



UNIVERSITY OF IDAHO

CS CAPSTONE DESIGN

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# Capstone Portfolio

## Drone Mission Planning Software

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Mission Control

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*Customer:*  
Brandon ORTIZ

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## 1 Team Member Contact Information

Name	Phone Number	Email Address
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Taylor Trabun	(509) 995-0904	trab1744@vandals.uidaho.edu

Table 1: Team Member Contact Information

## 2 Introduction

Software to create and upload a flight plan to a quad copter drone. The flight plan will be uploaded using xBee radio communication.

This project will use off-the-shelf parts. ATMEL<sup>©</sup> based microcontrollers found on arduino based open source boards is the current preference.

### 2.1 Target Priorities

Number	Category	Need	Importance
1	Quadcopter	Center of Gravity Refined	5
2	Quadcopter	Reliable Flight	5
3	Quadcopter	Functioning xBee Hardware	4
4	Quadcopter	Hardware (Microcontroller) with xAPI and services to control flight	5
5	Quadcopter	Controlled with XP communications	4
6	Quadcopter	Autoland	5
7	Software	software package for flight planning	2
8	Software	API for sending commands from computer	2

Table 2: Priorities

## 3 Initial Client Interview Transcript 9/10/14

**Mentor/Client:** Brandon Ortiz

### 3.1 Meetings

We will be having weekly meetings in Brandon's office on Thursdays at 3:30 PM. These meeting will include status updates, further work on designs, troubleshooting, and assignment of tasks

### 3.2 End Goal

To have a stable and flying quadcopter that can be communicated with remotely. In addition, work done on a flight planning software (including GUI) should be underway. The project will be done in small steps, as this project requires research and development throughout.

### 3.3 First Steps

- Learn how quadcopter works
- Reconstruct quadcopter to be stable
- Learn how to fly quadcopter
- Understand flight computer documentation
- Design communications
- Be sure to use xAPI

### 3.4 Requirements

- Functional quadcopter (stable)
- Documentation of quadcopter construction
- Use of xAPI on arduino communication system
- Communication system using xBEE to communicate from computer to quadcopter
- Ability to send commands to quadcopter
- Flight planning software, including GUI

### 3.5 Other Notes

Other notes from the meeting included aviation terminology, how to pair the remote control and quadcopter receiver, quick tour of controller and motor adjustments, and a quick tour of flight computer.

## 4 Meeting Agendas

4.1 Sept. 10, 2014

### Mission Control Team Agenda

**Friday September 10, 2014.**  
**1500 — 1600 in JEB Think Tank.**

**Type of Meeting**

Initial client interview.

**Attendees**

David Klingenberg

Taylor Trabun

Brandon Ortiz

**Topics**

Topic	Responsible	Time (in minutes)
Product Overview	Brandon	15
System Requirements	Brandon	15
Tasks Breakdown	Open Discussion	15
Question & Answers	Open Discussion	25

**Additional Information:** This is our initial client interview.

4.1.1 Minutes from Friday September 10 Meeting

Refer to [Section 3](#) initial client transcript.

4.2 Sept. 18, 2014

### Mission Control Team Agenda

**Thursday September 18, 2014.**  
**1500 — 1600 in JEB Think Tank.**

### **Type of Meeting**

Initial Planning

### **Attendees**

David Klingenberg

Taylor Trabun

Brandon Ortiz

Bruce Bolden

### **Topics**

<b>Topic</b>	<b>Responsible</b>	<b>Time (in minutes)</b>
Progress Report	David, Taylor	5
System Overview	Brandon	10
Tasks Breakdown	Open Discussion	20
Additional Words of Wisdom	Bruce	5
Question & Answers	Open Discussion	20

### **Additional Information:**

The rerouting and reconfiguring of the drone is proceeding nicely. It progress will be shown at the meeting time.

#### **4.2.1 Minutes from Thursday September 18 Meeting**

- 1505 Meeting Started
- Discussed drone rebuild progress.
- Evaluated ESC bin for the drone.
  - Refer to [figur 8](#) in Appendix [C](#)
- Discussed, evaluated, and illustrated the communication sequence.
  - Refer to [figur 4](#) in Appendix [A](#)
- 1610 Meeting

#### **4.3 Sept. 25, 2014**

## **Mission Control Team Agenda**

**Thrusday September 25, 2014.  
1530 — 1630 in JEB 37**



### **Type of Meeting**

Status Report and Next Week Planning

### **Attendees**

David Klingenberg

Taylor Trabun

Brandon Ortiz

### **Topics**

<b>Topic</b>	<b>Responsible</b>	<b>Time (in minutes)</b>
Progress Report	David & Taylor	10
Demonstrations	David & Taylor	10
New Tasks	Open Discussion	20
Question & Answers	Open Discussion	20

### **Additional Information:**

#### **4.3.1 Minutes from Thursday September 25 Meeting**

- 1530 Meeting Start
- Discussed LCD use on Arduinos.
- Reviewed TUN packets.
- Status updates
  - Things moving along.
  - Getting closer to flying possibly next Thursday.
- xBee discussion on how to connect.
- Evaluated future problems.
  - Gyros and accelerometers need to be implemented separately from the flight computer.
- 1630 Meeting Ended

4.4 Oct. 2, 2014

## Mission Control Team Agenda

**Thursday October 2, 2014.  
1530 — 1630 in JEB 37**

### **Type of Meeting**

Status Report and Next Week Planning

### **Attendees**

David Klingenberg

Taylor Trabun

Brandon Ortiz

### **Topics**

<b>Topic</b>	<b>Responsible</b>	<b>Time (in minutes)</b>
Progress Report	David & Taylor	10
Demonstrations	David & Taylor	10
New Tasks	Open Discussion	20
Question & Answers	Open Discussion	20

### **Additional Information:**

#### **4.4.1 Minutes from Thursday October 2 Meeting**

- 1530 Meeting Start
- Status updates.
  - Taylor has one-way communications working.
  - David finished a prototype for the ECS bin.
    - \* Bin needs its weight reduced.
    - \* ECS cables need to be lengthened.
- To
  - Taylor will attempt to get XP comm working.
  - David will finish quadcopter.
  - Get a new adrenal for running a second xBee radio.
  - Solder new LCD board.

- xBee Configuration notes.
  - Use XCTU tool for configuration.
  - Need FID drivers installed for XCTU tool.
- 1630 Meeting Ended

4.5 Oct. 9, 2014

## Mission Control Team Agenda

**Thursday October 9, 2014.  
1530 — 1630 in JEB 37**

### Type of Meeting

Status Report and Next Week Planning

### Attendees

David Klingenberg  
Taylor Trabun  
Brandon Ortiz

### Topics

Topic	Responsible	Time (in minutes)
Progress Report	David & Taylor	10
Demonstrations	David & Taylor	10
New Tasks	Open Discussion	20
Question & Answers	Open Discussion	20

### Additional Information:

#### 4.5.1 Minutes from Thursday October 9 Meeting

- 1530 Meeting Start
- Update
  - Taylor is preparing for snapshot day.
  - David
    - \* Quadcopter rebuilt.
    - \* Simple xBee terminals working between two computers.

