

**Hardware Charter**

**Engineering Committee**

Terry Massey

QuadAutomotive Group

9/25/2012

Table of Contents

[Introduction 2](#_Toc336427670)

[Hardware Systems 2](#_Toc336427671)

[PD/PS Unit 3](#_Toc336427672)

[Flight Controller 3](#_Toc336427673)

[Inertial Management Unit (IMU) 4](#_Toc336427674)

[IMU SPI Master 4](#_Toc336427675)

[IMU Boot Initialization 4](#_Toc336427676)

[IMU Co-Processor 5](#_Toc336427677)

[Navigation Unit 6](#_Toc336427678)

# Introduction

The Hardware systems are the electronics systems that provide Power, Wireless Communications, Environmental Sensors, and Inertial Management Sensors. Through several iterations of research and development the following plan has been devised for the Hardware systems. One thing of note Hardware does not include Mechanical engineering that will fall under its own Charter. However Mechanical and Hardware will need to work together on mount points and potential Magnetic, Inductance and Capacitance interference that the mechanical systems could introduce based on materials used. The sensors used base their calculations on many different environmental factors. The Compass for one is greatly impacted by magnetic fields as it looks for the strongest magnetic field to find Magnetic north. The motors can be nowhere near the Compass as the inductive magnetic field produced by them will confuse the compass.

## Hardware Systems

The Hardware systems proposed for the Project Phase Alpha follow:

* PD/PS Unit
* Flight Controller Unit
  + Flight Stability
  + Inertial Management Unit (IMU)
  + Navigation Unit
  + Wireless Communication Unit

The Hardware systems proposed for the Project Phase Bravo follow:

* High Current Power Distribution Unit
* Balanced Battery Charger
* Enhanced Power Supply Unit
* Enhanced Navigational Unit
* Enhanced Inertial Management Unit (IMU)
* Custom High Current Electronic Speed Controller(ESC) Units
* Proximity Detection Unit
* Orientation Lighting System

The Hardware systems proposed for the Project Phase Charley follow:

* Dashboard Unit
* FM Radio with RBMS
* Orientation Lighting System

# PD/PS Unit

The Power Distribution and Power Supply Unit provide the input from the Li Poly batteries and produce an output of 1.8v, 3.3v, and 5V DC voltages at 800ma to power the other hardware systems.

# Flight Controller

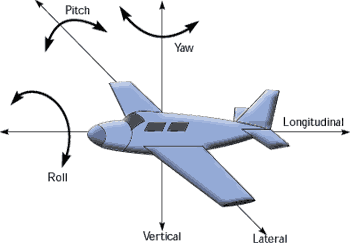
The Flight Controller provides the logic to control the motors providing a stable flight. It’s primary job it to read the IMU sensor data and calculate the optimum speed each motor should be turning at to maintain a smooth and stable flight. In addition to reading the data from the IMU it also gets offset signals to insure the vehicle moves to the intended Waypoint. There are four Variables set from the Navigation Unit. Each variable ranges from -1 to +1. With the exception of throttle the middle voltage of 1.65v DC is stable. Throttle goes from 0V DC motor Shutdown to 3.3V DC full throttle. The other three analog signals are Pitch, Roll, and Yaw. As shown in figure 1 to the right Pitch is the direction of travel that indicates if the vehicles is forward facing direction is pointed towards the ground or to the sky. Also shown in figure 1 is Roll which is the amount of left to right angling meaning is the left or right side pointed toward the ground and by how much. Third is Yaw; Yaw is like a flat amount of spin. The best way to describe it is a Top. A top stays level at a High Yaw in either direction. Now that would sicken a passenger of the vehicle so our goal is to keep yaw at a minimum except during heading changes. In fact the smoothest maneuver for a passenger would be a slight yaw rate to the right or left. In an airplane forward momentum is achieved typically through 0o Pitch, Roll and Yaw. In our vehicle that is not the case by adjusting the pitch slightly forward the vehicle would have its thrust to move forward. We could use a slight roll by itself and the vehicle would move in direction of the roll. A Combination of Roll and Pitch would allow continued forward momentum but alter the heading. The flight controller accepts these signals and applies offsets to the stable flight speeds based on the IMU.

Figure 1

# Inertial Management Unit (IMU)

The inertial management unit or IMU provides many sensors to both the flight controller and the Navigation Unit. There are two primary sensors in the IMU a 3 Axis Gyro and a 3Axis Accelerometer. The 3 Axis Gyro provides the Flight controller with information about the Rate of Pitch, Roll and Yaw. The X axis tells us Pitch, the Y axis is Roll, and the Y axis is Yaw. The 3 Axis tells us based on our Pitch, Roll, and Yaw the amount of g forces in X, Y, Z. In a stable Hover a stable flight would attempt to keep all three at 0g. This is not likely a true situation. In a flat parallel to the ground Hover the Z axis tells us if we are ascending or descending. Meaning we are going higher or Lower in altitude. The X Axis tells us if we are moving forward or backwards. And the Y Axis tells us if we are moving to either side.

