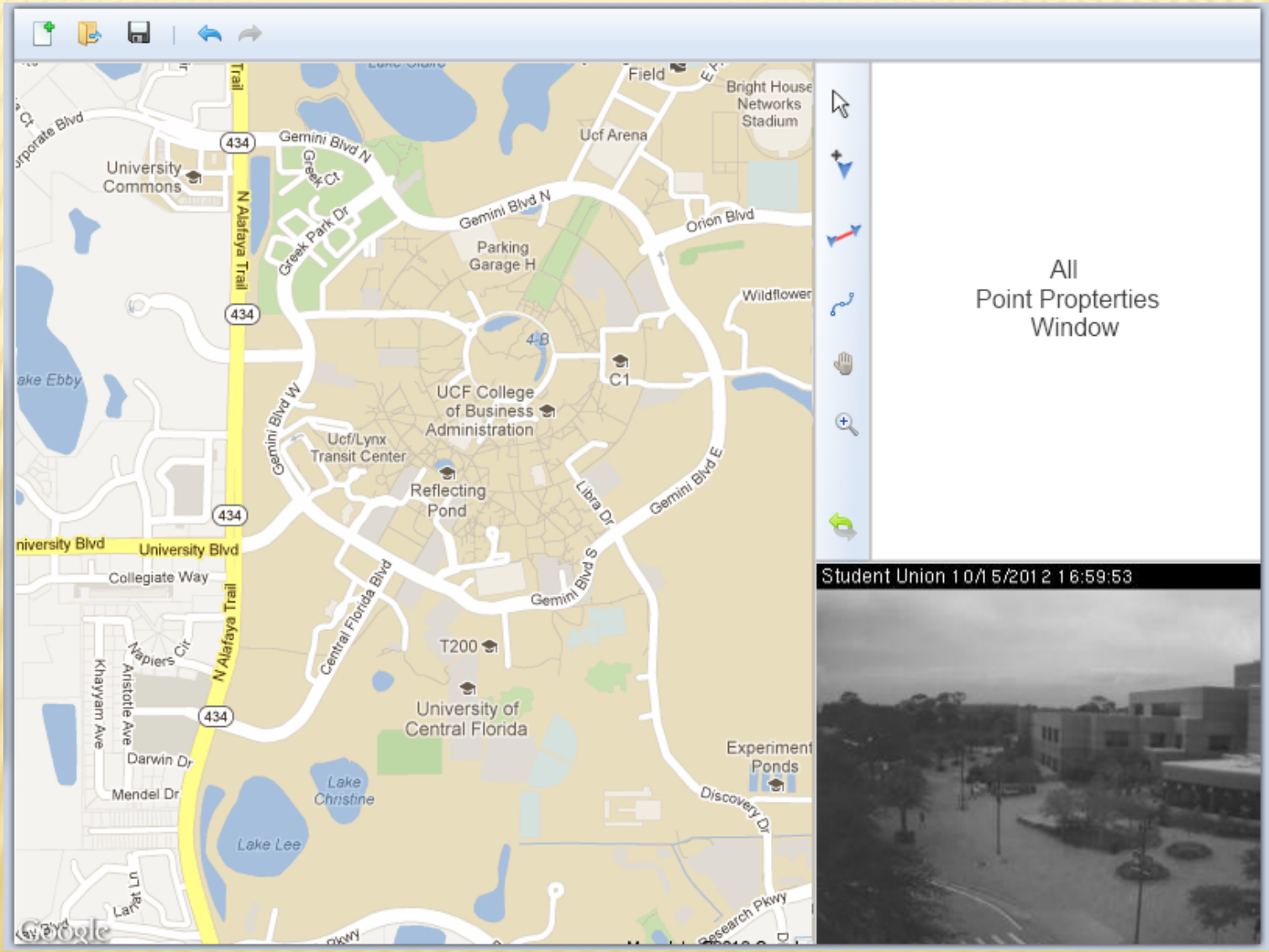
C-203A	
Imaging Sensor	1/3 inch CMOS
Total Pixels	510x492(NTSC)
View Angle	62 degree
Minimum Illumination	1.5 Lux
Transmission Power	10 mW
Modulation Type	FM
Bandwidth	18MHz
Power Supply	built-in Li battery
Effective Range	100m
Dimensions	23x25x20 (mm)

