University of Idaho

CS Capstone Design

Capstone Portfolio

Drone Mission Planning Software

Team:
Mission Control

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Dr. Robert Rinker

Customer:
Brandon Ortiz

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1 Team Member Contact Information

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David Klingenberg	(208) 310-9657	bigwookiee@Gmail.com
Emeth Thompson		thom5468@vandals.uidaho.edu
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© based microcontrollers found on ardunio 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

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

Type of Meeting
Initial Planning

Attendees
David Klingenberg
Taylor Trabun
Brandon Ortiz
Bruce Bolden

Topics

Topic	Responsible	Time (in minutes)
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

- 1505Meeting Started
- Discussed drone rebuild progress.
- Evaluated ESC bin for the drone.
  - Refer to figur 9 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

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:

4.3.1 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

Thrusday 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

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:

4.4.1 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

Thrusday 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

Thrusday 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

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 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

Thrusday 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

Thrusday 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

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 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 satick :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 FULL_STICK_LEFT_FORWARD   900
36 #define FULL_STICK_RIGHT_BACK     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 secttion. */
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,
        FULL_THROTTLE));
166   //Serial.println(map(val, 0, 100, ZERO_THROTTLE, FULL_THROTTLE));
167 }
168
169 /*  Set the ailerons. Use a range of -100 to 100. */
170 void set_ail (int val) {
171   if (val == 0)
172     aileron.writeMicroseconds(ZERO_STICK);
173   else
174     aileron.writeMicroseconds(map(val, -100, 100,
          FULL_STICK_LEFT_FORWARD, FULL_STICK_RIGHT_BACK));
175 }
176
177 /*  Set the  elevator. Use a range of -100 to 100. */
178 void set_elv (int val) {
179   if (val == 0)
180     elevator.writeMicroseconds(ZERO_STICK);
181   else
182      elevator.writeMicroseconds(map(val, -100, 100,
          FULL_STICK_LEFT_FORWARD, FULL_STICK_RIGHT_BACK));
183 }
```