- New Resources
  - UAV control paper with GUI design example.
  - Survey of UAV papers.
- Action Items
  - David will experiment with PWM and the quadcopter and portfolio.
  - Taylor will work on poster for snapshot day and continue working on communications.
- Test Flight
  - Quadcopter has severe drift forward. David will work on solution.
- 1630 Meeting Ended

4.6 Oct. 16, 2014

## Mission Control Team Agenda

**Thursday October 16, 2014.  
1530 — 1630 in JEB 37**

### **Type of Meeting**

Status Report and Next Three Week Planning

### **Attendees**

David Klingenberg  
Taylor Trabun  
Brandon Ortiz

### **Topics**

<b>Topic</b>	<b>Responsible</b>	<b>Time (in minutes)</b>
Progress Report	David & Taylor	10
Demonstrations	David & Taylor	10
New Tasks	Open Discussion	20
Question & Answers	Open Discussion	20

### **Additional Information:**

Our next meeting will be in 3 weeks Nov 6, 2014.

#### 4.6.1 Minutes from Thursday October 16 Meeting

- 1530 Meeting Start
- Update
  - Tatlor reported on snapshot day and his progress with the zigBee radios.
  - David
    - \* Begin fine-tuning the drone for stabilization and self level flight. Drifting stability have been greatly improved.
- Action Items
  - David will continue to experiment with PWM and the quadcopter. He will explore control algorithms.
  - Taylor will continue his work on communications.
- Test Flight
  - Quadcopter severe forward drift has been improved. David needs to develop a battery frame to stop the batteries from shifting which is causing some of the uncontrolled drift.
- 1630 Meeting Ended

4.7 Nov. 6, 2014

## Mission Control Team Agenda

Thursday November 6, 2014.  
1530 — 1630 in JEB 37

### Type of Meeting

Status Report and additional Short-term Planning.

### Attendees

David Klingenberg  
Taylor Trabun  
Brandon Ortiz

### Topics

Topic	Responsible	Time (in minutes)
Progress Report	David & Taylor	10
Demonstrations	David & Taylor	10
New Tasks	Open Discussion	20
Question & Answers	Open Discussion	20

### Additional Information:

Our next meeting will be Nov 20, 2014.

#### 4.7.1 Minutes from Thursday October 16 Meeting

- 1530 Meeting Start
- Update
  - Taylor
    - \* Gui mock-up finished, class documentation work (design review presentation, wiki).
  - David
    - \* Having a great deal of problem with PWM as an input to flight computer. Will have to try different firmware's for the flight computer and explore possible alternatives to PWM.
- New Resources
- Action Items

- David will continue to experiment with PWM and the quadcopter. Will explore control algorithms used by existing quad copters.
  - Taylor will continue his work on communications.
- Test Flight
  - Quadcopter severe forward drift has been improved. David needs to develop a battery frame to stop the batteries from shifting.
- 1630 Meeting Ended

4.8 Nov. 20, 2014

## Mission Control Team Agenda

**Thursday November 20, 2014.  
1530 — 1630 in JEB 37**

### **Type of Meeting**

Status Report and additional Short-term Planning.

### **Attendees**

David Klingenberg  
Taylor Trabun  
Brandon Ortiz

### **Topics**

<b>Topic</b>	<b>Responsible</b>	<b>Time (in minutes)</b>
Progress Report	David & Taylor	10
Demonstrations	David & Taylor	10
New Tasks	Open Discussion	20
Question & Answers	Open Discussion	20

### **Additional Information:**

Our next meeting will be Dec 4, 2014.

#### **4.8.1 Minutes from Thursday October 16 Meeting**

- 1530 Meeting Start
- Update
  - Taylor
    - \* Worked with Brandon to debug XBee comms, still under-way Action Items 15min
  - David
    - \* Focusing more on senior design and plans on continuing to work on project next semester, code written for PWM flight control
- Action Items
  - David is working on PWM, PWM flight service, team citizenship form.



- Taylor is working on design document, wiki update, team citizenship form, continue working out XBee comm bugs and send EXTERNAL\_LCD TUN packet to another Arduino successfully.
- Test Flight
  - Broken bones and foul weather will place any future flight testing on hold.
- 1630 Meeting Ended

## 5 Code

### 5.1 Supplemental quad copter autopilot V1.4

```
1  /*****
2  Version 1.4
3
4  Supplemental quad copter Autopilot.
5
6  Contains a prototype controller algorithm
7  to maintain an altitude hold. In this
8  version only an ultrasonic rangefinder
9  is used to measure altitude.
10
11 Important numbers for the kk2.1
12
13 center stick :1500 micro seconds
14 Full Right/Back: 2100
15 Full Left/Forward: 900
16
17 100% Throttle: 2300
18 0% Throttle: 1000
19 *****/
20
21 #include <Servo.h>
22 #include <NewPing.h>
23 #include <PID_v1.h>
24 #include <Adafruit_LSM303_U.h>
25 #include <Adafruit_BMP085_U.h>
26 #include <Adafruit_L3GD20_U.h>
27 #include <Adafruit_Sensor.h>
28 #include <Wire.h>
29
30
31 /* INPUT RANGE */
32 #define ZERO_THROTTLE 1000
33 #define FULL_THROTTLE 2300
34
35 #define FULLSTICKLEFTFORWARD 900
36 #define FULLSTICKRIGHTBACK 2100
37 #define ZERO_STICK 1500
38
39 /* Pin assignments. */
```

```

40 #define AILERONS_PIN 2
41 #define ELEVATOR_PIN 3
42 #define THROTTLE_PIN 4
43 #define RUDDER_PIN 5
44 #define AUX 6
45
46
47 /* Sonar Setup */
48 #define GROUND_PING_PIN 12
49 #define GROUND_ECHO_PIN 11
50 #define GROUND_MAX_SONAR_DISTANCE 200
51 #define GROUND_SONAR_ITERATION 5
52
53 /* PID Setup */
54 #define thr_out_range 1.25
55 #define Kp_add 0
56 #define Ki_add 1
57 #define Kd_add 2
58 #define auxset_add 3
59 #define pidMode_add 4
60
61 void zero_stick();
62 void zero_all_inputs();
63 void set_thr(int);
64 void set_ali(int);
65 void set_elv(int);
66 void set_rud(int);
67 void setup_pins();
68 byte arm();
69 byte disarm();
70
71
72 /* Global Variables */
73 double altitude_hold, ground_range_value,
    throttle_position;
74 byte RangeTime_1cm;
75 int groundRangeTime;
76 Servo throttle, rudder, aileron, elevator, aux;
77 byte armed;
78 NewPing ground_range(GROUND_PING_PIN, GROUND_ECHO_PIN,
    GROUND_MAX_SONAR_DISTANCE);
79

