HARDING UNIVERSITY

System Design and Project Plan

Sky Vision

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10/12/2010

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Background

The goal of *Sky Vision* is to design and construct a cost effective, mobile flight platform with the capability to remotely capture video and transmit the data to a user on the ground in real time. The need for aerial imaging spans a wide array of markets, such as search and rescue, law enforcement, construction, the media, fire fighting, and general recreation.

Aerial imaging greatly expands the capabilities of the aforementioned markets. It reduces the manpower (and thus costs and risks) needed for many dynamic situations, such as monitoring the scene of a crime or surveying the extent of a wildfire. In short, aerial imaging extends the sensing capabilities of a market from a two dimensional field into a third dimension: the sky.

Currently, this capability is far too often accomplished through the use of expensive rotary and fixed wing aircraft. The costs of the prior options often far eclipse the resources of many markets, thus necessitating a cost effective alternative. The goal of *Sky Vision* is therefore to create an aerial imaging product which meets both the high performance and low cost requirements of many under financed markets.

Sky Vision will meet the above stated needs by being far less expensive than the current methods used to obtain aerial images. As an alternative to renting or purchasing expensive equipment outright, *Sky Vision* customers will be able to purchase one of our aerial surveillance systems. Using *Sky Vision* will be much more convenient for the customer, since the system can be easily transported to the required location. *Sky Vision* will use a lifting gas such as helium to fly a small video camera to the altitude necessary to obtain the desired live video feed. The camera will transmit the live video feed to a user interface on the ground. The system will be able to be maneuvered and rotated by a lightweight propulsion system. This propulsion system will be remote-controlled from the user interface on the ground.

System Overview

The goal of *Sky Vision* is to provide a cost effective method of aerial surveillance for dynamic situations. *Sky Vision* will consist of a lighter-than-air aerial platform with stable live video imaging and a limited propulsion system. Since most markets with a need for aerial surveillance also demand high adaptability, *Sky Vision* will measure no more than 1.30 m x 1.04 m x 0.56 m. To satisfy the needs of the customer, *Sky Vision* will be capable of both 360° of azimuth rotation and 90° of elevation rotation. Azimuth rotation is defined as a horizontal rotation in a fixed reference plane; in this case the fixed reference plane is the plane perpendicular to an axis fixed to the device which passes vertically through the center of gravity of the device when it is in a vertical orientation. Ninety degrees of elevation rotation is defined as a rotation from the previously mentioned fixed plane to a position perpendicular to the plane, directed downward. The propulsion system will provide lateral translation and also rotation to position and orient the azimuth angle of the imaging system. The elevation rotation will be provided independent of the propulsion/orientation system.

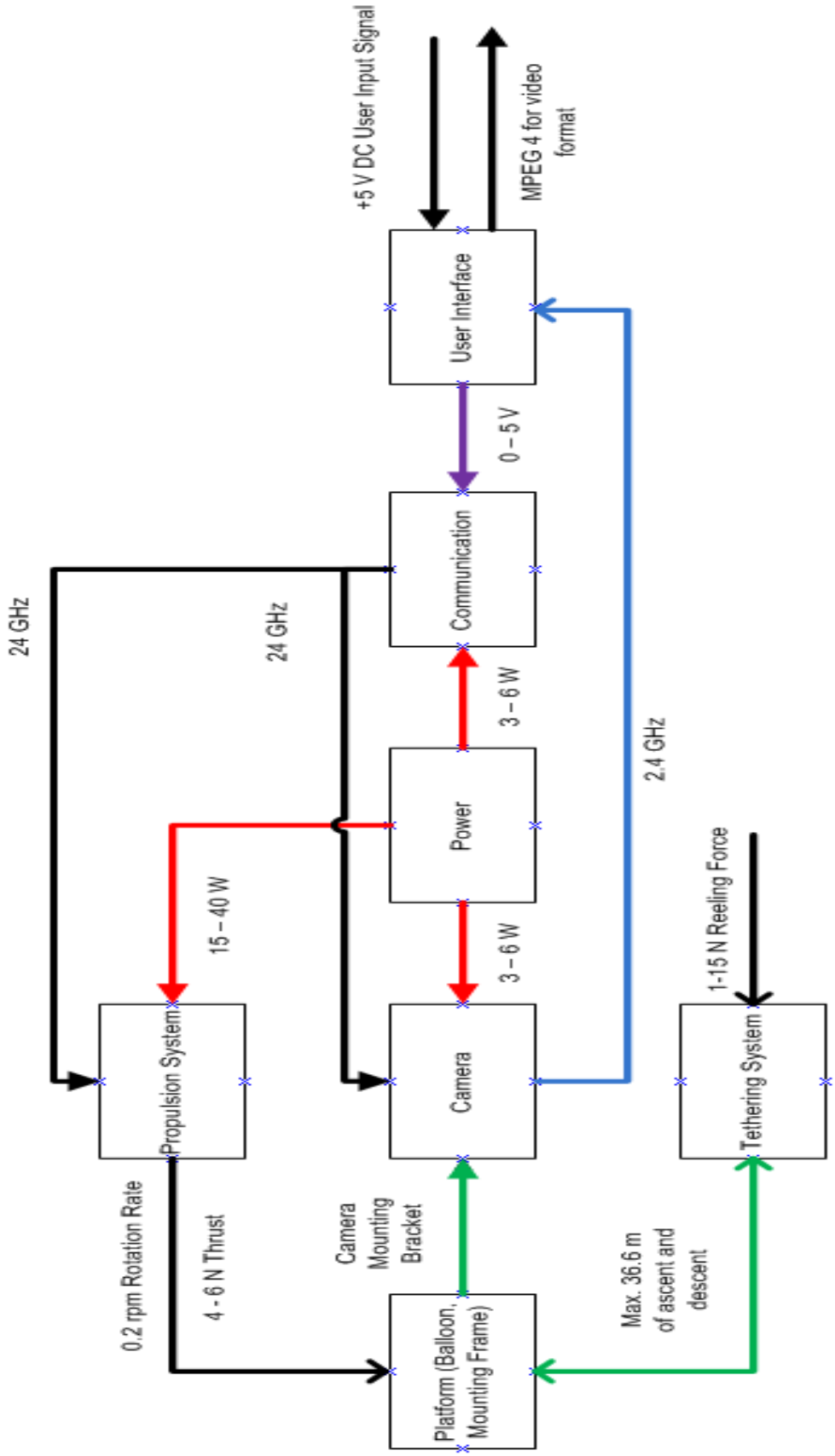
Sky Vision will be operated by the customer using a portable user interface device. The user interface will provide four important functions: control of the imaging system and viewing of the live video feed, control of the propulsion system (rotation and translation), and control of deflation of the balloon in case of separation from the tethering system (as required FAA regulation 101 subpart B, see Appendix B).

To use *Sky Vision,* the user will remove the system from storage and ensure the aerial platform is correctly secured to the tethering system (prior to inflation with helium gas). The platform will then be connected to the power source and both the platform and user interface will be powered on. The user will then add the required volume of helium gas to inflate the platform (note that the customer will provide any required helium gas, except for that required by system development and testing). The tethering system will then be slowly released, allowing *Sky Vision* to slowly rise to the desired altitude. Once *Sky Vision* has reached the desired altitude, the user may then utilize the imaging and propulsion systems to obtain the desired field of view for the live video feed. Once imaging is complete, the user will slowly reel in the device, while

visually inspecting the tether for damage. Once the platform has reached ground level, the user will inspect it to ensure the integrity of the platform has not been compromised. The valve system will then be used to remove the helium gas from the platform. Following helium gas removal, the system will be powered off and returned to storage.

System Design

Block Diagram



Functional Description of Blocks

Propulsion System:

The propulsion system will consist of two propulsion units (probably fans) mounted on a rotating shaft. The shaft will be capable of 360° of azimuth rotation. The propulsion units will be capable of providing both stability against wind and lateral translation of balloon.