Additionally the IMU has a Barometer. The Barometer translates to an Altimeter. Air pressure changes as we increase altitude. Based on temperature also provided by the Barometer we can calculate our altitude and allow the Flight controller and Navigation Units maintain a consistent Altitude.

The IMU also contains a 3Axis Tilt Compensated Magnetometer or Compass. The Magnetometer provides us with a measure of Lorentz force. Lorentz force is the force on a point charge due to electromagnetic fields. If a particle of charge q moves with velocity v in the presence of an electric field E and a magnetic field B, then it will experience a force. By taking all three measurements from the Magnetometer and combining them with the integrated 3 Axis Accelerometer in the Chip we can derive an accurate heading based on where Magnetic North is. One item of note is that if we want to calculate a true north vs. magnetic north heading we can apply an offset published yearly. The Phase Alpha version of the IMU will not take that information into account and will simply use the Magnetic north as a Point of reference. Magnetic north shifts annually based on variables outside the planet. Solar flares and weather patterns do alter it. However the deviation is not enough to have an effect on the Alpha Phase.

While not technically a Sensor the IMU also contains a GPS receiver. The GPS receiver serves many navigational purposes however it also provides a great deal of information that can be used by the Communication Unit, Flight Controller Unit and can provide a time reference for all systems that get data from the IMU. We get Current Latitude, Longitude and Calculated Altitude from the GPS as well is a Forward speed and heading.

Finally the IMU contains a Landing Proximity sensor. This sensor will be a Lazer or a Ultra-Sonic Ping sensor. Both work on the same concept and report back a distance. During landing the proximity sensor will provide distance to ground measurements and feed that to the Navigation Unit. That data will be used to make the smoothest possible landing.

## IMU SPI Master

The IMU will communicate with connected systems over SPI as the Master. This might seem backwards given that each of the connected systems might need data at different times. However the IMU Micro Controller will make this a huge consideration in how often it communications with each connected sub system.

### IMU Boot Initialization

On boot after a 5 Second delay the IMU will query each connected system to determine first who is connected to the Carrier Select Pin (CS), update Rate needed, and what Values the connected system needs. Based on the connected systems Timers will be setup to feed data based on the rate of data. However because the Flight Controller needs the highest rate of IMU data the IMU will set a priority for the Flight Controller to get the latest data.

## IMU Co-Processor

Because the IMU is talking to all the sensors it performs a bit of Math Co-Processing by offloading the calculations the Primary processor would normally handle off the sensor data. The IMU will send the Calculated Data instead of the Raw Sensor Data. For example the Magnetometer only provides the basic Lorentz force reading and does not provide a true heading the Navigational and Flight Control systems would need to calculate a heading based on those readings. By off-loading the calculation the IMU takes load of the other systems allows them to focus on the data they really need. This does not mean that the raw sensor data cannot be sent it simply means that it is not the default method of retrieving the data.

# Navigation Unit

The Navigation unit is an integral portion of the vehicle. It really makes achieving one of the Primary Directives of the Project possible. Our ability to simply put in a destination and the vehicle handles the rest is where the Navigation Unit comes in. It takes information from the IMU, Communications, and the Collision Avoidance Unit and sends signals to the Flight Controller to control the direction, speed and altitude of flight.

The Navigation Unit contains a level of storage that allows the unit to remember locations or Way Points. Then a waypoint can be recalled as a destination. The Navigation Unit works closely with the Communications Unit, IMU and Flight Controller. As an SPI Slave to the IMU it is feed Heading and GPS data.

# Wireless Communications Unit

The Communications Unit is a hardware Component for the Navigational Unit’s Communications Module. The Communications Unit’s Software elements are Covered under the Communication Charter. However from a hardware stand point it makes use of an off the shelf Transceiver Module that controls the Data Reliability and Transmission. However there is a Board that is designed to interface the XBee Transceiver Module and the Navigational Unit. This board provides LED indicators and connections via 9600 Baud Serial communications. An off the shelf solution might be Sparkfun’s “XBee Explorer Regulated” Breakout Board.

# Phase Bravo and Charley Hardware Units

To define the Specifications of the Modules in Phase Bravo and Charley would be premature at this point; particularly with regard to the PD/PS Unit. Findings and engineering needs for the Power will depend on components chosen. Scaling up the project to the level required in Phase Bravo and Charley will require some considerable thought. I can say that more redundant systems will be required as well as a greater current Power Distribution unit will be needed.