```

```

80 /* Global Sensor Variables */
81 Adafruit_LSM303_Accel_Unified acc =
    Adafruit_LSM303_Accel_Unified(30301);
82 Adafruit_LSM303_Mag_Unified mag =
    Adafruit_LSM303_Mag_Unified(30302);
83 Adafruit_BMP085_Unified bmp = Adafruit_BMP085_Unified(18001);
84 Adafruit_L3GD20_Unified gyro = Adafruit_L3GD20_Unified(20);
85 sensors_event_t event;
86
87 /* Global PID Variables */
88 PID altPID(&ground_range_value, &throttle_position, &altitude_hold, 2,
    5, 1, DIRECT);
89
90 /* Pin section. */
91 void setup_pins() {
92     aileron.attach(AILERONS_PIN);
93     elevator.attach(ELEVATOR_PIN);
94     throttle.attach(THROTTLE_PIN);
95     rudder.attach(RUDDER_PIN);
96 }
97
98 /*
99 void displaySensorDetails(void)
100 {
101     sensor_t sensor;
102
103     accel.getSensor(&sensor);
104     Serial.println(F("----- ACCELEROMETER -----"));
105     Serial.print(F("Sensor:      ")); Serial.println(sensor.name);
106     Serial.print(F("Driver Ver:  ")); Serial.println(sensor.version);
107     Serial.print(F("Unique ID:   "));
        Serial.println(sensor.sensor_id);
108     Serial.print(F("Max Value:   ")); Serial.print(sensor.max_value);
        Serial.println(F(" m/s^2"));
109     Serial.print(F("Min Value:   ")); Serial.print(sensor.min_value);
        Serial.println(F(" m/s^2"));
110     Serial.print(F("Resolution:  "));
        Serial.print(sensor.resolution); Serial.println(F(" m/s^2"));
111     Serial.println(F("-----"));
112     Serial.println(F(""));
113
114     gyro.getSensor(&sensor);

```

```

115 Serial.println(F("----- GYROSCOPE -----"));
116 Serial.print (F("Sensor:      ")); Serial.println(sensor.name);
117 Serial.print (F("Driver Ver:   ")); Serial.println(sensor.version);
118 Serial.print (F("Unique ID:    "));
    Serial.println(sensor.sensor_id);
119 Serial.print (F("Max Value:     ")); Serial.print(sensor.max_value);
    Serial.println(F(" rad/s"));
120 Serial.print (F("Min Value:     ")); Serial.print(sensor.min_value);
    Serial.println(F(" rad/s"));
121 Serial.print (F("Resolution:   "));
    Serial.print(sensor.resolution); Serial.println(F(" rad/s"));
122 Serial.println(F("-----"));
123 Serial.println(F(""));
124
125 mag.getSensor(&sensor);
126 Serial.println(F("----- MAGNETOMETER -----"));
127 Serial.print (F("Sensor:      ")); Serial.println(sensor.name);
128 Serial.print (F("Driver Ver:   ")); Serial.println(sensor.version);
129 Serial.print (F("Unique ID:    "));
    Serial.println(sensor.sensor_id);
130 Serial.print (F("Max Value:     ")); Serial.print(sensor.max_value);
    Serial.println(F(" uT"));
131 Serial.print (F("Min Value:     ")); Serial.print(sensor.min_value);
    Serial.println(F(" uT"));
132 Serial.print (F("Resolution:   "));
    Serial.print(sensor.resolution); Serial.println(F(" uT"));
133 Serial.println(F("-----"));
134 Serial.println(F(""));
135
136 bmp.getSensor(&sensor);
137 Serial.println(F("----- PRESSURE/ALTITUDE -----"));
138 Serial.print (F("Sensor:      ")); Serial.println(sensor.name);
139 Serial.print (F("Driver Ver:   ")); Serial.println(sensor.version);
140 Serial.print (F("Unique ID:    "));
    Serial.println(sensor.sensor_id);
141 Serial.print (F("Max Value:     ")); Serial.print(sensor.max_value);
    Serial.println(F(" hPa"));
142 Serial.print (F("Min Value:     ")); Serial.print(sensor.min_value);
    Serial.println(F(" hPa"));
143 Serial.print (F("Resolution:   "));
    Serial.print(sensor.resolution); Serial.println(F(" hPa"));
144 Serial.println(F("-----"));

```

```

145   Serial.println(F(""));
146
147   delay(1500);
148 }
149 */
150
151 /* Zero out the control x,y and rotational inputs. */
152 void zero_stick(){
153   aileron.writeMicroseconds(ZERO_STICK);
154   elevator.writeMicroseconds(ZERO_STICK);
155   rudder.writeMicroseconds(ZERO_STICK);
156 }
157
158 void zero_all_inputs(){
159   zero_stick();
160   set_thr(0);
161 }
162
163 /* Sets the throttle. Use a range of 0 to 100. */
164 void set_thr (int val){
165   throttle.writeMicroseconds(map(val, 0, 100, ZERO_THROTTLE,
166   FULL_THROTTLE));
167   //Serial.println(map(val, 0, 100, ZERO_THROTTLE, FULL_THROTTLE));
168 }
169
170 /* Set the ailerons. Use a range of -100 to 100. */
171 void set_ail (int val) {
172   if (val == 0)
173     aileron.writeMicroseconds(ZERO_STICK);
174   else
175     aileron.writeMicroseconds(map(val, -100, 100,
176     FULL_STICK_LEFT_FORWARD, FULL_STICK_RIGHT_BACK));
177 }
178
179 /* Set the elevator. Use a range of -100 to 100. */
180 void set_elv (int val) {
181   if (val == 0)
182     elevator.writeMicroseconds(ZERO_STICK);
183   else
184     elevator.writeMicroseconds(map(val, -100, 100,
185     FULL_STICK_LEFT_FORWARD, FULL_STICK_RIGHT_BACK));
186 }

```

```

184
185 /* Set the rudder. Use a range of -100 to 100. */
186 void set_rud (int val) {
187     if (val == 0)
188         rudder.writeMicroseconds(ZERO_STICK);
189     else
190         rudder.writeMicroseconds(map(val, -100, 100,
191                                     FULL_STICK_LEFT_FORWARD, FULL_STICK_RIGHT_BACK));
192 }
193 /* Arms the motors */
194 byte arm() {
195     set_thr(0);
196     set_rud(-100);
197     delay(1000);
198     set_rud(0);
199
200     return 1;
201 }
202 }
203
204 /* Disarms the motors */
205 byte disarm() {
206     set_thr(0);
207     set_rud(100);
208     delay(1000);
209     set_rud(0);
210
211     return (0);
212 }
213
214 byte time_1cm() {
215     float temperature, time;
216     bmp.getTemperature(&temperature);
217     time = 2/((331.3 * sqrt(1 + temperature / 273.15))/10000);
218
219     // Serial.print(temperature);
220     // Serial.print(" C, time: ");
221     // Serial.println(time,6);
222     return time;
223 }
224