Input: User control signal from user interface via motor control circuit (see ôUser Interfaceô functional description for specifics on user input mechanism)

Output: Desired rotation (360° in five minutes, or 0.2 rpm) and translation of balloon (maximum of 5 N thrust to stabilize against maximum wind speed)

Communication System:

The communication system will remotely control the propulsion system of the blimp. It will transmit a signal from the user interface to a motor control circuit that determines the direction and speed of movement. This signal will be transmitted wirelessly and will be in compliance with all relevant FCC communication standards and regulations.

Input: Signal generated from remote-control device on user interface and transmitted at radio frequency at 2.4 GHz.

Output: Signal to motor control circuit and camera control circuit which sends power to the propulsion units and camera (40 ï 100 W to propulsion units and 2 ï 6 W to camera system)

Power System:

The power system provides the necessary power for the propulsion system, user interface, and communication system. The power system consists of a battery, a voltage regulator, and on/off switching system. The power system will provide power to the system for a minimum of one hour, with

Input: Power from battery (30 to 100 W).

Output: Power to other systems (15 ï 40 W to propulsion units and 2 ï 6 W to camera system)

Tethering System:

The tethering system includes both a reel device to allow for ascending and descending of the balloon and also a tethering cable which is capable of supporting the balloon. The device should be deployable to and from its maximum height of 36.6 meters within ten minutes. In order to ensure that the height of the device does not exceed 36.6 meters, the tethering system will only be capable of letting out 36.6 meters of cable. The material will have a factor of safety against rupture of at least 2.0

Inputs: Mechanical reeling force, 1 ï 15 N force applied at a sufficient distance.

Outputs: Change in device elevation, from zero meters to the maximum height of 36.6 meters.

Camera System:

The camera system will consist of a small camera mounted onto the balloon. The camera will be capable of 90° elevation rotation, accomplished independent from motion provided by propulsion system. The live video feed will be transmitted to the ground and made viewable on the user interface. The camera will be adjusted to focus at a distance sufficient to accommodate the maximum flight height. The video frame rate will be a constant value (yet to be determined) as predetermined by specific camera selection.

Inputs: Control signal from user interface. 9 volt power supply from battery.

Outputs: Live video feed displayed on the user interface. Up to 90° elevation rotation.

Platform:

The platform consists of both a helium filled balloon and the required mounting infrastructure. The helium filled balloon will provide enough lift to bring the system to the desired elevation, and the required mounting infrastructure will support the imaging and propulsion systems. The platform will also contain a subsystem to rapidly deflate the device in case of tether separation, as dictated by FAA regulation 101 subpart B.

Input: Specified volume of helium gas required to lift system (helium gas can lift approximately 1.1 kg/m^3 at 20° C and 1 atm. Emergency signal from tether separation sensor.

Output: Desired elevation of the system. Rapid deflation of device when emergency tether signal is received; separation of device from tether is a worst case scenario and would result in catastrophic failure of device (most likely outcome: complete destruction of device.

User Interface:

The user interface consists of the controls necessary to control the propulsion system and imaging system. The user will be able to use the user interface to rotate the system 360° and rotate the camera 90°. The propulsion system controls allow for user control of camera stability. The live video feed will be viewable on the user interface

Input: Desired manipulation of propulsion and imaging systems as dictated by user via a system of buttons and/or joysticks in order to accomplish desired imaging.

Output: Control signal sent to communication system at 0 to 5 V DC

Project Plan

Organization and Management

Sky Vision's team consists of two electrical engineering students and two mechanical engineering students. The project tasks will be distributed between the project members as follows:

- **Philip Varney** (Mech. Eng.) - Phil is the project manager of *Sky Vision*, and primarily responsible for making sure the subsystem plans are completed, integrated, and tested on time. Phil is also responsible for finalizing all required reports and ensuring they are completed on time. Phil will also be responsible for the design and implementation of the propulsion system and the camera rotation system. Phil will work with Cristina to assist her with any difficulties that arise during the development of her responsibilities.

- **Julianne Pettey** (Elec. Eng.) - Julianne is responsible for project financing; specifically, ensuring the budget is under control. The purchasing of any system components will be done through her to ensure the budget outline is followed. Julianne will also be responsible for the design and implementation of the camera system and communication system. She will be responsible for integrating all of the electrical subsystems and ensuring they function properly with the mechanical systems. Julianne will work with Peng to ensure his tasks are done properly and efficiently.

- **Peng Yeng** (Elec. Eng.) - Peng is primarily responsible for designing and implementing the power system. He will also design the user interface system, including controls for both the imaging and propulsion systems. Peng will also work with Julianne to make sure her tasks are completed on schedule and also to assist her in any difficulties which arise during the design and implementation of the camera and communication systems.

- **Cristina Belew** (Mech. Eng.) - Cristina is responsible for the design and implementation of the platform (balloon and mounting frame) and tethering systems. She is also responsible for examining any relevant FAA regulations and dictating to the entire team what is required to ensure FAA regulations are adhered to. Cristina will collaborate with Peng on the mechanical aspect of the user interface design. She will also assist Phil in any difficulties encountered during the design and implementation of the propulsion and camera rotation systems.

Work Breakdown Schedule Fall 2010

ID	Activity	Description	Deliverables/ Checkpoints	Duration (days)	People
F1.0	**Project Management**	Ensure project is completed correctly and on time	Description of team member task completion	Aug. 23rd ï Dec. 9th	Ph
F 2.0	**Documentation**	Ensure changes and progress is recorded	Engineering notebooks, A3 reports, and design reports	Aug. 23rd ï Dec. 9th	Ph, P, J, C
F 3.0	**Project Choice**	Decide on which problem solution to pursue	Problem specification report	Aug. 23rd ï Sept. 7th	Ph, P, J, C
F4.0	**Requirements Specification**	Complete set of all system requirements	Requirements specification document	Sept. 7th ï Sept 28th	Ph, P, J, C
F 5.0	**System Design & Project Plan**	Report of semester goals and deadlines, along with functional descriptions of subsystems	System Design and Project Plan final report	Sept. 28th ï Oct. 12th	Ph, P, J, C
F6.0	**Device Design**	Complete design of subsystems	Component selection and performance specifications. of subsystems	Oct. 12th ï Nov. 16th	Ph, P, J, C
F6.1	Platform Design	Design of balloon and mounting infrastructure	Type of balloon; performance specifications of balloon; design of mounting brackets	Oct. 12th ï Nov. 2nd	C (1), Ph (2)
F6.2	Camera Design	Design of imaging system and camera rotation system	Camera selection; camera rotation design	Oct. 12th ï Oct. 26th	J, Ph
F 6.2.1	Imaging Design	Design of camera system to provide live video feed	Camera selection and performance specifications; data transmitter and receiver	Oct. 12th ï Oct. 26th	J
F 6.2.2	Camera Rotation Design	Design of system to rotate camera 90°	Motor and mounting system selection; performance specifications	Oct. 12th ï Oct. 26th	Ph
F6.3	Propulsion Design	Stabilize, rotate, and translate device	Propulsion unit design and selection; movement specifications; mounting design; performance specifications	Oct. 12th - Oct. 26th	Ph (1), C (2)
F6.4	Power Design	Design power system to power device	Battery selection; power distribution design; performance specifications	Nov. 2nd ï Nov. 16th	P (1), J (2)
F6.5	Communication Design	Design system to transmit user inputs/outputs to/from device	Communication method selected; control circuitry design; performance specifications	Oct. 26th ï Nov. 9th	J (1), P (2)
F6.6	Tether Design	Design system to secure device and transmit power	Selection of tethering cord; reeling device design; performance specifications	Nov. 2nd ï Nov. 16th	C (1), Ph (2), P (1)
F6.7	User Interface Design	Design system to receive inputs and display live video feed	User interface control circuitry designed; case/type of controls designed; performance specs.	Oct. 22nd ï Nov. 9th	P (1), J (2)
F7.0	**System Design and Analysis**	Ensure correct integration of subsystems and order parts	Final system design and documentation of parts ordering	Nov. 9th ï Dec. 7th	Ph, P, J, C
F8.0	**Final Design**	The final design of system and subsystems	Final Design Report (includes schematics and project model)	Nov. 9th ï Dec. 9th	Ph, P, J, C