```
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,
          FULL_STICK_LEFT_FORWARD, FULL_STICK_RIGHT_BACK));
191 }
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
        connections */
244     Serial.println(F("Ooops, no LSM303 detected ... Check your
        wiring!"));
245     while(1);
246   }
247   if(!mag.begin())
248   {
249     /* There was a problem detecting the LSM303 ... check your
        connections */
250     Serial.println("Ooops, no LSM303 detected ... Check your wiring!");
251     while(1);
252   }
253   if(!bmp.begin())
254   {
255     /* There was a problem detecting the BMP085 ... check your
        connections */
256     Serial.print("Ooops, no BMP085 detected ... Check your wiring or
        I2C ADDR!");
257     while(1);
258   }
259   if(!gyro.begin())
260   {
261     /* There was a problem detecting the L3GD20 ... check your
```

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

Problem Definition

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

Requirements:

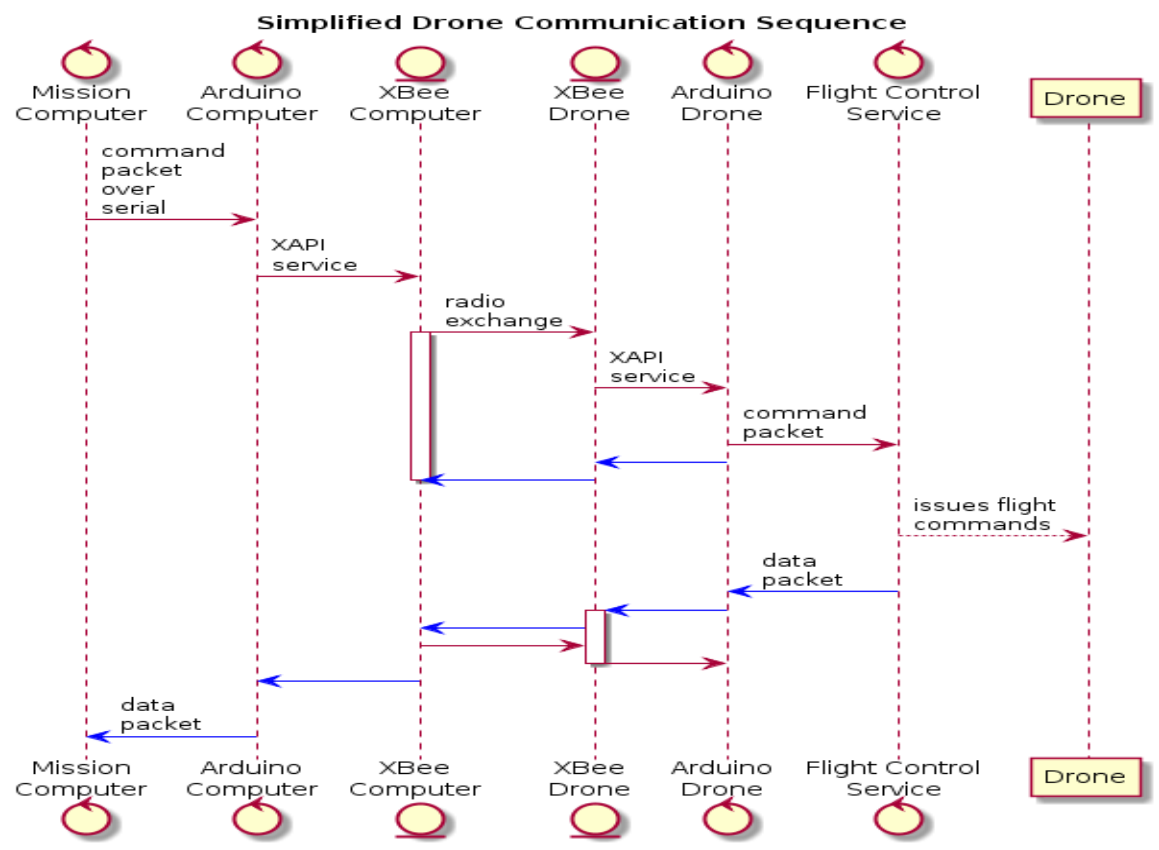
- A user-friendly interface
- Allow 3-dimensional mission planning
- Upload the flight plan using XAPI and XBee
- Allow manual override
- Implement drone hardware for flight control

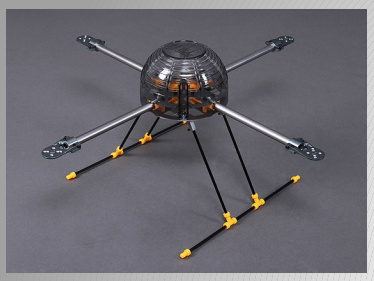
Communication Design

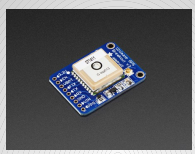
The communication system for this project must allow for commands to be sent from a computer to a drone.