```

```

225
226 void pid_loop(){
227   int thr_min, thr_max;  //
228
229   //thr_min = throttle_position - thr_out_range;
230   //thr_max = throttle_position + thr_out_range;
231   //altPID.SetOutputLimits(thr_min,thr_max);
232   altPID.Compute();
233   Serial.print((int)throttle_position);
234   throttle.writeMicroseconds((int)throttle_position);
235
236 }
237
238 void setup() {
239   Serial.begin(115200);
240
241   if(!acc.begin())
242   {
243     /* There was a problem detecting the ADXL345 ... check your
244        connections */
245     Serial.println(F("Oops, no LSM303 detected ... Check your
246        wiring!"));
247     while(1);
248   }
249   if(!mag.begin())
250   {
251     /* There was a problem detecting the LSM303 ... check your
252        connections */
253     Serial.println("Oops, no LSM303 detected ... Check your wiring!");
254     while(1);
255   }
256   if(!bmp.begin())
257   {
258     /* There was a problem detecting the BMP085 ... check your
259        connections */
260     Serial.print("Oops, no BMP085 detected ... Check your wiring or
261        I2C ADDR!");
262     while(1);
263   }
264   if(!gyro.begin())
265   {
266     /* There was a problem detecting the L3GD20 ... check your

```



```

262         connections */
263         Serial.print("Oops, no L3GD20 detected ... Check your wiring or
264         I2C ADDR!");
265     while(1);
266 }
267 altPID.SetMode(AUTOMATIC);
268 altPID.SetOutputLimits(1000, 2300);
269 throttle_position = 1500;
270 altitude_hold = 20;
271 RangeTime_1cm = time_1cm();
272 setup_pins();
273 zero_all_inputs();
274 throttle.writeMicroseconds(throttle_position);
275 delay (1500);
276 //displaySensorDetails();
277 }
278
279 void loop(){
280     ground_range_value =
281         ground_range.ping_median(GROUND_SONAR_ITERATION);
282     ground_range_value = (int)ground_range_value / RangeTime_1cm;
283     pid_loop();
284     acc.getEvent(&event);
285     Serial.print(" Acc Z: ");
286     Serial.print(event.acceleration.z);
287     gyro.getEvent(&event);
288     Serial.print(" gyro Z: ");
289     Serial.print(event.gyro.z);
290     Serial.print(" Ping: ");
291     Serial.print(ground_range_value);
292     Serial.println(" cm");
293
294
295
296
297
298
299
300

```

```
301  //armed = arm();  
302  
303  //delay (5000);  
304  
305  //armed = disarm();  
306  
307  //delay (10);  
308 }
```

`./Supplementary_autopilot.c`

## 6 Design Presentation

### 6.1 Nov 13, 2014

See Next Page

# **Drone Mission Planning Software**

David Klingenberg  
Taylor Trabun

- Problem Definition
- Specific Component Design
  - Communications Design
  - Drone Design
  - Graphical User Interface Design
- Timeline
- Questions/Concerns

## Overview

The goal of this project is to design and develop a graphical user interface (GUI) for drone mission planning.

Requirements:

- A user-friendly interface
- Allow 3-dimensional mission planning
- Upload the flight plan using XAPI and XBee
- Allow manual override
- Implement drone hardware for flight control

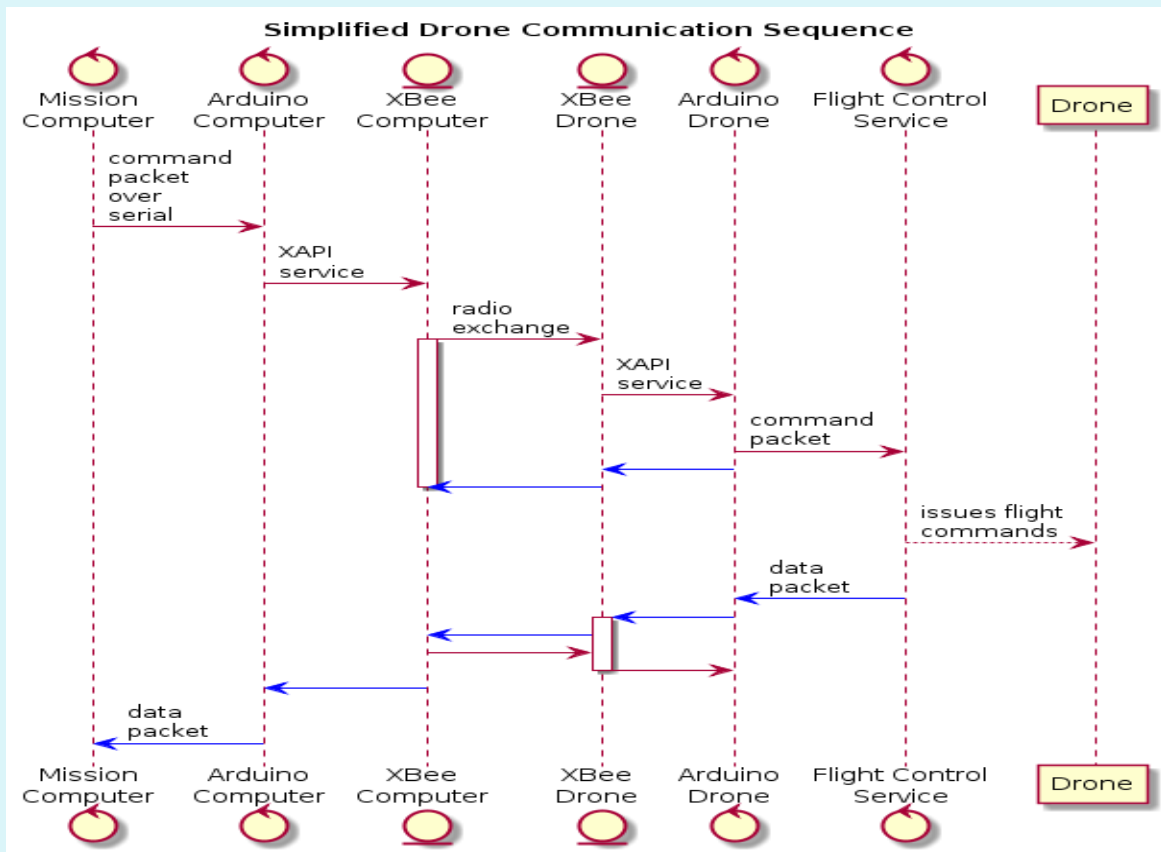
## **Problem Definition**

The communication system for this project must allow for commands to be sent from a computer to a drone.

