Long Range FPV Project Overview

J. Striker





Objective:

Develop a devoted airframe for long range missions under tight budget requirements.

Equipment:

Ground station equipment

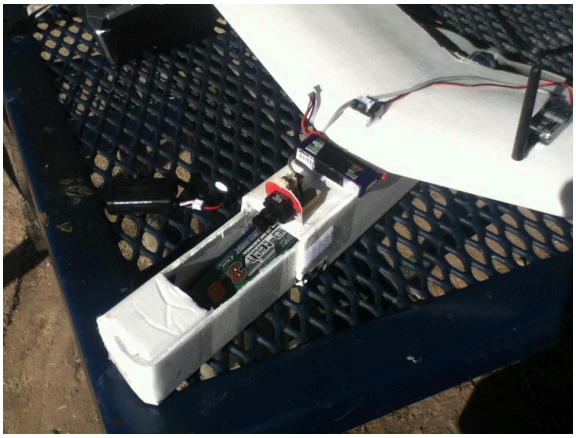
- Lawmate 1.3 Ghz video receiver
    - Visual Aerial Systems (VAS) Pepperbox antenna
    - 2200 mAh LiPo
- Dragonlink 433 MHz telecommand transmitter radio
    - Nagoya full wave monopole antenna
- Turnigy 9XR “transmitter”
    - 1800 mAh 3 cell LiPo
- Mission Planner Software
- RCtimer 913 MHz telemetry transceiver
- Fatshark Predator V2 vision system

Airborne Systems and equipment

- Skyhunter airframe
    - Turingy 3548, 1100kv Motor
        - 10x7 APC prop
    - HK 60 Amp ESC with 4 amp SBEC
    - Turnigy TGY-9018 Metal Gear Servos (3x)
    - Nano-Tech 3000 mAh 4 cell LiPo (2x)
- RCtimer ‘Arduflyer’ APM 2.5 flight controller
    - Running ArduPilot firmware
    - RCtimer remote 913 MHz telemetry transceiver
- Lawmate 1.3 GHz Video Transmitter
    - VAS ‘Mad Mushroom’ omni-directional antenna
- Dragonlink 9 Channel 433 MHz receiver
    - Dragonlink quarter wave dipole antenna
- Fatshark 600TVL CMOS camera
- Mobius HD camera with onboard DVR

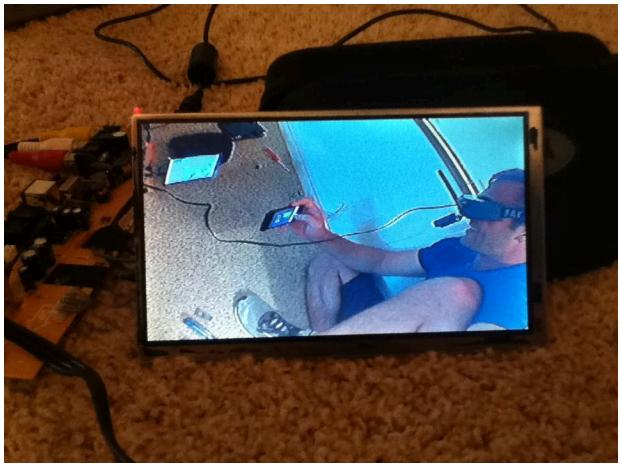
Initial Experimentation:

FPV “Synapse” design:

The FPV synapse was a scratch built airframe used to practice flying through the FPV camera without risking and expensive airframe. Build completely out of dollar foam board and spare electronics, a total of $4 worth of material was used in its construction.

FPV monitor constructed out of an old VCR and portable DVD player:




The screen from a portable DVD player was frankensteined together with the AV output from a VCR to create a potential FPV monitor. Although the monitor had been modified to run off a standard 3 cell LiPo battery and glare was minimal, outdoor performance was poor due to a dim back light.