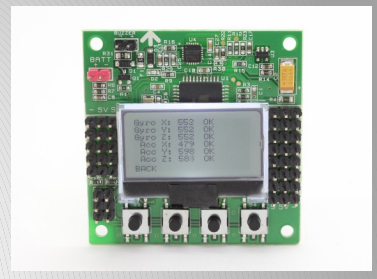
Requirements:

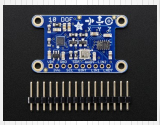
- XAPI and XBee hardware
- Specific TUN packets:
  - Manual drone instructions (altitude, direction, takeoff, etc..)
  - Settings
  - Acknowledgement of packet received
  - Heartbeat/status updates
  - Override (manual, land)
  - Flight plan protocol
    - Initialize for upload
    - Get instructions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

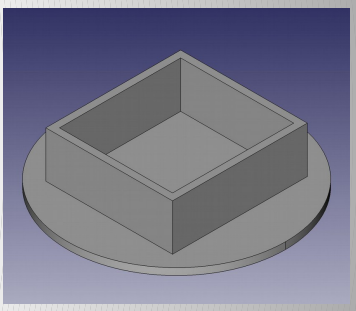

Simplified Drone Communication Sequence
Mission Computer
Arduino Computer
XBee Computer
XBee Drone
Arduino Drone
Flight Control Service
Drone
command packet over serial
XAPI service
radio exchange