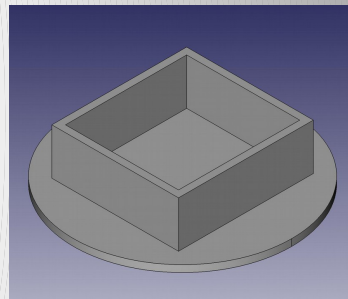
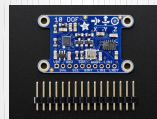
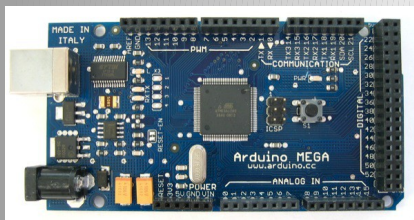
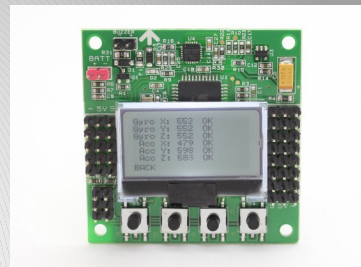
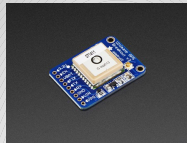
**Requirements:**

- XAPI and XBee hardware
- Specific TUN packets:
  - Manual drone instructions (altitude, direction, takeoff, etc..)
  - Settings
  - Acknowledgement of packet received
  - Heartbeat/status updates
  - Override (manual, land)
  - Flight plan protocol
    - ▮ Initialize for upload
    - ▮ Get instructions
    - ▮ Echo instructions
    - ▮ Terminate upload