- **Please note that 'performance specifications' includes test results**

Work Breakdown Schedule Spring 2011

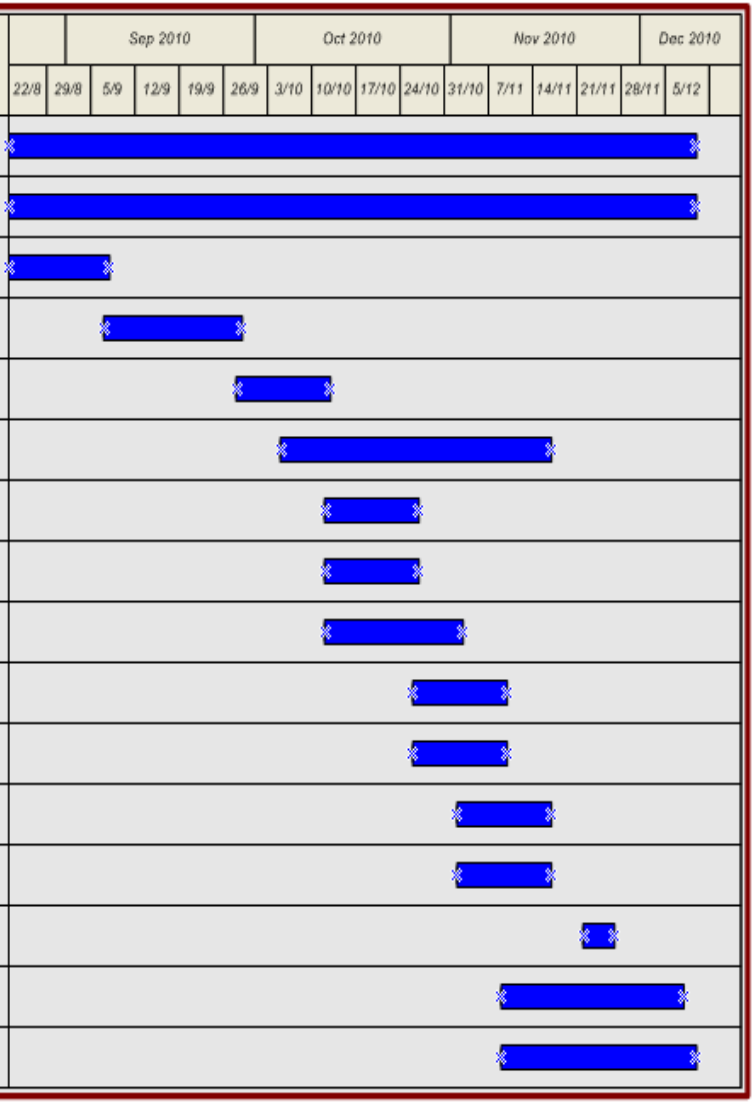
ID	Activity	Description	Deliverables/ Checkpoints	Duration (days)	People
S 1.0	**Project Management**	Ensure project is completed correctly and on time	Description of team member task completion	Jan. 18th ï May 5th	Ph
S 2.0	**Documentation**	Ensure changes and progress is recorded	Engineering notebooks, A3 reports, design reports	Jan 18th ï May 5th	Ph, P, J, C
S 3.0	**Device Build**	Complete builds of subsystems	All of subsystems connected as specified by design	Jan. 18th ï Feb. 22nd	Ph, P, J, C
S 3.1	Platform Build	Connect mounting infrastructure to balloon	Mounting brackets for tether, propulsion system, and imaging system attached to balloon	Jan. 18th ï Feb. 8th	C (1), Ph (2)
S 3.2	Camera Build	Build imaging system and camera rotation system	Imaging and camera rotation subsystems connected. Camera control circuitry built for both imaging and camera rotation	Jan. 18th ï Feb. 1st	J, Ph
S 3.2.1	Imaging Build	Build camera system	Receiver/transmitting circuitry built and connected to camera	Jan. 18th ï Jan. 25th	J
S 3.2.2	Camera Rotation Build	Build of camera rotation system	Camera mounted to elevation rotation shaft and motor. Motor connected to control circuitry	Jan 25th ï Feb. 1st	Ph
S 3.3	Propulsion Build	Build of propulsion system to stabilize, rotate, and translate device	Propulsion units built, assembled, and mounted to platform frame	Jan 18th ï Feb. 1st	Ph (1), C (2)
S 3.4	Power Build	Build power system to power device	Power distribution system and voltage regulating system built and connected to battery	Feb. 8th ï Feb. 22nd	P (1), J (2)
S 3.5	Communication Build	Build system to transmit user inputs/outputs to/from device	Remote control circuitry built and ready to be mounted to user interface and aerial portion of platform	Feb. 1st ï Feb. 15th	J (1), P (2)
S 3.6	Tether Build	Build system to secure device and transmit power	Reeling mechanism built and connected to cable. Cable attachment to balloon mechanism built	Feb. 8th ï Feb. 22nd	C (1), Ph (2), P (1)
S 3.7	User Interface Build	Build system to receive inputs and display live video feed	Device to contain interface control circuitry and display screen built. Display screen circuitry built and connected to user interface	Feb. 1st ï Feb. 15th	P (1), J (2)
S 4.0	**Device Testing**	Complete testing of each subsystem	Test results of subsystems; modification recommendations	Feb. 1st ï Mar. 8th	Ph, P, J, C
S 4.1	Platform Testing	Test the platform to ensure it can support subsystems	Results of balloon lift and stability tests; modification recommendations	Feb. 8th ï Feb. 22nd	C (1), Ph (2)
S 4.2	Camera Testing	Ensure camera can provide live feed and rotate through specified angle	Results of camera imaging and rotation tests; modification recommendations	Feb. 1st ï Feb. 15th	J, Ph
S 4.2.1	Imaging Testing	Ensure the camera can provide satisfactory video feed	Results of imaging testing; modification recommendations	Feb. 1st ï Feb. 15th	J

S 4.2.2	Camera Rotation Testing	Ensure camera can rotate specified elevation range	Actual range of rotation specified; modification recommendations	Feb. 1st ï Feb. 15th	Ph
S 4.3	Propulsion Testing	Ensure propulsion provides for rotation and translation	Actual thrust output and rotation rate of mounting shaft quantified; modification recommendations	Feb. 1st ï Feb. 15th	P (1), C (2)
S 4.4	Power Testing	Ensure power outputs can provide power for all subsystems	Actual power output quantified; modification recommendations	Feb. 22nd ï Mar. 8th	P (1), J (2)
S 4.5	Communication Testing	Ensure system can communicate to device at max. altitude and receive/transmit user signals	Actual communication range quantified; modification recommendations	Feb. 15th ï Mar. 1st	J (1), P (2)
S 4.6	Tether Testing	Ensure tether can support system and transmit power	Actual reeling force quantified; modification recommendations	Feb. 22nd ï Mar. 8th	C (1), Ph (2)
S 4.7	User Interface Testing	Ensure user interface can transmit/receive signal from/to communication system	Test results, modification recommendations	Feb 15th ï Mar. 1st	P (1), J (2)
S 5.0	**Project Status**	Statement of project status	Project status report	Feb. 15th ï April 5th	Ph, P, J, C
S 6.0	**System Integration**	Integrate subsystems to ensure correct functionality	Provides fully integrated prototype to test	Mar 1st ï Mar. 29th	Ph, P, J, C
S 7.0	**System Testing and Modifications**	Testing of total integrated system and corresponding modifications	Complete system prototype	Mar. 22nd ï April 12th	Ph, P, J, C
S 8.0	**User's Manual**	Instructions to user on how to operate system	Userôs manual report	April 19th ï May 3rd	Ph, P, J, C
S 9.0	**Final Report**	Presentation of final device and system capabilities	Final report document	April 12th ï May 3rd	Ph, P, J, C