XAPI service
command packet
issues flight commands
data packet
data packet
Mission Computer
Arduino Computer
XBee Computer
XBee Drone
Arduino Drone
Flight Control Service
Drone



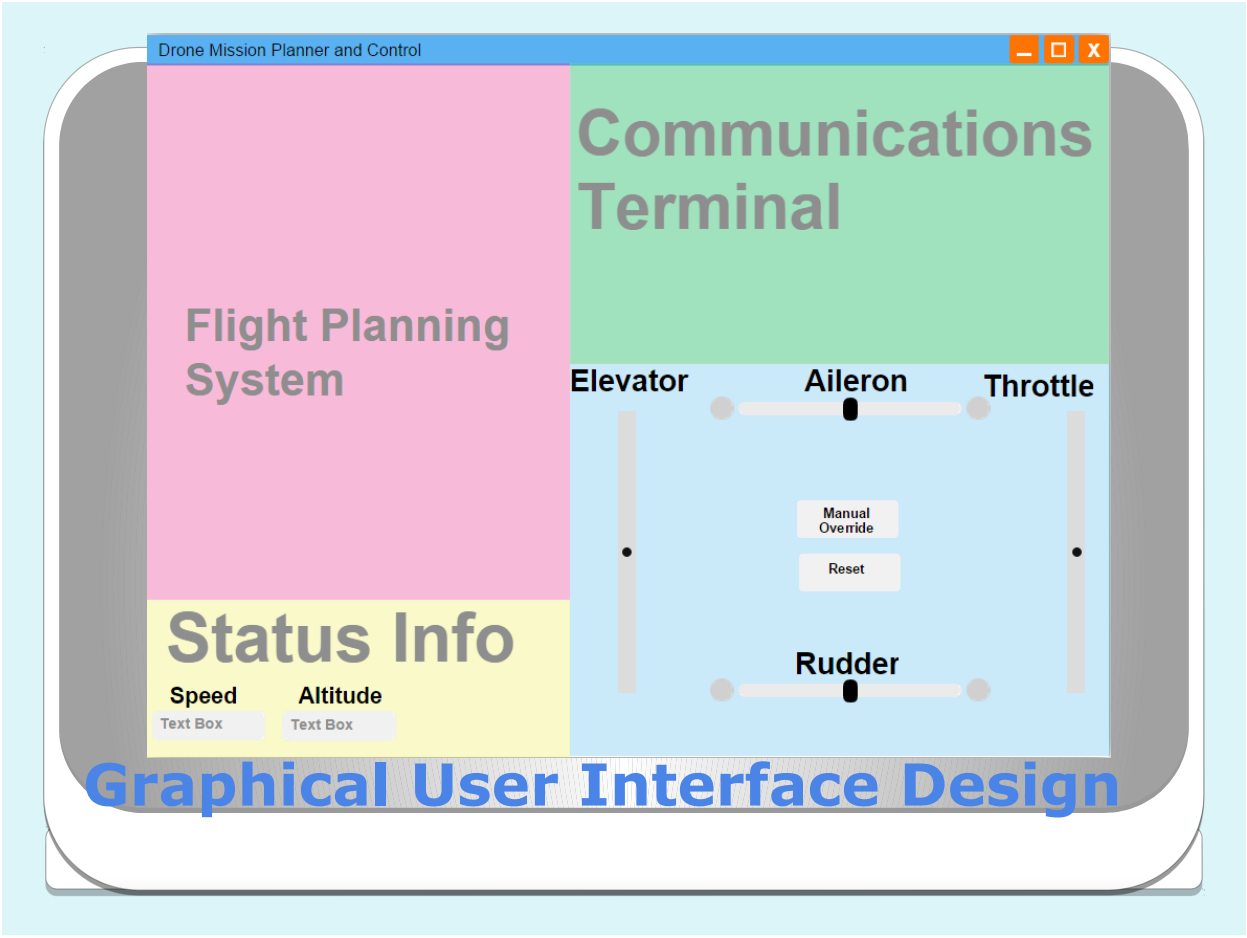


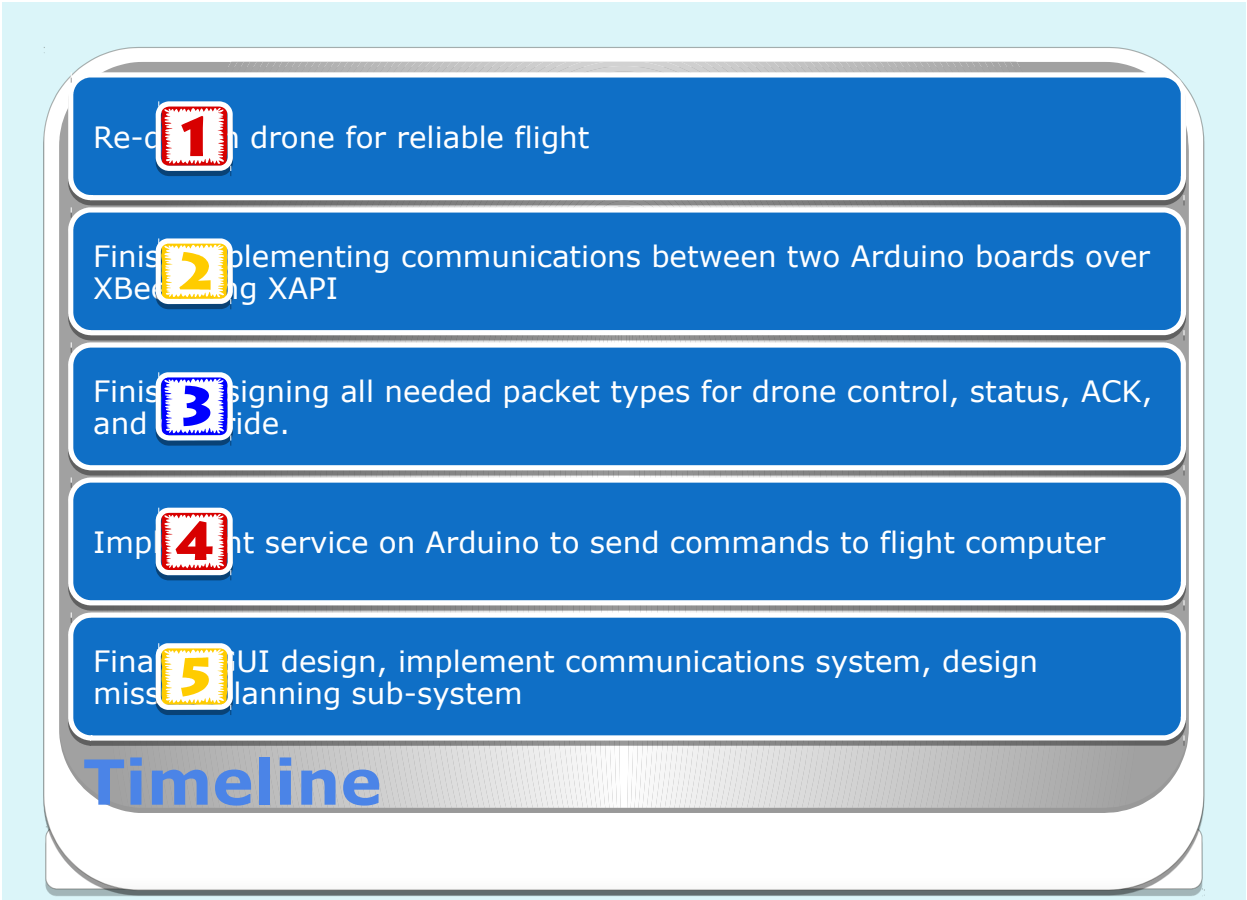






Drone Design


Drone Mission Planner and Control
Communications Terminal
Flight Planning System
Elevator
Aileron
Throttle
Manual Override
Reset
Rudder
Status Info
Speed
Altitude
Text Box
Text Box
Graphical User Interface Design


1
drone for reliable flight
2
lementing communications between two Arduino boards over
g XAPI
3
signing all needed packet types for drone control, status, ACK,
ide.
4
t service on Arduino to send commands to flight computer