	KY-2.4GR01	USB
Receiving Sensitivity	-85dBm	- 80dBm
Bandwidth	18MHz	2.4GHZ
Power Supply	12V 500mA	5V

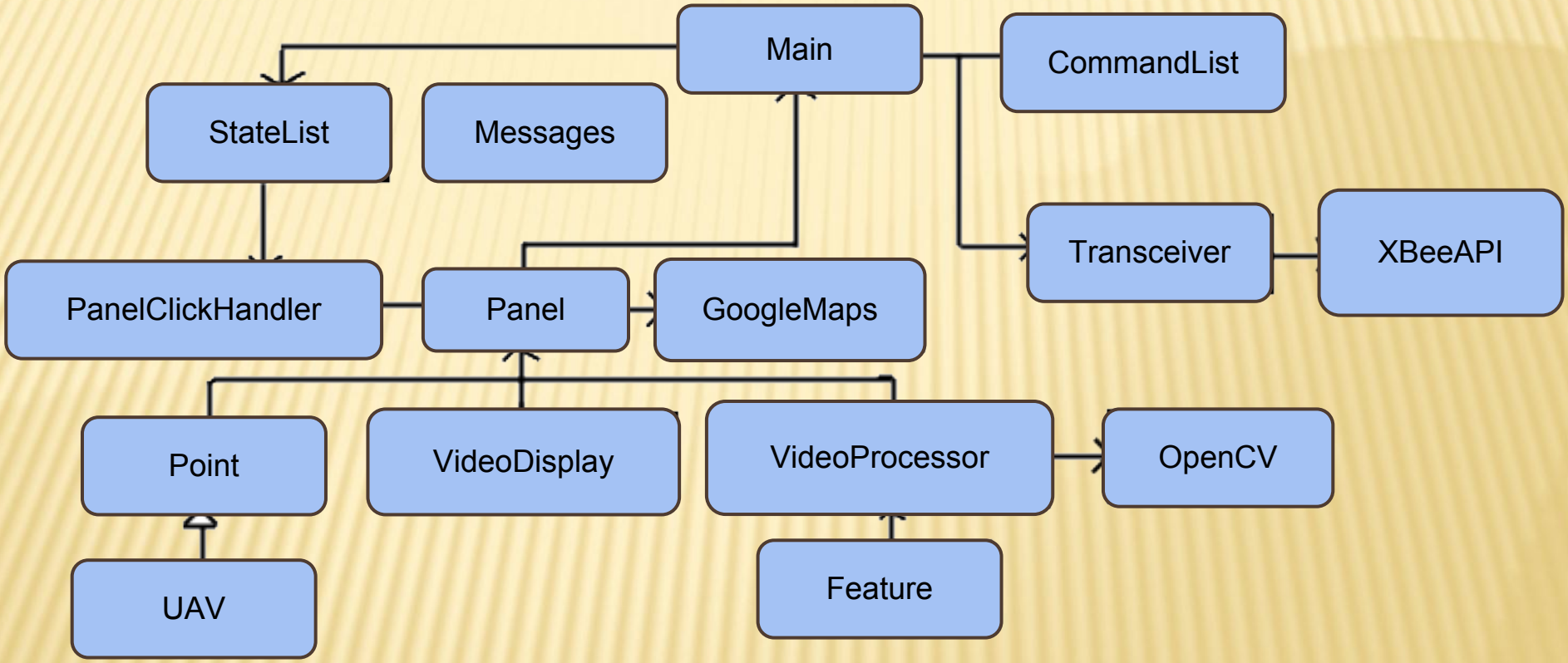
Application

- Functional Requirements:
  - Interfaces with a map resource
  - plots and stores flight routes
  - conveys flight routes via transmitter
  - displays video feed
- Non-Functional Requirements:
  - Intuitive interface
  - seamless video integration to interface