Gantt Chart

Fall 2010

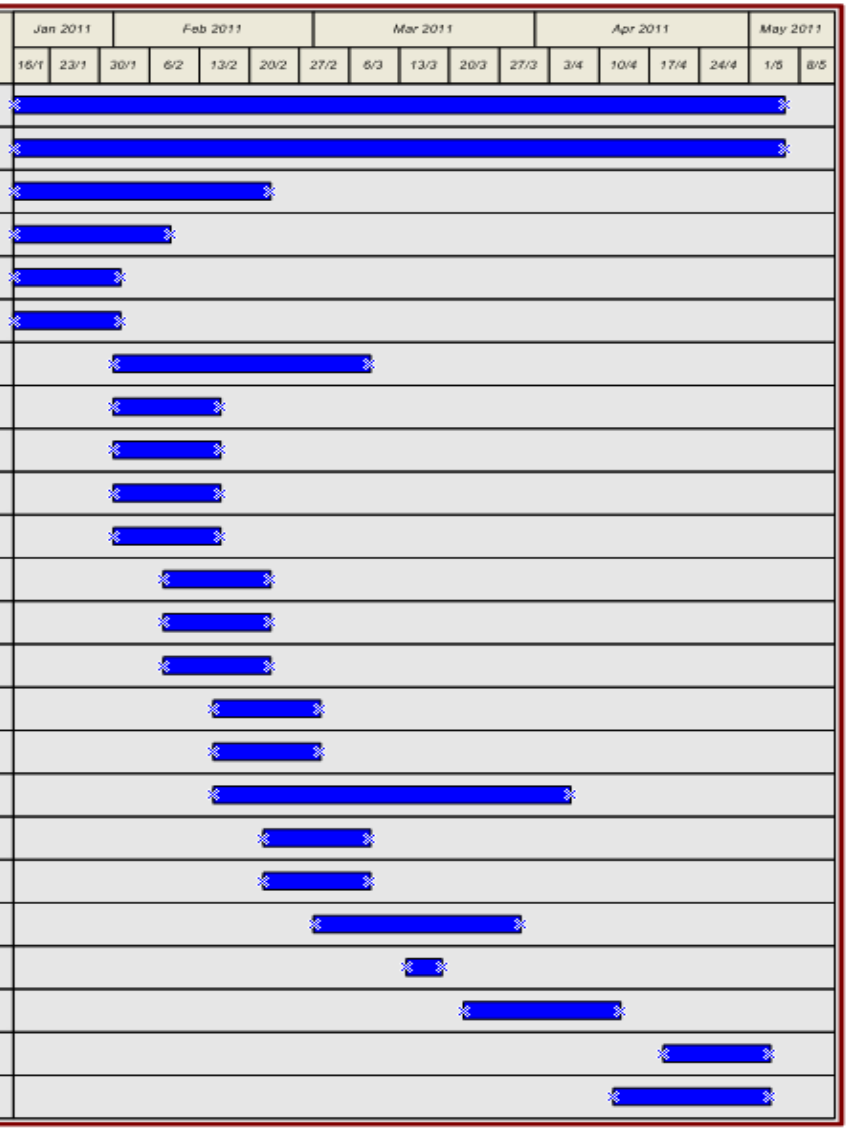
ID	Task Name	Start	Finish	Duration
1	Project Management	8/23/2010	12/9/2010	79d
2	Documentation	8/23/2010	12/9/2010	79d
3	Project Choice	8/23/2010	9/7/2010	12d
4	Requirements Specification	9/7/2010	9/28/2010	16d
5	System Design and Project Plan	9/28/2010	10/12/2010	11d
6	Device Design	10/5/2010	11/16/2010	31d
7	Propulsion Design	10/12/2010	10/26/2010	11d
8	Camera System	10/12/2010	10/26/2010	11d
9	Platform Design	10/12/2010	11/2/2010	16d
10	Communication Design	10/26/2010	11/9/2010	11d
11	User Interface	10/26/2010	11/9/2010	11d
12	Tethering Design	11/2/2010	11/16/2010	11d
13	Power Design	11/2/2010	11/16/2010	11d
14	Thanksgiving Break	11/22/2010	11/26/2010	5d
15	System Design and Analysis	11/9/2010	12/7/2010	21d
16	Final Design	11/9/2010	12/9/2010	23d

