

# **Fixed-Wing Survey Drone**

## **Project Proposal**

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## Project Summary

This project will develop an unmanned aerial system, commonly referred to as a “drone”. The drone will start as a commercially-available radio-controlled airplane. The addition of microcontrollers, cameras, and other sensors will allow the aircraft to operate autonomously. The purpose of the drone is to perform aerial imaging surveys of user-specified regions, such as crop fields, for use in precision farming applications. An important feature of our drone is its autonomous nature. The operator first defines the boundaries of the survey area via GPS coordinates. Next, the drone is hand-launched somewhere near the field. The drone determines its location (via GPS) and calculates a navigational route allowing it to image the entire area. The drone lands in the location from which it was launched, or some other user-specified location. The images are assembled into a single large image, which is then emailed to the user, along with a notification that the drone is ready for retrieval.

## Detailed Description

The drone will accept GPS (global positioning system) coordinates of a user-selected area of land. In this way, a particular region can be specified for the drone to survey. Using that data, it will generate its own route to navigate the field and capture GPS-registered images of the entire area. The drone will be entirely autonomous, piloting itself on the self-generated flight path, with the option to take manual control at any time. It will also have the ability to detect obstacles (such as towers) during flight, and maneuver to avoid those obstacles. When the survey is complete, software will assemble all of the images it has captured into a single, high-resolution image of the entire area. The GPS data stored with each image will allow the images to be assembled into a single large image. After surveying the entire area, the plane will land where it was launched, or at another user-specified (via GPS) location. The drone will contain a wireless data link to enable internet access via a consumer wireless network. After landing, the drone will email the user that the survey is complete and that the plane is ready to be picked up. A link to the high-resolution image will also be included.

The survey drone will have the following components:

- Ready-to-fly, commercial, radio control airplane (hand launched, electrically powered, servos and radio receiver included)
- Two digital cameras: one for high-resolution imagery, and another for obstacle

avoidance

- Two microcontrollers: one for high-level autonomous behavior and image processing, and another for low-level sensor management
- GPS Receiver
- An inertial measurement unit (IMU) containing three accelerometers, three gyroscopes, three magnetometers, and a barometric sensor (for altitude).
- Data link module used for email and other communications

## **Block diagrams and functional descriptions**

The fixed-wing survey drone has two primary subsystems. The first is the autopilot system, which includes the front facing camera, GPS receiver, the IMU, and both of the microcontrollers. The second subsystem provides image processing. This system utilizes the BeagleBone Black (or equivalent) microcontroller, GPS receiver, and image processing software to capture all of the images and to create the final complete image.

Two separate microcontrollers are necessary for the two types of functionality required on the drone. The BeagleBone Black (BBB) is a linux-based machine and excels in multitasking, so it will be used for the overall system control. However, more precise timing is needed to process the real-time responses from the IMU and other sensors. To sustain precise flight control, the plane must receive accurate signals. An Atmel ATmega series (or equivalent) microcontroller has very precise timing and will be used for this function. The two separate microcontrollers will assure precise control of the aircraft while maintaining fast processing ability for the other systems.

### **Autopilot System**

The autopilot subsystem (see Figure 1) runs on the BBB, a Linux-based single-board computer. The developed autopilot software will be loaded onto the BBB where a route for the aircraft will be automatically generated based on the user input. Input data will be sent to the BBB to process and establish navigational waypoints. The aircraft will follow its set path autonomously, driven by the autopilot system. If emergency remote control is necessary, manual operation can be enabled at any point during flight. A standard R/C transmitter will initiate a signal to the BBB to shut down, and the aircraft will respond only to manual control. The transmitter's signals will manipulate the servos and electronic speed control on the aircraft to direct flight.