Application



Application Overview



Power

On Board Component	Quantity	Current (A)	Voltage (V)	Power Consumption (W)
Camera & Transmitter	1	Separate Battery	Separate Battery	Separate Battery
GPS	1	0.09	1.8	0.162
MCU	1	1µ	3.3	3.3µ
Servos	8	0.1	6	0.6
IMU	1	0.1	3.3	0.33
Magnetometer	1	.01	3.3	.033
Propeller Motor	1	7	11.1	77.7
Transceivers	1	0.22	3.3	0.726
Total Power Consumption		~7.22 Amps		79.55 Watts

VEHICLE BATTERY POWER

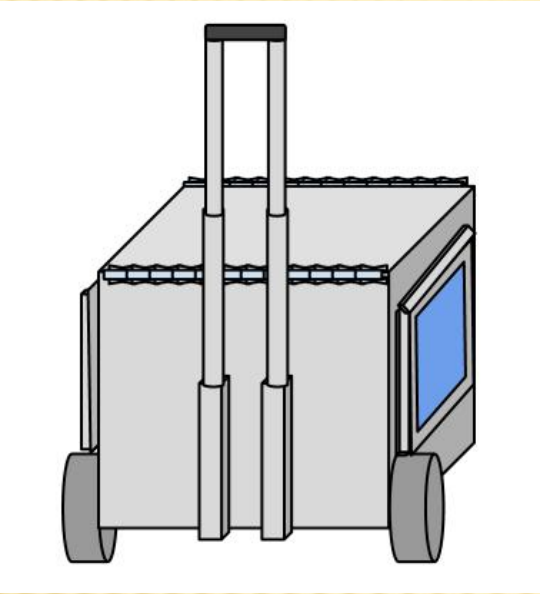
Battery Capacitance (AH) = Total Current Draw (A) * Desired Flight Time (min))
Battery Capacitance (AH) = ~7 (A) * 10 (min) / 60 (min)
Battery Capacitance (AH) = 1.2 (AH)

Note: 60% Discharge of Lithium Polymer battery to increase battery life

Therefore,
1.2 AH / 60% = 2.00 AH minimum battery capacitance desired

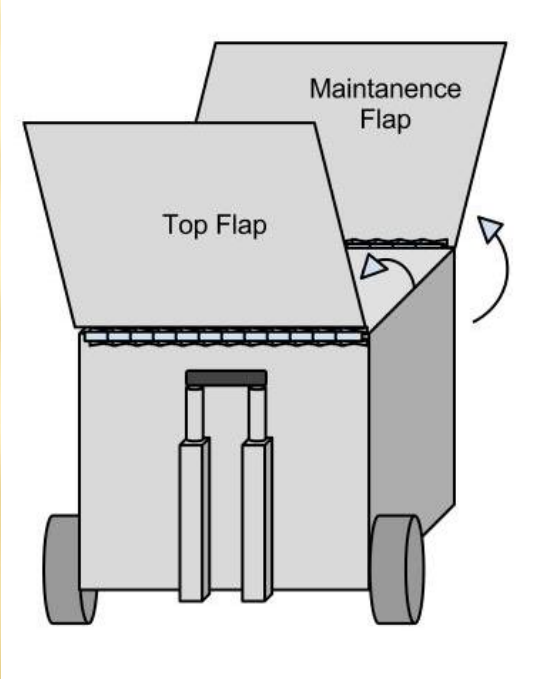
Voltage: 11.1V
Cells: 3SPL
Capacity: 2000mAh
Max Continuous Discharge: 16C
Max Burst Discharge: 30C
Max Continuous Current: 32A
Max Burst Current: 60A
Weight: 122g
Dimensions: 20 x 50 x 65 mm