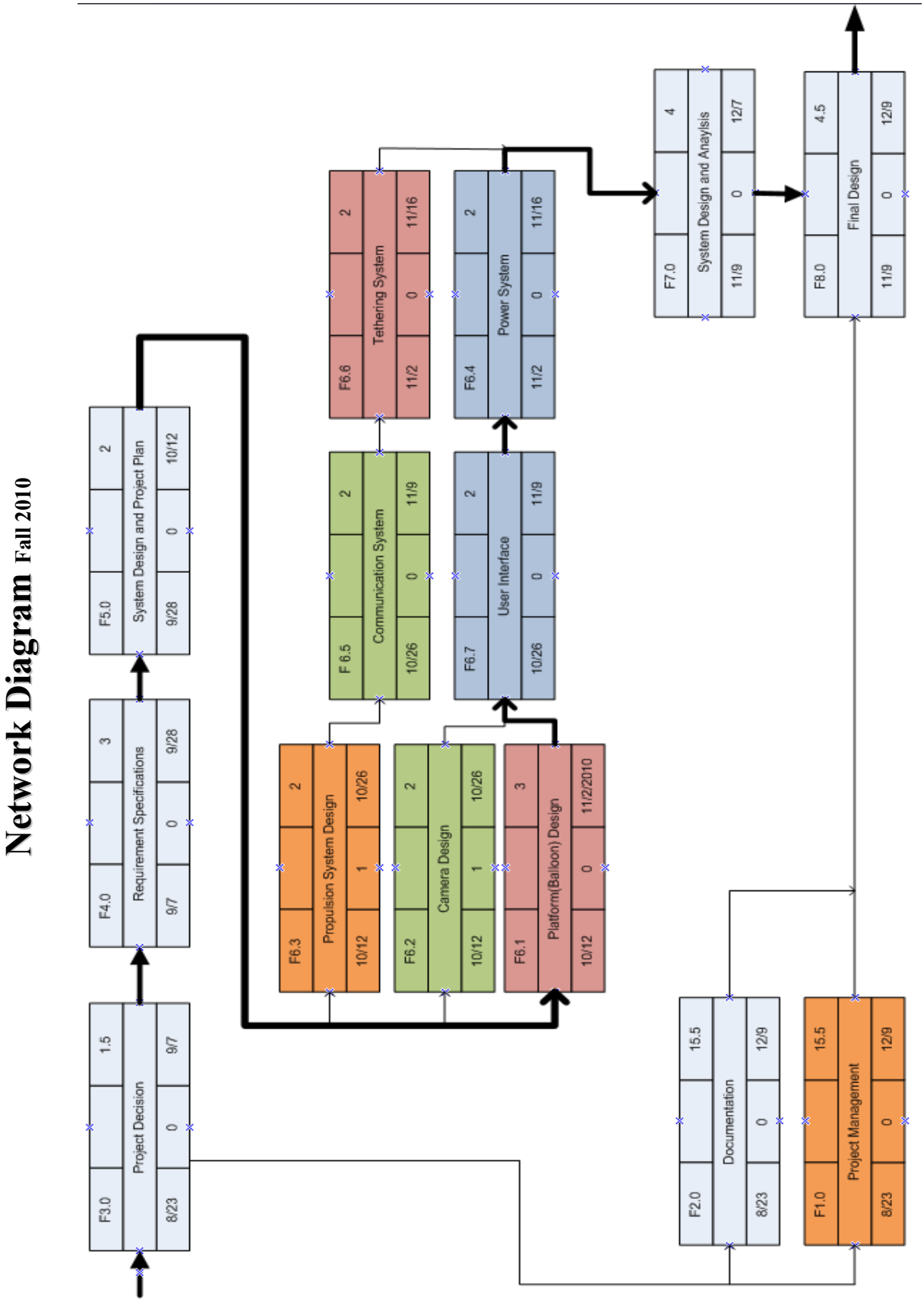


Gantt Chart

Spring 2011

ID	Task Name	Start	Finish	Duration
1	Project Management	1/18/2011	5/5/2011	78d
2	Documentation	1/18/2011	5/5/2011	78d
3	Device Build	1/18/2011	2/22/2011	26d
4	Platform Build	1/18/2011	2/8/2011	16d
5	Camera Build	1/18/2011	2/1/2011	11d
6	Propulsion Build	1/18/2011	2/1/2011	11d
7	Device Testing	2/1/2011	3/8/2011	26d
8	Propulsion Testing	2/1/2011	2/15/2011	11d
9	Camera Testing	2/1/2011	2/15/2011	11d
10	Communication Build	2/1/2011	2/15/2011	11d
11	User Interface Build	2/1/2011	2/15/2011	11d
12	Power Build	2/8/2011	2/22/2011	11d
13	Tether Build	2/8/2011	2/22/2011	11d
14	Platform Testing	2/8/2011	2/22/2011	11d
15	Communication Testing	2/15/2011	3/1/2011	11d
16	User Interface Testing	2/15/2011	3/1/2011	11d
17	Project Status Report	2/15/2011	4/5/2011	36d
18	Power Testing	2/22/2011	3/8/2011	11d
19	Tether Testing	2/22/2011	3/8/2011	11d
20	System Integration	3/1/2011	3/29/2011	21d
21	Spring Break	3/14/2011	3/18/2011	5d
22	System Testing and Modifications	3/22/2011	4/12/2011	16d
23	User's Manual	4/19/2011	5/3/2011	11d
24	Final Report	4/12/2011	5/3/2011	16d




Network Diagram Fall 2010
F3.0
Project Decision
1.5
8/23
0
9/7
F4.0
Requirement Specifications
3
9/7
0
9/28
F5.0
System Design and Project Plan
2
9/28
0
10/12
F6.3
Propulsion System Design
2
10/12
1
10/26
F6.2
Camera Design
2
10/12
1
10/26
F6.1
Platform(Balloon) Design
3
10/12
0
11/2/2010
F 6.5
Communication System
2
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0
11/9
F6.7
User Interface
2
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0
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F6.6
Tethering System
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11/2
0
11/16
F6.4
Power System
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11/2
0
11/16
F2.0
Documentation
15.5
8/23
0
12/9
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Project Management
15.5
8/23
0
12/9
F7.0
System Design and Anaylsis
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11/9
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12/7
F8.0
Final Design
4.5
11/9
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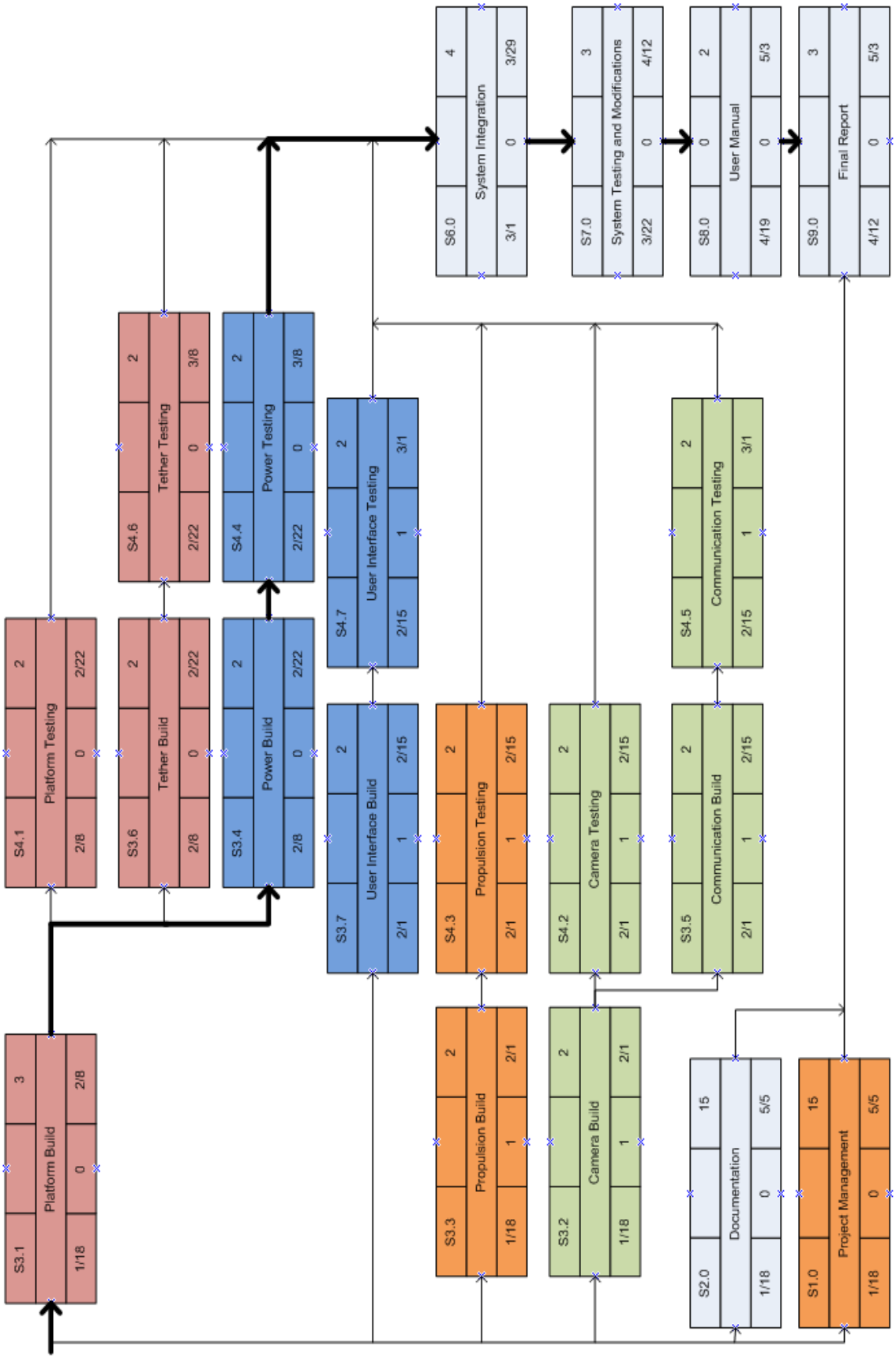
12/9