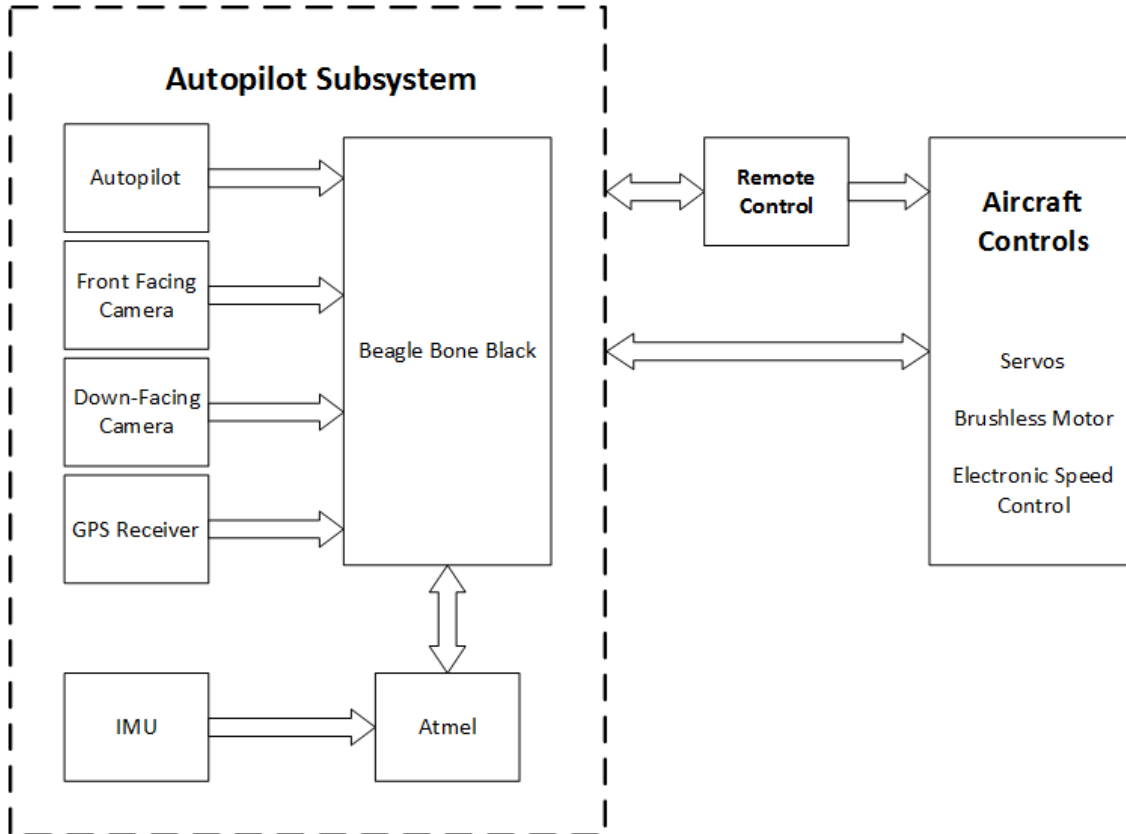


Figure 1. Autopilot Block Diagram

During flight, the front-facing camera will allow obstacle avoidance, using techniques from computer vision such as optical flow and pattern recognition. The autopilot software will automatically adjust the flight path to avoid colliding with the object and remain on course. The Atmel microcontroller will process information gathered from the IMU and other sensors, and communicate that information to the BBB. The software will adjust the flight path based on this data to sustain stable, accurate flight.

### **Image Processing System**

Figure 2 shows the data collection and delivery process. As the drone passes over the selected area, the down-facing camera will collect images that cover the entire area. As each image is taken, the BBB will store location data from the GPS receiver. These images will later be assembled into one image of the entire user-selected area based on GPS location. This camera will also have optical filter capabilities to allow specialized imaging applications.

After all the GPS data and images have been stored in the BBB, the image processing software will create a single large image of the surveyed area (or several images, depending on how many filters were used). This image will be transferred to a Dronecell GPRS (General Packet Radio Service) data link module (or equivalent), with cell phone capabilities and internet access. The data link module will email the final image(s) to the operator and provide notification that the aircraft can be retrieved at the user-specified landing site.