Charging Station

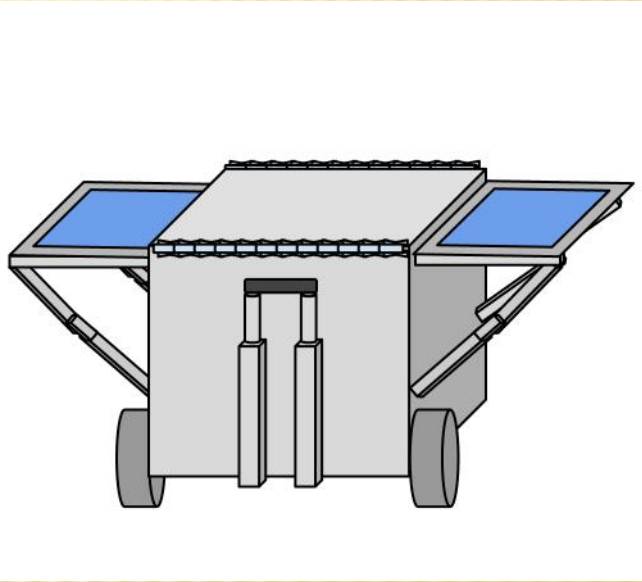


Portable with extendable, easy grip handle

Easily accessible maintenance doors



610 x 610 x 610mm

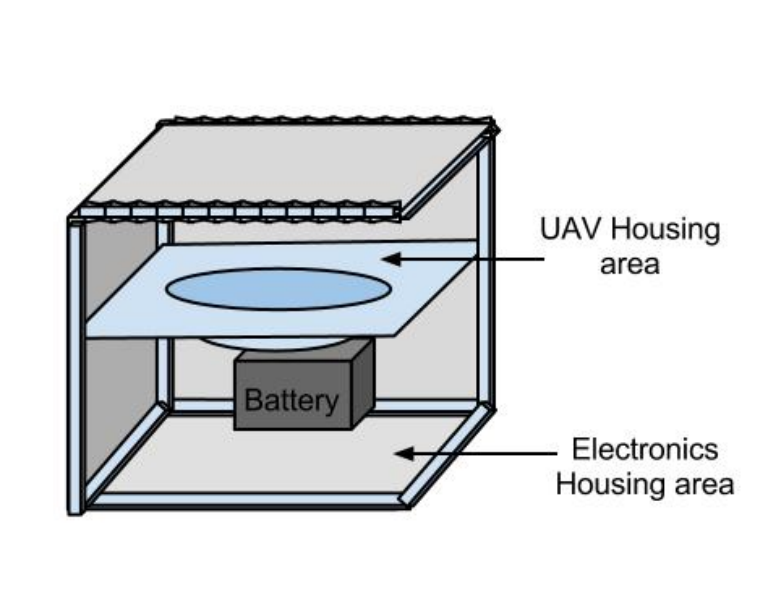


Adjustable Solar Panel positioning

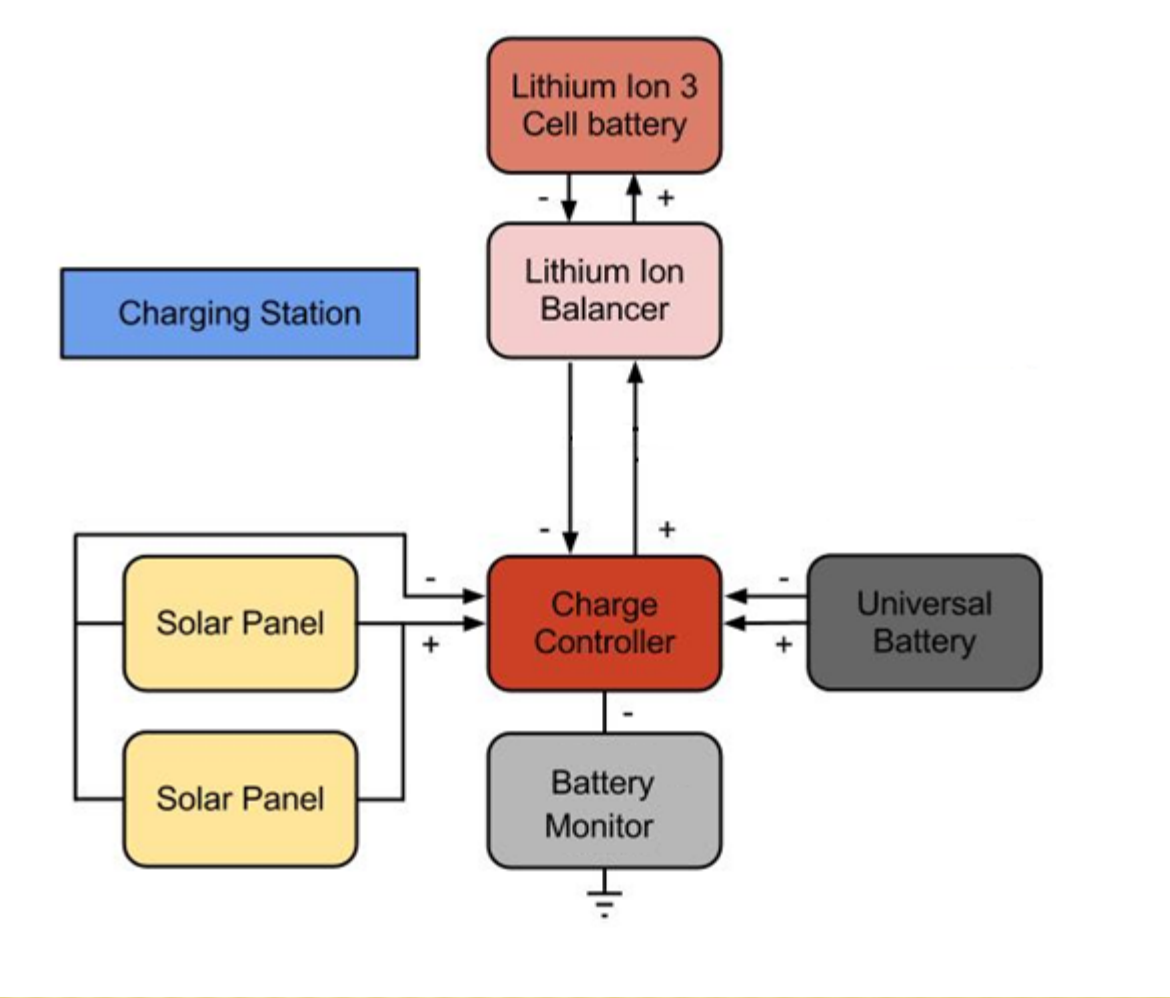
CHARGING STATION: FEATURES

Two bay compartment provides

1. Vehicle docking ease
2. Safety to Station electronics
3. Visually appealing during operation



POWER SYSTEM



POWER SYSTEM: SOLAR PANELS

Dimensions: 350 x 300 x 25mm

- Desire 3 complete vehicle charges per day
- Load requires 2AH * 11.1v = 22.2 Watt-hours
- Power min. needs = ~66.6 Watt-hours

Therefore, we estimate a need a solar contribution of at least 70 Watts-hours per day

- Estimate min. of 4 Sun light hours per day
- 70 Watt-hours / 4 hours = 17.5 Watts

