The pitot-static tube as well as the pilot's-eye-view camera installed in the ⅕ ASK-18 configured for Auto Soaring.

Auto Soaring

An introduction to this cutting edge technology in the world of RC soaring.

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Jun 12 · 7 min read

Introduction

In the RCSD May issue, Mr. Peter Scott introduced some very attractive applications of the Arduino microcomputer technology to RC airplanes. Here is another application of the microcomputer and sensor technology to RC airplanes wherein you can fly your RC glider in many styles including Auto Soaring.

I admit that the true fun of RC soaring is to predict where the thermal is, fly your glider into it and control the aircraft to stay within the thermal considering the best bank angle and other factors. But I believe that to experience and work with new technology is another interesting aspect of our RC hobby. After I completed the 1/3rd Mita construction (which some of you may have been reading about here in RCSD) I took on the challenge of using this new technology. Let me explain how you might experience this new technology as well.

Do I Need Computer Knowledge?

No special knowledge is required. What is required is to get a flight controller (FC), a GPS/compass sensor and, if necessary, a power module.

The FC is a module on which a microcomputer, memory, sensors — such as 3-axis gyro, 3-axis accelerometer, compass and barometer — are packed. The microcomputer calculates and sends commands to servos by executing the program stored in the memory and using data from the sensors. The gyro determines the attitude of the plane, the compass its heading, the accelerometer measures X,Y and Z directional accelerations and the barometer measures the aircraft's barometric altitude. Taking GPS data, the FC knows where the aircraft is and its velocity vectors in relation to the earth.

There are many kinds of FCs available, many of which are listed in the *ArduPilot Hardware Options* listed in the the *Resources* section at the end of this article.

What Kinds of Flight Are Possible?

You can fly your airplane in many regimes of flight. These are referred to as flight modes. The flight modes are grouped in two categories: assisted flight and autonomous flight.

In the assisted flight modes, the FC assists you by increasing aircraft stability or maintaining its attitude so you can fly it much more easily than fully manual flight. Straight and level flight is a typical mode of this assisted group. You can fly your aircraft straight and level even in a harsh wind. There is also acro mode, circle mode and others from which to choose.

In the autonomous flight modes the aircraft flies autonomously, which is to say with your hands entirely off your RC transmitter's controls. The FC assumes all responsibility for controlling the aircraft according to the specified mission. It can even automatically take off or land and fly through specified waypoints on a map. The autonomous flight mode in which we're interested, of course, is Auto Soaring.

What Program Is Used?

The program used in conjunction with the FC is *ArduPilot* which is free, open source software. If the FC you purchase does not have *ArduPilot* installed, you are free to download it and load it into your FC.

The Ground Control Station

One more element is required, which is the Ground Control Station (GCS). This is a normal PC with special software such as *Mission Planner* or *QGroundControl* installed (see *Resources* section, below). Both of these packages are also free and open source and you can download either one and install it. The GCS is used to download the *ArduPilot* program, calibrate sensors, calibrate the RC transmitter's sticks throw ranges and assign flight modes to the RC transmitter's switches, for example. If you want to fly your aircraft through predefined waypoints, you can use the GCS to specify these waypoints using Google Maps along with altitudes and flight speeds. These mission data are uploaded on the FC using a USB cable before flight and stored in the memory.

If you connect telemetry devices on both PC and aircraft, you can communicate with the aircraft while it is flying. You can monitor its flight path on a map, check its flight speed, altitude, attitude, heading. You can even change control parameters mid-flight.

The FC has a micro SD card and stores various flight data such as position, speed, altitude, attitude, RC inputs, servo outputs, battery voltage and current for the motor. You can download these log data with the GCS and analyze these data after flight.

Auto Soaring Flight Parameters

There is a parameter SOAR_ENABLE in the *ArduPilot*. When you set this parameter to 1, the glider will Auto Soar. With this parameter, you must specify additional parameters which define the Auto Soar profile:

SOAR_ALT_MAX and SOAR_ALT_MIN define the thermal hunting maximum and minimum altitude. Flight is limited to within these altitudes. SOAR_ALT_CUTOFF is the altitude where the motor is cut off and the glider begins gliding. If the glider can't find any thermals and its altitude reaches the SOAR_ALT_MIN, the motor automatically turns on and the glider begins to climb again. During gliding, when the aircraft determines by the data from accelerometer and barometer that it gains vertical speed more than SOAR_VSPEED, it starts auto thermal centering with bank angle SOAR_THML_BANK and soars with the thermal. The parameters SOAR_POLAR_B and SOAR_POLAR_CD0 are the polar curve coefficients of the glider.