5
UI design, implement communications system, design
lanning sub-system
Timeline

Questions or concerns?

Thank You

Drone Mission Planning Software: Design Document

Taylor Trabun

March 7, 2015

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.

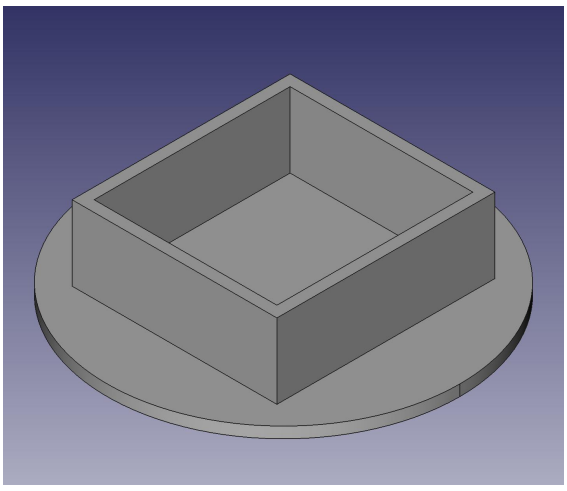


Figure 1: 3D sketch of partbin

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)

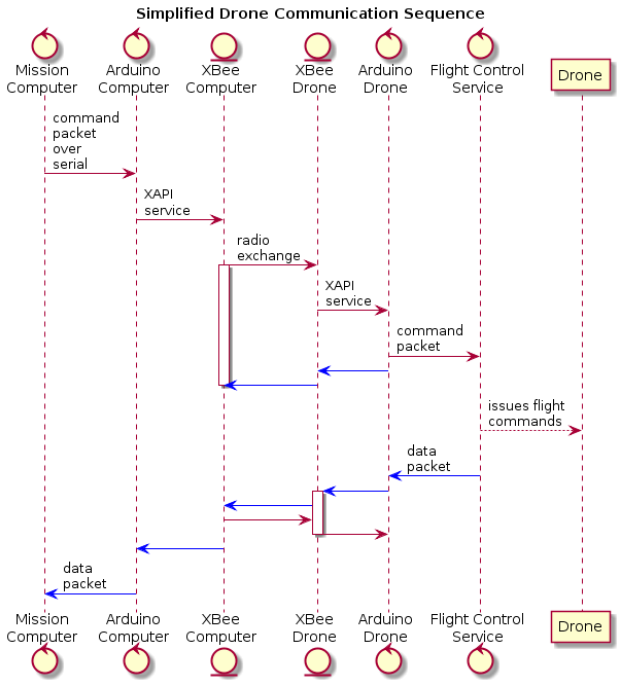


Figure 2: Overview of communications system

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.

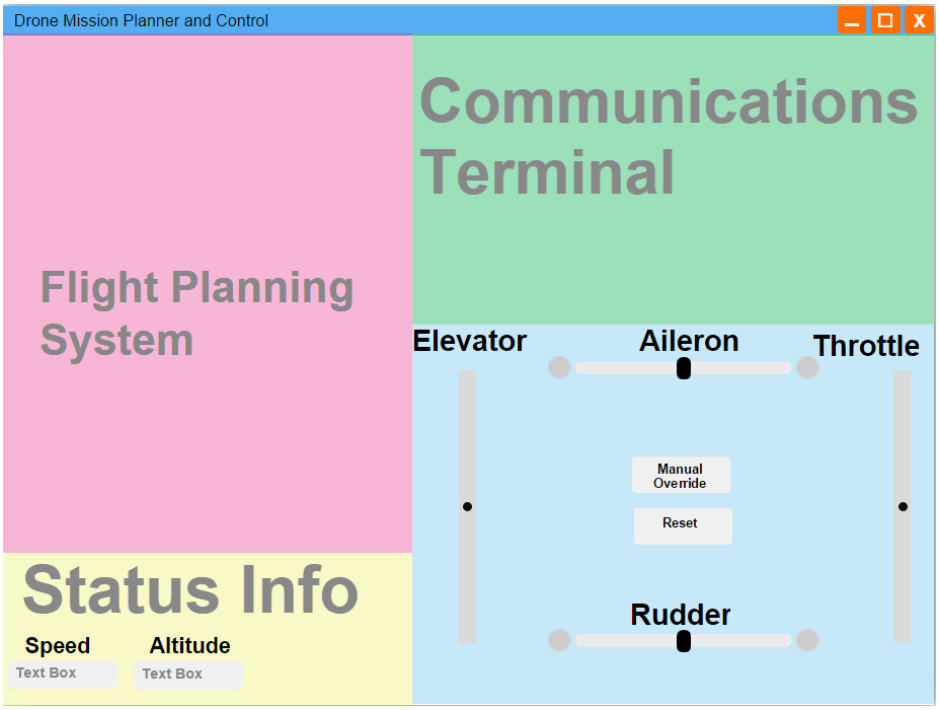


Figure 3: Graphical user interface mock-up design

Appendices

A Miscellaneous UML Charts

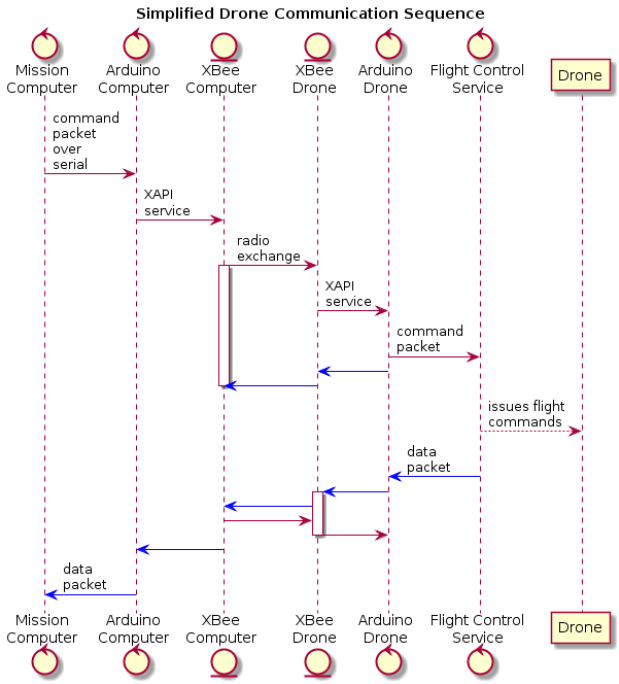