Network Diagram Spring 2011



Budget

Item	Possible Vendor	Cost	Date Estimated
Propulsion System			
2 Fans w/ motor Model DFR6B	www.ductedfans.com	$80.00	Sept. 20th, 2010
Mount	www.onlinemetals.com	$10.00	
Third positioning motor	www.ductedfans.com	$20.00	Oct. 4th, 2010
Camera System			
Camera	www.boostervision.com	$69.99	Sept. 8th, 2010
Receiver	www.boostervision.com	Included	Sept. 8th, 2010
Transmitter	www.boostervision.com	Included	Sept. 8th, 2010
Battery for camera	Wal-Mart	$2.00	Oct. 4th, 2010
Main Power Supply			
Tether cable	Amazon.com	$50.00	Oct. 4th, 2010
Misc. cord, etc	TBA	$25.00	Oct. 4th, 2010
Main battery	Ebay.com	$60.00	Oct. 4th, 2010
Alternative battery	*www.maxprod.com*	*$20.00 -$40.00*	*Oct. 11th, 2010*
Tethering System			
All components	TBA	$25.00	Oct. 4th 2010
Tethering cord	http://secure.cartsvr.net	$25.00	Oct. 11th, 2010
Platform			
Balloon	www.giantadvertisingballons.com	$250.00	Sept. 28th, 2010
Helium gas	www.hicodallas.com	$100.00	Oct. 11th, 2010
Communication System			
RC control system	www.hobbypartz.com	$44.95	Oct. 3rd, 2010
Control circuitry	www.sparkfun.com	$30.00	Oct. 11th 2010
User Interface			
Display screen			
Materials	www.onlinemetals.com www.eplastics.com	$13.00 $20.00	Oct. 11th, 2010 Oct. 11th, 2010
Control circuitry	TBA	$15.00	Oct. 11th, 2010
Misc/Contingency		$202 - $182	
Total Estimated Cost		$1000	

Appendix A:
Requirements Specification

Overview

The goal of *Sky Vision* is to design and construct a cost effective, mobile flight platform with the capability to remotely capture video and transmit the data to a user on the ground in real time. The need for aerial imaging spans a wide array of markets, such as search and rescue, law enforcement, construction, the media, fire fighting, and general recreation.

Aerial imaging greatly expands the capabilities of the aforementioned markets. It reduces the manpower (and thus costs and risks) needed for many dynamic situations, such as monitoring the scene of a crime or surveying the extent of a wildfire. In short, aerial imaging extends the sensing capabilities of a market from a two dimensional field into a third dimension: the sky.

Currently, this capability is far too often accomplished through the use of expensive rotary and fixed wing aircraft. The costs of the prior options often far eclipse the resources of many markets, thus necessitating a cost effective alternative. The goal of *Sky Vision* is therefore to create an aerial imaging product which meets both the high performance and low cost requirements of many under financed markets.

Problem Statement

Obtaining aerial imaging of a dynamic situation can be both costly and complicated. There is a need spanning a wide range of markets for an aerial device with the capability of remotely capturing aerial images at a low cost. In order to fulfill the market requirements, the device should have the capability to be easily transported to the area of interest.

Requirements

- The power system should allow for a minimum of one hour flight time and also a minimum of 30 minutes of live video, not necessarily continuous, from the camera system.
- The motion of the device and/or camera should allow for both 360° of azimuth rotation and 90° of elevation rotation of the camera in order to provide a stabilized image (Stabilized: no more than 25% displacement within a 0.5 s interval of a screen centered, locked object)
- The 360 degrees of azimuth rotation should be accomplished in a five minute time interval
- The camera system will be able to lock on (via either user control or automation) to some object on the ground and remain fixed on that object until the user acquires a new target object
- The device will be able to rise to a maximum height of no less than 36.6 meters (120 ft) in order to ensure customerôs needs for aerial imaging are met
- The device should obey all pertinent FAA regulations (FAA regulation 101, subparts A and B; see Appendix A)
- The communication range of the device should be at least 50 meters
- The device should be able to withstand maximum winds of at least 5 m/s.
- The device should be no more than 0.43 m^3 (15 cu. ft) and the dimensions should not exceed 1.30 m x 1.04 m x 0.56 m. when deflated, in order to fit into the trunk of a standard mid-sized car (based on stats for 2011 Honda Accord)
- The device development costs should cost no more than 1,000 USD.

Deliverables

- Parts manual and corresponding budget
- User manual
- Detailed schematic and final report on device capabilities
- System capability specifications

- Aerial surveillance device
- User interface
- Non-supplied parts:
  - Helium gas will be provided for development and testing purposes, but the customer will be responsible for obtaining helium gas for later flight
  - A user provided laptop computer may be necessary to view the live video feed

User Manual

1. Remove device from storage and ensure the tether system is correctly connected to the blimp
2. Connect the power system to the tethering system and power on the device and user interface
3. Add necessary helium gas to the blimp until fully inflated
   - User must supply helium gas
4. Slowly extend tethering line to allow blimp to rise to desired elevation
5. Obtain desired imaging using camera and blimp positioning systems, done via the user interface
6. Slowly reel in tethering line until blimp has reached ground level
   - Maintenance: ensure blimp is intact with no leaks
   - Maintenance: when reeling in tethering line, check visually for damaged areas
7. Remove gas from blimp and disconnect tether system from power system
8. Place system in storage

Test Plans

- The power system will be connected to the imaging and propulsion systems and tested at a short vertical height for one hour to verify power needs (this includes 30 min. of video feed testing). The time duration will be tested using a commercial stopwatch device.
- To test image stability, one minute of continuous video will be recorded with the camera locked onto a single object for the entire one minute duration. The one minute video clip will then be broken into 0.5 second intervals and it will be verified that the locked object did not drift more than 25% of the screen size during each interval.
- To test 360° of azimuth rotation and 90° of elevation rotation, the device will be flown indoors and the 360° will be verified by the ability of the camera to capture a full panoramic picture (or protractor in case of camera failure), and the 90° elevation

rotation measured using a protractor. The 360° azimuth rotation will be timed using a commercial stopwatch device to verify the 5 minute rotation duration.

- The device will be flown outdoors to verify camera locking ability. An object on the ground will be preselected and the camera should keep the object in the video feed for a duration of five minutes.
- To verify the maximum flight height of 36.6 meters, the device will be flown and the amount of tethering cable measured using a measuring tape and related appropriately (accounting for cable droop due to the weight of the cable) to the height of the device. This will cause the measured tether cable to be greater than the maximum flight height. The appropriate relation for cable droop will be provided following appropriate testing and analysis.
- The device will be flown in 5 m/s or greater winds to test flight stability. To verify flight stability, the positioning and camera systems should still be capable of locking onto an object on the ground and remaining locked onto that object for a duration of five minutes with 5 m/s wind present.
- To allow for wind variability, a two week testing period will be selected and the device tested at different states of wind speed. The extended testing time allows for adjustments to be made to the device, as well as to account for random wind speed variation.
- The communication system will be tested by carrying the deflated device (including propulsion and camera system) a distance of 36.6 meters on the ground away from the user interface and verifying that the user can still maintain required communication with the device. The distance between the device and the user interface should be straight and free from obstructions.
- The dimensions of the deflated device will be measured to ensure that both the volume and dimensions of the device do not exceed the specified dimension/volume requirements. The dimensions will be measured using a standard measuring tape.

Appendix B: FAA Regulations

Subpart A - General

101.1 Applicability.

(a) This part prescribes rules governing the operation in the United States, of the following:

(1) Except as provided for in 101.7, any balloon that is moored to the surface of the earth or an object thereon and that has a diameter of more than 6 feet or a gas capacity of more than 115 cubic feet.

(2) Except as provided for in 101.7, any kite that weighs more than 5 pounds and is intended to be flown at the end of a rope or cable.

(3) Any unmanned rocket except:

(i) Aerial firework displays; and,

(ii) Model rockets:

(a) Using not more than four ounces of propellant;

(b) Using a slow-burning propellant;

(c) Made of paper, wood, or breakable plastic, containing no substantial metal parts and weighing not more than 16 ounces, including the propellant; and

(d) Operated in a manner that does not create a hazard to persons, property, or other aircraft.