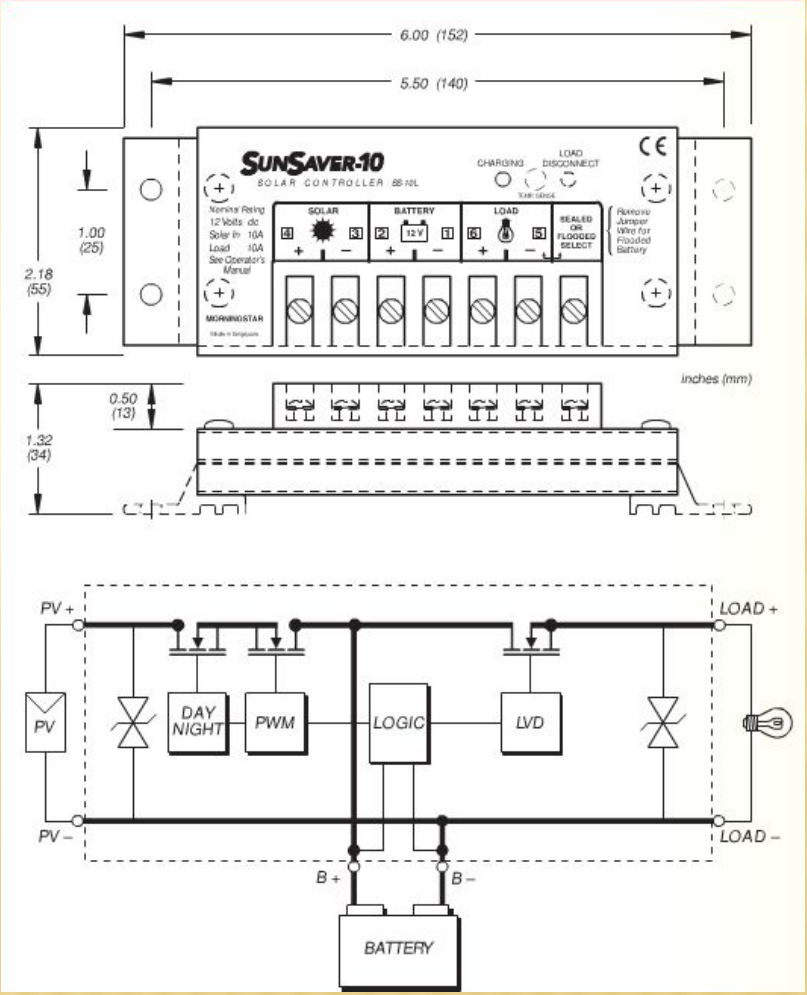
Therefore, we chose two 10 Watt Solar panels to yield an average of 80 Watts-hours per day.

Power system: Charge Controller

Features of interest:

- Full electronic protections
- 4 stage battery charging
- Self-diagnostics to detect critical faults
- Multi-color status LED
- 3 LED's for battery state of charge
- 10 Amp max load