Trade Study: Video Receiver Antenna

	Yagi	Helical 5 turn	Helical 3 turn	Pepperbox	Crosshair	Cloverleaf	Weight
Range	10	6	4	8	6	3	35%
Horizontal Beamwidth	1	3	2	9	8	1	30%
Price	5	4	4	2	4	5	20%
Portability	7	4	5	2	5	10	10%
Polarization Restrictions	5	10	10	10	10	10	5%
TOTAL	5.75	4.70	3.80	6.6	6.30	3.85	

Weight:

Because the mission statement was to reach a far distance and maintain the ability to fly over a large area, the range and beam width criterion were nearly equivalently weighted. Price was highly weighted as well as to reduce out-of pocket cost. Portability was taken into consideration because the most likely place for the ground antenna to be damaged is during transit. The differences in polarization were noted because my most frequent flying sites would be around mountains and other RF noise. Circular polarized antennas have a distinct advantage over linearly polarized antennas due to their ability to reject oppositely polarized noise made by reverberating signals that can be present in canyons or off around cliff faces.

Criteria:

Range grading criteria is rather simple; higher antenna gain theoretically results in more range. The desired beamwidth was a full 180 degrees, so candidates were rated based on the difference between actual and desired beamwidth: (actual angle – desired angle). Price values are scaled from highest to lowest cost, $150+ corresponding to a 1 and $0 corresponding to a 10. Portability was rated based on the antenna length and reflector area. Large reflectors and long antenna lengths reduced the score.

Conclusion:

The Pepperbox antenna represents the antenna with the most desired performance. Although the Pepperbox lacks in areas of portability and cost, its theoretical performance gains outweigh the risks involved with transporting a cumbersome antenna. Although it is the most costly antenna in the study, the cost savings from other areas of the project give a good reason to go for a quality antenna.

Trade Study: Long Range Airframe



X8



Skyhunter



Skywalker

	X8	Skyhunter	Skywalker 1900	Weight
Payload Volume	8	10	4	30%
Cruise Speed	8	6	4	25%
Glide	3	5	8	25%
Ease of Hand Launch	3	5	9	10%
Portability	2	5	8	10%
TOTAL	5.65	6.75	5.90	

Weight:

Payload volume is one of the most important aspects to consider when choosing a long range airframe. Payload space allows for more flexibility in the installation of batteries, autopilot hardware, and RF related equipment. Because the APM 2.5 board has an integrated manometer and barometer, it is imperative that the board remain isolated from high current wires and transmitters but remain contained within the fuselage to mitigate the effects of air velocity moving over the barometer. Cruise speed and Glide characteristics are equally weighted and of high importance because both characteristics are indicators of airframe efficiency. Hand launch ease was researched to help reduce prop related injuries and unsuccessful launches.

Criteria:

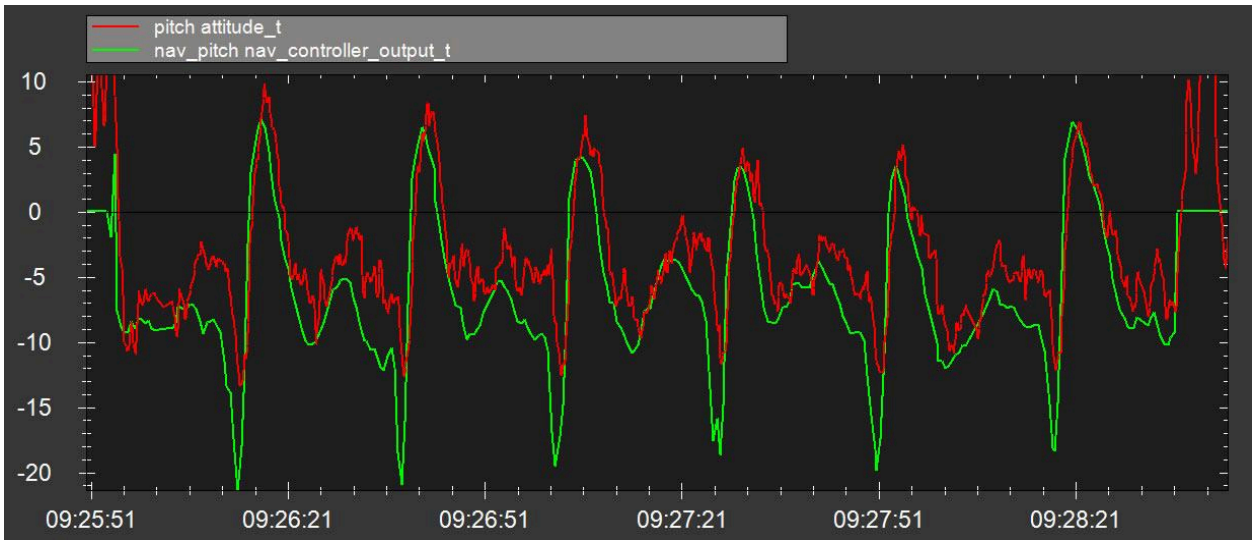
Payload Volume was rated based on manufacturer's specifications and battery size recommendations. Cruise speeds and stall speeds were researched via online forum discussions. Low stall speeds rendered more favorable glide characteristics (0 mph = 10 , 45 mph = 1). Portability was determined based on wingspan, and the model's ability to break down. A perfect score would require no breakdown and be able to fit in a car's trunk (50 in. length), a rating of 5 would require complete breakdown to fit the length constraint.