(4) Except as provided for in 101.7, any unmanned free balloon that-

(i) Carries a payload package that weighs more than four pounds and has a weight/size ratio of more than three ounces per square inch on any surface of the package, determined by dividing the total weight in ounces of the payload package by the area in square inches of its smallest surface;

(ii) Carries a payload package that weighs more than six pounds;

(iii) Carries a payload, of two or more packages, that weighs more than 12 pounds; or

(iv) Uses a rope or other device for suspension of the payload that requires an impact force of more than 50 pounds to separate the suspended payload from the balloon.

(b) For the purposes of this part, a gyroglider attached to a vehicle on the surface of the earth is considered to be a kite.

[Doc. No. 1580, 28 FR 6721, June 29, 1963, as amended by Amdt. 101-1, 29 FR 46, Jan. 3, 1964; Amdt. 101-3, 35 FR 8213, May 26, 1970]

101.3 Waivers.

No person may conduct operations that require a deviation from this part except under a certificate of waiver issued by the Administrator.

[Doc. No. 1580, 28 FR 6721, June 29, 1963]

101.5 Operations in prohibited or restricted areas.

No person may operate a moored balloon, kite, unmanned rocket, or unmanned free balloon in a prohibited or restricted area unless he has permission from the using or controlling agency, as appropriate.

[Amdt. 101-1, 29 FR 46, Jan. 3, 1964]

101.7 Hazardous operations.

(a) No person may operate any moored balloon, kite, unmanned rocket, or unmanned free balloon in a manner that creates a hazard to other persons, or their property.

(b) No person operating any moored balloon, kite, unmanned rocket, or unmanned free balloon may allow an object to be dropped there from, if such action creates a hazard to other persons or their property.

(Sec. 6(c), Department of Transportation Act (49 U.S.C. 1655(c)))

[Doc. No. 12800, Amdt. 101-4, 39 FR 22252, June 21, 1974]

Subpart B - Moored Balloons and Kites

Source: Docket No. 1580, 28 FR 6722 June 29, 1963, unless otherwise noted.

101.11 Applicability.

This subpart applies to the operation of moored balloons and kites. However, a person operating a moored balloon or kite within a restricted area must comply only with 101.19 and with additional
limitations imposed by the using or controlling agency, as appropriate.

101.13 Operating limitations.

(a) Except as provided in paragraph (b) of this section, no person may operate a moored balloon or kite-

(1) Less than 500 feet from the base of any cloud;

(2) More than 500 feet above the surface of the earth;

(3) From an area where the ground visibility is less than three miles; or

(4) Within five miles of the boundary of any airport.

(b) Paragraph (a) of this section does not apply to the operation of a balloon or kite below the top of any structure and within 250 feet of it, if that shielded operation does not obscure any lighting on the structure.

101.15 Notice requirements.

No person may operate an unshielded moored balloon or kite more than 150 feet above the surface of the earth unless, at least 24 hours before beginning the operation, he gives the following information to
the FAA ATC facility that is nearest to the place of intended operation:

(a) The names and addresses of the owners and operators.

(b) The size of the balloon or the size and weight of the kite.

(c) The location of the operation.

(d) The height above the surface of the earth at which the balloon or kite is to be operated.

(e) The date, time, and duration of the operation.

101.17 Lighting and marking requirements.

(a) No person may operate a moored balloon or kite, between sunset and sunrise unless the balloon or kite, and its mooring lines, are lighted so as to give a visual warning equal to that required for obstructions to air navigation in the FAA publication "Obstruction Marking and Lighting" .

(b) No person may operate a moored balloon or kite between sunrise and sunset unless its mooring lines have colored pennants or streamers attached at not more than 50 foot intervals beginning at 150 feet above the surface of the earth and visible for at least one mile.

(Sec. 6(c), Department of Transportation Act (49 U.S.C. 1655(c)))

[Doc. No. 1580, 28 FR 6722, June 29, 1963, as amended by Amdt. 101-4,
39 FR 22252, June 21, 1974]

101.19 Rapid deflation device.

No person may operate a moored balloon unless it has a device that will automatically and rapidly deflate the balloon if it escapes from its moorings. If the device does not function properly, the operator shall immediately notify the nearest ATC facility of the location and time of the escape and the estimated flight path of the balloon.

Appendix C: Budget References

Balloon Prices

The following were used as references for different sizes and types of balloons. They were found at http://www.customadvertisingballoons.com/. The size of the balloon will not be larger than eight feet or 2.4 meters in diameter. From the below reference, it is clear that a blimp shaped balloon exceeds budget allowances, thus necessitating the use of a spherical balloon.

Advertising Balloons

»balloon 4.5' - $109.00
»balloon 6.0' - $169.00
»balloon 7.0' - $269.00
»balloon 8.0' - $339.00
»balloon 10.0' - $471.00
»balloon 12.0' - $996.00
»balloon 14.0' - $1530.00

Helium Blimps

»11 ft. Blimp - $461.00
»14 ft. Blimp - $665.00
»17 ft. Blimp - $951.00
»20 ft. Blimp - $1334.00

Helium Gas Costs

These are prices found for helium gas at a location in the Dallas/Fort Worth Area. The monthly rental option would be used because of testing (testing would span approximately a two week period). The prices were found on http://www.hicodallas.com/helium.php. There is also a ten dollar pick-up and delivery fee.

Size	Cubic Feet	Helium Content	Monthly Rental[2]
Large	219	$95.00	$7.00
Medium	101	$65.00	$7.00
Small	55	$45.00	$7.00

Material References

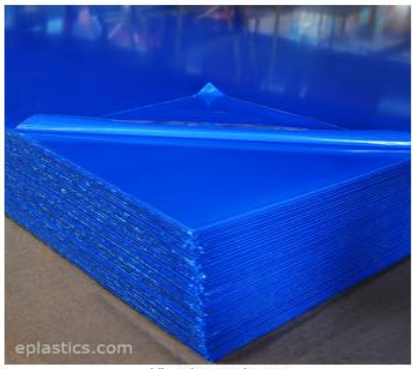
Aluminum

Quote of prices for sheets of 2024 alloy aluminum. The prices were found on http://www.onlinemetals.com/ . This material will potentially be used for the foundation of the platform and user interface.

- 12 inches x 12 inches - $4.17
- 12 inches x 24 inches - $8.06
- 12 inches x 36 inches - $10.36
- 12 inches x 48 inches - $12.96
- 24 inches x 24 inches - $12.96
- 24 inches x 36 inches - $19.00
- 24 inches x 48 inches - $24.76
- 36 inches x 36 inches - $27.86
- 36 inches x 48 inches - $35.42

Plexiglass

This is an alternative material for the user interface and platform. It was found on http://www.eplastics.com/.



View Larger Image

Plexiglass Sheets in Clear 1/16"x24"x48" sheet
Item ID: ACRYCLR0.060FM24X48
.060"x24"x48" Clear Plexiglass Acrylic Sheet Film Masked
Perfect size for small picture framing...

Item Weight: 2.8 lb
Quantity Price:

1	5	10	25
$20.06	$17.60	$15.63	$14.08

Please enter the sizes you would like us to cut.

Qty: 1 Add to Cart

View Larger Image

Plexiglass Acrylic Glue IPS16-1.5OZ
Item ID: IPS16-1.5OZ
Weld-On #16 1.5 oz. Tube

Item Weight: .5 lb
Quantity Price:

1	48	96
$4.23	$3.52	$2.82

Qty: 1 Add to Cart

Camera

BoosterVision GearCam *(BVGM-1)*

Features: Small Size & Light Weight Low Power Consumption Powered by 9 Volt Battery 2.4 GHz Wireless Mini Color Camera with Audio from built in microphone.

Size: 20mm (W) 20mm (H) 20mm (D) About 3/4 of an inché the size of a dime!

Comes with no tuning needed PLL receiver, 12 volt ac/dc supply for receiver and camera 9 volt battery clip, and ac power pack for Mini GearCam. Camera/transmitter weight is only .5oz, 2.5oz with 9 volt battery. Field of view 60 degrees, CMOS 380 TV lines of resolution sensor.

