Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2012
Advisors	Prof. Meyer and Dr. Johnson
Team Number	3
Project Title	Eye In The Sky

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Joe Katz	EE	Analog Circuit Design, PCB Layout, Hardware Debugging, Aeronautics	May 2012
Upsham Dawra	CompE	Base station Programming, Software Architecture, Integration	May 2012
Samit Sura	EE	Hardware Design, Embedded Software, Systems Engineering	May 2012
Ashwin Shankar	EE	Embedded Software, Hardware Interfacing and Debugging	May 2012

Project Description: Provide a brief (2-3 page) technical description of the design project, as outlined below:

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

The project is a relatively small, low cost aerial drone capable of providing a user with a "virtual cockpit" including live video feed and sensor data. It is also able to take high resolution images of the ground below the plane and store them in non-volatile memory. Additionally, sensor data can be stored to non-volatile memory throughout the flight. The product is ideal for surveillance and non-stealth reconnaissance. For instance, farmers can record images of their crops throughout the growing season without walking through large fields. Search and rescue teams could use one or more planes to cover large areas of difficult terrain without endangering themselves.
The plane has a wingspan of approximately 5 feet, and a weight of approximately 3-4 pounds, making it roughly the size of a large bird. This iteration is only capable of flying for about 10 minutes on a single battery charge.
Once the objectives were specified, components were selected, then a board was designed, built, and programmed. Mounting of the custom electronics into the plane was the final step.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

This project built upon prior coursework in several ways. First and foremost, linear circuit analysis was used in simple incidental estimates such as current-limiting resistor values, voltage feedback networks, and, most significantly, hardware debugging. Another class without which this project would have been insurmountable is ECE362. The knowledge gained from that class in microcontroller interfacing and peripherals was essential. Some information from ECE311 was applied to board layout, namely minimizing current loops and optimizing decoupling capacitor placement. Other topics learned from courses that were

applied to this project include programming (ECE264) and semiconductor circuit design (ECE255).

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

This project was a learning experience in several ways. For one, part selection to such a large scale was a new experience for most members of the team. In addition, none of the members of this team had used I2C peripherals before. The motion processing algorithms were also new to all team members.
There were several software tools that were new to the team as well. For example, no one on the team had used ATMEL's AVR design studio for embedded programming before. Eagle design and layout editor was new to all of us as well. While we all had some prior experience with schematic CAD programs, the PCB layout software was entirely new to everyone on the team.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

The objectives of the project were chosen based on the need for a UAV that can be used perform functions like aerial photography, weather mapping and land surveying. The UAV was targeted for the consumer market, so the success criteria were based on safety, ease of use and seamless control of the R/C plane. Through analysis of R/C planes available in the market, we came up with the ability to monitor pressure, altitude,temperature, gps co-ordinates and compass readings. We would also give the plane the ability to capture high resolution pictures and relay video feedback to the ground. Sensor data will also be stored on board an SD card. For ease of control and functionality, the system will be controlled using an Xbox controller. Low-cost and lightweight components need to be used in order to increase affordability and chances of flight respectively. The PCB had to be designed taking into account the limited space available in the payload bay of the aircraft. Once the components were chosen, they had to be carefully packaged into the payload bay in order to maintain the center of mass of the plane. Once the hardware was decided, the communication protocol and the software design on the base station were thought about. The microcontroller would use an XBee wireless module to communicate with the base station. The base station GUI would be built using Visual C. After construction of the PCB, the system was tested on the ground for the success criteria listed above. The system functioned as expected for the criteria and is expected to work in the air during flight.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of most of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Economic: There were a few products in the market which had part of the functionality of Eye In The Sky. The cost of these products formed the basis of the economic constraints. Since the product is targeted towards RC plane hobbyists, making it affordable to that particular market segment was another constraint. In conclusion, it was decided that the total costs of the project should not exceed $1000.

Environmental: Several environmental issues will arise during the manufacturing, use and disposal of the system. These involve the PCB manufacturing process, increasing the lifetime of the lithium-polymer battery, using environmentally friendly parts and disposing the non-biodegradable plane components and the battery. One constraint that was of

particular concern was that of choosing RoHS certified products, so as to minimize the proliferation of environmentally harmful chemicals.

Ethical: Several ethical issues regarding the implications of using the UAV also need to be addressed. These include the UAV being used to breach the privacy of unsuspecting people, or someone getting injured because the plane was operated with questionable purpose. Given the high cost of the system and the crash-prone nature of operation, only a person with prior experience in controlling RC planes should operate it.

Health & Safety: The finished product will weigh slightly less than two kilograms, so loss of control could pose a non-lethal safety hazard if the plane were to crash into someone. One more constraint was that all the wires were properly insulated and capable of carrying high currents, given the system running at 11.1V and motor running at few Amperes of current.

Social: Because of the ethical issues of breaching of privacy or the plane being used to intentionally/ unintentionally cause destruction, there is a limited consumer market for the plane which is a social constraint.

Political: Eye In The Sky, if misused, has the potential of causing political tensions. Unmanned surveillance is a controversial topic involving privacy and safety of people.

Sustainability: Eye In The Sky was designed to withstand a limited degree mechanical stress, given that it would be landing at quick speeds or could be crashing due to operator error. So giving extra protection to the sensors and battery was a constraint in packaging.

Manufacturability: Manufacturability constraints would include not having a steady supply of sensors at the time of assembly, which could factor in this project, given the different sensors it requires.

(f) Description of the multidisciplinary nature of the project.

The project is a combination of Electrical and Computer Engineering with a strong intuition of flight mechanics. The PCB design and interfacing circuitry involved heave use of Electrical Engineering knowledge. The embedded system design on board the plane and the base station GUI required knowledge of computer engineering. The packaging of the plane required a strong mechanical intuition as it was important to keep the center of mass of the plane intact.

(g) Description of project deliverables and their final status.

This project had 5 Project Specific Success Criteria which were as follows:

- Ability to wirelessly control engine rpm, elevators, ailerons and rudders of a UAV from a base station.
- Ability to control the direction of the onboard video camera.
- Ability to transmit real-time sensor data from the UAV to the base.
- Ability for the user to trigger the capture of still images by a camera on a UAV.
- Ability to store relevant data in non-volatile memory on a UAV.

All these success criteria were successfully met. The finished product consists of a fully packaged UAV along with a base station app which is able to connect to the UAV via an Xbee module and can remotely control the UAV successfully via an Xbox 360 controller. All aspects of the PSSCs, including storing sensor data to an SD card, being able to capture a still image remote, transmitting and displaying real-time sensor data on base station and being able to control all components of the UAV as well change the direction of the on-board video camera wirelessly were successfully completed. Some additional features, like

being able to switch to the original Spektrum controller as a fail-safe were also added successfully.