How To Get Started

Here is a high level overview of the steps required to setup Auto Soaring:

1. Acquire the hardware (FC, GPS/compass, power module, telemetry devices).
2. Install this hardware and connect them with your RC receiver and servos.
3. Download the GCS and install on your PC.
4. Download the *ArduPilot* software and install on your FC.
5. Setup your hardware (sensor calibration, RC stick calibration for example).
6. Flight test in various flight modes.
7. Set soaring parameters and you can fly Auto Soar.

You can find a detailed explanation of each step at the following site in the *User Manual* documentation found in the *Resources* section at the end of this article.

An Example

Let me show you my case study as an example:

The Glider

This is the glider I used to test the Auto Soaring. It is a 1/5th scale of the ASK-18 which has 3.2m wingspan and around 2Kg gross weight.

Photo 2: ⅕ scale ASK-18 by which I tested the ArduPilot Auto Soaring function.

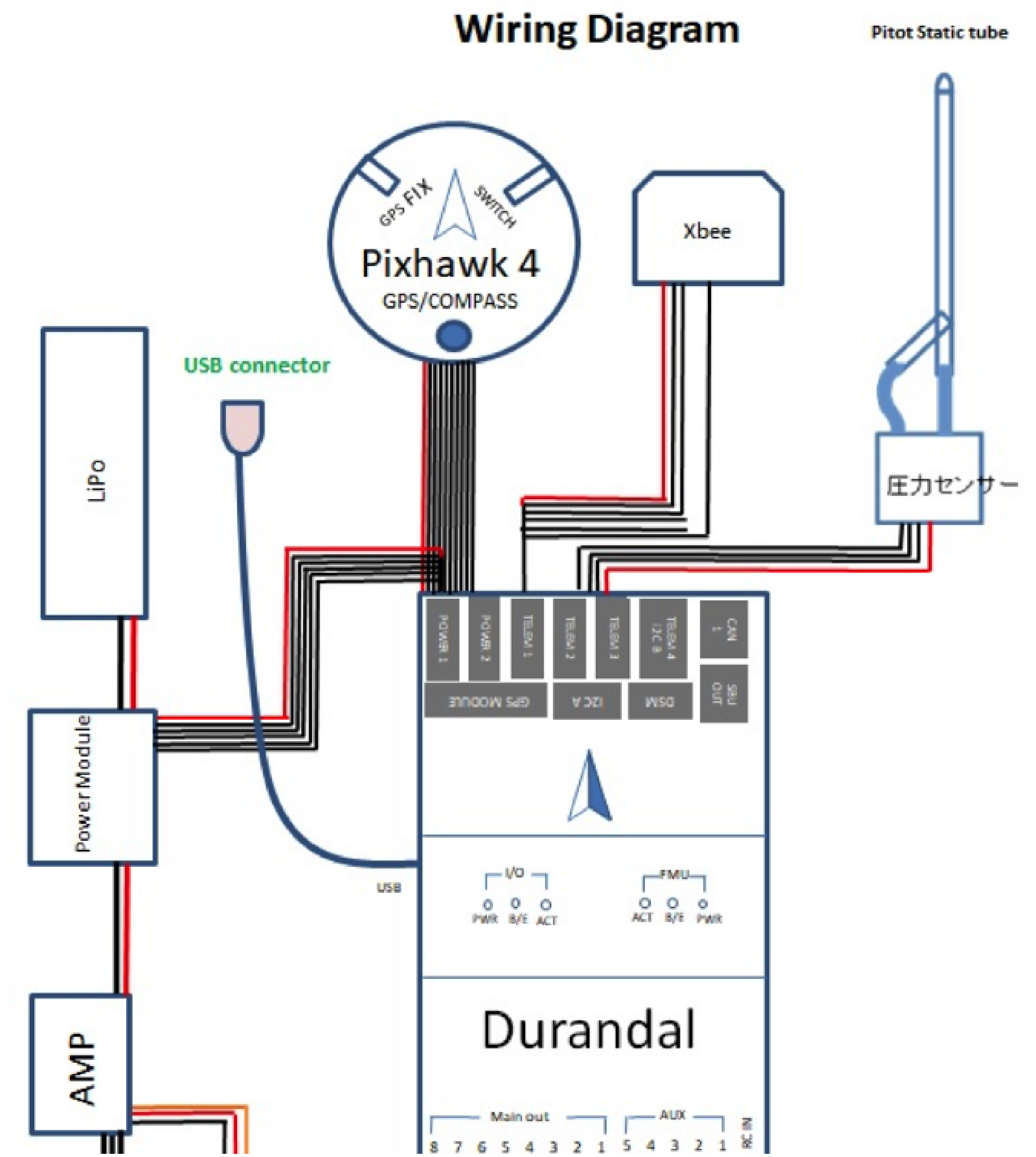
The Hardware

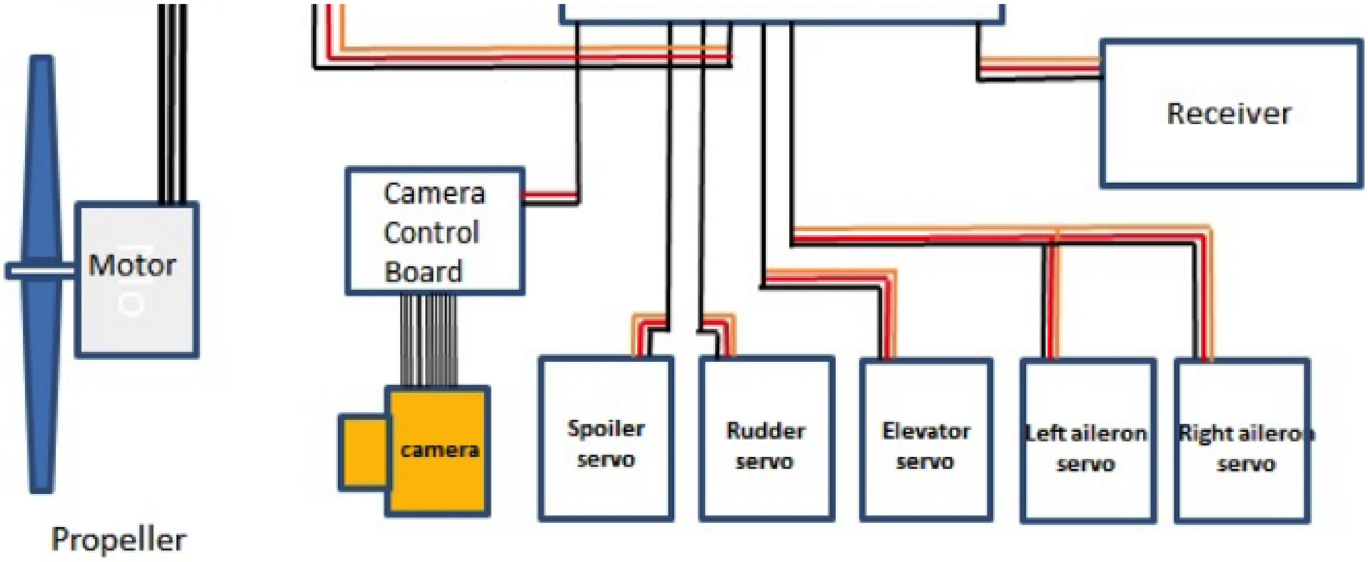
I purchased a Durandal FC, its power module and a Pixhawk 4 GPS/Compass module from Holybro. Photo below shows these this along with its connecting wires. Links can be found in the *Resources* section at the end of this article.

Photo 3: The hardware I purchased.

Wiring Diagram

The above hardware was installed on the ⅕ scale ASK-18 glider and was connected following the wiring diagram below. In addition to the above hardware I installed a pitot-static sensor for airspeed measurement, an Xbee telemetry device and a mini camera to take flight video.





Drawing 4: Wiring diagram for the ⅕ scale ASK-18. (image: Durandal)

Installation

This picture shows the FC, camera and pitot-static sensor installation.