Range 300-700 feet in the air on an aircraft, 300-500 feet on the ground. Over 1 mile with the 14db patch antenna.

Receiver unit has SMA antenna connector with rubber duck antenna. Use optional Hi-Gain receiver antenna available for additional range.

Consumer use item, no license needed. FCC certified.

List Price:
Our Price: $69.95
You Save: $5.00 (7%)

Radio Controller for Communication System

Highlights

6 Channel 2.4GHz R/C Transmitter Complete Set w/ Receiver. Features complete Forward/Backward, Left/Right, Up/Down & Pitch Control (RUDDER, AILERON, ELEVATOR, Pitch AND THROTTLE)

New longer 3K battery mounting plate connects to main frame. It makes the center of gravity closed to rotor blade, and can adjust the center of gravity according to the weight of battery, it reduces the correction when the heli-rolling.

Rotor head for precision and smooth movements.

Great stable and sensitive mixing lever design! Can display the great stability and

precision for 3D flight.

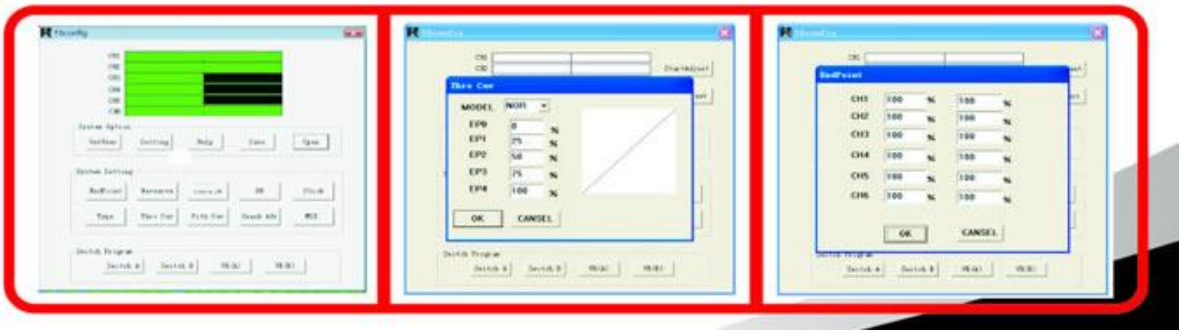
Using Ball and Hiller two systems mixing control. Through simple structure of Ball control system, power-saving of Hiller system and CCPM control, can simultaneously control 3 servo for AILE, EVLE, PIT 3 actions. This control system is great for 3D flying control and extending life cycle of servos.

Software for Radio available for download from the website.

BASIC PARAMETER:

- MODEL NAME: 6 CHANNELS TRANSMITTERS
- MODEL NO: FS-CT6X
- CHANNELS: 6 CHANNELS
- MODE TYPE: AIRPLANE, HELICOPTER, GLIDER
- STICK MODE: LEFT HAND OR RIGHT HAND
- MODULATION: FREQUENCY MODULATION
- MODULE FREQUENCY: 35MHZ,40MHz,72MHz,2.4GHz
- ANTENNA LENGTH: 115CM/26MM
- CODE TYPE: PPM/GFSK
- POWER : 12 VDC
- RF POWER: LESS THAN 0.8W
- WEIGHT: 575 GRAMS
- SIZE: 189*72*218MM

COMPUTER PROGRAMMABLE



Battery

Option 1: Power supply on balloon

The following lithium polymer batteries were found at http://www.maxxprod.com/mpi/mpi-701.html. The lithium polymer batteries could be a suitable alternative to other battery types, such as lead acid or lithium ion.

	3-CELL Lipo Pack for Electric Planes	
Product Description	**Rtl**	Sale
3Li-830 Lipo; 11.1V / 830mah; (Max discharge) 10-12C; (Size) 36mm x 53mm x 21mm; (Wt) 63g	$19.95	No Connector Order $10.00
3Li-1050 Lipo; 11.1V / 1050mah; (Max discharge) 10-12C; (Size) 36mm x 66mm x 20mm; (Wt) 80g	$31.95	No Connector Order $15.00
3Li-1500 Lipo; 11.1V / 1500mah; (Max discharge) 15-20C; (Size) 32mm x 102mm x 25mm; (Wt) 124g	$45.95	No Connector Order $29.00
3Li-1550 Lipo; 11.1V / 1550mah; (Max discharge) 10-12C; (Size) 44mm x 72mm x 21mm; (Wt) 110g	$29.95	No Connector Order $17.00
3Li-1760 Lipo; 11.1V / 1760mah; (Max discharge) 15-20C; (Size) 32mm x 100mm x 27mm; (Wt) 143g	$54.95	No Connector Order $33.99
3Li-2500 Lipo; 11.1V / 2500mah; (Max discharge) 10-12C; (Size) 58mm x 95mm x 19mm; (Wt) 175g	$35.95	No Connector Order $20.00

Option 2: Power through tether (not feasible at this point)

UB1270 12V 7Ah Wheelchair Medical Mobility SLA Battery (12 V, 7 AH)

Price: $12.95 (http://cgi.ebay.com/UB1270-12V-7Ah-Wheelchair-Medical-Mobility-SLA-Battery-/120605337758?pt=US_Batteries&hash=item1c14a3689e)

Cost of cable: $23.00 for 100ô(need 120ô $50.00)

Propulsion

ñUsing brushless motor can yield 16 to 40 + oz of thrust.

USD $28.00 (No motor)

Replacement rotor #wattr01 $9.99

With 400 motor USD $39.80 (Chart below)ò

Volts	Amps	RPM	Thrust	Thrust	Power	Efficiency
V	A	RPM	Grams	Ounces	Watts	g/w
9	8	19000	225	8.04	72	3.125
10	9	20700	265	9.29	90	2.944
11	10	22100	300	10.58	110	2.727
12	11	24500	360	12.62	132	2.727

Tethering Cord

Solid Braid Nylon Rope

Click to Enlarge

Ideal for blocks, pulleys, winches, mooring lines and general tie-downs and other similar uses.

Item No.	Description	Amount	Qty.
	1/8" - 570 lbs Breaking Strength - Per Foot	$0.20	0
	1/8" - 570 lbs Breaking Strength - 1000' Spool	$94.00	0
	3/16" - 825 lbs Breaking Strength - Per Foot	$0.22	0
	3/16" - 825 lbs Breaking Strength - 1000' Spool	$139.00	0
	1/4" - 1325 lbs Breaking Strength - Per Foot	$0.30	0
	1/4" - 1325 lbs Breaking Strength - 1000' Spool	$191.00	0
	3/8" - 3,050 lbs Breaking Strength - Per Foot	$0.69	0
	3/8" - 3,050 lbs Breaking Strength - 1000' Spool	$472.00	0
	1/2" - 5,300 Breaking Strength - Per Foot	$0.98	0
	1/2" - 5,300 Breaking Strength - 500' Spool	$403.00	0
	1/2" - 5,300 Breaking Strength - 1,000' Spool	$799.00	0

http://secure.cartsvr.net/catalogs/catalog.asp?prodid=1976902

Control Circuitry

H-Bridge Motor Driver 1A
sku: COM-00315

Description: Faster, cheaper, smaller, better, right? The SN754410 Quad Half H-Bridge is just that. Capable of driving high voltage motors using TTL 5V logic levels, the SN754410 can drive 4.5V up to 36V at 1A continuous output current! Please see datasheet for more information. This is a pin to pin compatible replacement for the L293D.

Datasheets: SN754410
Pricing

$2.35	**price**
$2.12	10-99 (10% off)
$1.88	100+ (20% off)

This is a good IC for robotics. It is a quadruple half-H driver but by connecting certain pins it can be used as a dual full H-bridge. See data sheet for more info.

www.sparkfun.com