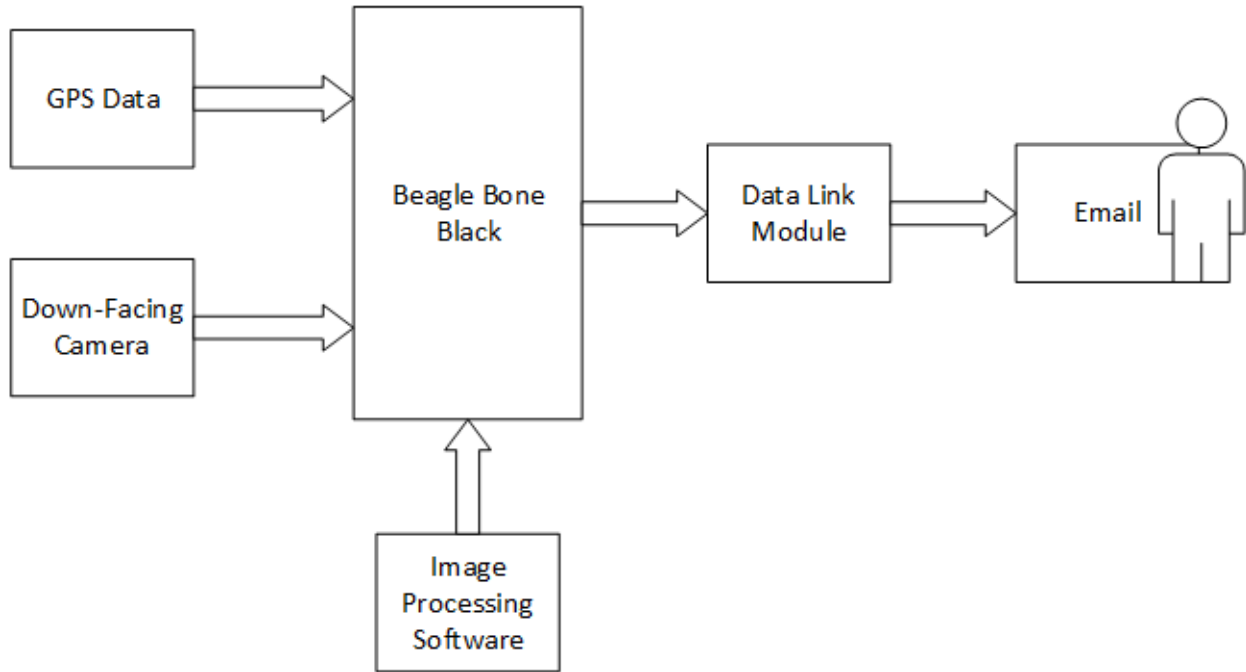


Figure 2. Image Processing Software and Final Image Delivery

# Schedule

The tentative schedule plan for each week is described below, and represented as a Gantt chart in Figure 3. There will be planned time for simulation, testing, and preparation for the final oral presentation.

- Week 1: Image processing with BeagleBone Black
- Week 2: Image processing with BeagleBone Black and GPS-tagged images
- Week 3: Autostitch software
- Week 4: Obstacle avoidance software and simulations
- Week 5: Begin adding components to the aircraft
- Week 6: Waypoint Generation Code
- Week 7: Test Flight
- Week 8: Tweak necessary components
- Week 9: Work through any remaining issues
- Week 10: Work through any remaining issues
- Week 11: Create senior project webpage
- Week 12: Prepare for final presentation
- Week 13: Final Presentation