Figure 4: Communication Sequence

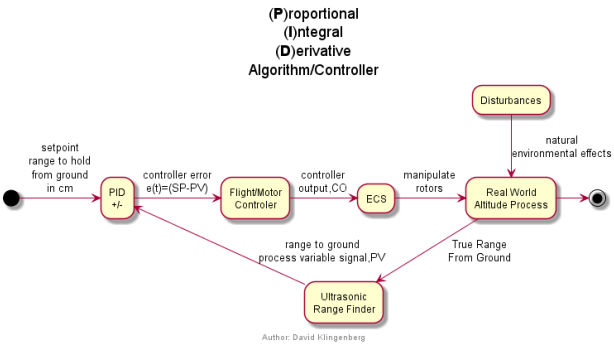


Figure 5: PID Controller

B ATMEL© Microcontrollers

Features

- High-performance, Low-power Atmel® AVR® 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 cyles: 10,000 Flash/100,000 EEPROM(1)(3)
  - Data retention: 20 years at 85°C/100 years at 25°C(2)(3)
  - 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

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 × 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
    - Endurance: Up to 64Kbytes Optional External Memory Space
- 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

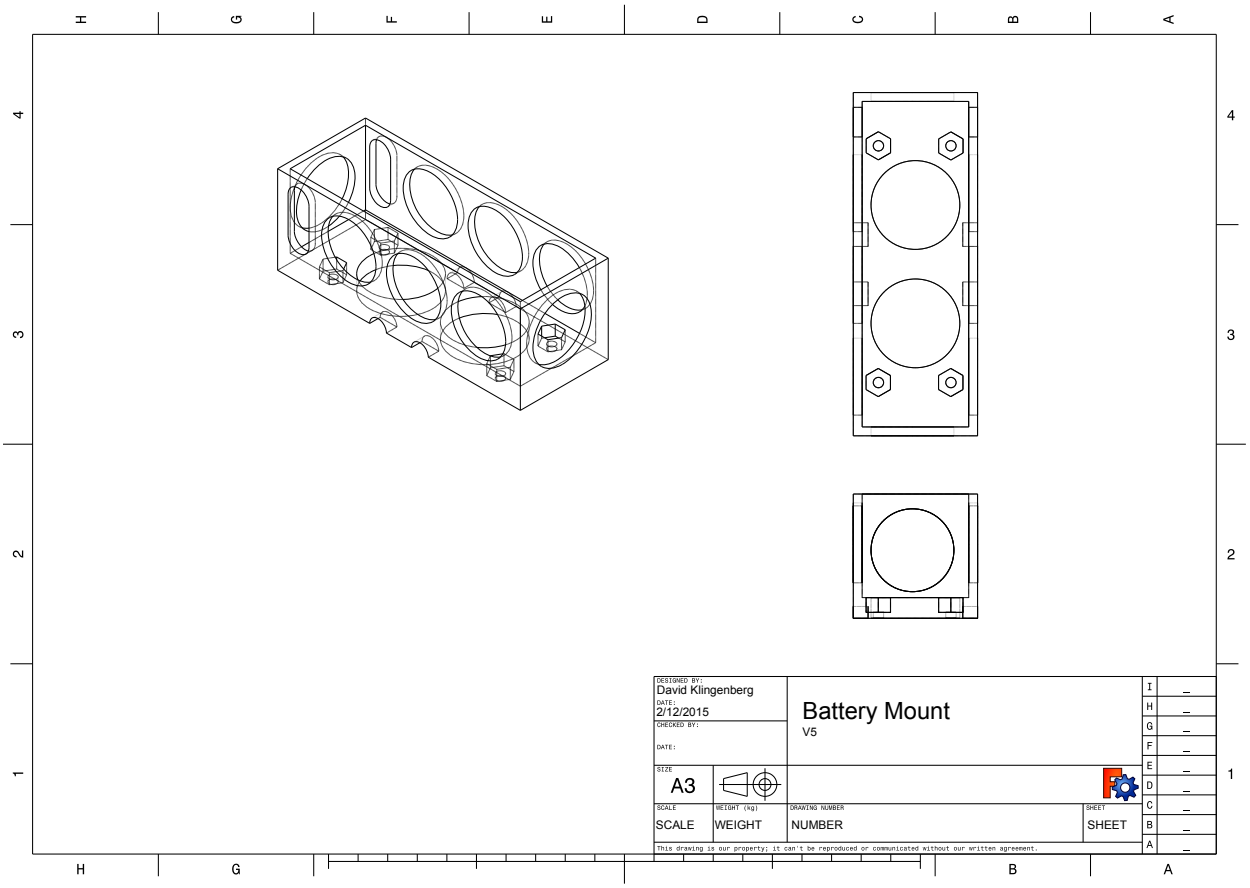


Figure 8: Battery Bracket

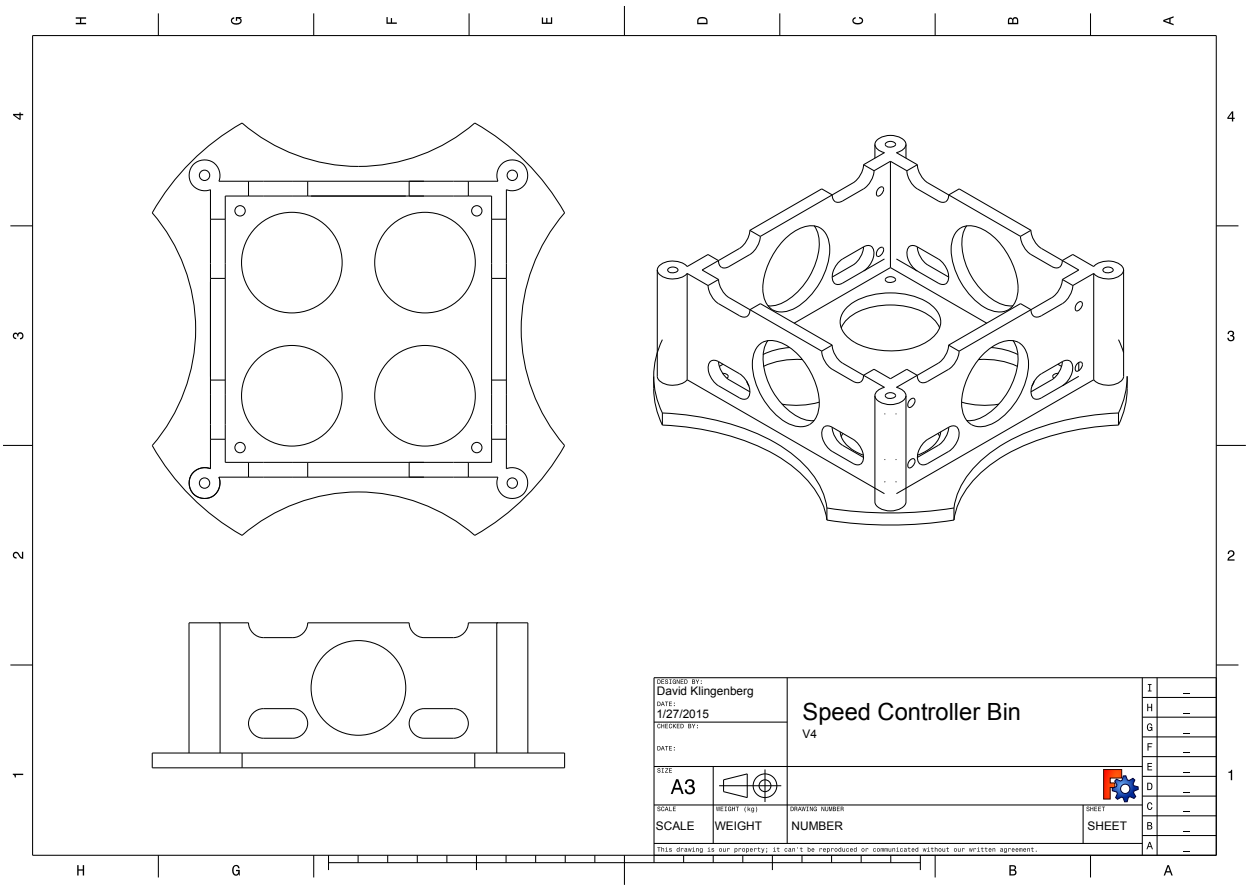