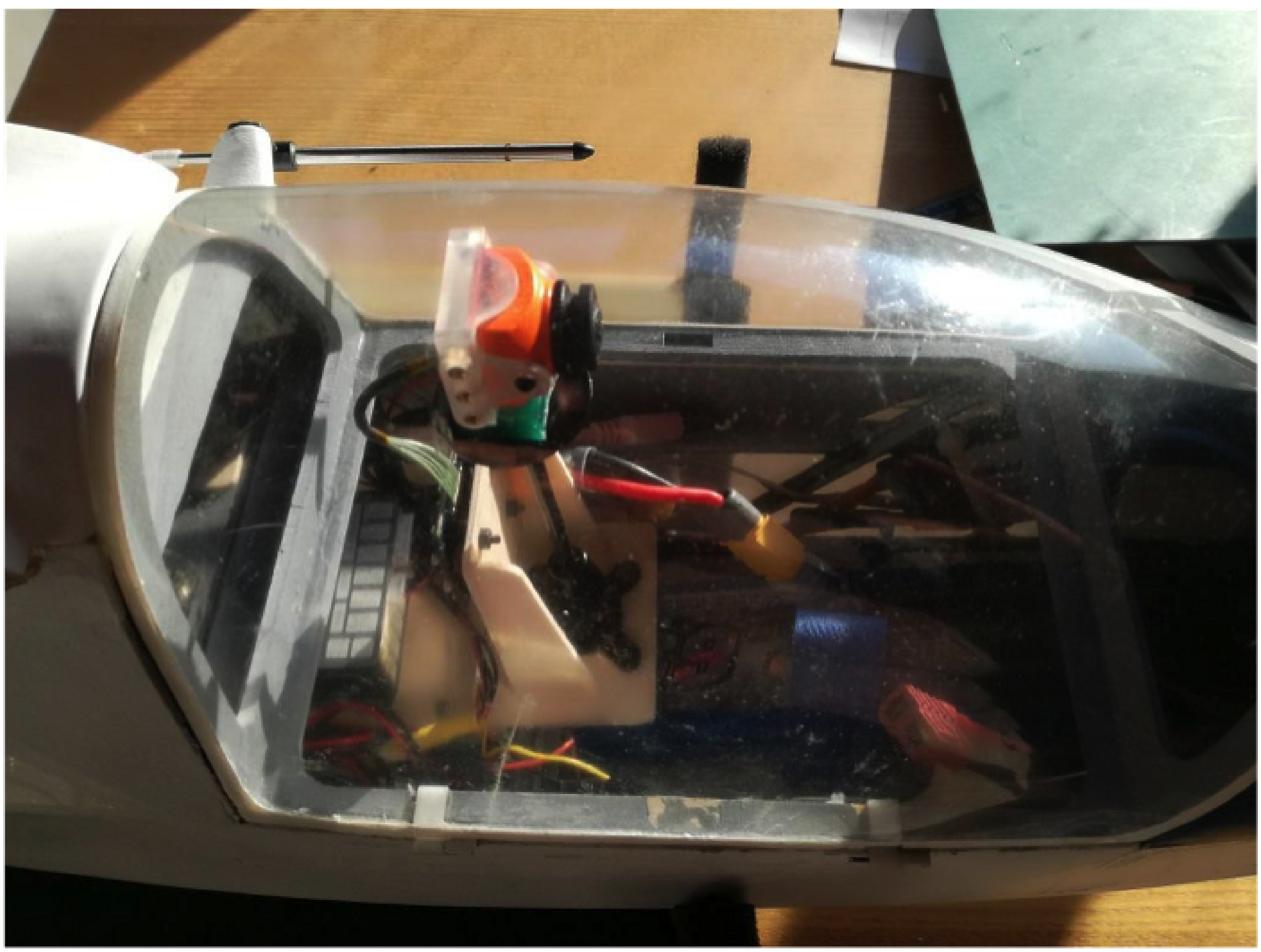


Photo 5: FC, camera and pitot-static tube installation.

Flight Test

With the above configuration, I conducted a series of *ArduPilot* Auto Soaring function tests.

Below is a case where the test was successful. This is the flight path the ASK-18 flew which was stored in the SD card of the FC.

Figure 6: Auto Soaring flight path.

The white dotted square lines are lines connecting the waypoints. The ASK-18 glided along these lines. The yellow flight path is the area where the glider soared automatically (Loiter mode).

There are three Loiter groups, and the top one is the most successful case, where the glider caught a medium strength thermal and climbed 45 meters during eight turns in about two minutes and 15 seconds..

In the middle altitude part, because it was not a strong thermal, it went up for the first 10 seconds or so, but after that, it slowly flowed to the north (left side of the screen) while decreasing the altitude at the descent rate of about 0.1m per second.

Below is the airspeed logged during this flight correlated with the flight mode.

Figure 7: Airspeed log.

In Figure 7, the vertical axis represents both the aircraft's airspeed (m/sec) — that's the orange line — and the numeric value of the flight mode, which is the green line. A flight mode of 5 is manual control, 10 is gliding flight, and 12 soaring flight. It is clear that both gliding and soaring are flying at the specified 10 m/sec.

There are many peripherals and free software in the *ArduPilot* ecosystem that provide many kinds of data analysis. Below is the flight replay animation using one of such peripheral software and flight log data.

Video 8: Flight replay animation.

What I have provided in this article is a high level overview which does not provide cover many of the details you will require. However, I hope this article has at least sparked your interest in this technology and that you take this next challenging step.

Resources

- AutoPilot Hardware Options
- User Manual Introduction
- Mission Planner GCS
- QGroundControl
- Durandal Flight Controller

- Pixhawk GPS Module
- Mita 3 Project

All images and video are by the author unless otherwise specified. Read the ***next article*** *in this issue, return to the* ***previous article*** *or go to the* ***table of contents****. Downloadable PDFS: just this article or this entire issue.*