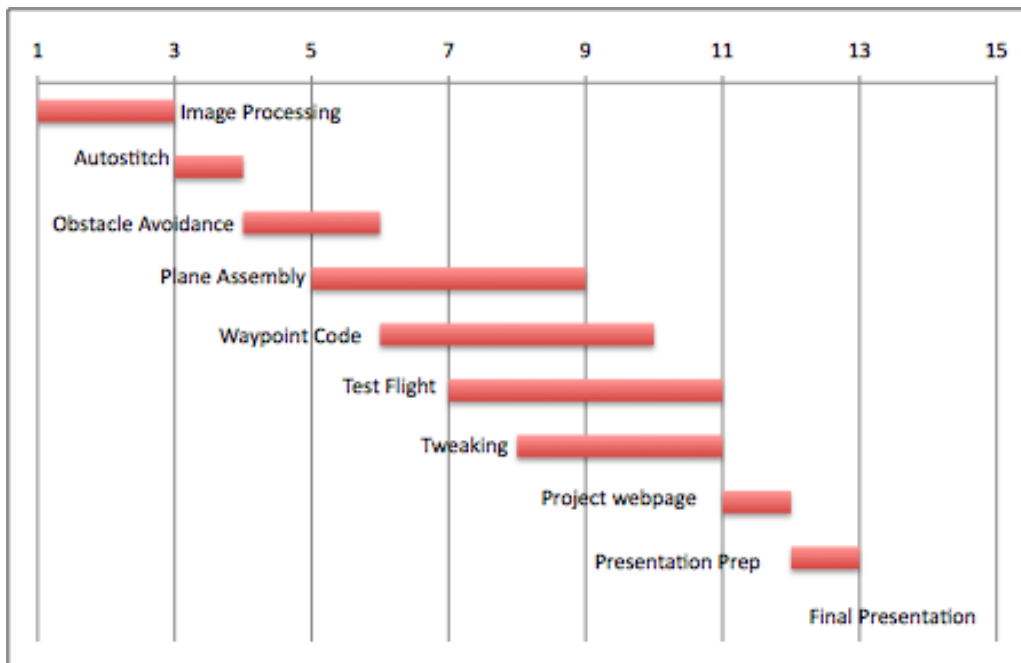


Figure 3. Gantt Chart Project Completion Schedule in Weeks

# Equipment List

Bixler Aircraft	Received
LiPo Battery	Received
RC Controller	Received
BeagleBone Black	Received
Autopilot	APM 2.6 with external compass and external GPS
Data transfer unit	DroneCell - GSM Telemetry
Camera	Raspberry Pi NoIR Camera Board
Obstacle Avoidance Camera	5 Megapixel Camera Module OV5642 1080p JPEG

## Bibliography

- [1] Association for Unmanned Vehicle Systems International (AUVSI). *The Economic Impact of Unmanned Aircraft Systems Integration in the United States*. March 2013. Available at <http://www.auvsi.org/econreport>
- [2] Chao, HaiYang, YongCan Cao, and YangQuan Chen. "Autopilots for Small Unmanned Aerial Vehicles: A Survey." *International Journal of Control, Automation, and Systems*. 8.1 (2010): 36-44. Web. 25 Sep. 2013. <DOI 10.1007/s12555-010-0105-z>.
- [3] Felderhof, Leasia. *Linking UAV (unmanned aerial vehicle) technology with precision agriculture*. Diss. James Cook University, privately published, 2008. Web. <<http://eprints.jcu.edu.au/8029/>>.
- [4] Grenzdörffer, G. J. "THE PHOTOGRAMMETRIC POTENTIAL OF LOW-COST UAVs IN FORESTRY AND AGRICULTURE ." Diss. Rostock University, 2008. Web. <[http://www.isprs.org/proceedings/XXXVII/congress/1\\_pdf/206.pdf](http://www.isprs.org/proceedings/XXXVII/congress/1_pdf/206.pdf)>.>.
- [5] Haitao Xiang, Lei Tian, "Development of a low-cost agricultural remote sensing system based on an autonomous unmanned aerial vehicle (UAV)", *Biosystems Engineering*, Volume 108, Issue 2, February 2011, Pages 174-190, ISSN 1537-5110, <http://dx.doi.org/10.1016/j.biosystemseng.2010.11.010>. (<http://www.sciencedirect.com/science/article/pii/S1537511010002436>)
- [6] Jensen, A., M. Baumann, and Y-Q Chen. "Low-Cost Multispectral Aerial Imaging using Autonomous Runway-Free Small Flying Wing Vehicles." *Geoscience and Remote Sensing Symp.* (2008): 506-509. Web. 25 Sep. 2013. <[http://mechatronics.ece.usu.edu/yqchen/paper/08/08C30\\_igarss\\_4051FinalPaper.pdf](http://mechatronics.ece.usu.edu/yqchen/paper/08/08C30_igarss_4051FinalPaper.pdf)>.