Conclusion:

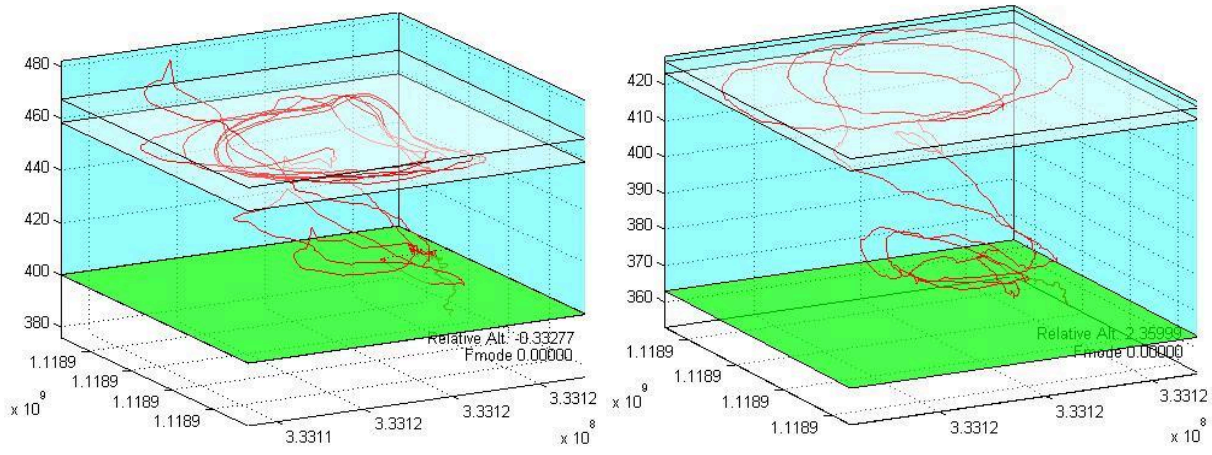
The Skyhunter is the clear choice given the grading criteria and their respective weights. Because all 3 of the airframes ran around the same price, the Skyhunter airframe was chosen for exhibiting ideal characteristics for long range flight while still being practical for transport and solo launching.

Aircraft Tuning Process

Tune Aircraft PID (Proportional, Integral and Derivative) controllers to improve disturbance reaction time while minimizing oscillations and system overshoot. An example being the error in target and “actual” pitch as measured by the IMUs:



Matlab analysis was used to measure the system overshoot while in full autopilot mode. By placing the aircraft in loiter mode, wind and turbulent disturbances could be easily analyzed by eliminating any disturbance by the pilot.
In addition to eliminating system error, steps were taken to eliminate navigation error as well:



One of the the most important autopilot aspects that needed to be tuned was the altitude hold ability. With the aircraft in loiter; telemetry logs from the aircraft were compiled into Matlab and used to analyze the error and variation in target altitude. Further adjustments to the PID

controllers, maximum/target bank angle, loiter/turning radius, and target airspeed were made to minimize the target altitude error.