5.94 x 2.55 x 0.85 in



CHARGING STATION: HOLDING BATTERY

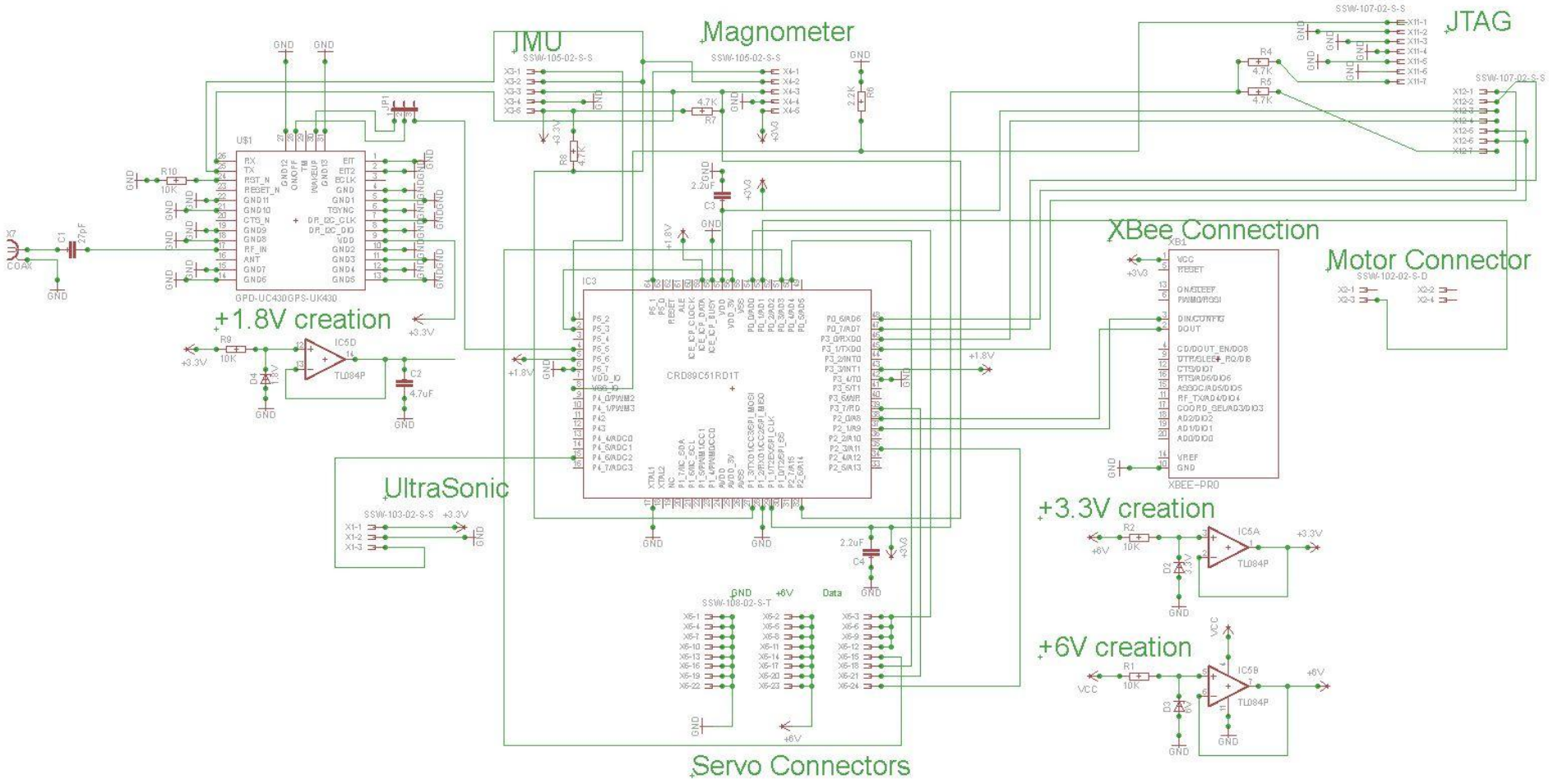
Battery Type	Relative Price	Required Maintenance	Unique Drawback	Unique Benefit
RV	Various	Low	Low life time	Economic
Flooded	Medium	Low	Release gas	Good lifetime value
Gel	Medium	Zero	Low lifetime at high temp	No gas release
AGM	High	Zero	Expensive	High efficiency & rigid to vibration