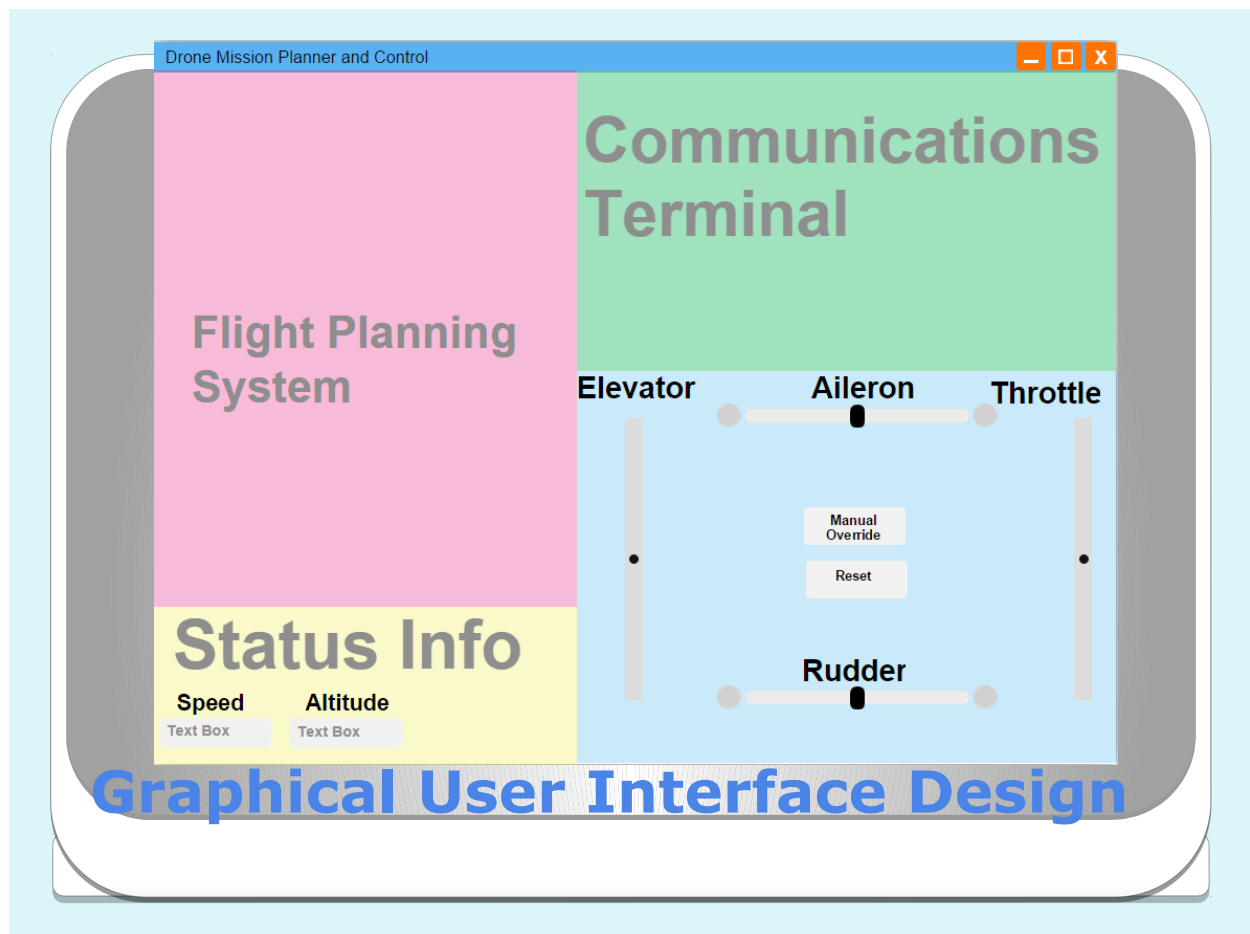
**Communication Design**

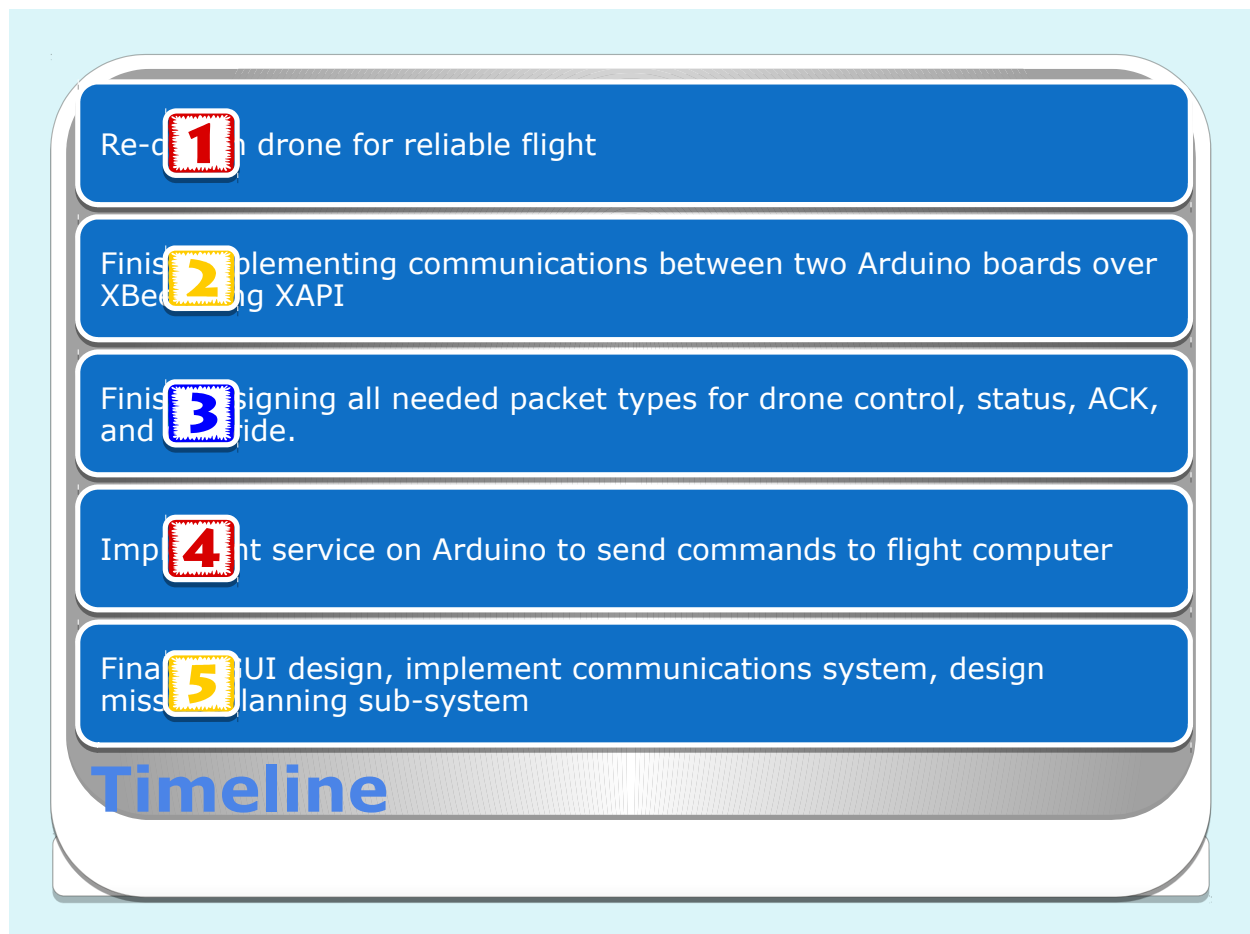






## Drone Design





Questions or concerns?

**Thank You**

# Drone Mission Planning Software: Design Document

Taylor Trabun

December 14, 2014

## 7 Design Document

### 7.1 Introduction

This document provides the general design of the Drone Mission Planning Software by breaking the entire project down into several components. The current components are the physical drone, the communication system, and the graphical user interface for mission planning.

### 7.2 Drone Design

The drone design's major requirement that needed to be met was to achieve stable and reliable flight.

By analyzing the drone, it was determined that its center of gravity was not directly centered on the drone, which resulted in drifting during flight. To remedy this issue, a "part holder" was designed to be mounted on the underside of the drone to hold all the motor controls, which moved the center of gravity to the center of the drone.

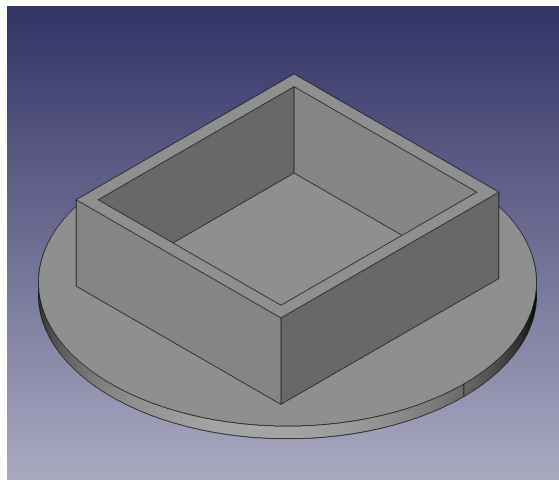


Figure 1: 3D sketch of partbin

## 7.3 Communication Design

The communications system needs to follow the following requirements:

- Use of XAPI and XBee hardware
- Define required TUN packets for communication system
  - Manual drone instructions
  - Settings and status
  - ACK
  - Heartbeat
  - Override
  - Flight plan protocol types

The following sections will break the communication system down into its several components and detail their design.

### 7.3.1 Communication Overview

Our communications system, as depicted in the graphic below, requires two-way communication between the computer (including the attached Arduino) and the Arduino located on the drone. This system will take an instruction created on the computer, send it over serial to the connected Arduino, pass it to XAPI, XAPI will ship it over XBee to the Arduino on the drone, and a flight control service will execute the instruction.

### 7.3.2 Hardware Components

Our current communications requires the following hardware components:

- Arduino Mega 2560
- XBee modules
- LCD Shields (for development and debugging)
- Serial add-on for Arduino
- A computer running Windows to communicate with base Arduino (Workstation needs to be able to run C# programs)

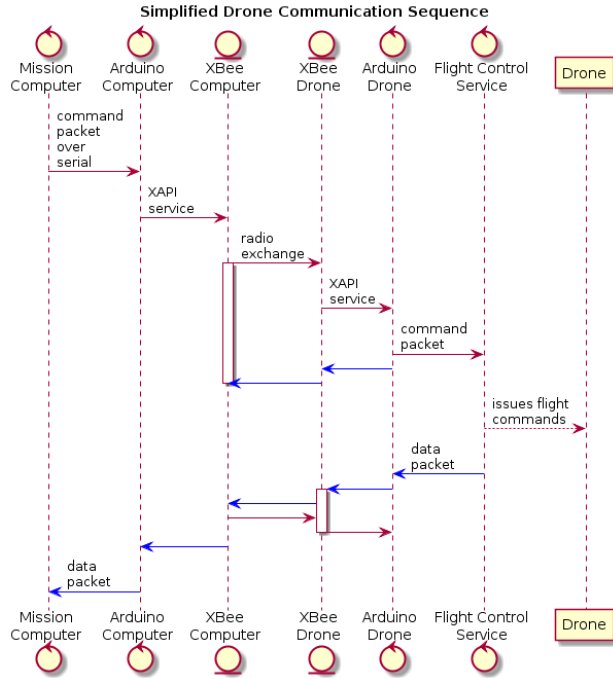


Figure 2: Overview of communications system

### 7.3.3 XAPI

To satisfy one of our major requirements, we run the XAPI on each Arduino in the communications system.

XAPI is, put simply, a micro-controller service manager that communicates, both internally and externally, using TUN packets. When communicating externally, the XAPI ships the TUN packet using the XBee hardware by embedding the TUN packet in a XBee packet.

Each service available with the API use XAPI to communicate, using XAPI as the core that each service "latches" to. For instance, if a chat service wanted to display a message on a attached LCD screen, the following steps would be carried out:

1. Chat service creates a LOCAL\_ LCD TUN packet
2. Chat service passes the newly created packet to the XAPI core
3. XAPI places the packet in its internal packet buffer
4. The LCD service latch queries XAPI for any packets designated for the LCD service
5. LCD service grabs LOCAL\_ LCD TUN packet
6. LCD service processes and displays the packet

To satisfy our project's requirements, we need to design a Flight Control service that will be able to handle any instruction packets and translate them to instructions that can be given to the drone's flight computer. In addition to this, there is a requirement for a Mission Plan service that will store and execute flight plan's designed by the user and sent to the drone.