Figure 9: Electronic Speed Controller Bracket

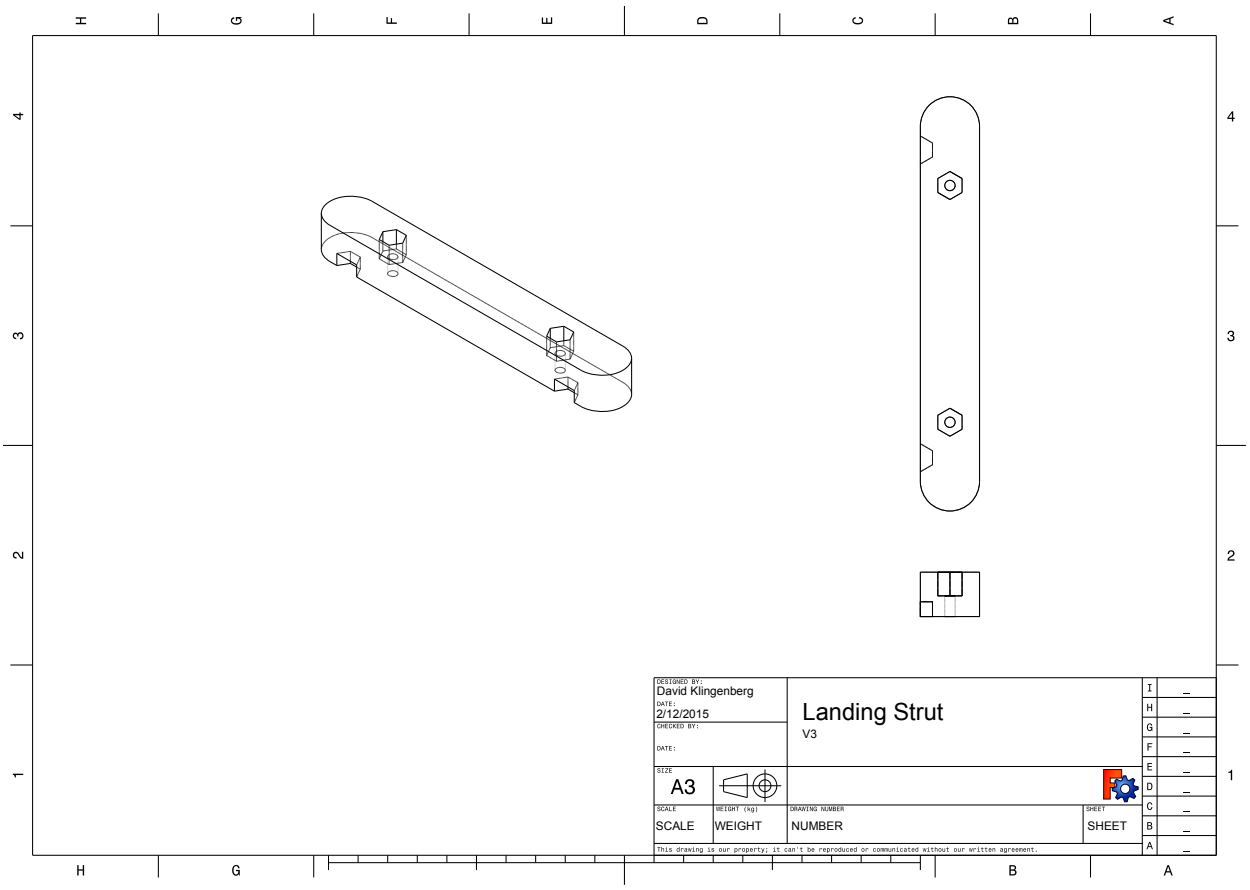


Figure 10: Landing Strut

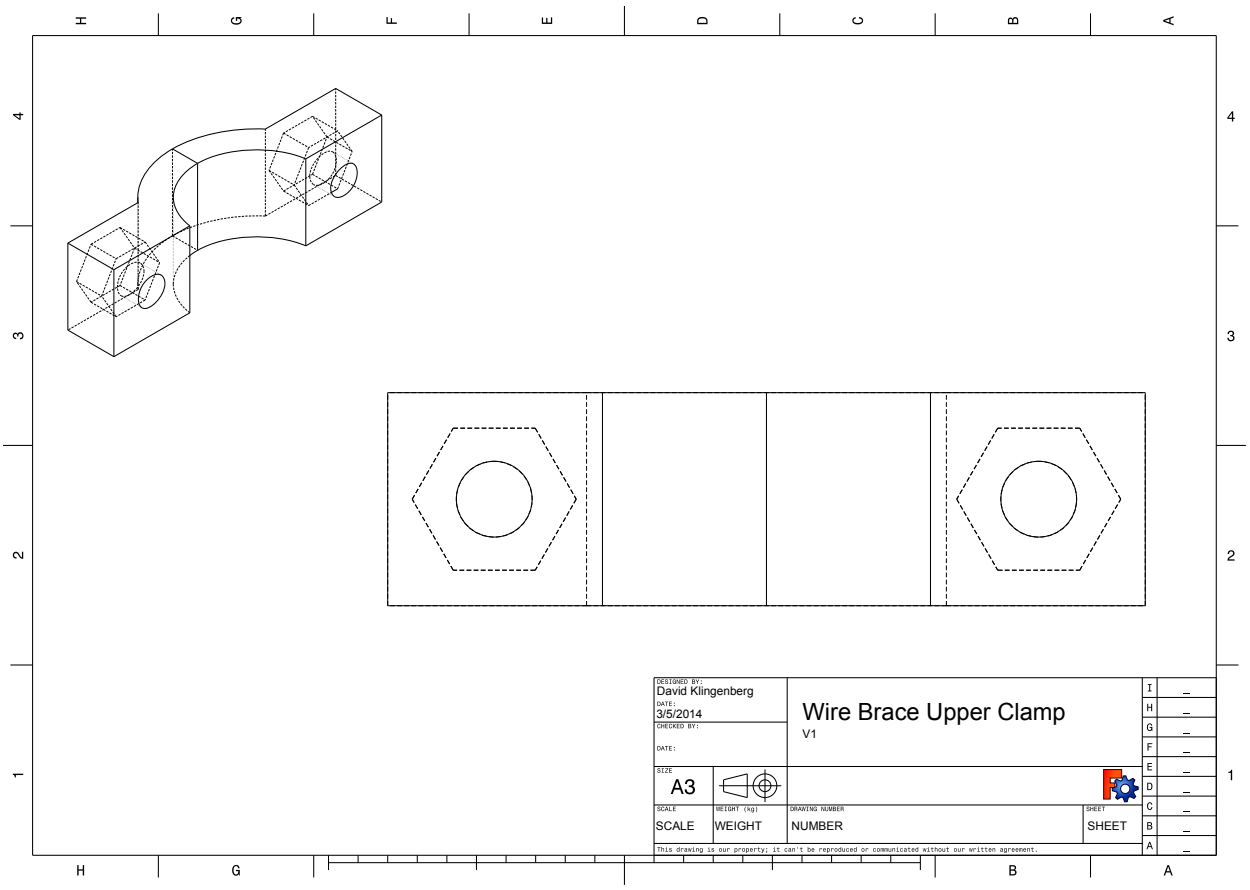


Figure 11: Wire Brace Upper Clamp

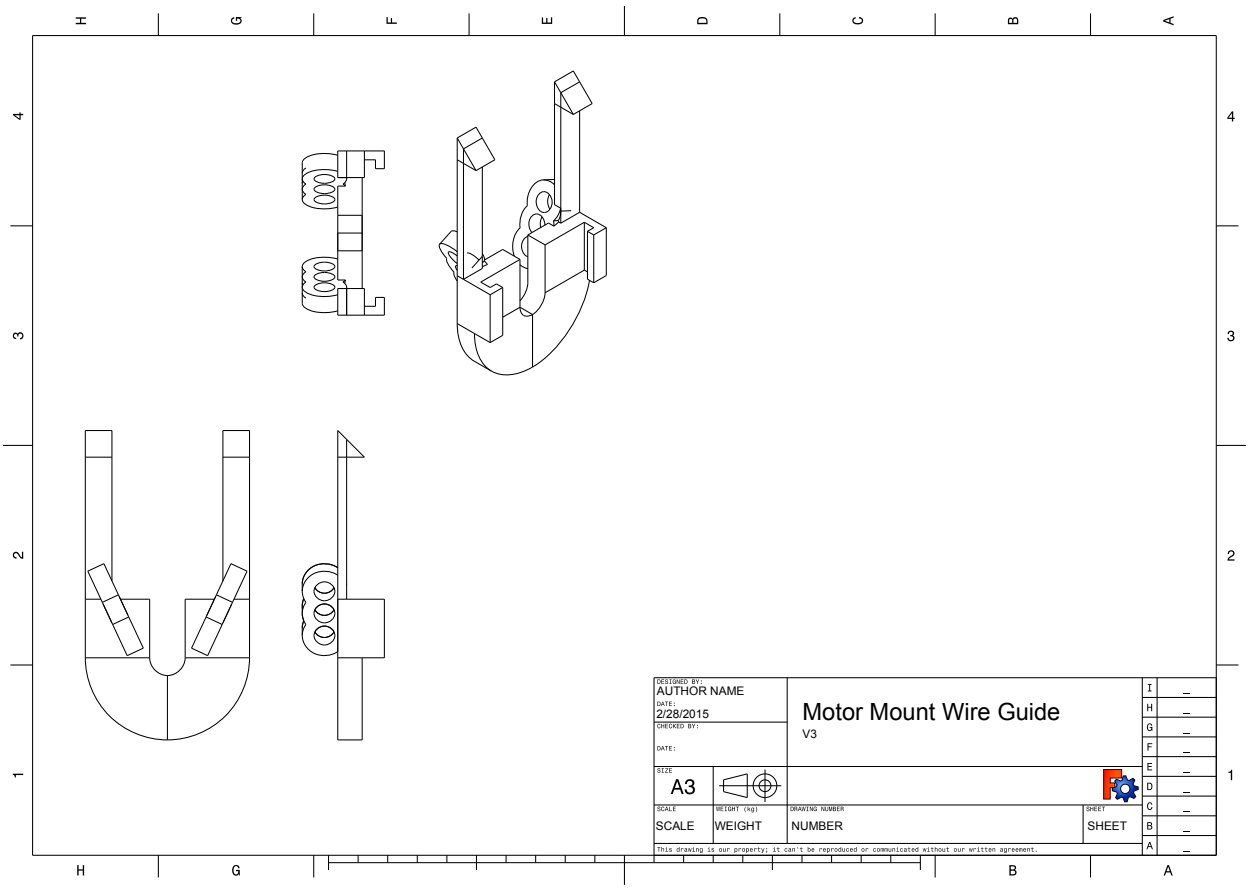


Figure 12: Motor Mount Wire Brace

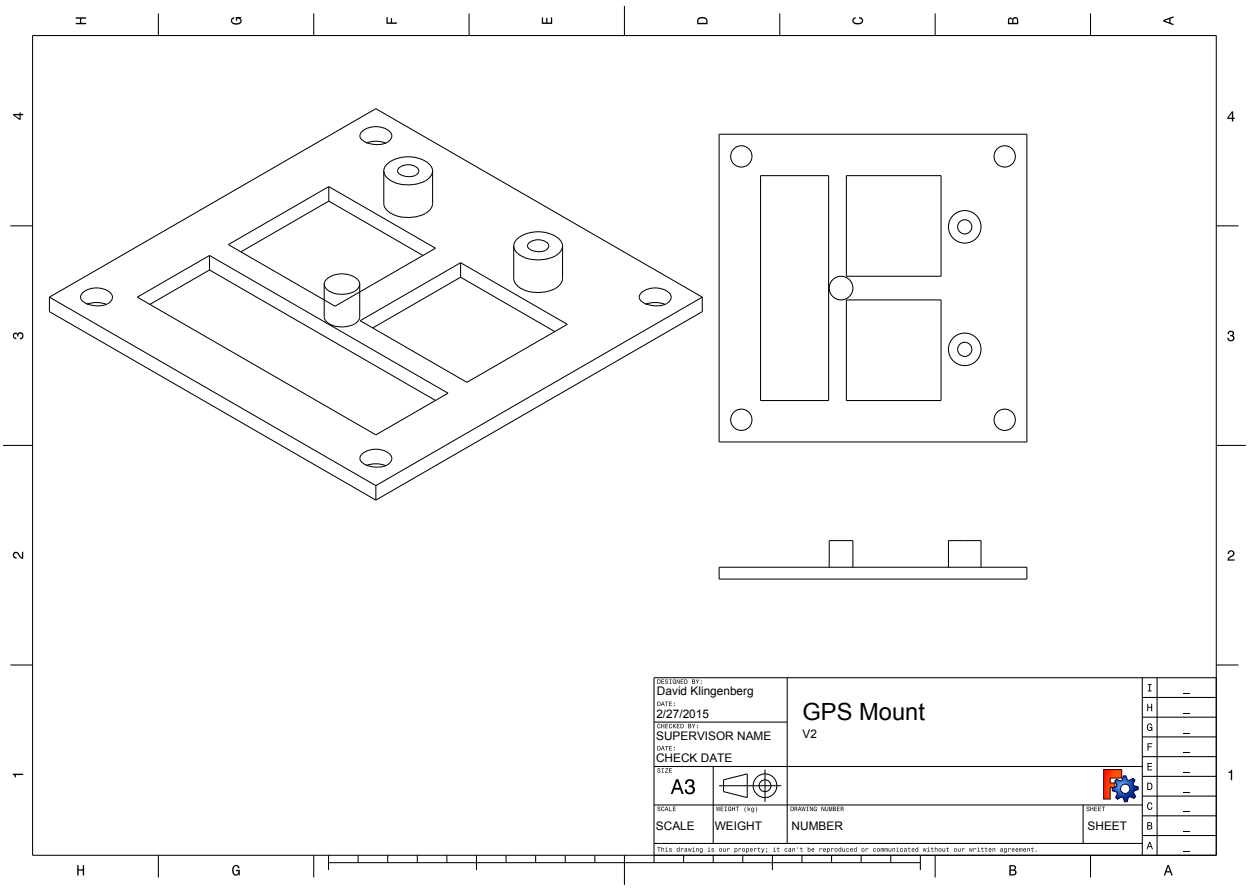


Figure 13: Gps Mount

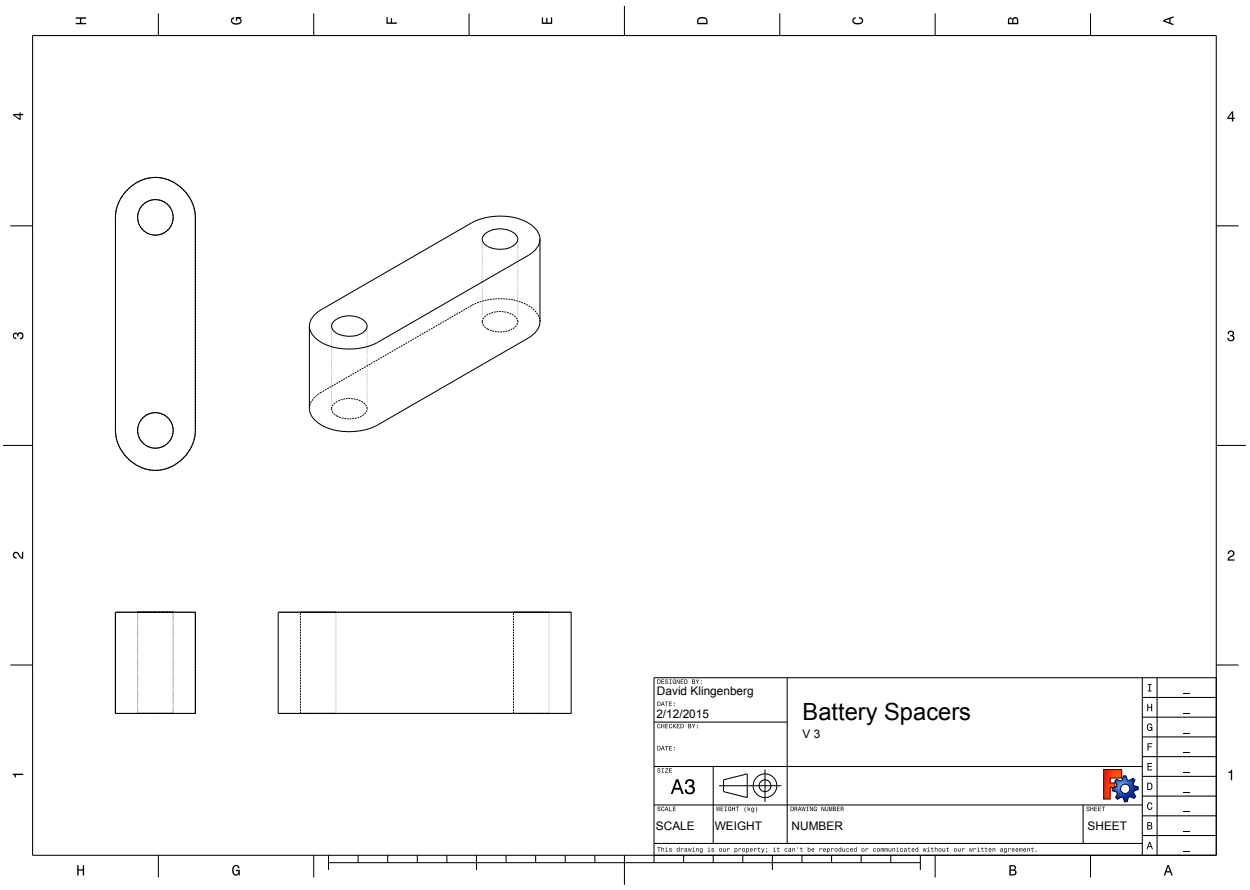


Figure 14: Battery Box Spacers

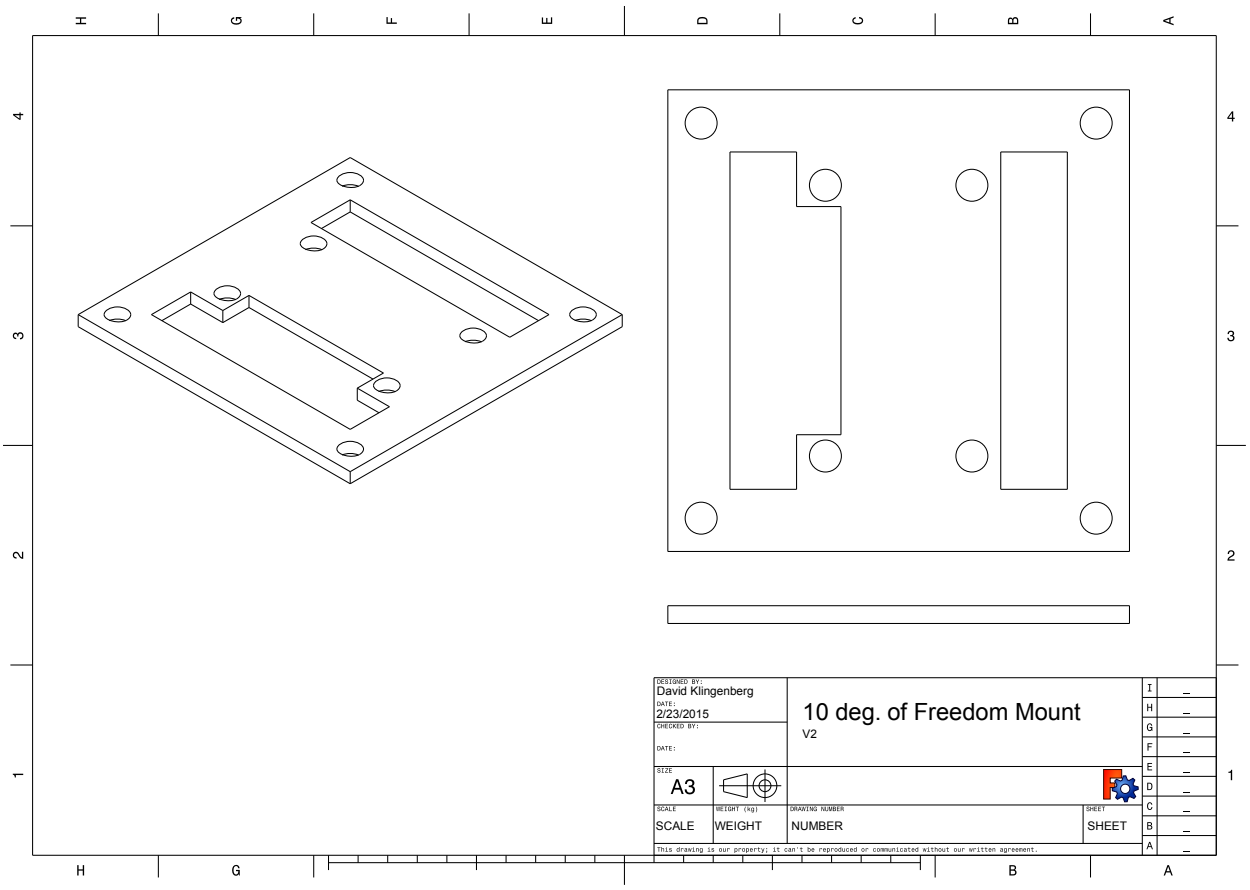


Figure 15: 10 Deg. of Freedom Sensor Platform

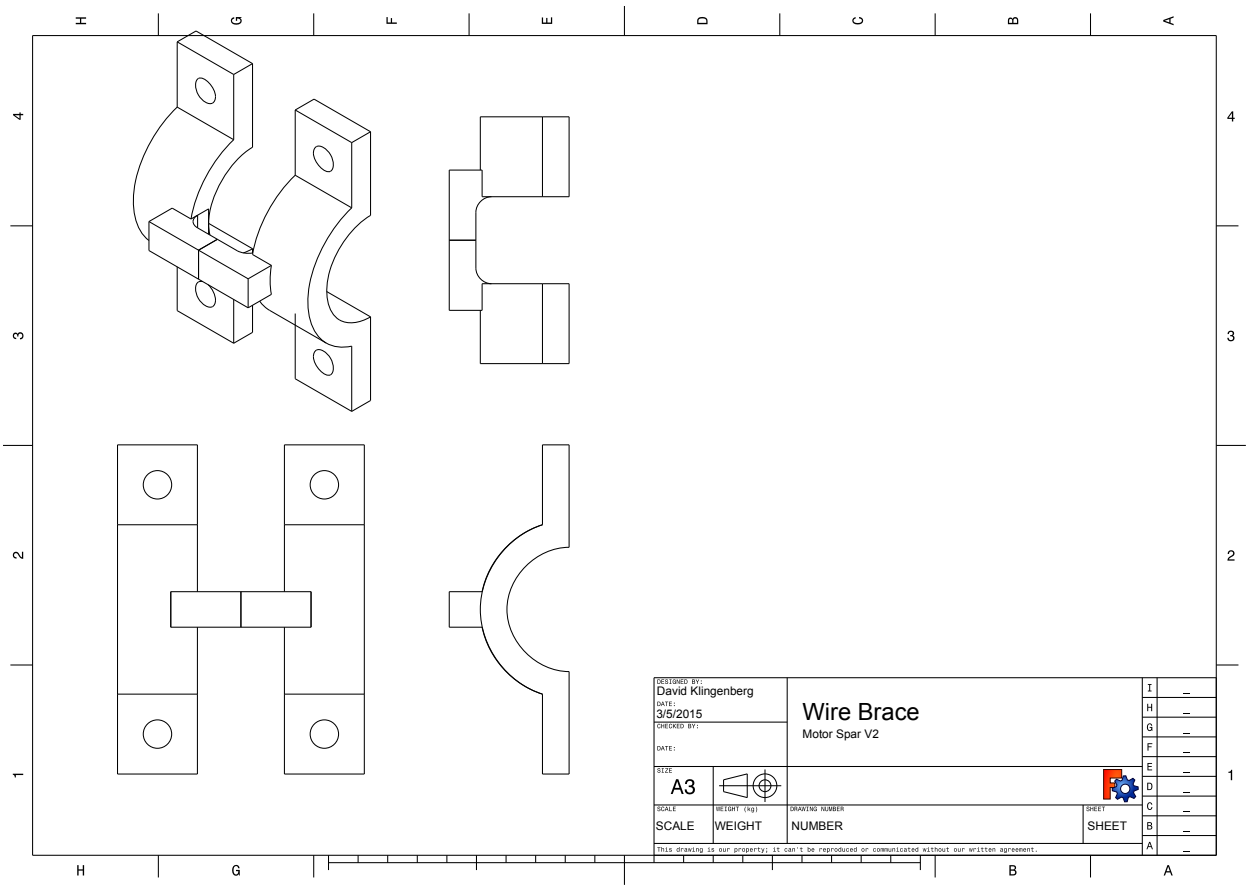


Figure 16: Wire Brace

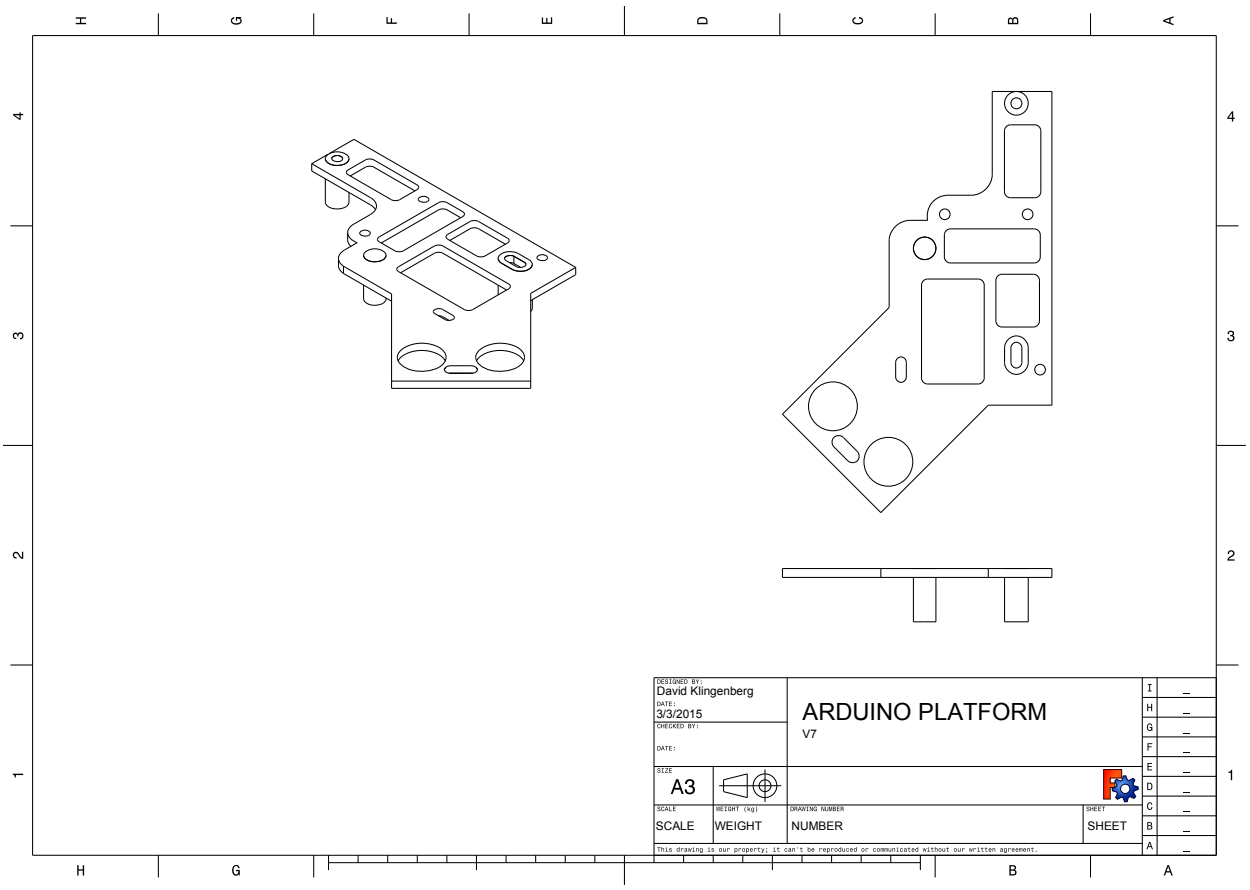


Figure 17: Arduino Platform

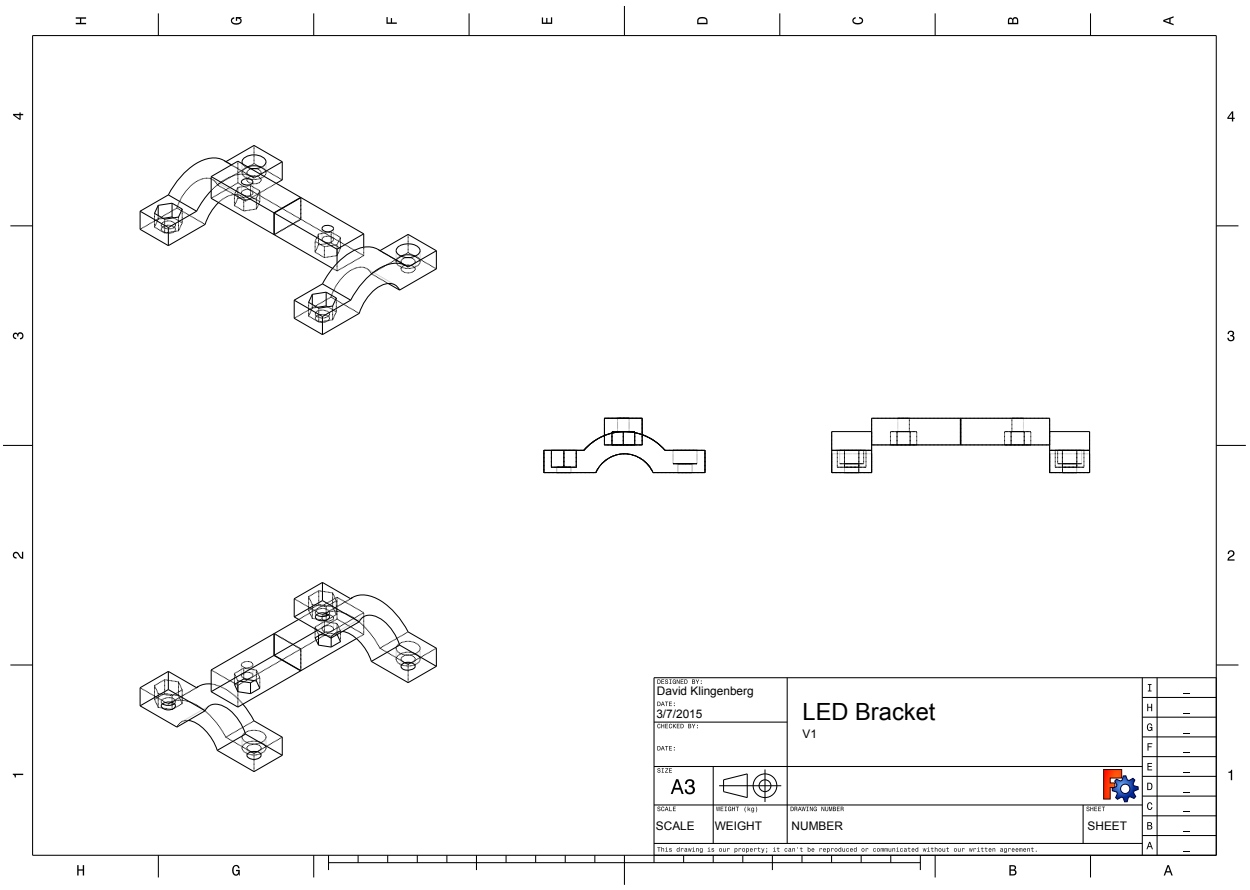


Figure 18: LED Bracket