Volts: 12V
Amp Hour: 12 AH
Chemistry: SLA / AGM
Weight: 8.38 Lbs

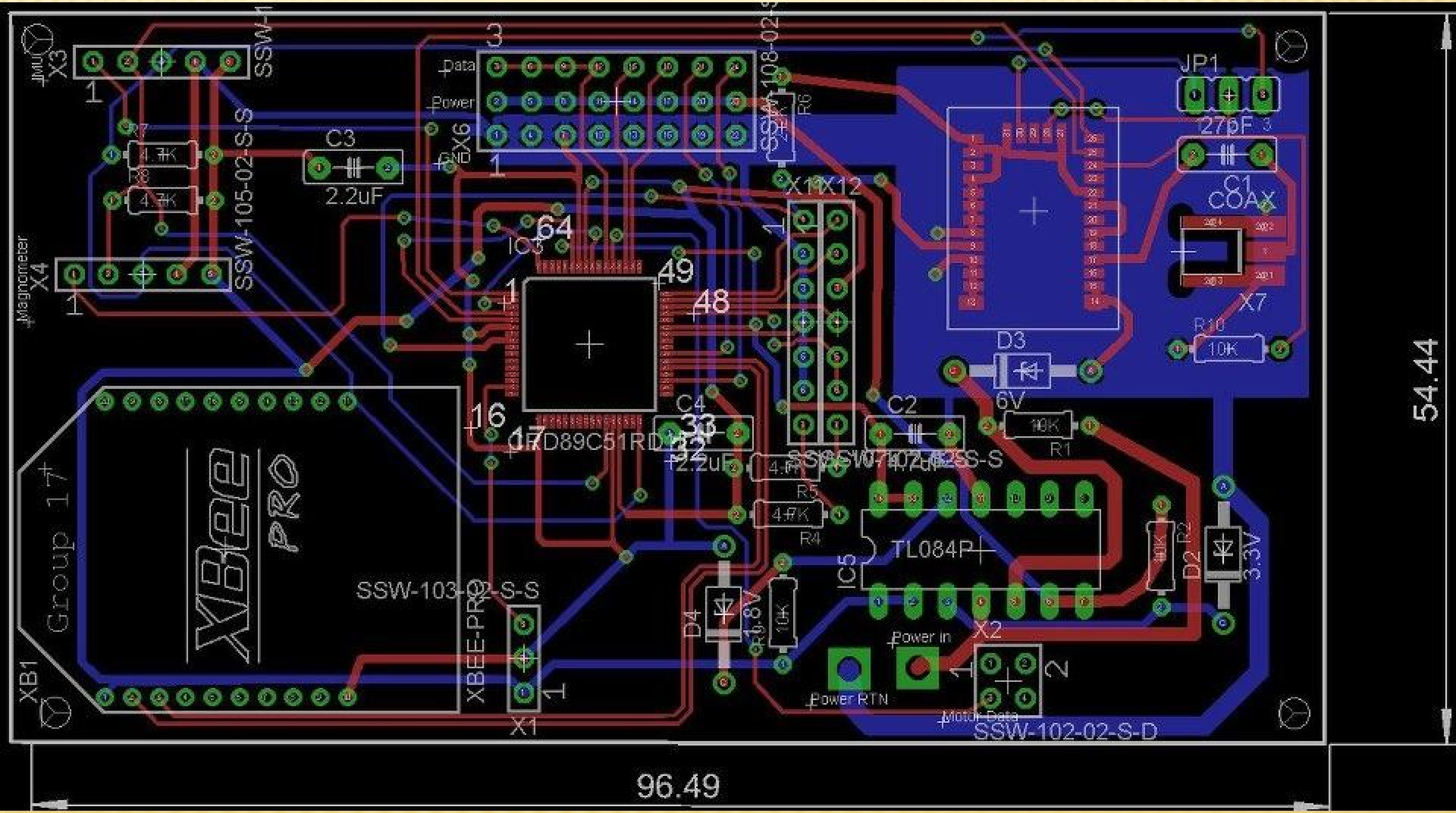
5.94x3.88x4.00 in

- Spill proof
- Non hazardous
- Low self discharge rate
- Withstand vibration and shock well
- No maintenance

Schematic


JMU
Magnometer
JTAG
XBee Connection
Motor Connector
+1.8V creation
UltraSonic
+3.3V creation
+6V creation
Servo Connectors
GPD-UC430GPS-UK430
CRD89C51RD1T
XBEE-PRO
TL084P

PCB



IMU
X3
Magnetometer
X4
SSW-105-02-S-S
R7
R8
4.7K
C3
2.2uF
Data
Power
GND
X6
X11
X12
IC3
64
49
48
1
16
17
33
C4
C2
R4
R5
R6
R1
10K
D3
6V
JP1
27pF
C1
COAX
X7
R10
TL084P
IC5
D2
R2
3.3V
D4
1.8V
Power in
Power RTN
Motor Data
X2
SSW-102-02-S-D
XB1
Group 17
XBee PRO
SSW-103-02-S-S
XBEE-PRO
X1
96.49
54.44

BUDGET

Category	Component	Quantity	Total Price
Electronics	Camera	1	$ 55.00
	GPS	1	$ 32.00
	MCU	1	$ 25.00
	Servos	8	$ 152.00
	IMU	1	$ 50.00
	Transcievers	2	$ 60.00
Testing Equipment	Wires	1	$ 20.00
	Harness	1	$ 15.00
	Dev Board	1	$ 20.00
	Safety Charging Bag	1	$ 22.95
	Bread Board	1	$ 20.00
	Testing Board	1	$ 50.00
Structure	Frame	1	$ 100.00
	LiPo Battery	1	$ 81.19
	Terminals/Connectors	1	$ 35.00
	Control Surfaces	1	$ 40.00
	Propellor	1	$ 16.99
	Housing	1	$ 15.00
Charging Station	Solar Panels	2	$ 140.00
	Balancer	1	$ 60.00
	Holding Battery	1	$ 22.99
	Frame	1	$ 150.00
	Fan Motor	1	$ 20.00
	Control Motors	1	$ 30.00
	Current Monitor	1	$ 35.00
	Fan	2	$ 15.00
Total Projected Cost			$ 1,283.12