## 7.4 Graphical User Interface Design

The graphical user interface must satisfy several requirements:

1. Must be user-friendly
2. Allow 3-dimensional mission planning
3. Allow upload of flight plan to drone
4. Allow manual override

Given these requirements we were able to design a general design for the graphical user interface (GUI), as shown below. This GUI is split into several sections that convey different information, that in some cases can be adjusted.

We have a flight control section (light-blue) that shows the status of the drone components and allows the user to "zero out" each component or take manual control. The status information section (yellow) shows different readings from the drone's on-board instruments. The flight planning system (light-red) will be where the user can develop a flight plan to be uploaded to the drone (note that this functionality is still under design and may end up being a separate window that needs to be opened up). The final section is the communications terminal (light-green) that displays all packets sent and received on the Arduino attached to the source computer. This communications terminal will allow the user to see that the drone is still connected and will allow for easy communications debugging.



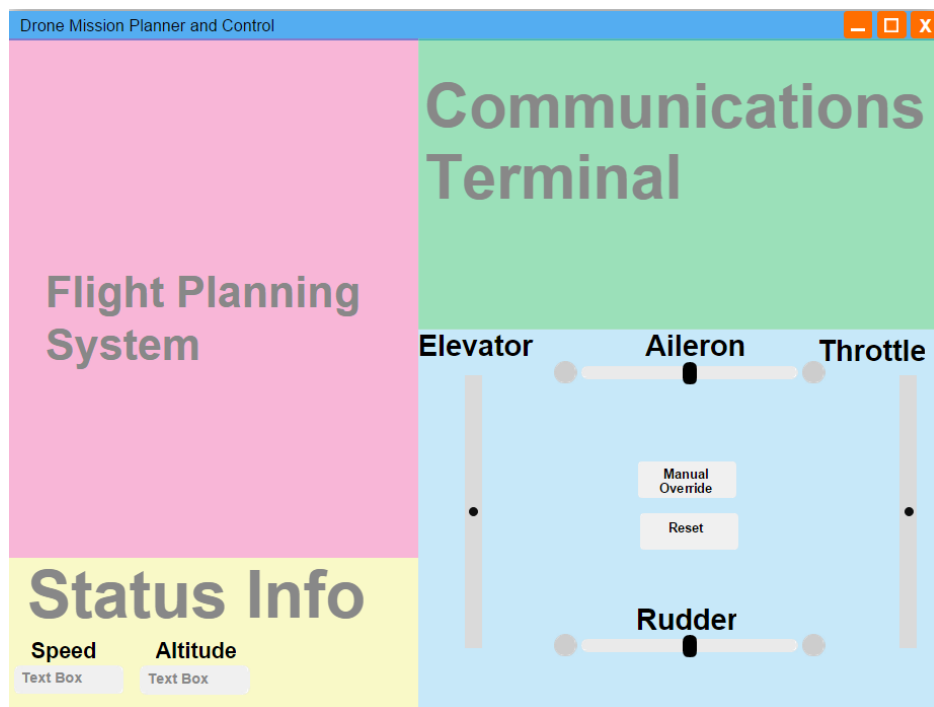


Figure 3: Graphical user interface mock-up design

# Appendices

## A Miscellaneous UML Charts

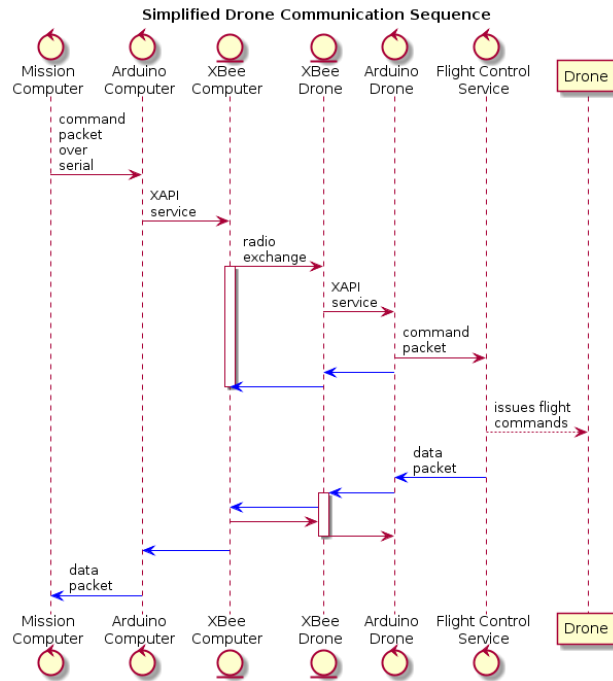


Figure 4: Communication Sequence

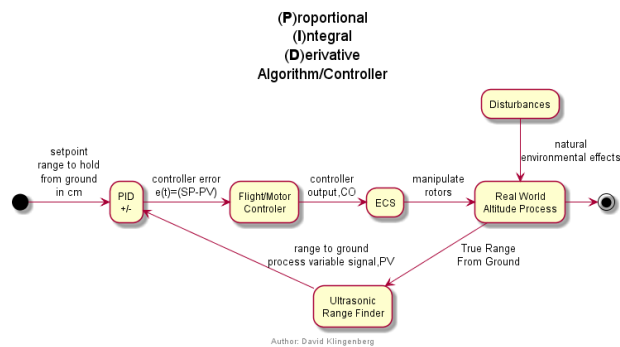


Figure 5: PID Controller

## B ATMEL<sup>®</sup> Microcontrollers

### Features

- High-performance, Low-power Atmel<sup>®</sup> AVR<sup>®</sup> 8-bit Microcontroller
- Advanced RISC Architecture
  - 131 Powerful Instructions – Most Single-clock Cycle Execution
  - 32 x 8 General Purpose Working Registers
  - Fully Static Operation
  - Up to 20 MIPS Throughput at 20MHz
- High Endurance Non-volatile Memory segments
  - 64 Kbytes of In-System Self-programmable Flash program memory
  - 2 Kbytes EEPROM
  - 4 Kbytes Internal SRAM
  - Write/Erase cycles: 10,000 Flash/100,000 EEPROM<sup>(1)(3)</sup>
  - Data retention: 20 years at 85°C/100 years at 25°C<sup>(2)(3)</sup>
  - Optional Boot Code Section with Independent Lock Bits
    - In-System Programming by On-chip Boot Program
    - True Read-While-Write Operation
  - Programming Lock for Software Security
- JTAG (IEEE std. 1149.1 Compliant) Interface
  - Boundary-scan Capabilities According to the JTAG Standard
  - Extensive On-chip Debug Support
  - Programming of Flash, EEPROM, Fuses, and Lock Bits through the JTAG Interface
- Peripheral Features
  - Two 8-bit Timer/Counters with Separate Prescalers and Compare Modes
  - One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture Mode
  - Real Time Counter with Separate Oscillator
  - Six PWM Channels
  - 8-channel, 10-bit ADC
    - Differential mode with selectable gain at 1x, 10x or 200x
  - Byte-oriented Two-wire Serial Interface
  - One Programmable Serial USART
  - Master/Slave SPI Serial Interface
  - Programmable Watchdog Timer with Separate On-chip Oscillator
  - On-chip Analog Comparator
  - Interrupt and Wake-up on Pin Change
- Special Microcontroller Features
  - Power-on Reset and Programmable Brown-out Detection
  - Internal Calibrated RC Oscillator
  - External and Internal Interrupt Sources
  - Six Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, Standby and Extended Standby
- I/O and Packages
  - 32 Programmable I/O Lines
  - 40-pin PDIP, 44-lead TQFP, and 44-pad QFN/MLF
- Speed Grades
  - ATmega644V: 0 - 4MHz @ 1.8V - 5.5V, 0 - 10MHz @ 2.7V - 5.5V
  - ATmega644: 0 - 10MHz @ 2.7V - 5.5V, 0 - 20MHz @ 4.5V - 5.5V
- Power Consumption at 1MHz, 3V, 25°C
  - Active: 240µA @ 1.8V, 1MHz
  - Power-down Mode: 0.1µA @ 1.8V

Notes: 1. Worst case temperature. Guaranteed after last write cycle.  
2. Failure rate less than 1 ppm.  
3. Characterized through accelerated tests.



**8-bit Atmel  
Microcontroller  
with 64K Bytes  
In-System  
Programmable  
Flash**

**ATmega644/V**

2593O-AVR-02/12



Figure 6: ATmega644



## Atmel ATmega640/V-1280/V-1281/V-2560/V-2561/V

8-bit Atmel Microcontroller with 16/32/64KB In-System Programmable Flash

### DATASHEET

#### Features

- High Performance, Low Power Atmel® AVR® 8-Bit Microcontroller
- Advanced RISC Architecture
  - 135 Powerful Instructions – Most Single Clock Cycle Execution
  - 32 x 8 General Purpose Working Registers
  - Fully Static Operation
  - Up to 16 MIPS Throughput at 16MHz
  - On-Chip 2-cycle Multiplier
- High Endurance Non-volatile Memory Segments
  - 64K/128K/256KBytes of In-System Self-Programmable Flash
  - 4Kbytes EEPROM
  - 8Kbytes Internal SRAM
  - Write/Erase Cycles:10,000 Flash/100,000 EEPROM
  - Data retention: 20 years at 85°C/ 100 years at 25°C
  - Optional Boot Code Section with Independent Lock Bits
    - In-System Programming by On-chip Boot Program
    - True Read-While-Write Operation
  - Programming Lock for Software Security
- Atmel® QTouch® library support
  - Capacitive touch buttons, sliders and wheels
  - QTouch and QMatrix acquisition
  - Up to 64 sense channels
- JTAG (IEEE® std. 1149.1 compliant) Interface
  - Boundary-scan Capabilities According to the JTAG Standard
  - Extensive On-chip Debug Support
  - Programming of Flash, EEPROM, Fuses, and Lock Bits through the JTAG Interface
- Peripheral Features
  - Two 8-bit Timer/Counters with Separate Prescaler and Compare Mode
  - Four 16-bit Timer/Counter with Separate Prescaler, Compare- and Capture Mode
  - Real Time Counter with Separate Oscillator
  - Four 8-bit PWM Channels
  - Six/Twelve PWM Channels with Programmable Resolution from 2 to 16 Bits (ATmega1281/2561, ATmega640/1280/2560)
  - Output Compare Modulator
  - 8/16-channel, 10-bit ADC (ATmega1281/2561, ATmega640/1280/2560)
  - Two/Four Programmable Serial USART (ATmega1281/2561, ATmega640/1280/2560)
  - Master/Slave SPI Serial Interface
  - Byte Oriented 2-wire Serial Interface
  - Programmable Watchdog Timer with Separate On-chip Oscillator
  - On-chip Analog Comparator
  - Interrupt and Wake-up on Pin Change
- Special Microcontroller Features
  - Power-on Reset and Programmable Brown-out Detection
  - Internal Calibrated Oscillator
  - External and Internal Interrupt Sources
  - Six Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, Standby, and Extended Standby
- I/O and Packages
  - 54/86 Programmable I/O Lines (ATmega1281/2561, ATmega640/1280/2560)
  - 64-pad QFN/MLF, 64-lead TQFP (ATmega1281/2561)
  - 100-lead TQFP, 100-ball CBGA (ATmega640/1280/2560)
  - RoHS/Fully Green
- Temperature Range:
  - -40°C to 85°C Industrial
- Ultra-Low Power Consumption
  - Active Mode: 1MHz, 1.8V: 500µA
  - Power-down Mode: 0.1µA at 1.8V
- Speed Grade:
  - ATmega640V/ATmega1280V/ATmega1281V:
    - 0 - 4MHz @ 1.8V - 5.5V, 0 - 8MHz @ 2.7V - 5.5V
  - ATmega2560V/ATmega2561V:
    - 0 - 2MHz @ 1.8V - 5.5V, 0 - 8MHz @ 2.7V - 5.5V
  - ATmega640/ATmega1280/ATmega1281:
    - 0 - 8MHz @ 2.7V - 5.5V, 0 - 16MHz @ 4.5V - 5.5V
  - ATmega2560/ATmega2561:
    - 0 - 16MHz @ 4.5V - 5.5V

2549Q-AVR-02/2014

Figure 7: ATmega2560

## C Technical Drawings

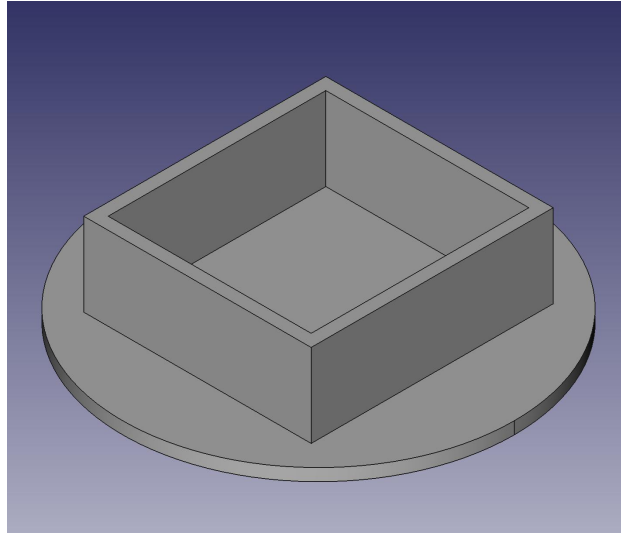


Figure 8: Electronic speed controller part bin