Functional Analysis

Senior Design I

Kristopher Kenney
Kostya Kravchenko
Ryan Maroney
Gavin Swietnicki

Introduction

The Alternatives Evaluation of this report describes the alternatives of the design that will accomplish the functionality of what is intended. Here, three designs will be explained with a decision matrix that weighs design metrics to decide on the most sensible design. Client/User operation will also be explained. This will consist of an explanation of how the user will interface and operate the product.

Design Alternatives

1) Quadcopter Solution

Table 3.1: Marked in green are the options that were chosen for design one.

Quad-copter	1	2	3	4	5	6
Collar/Receiver	VHF	GPS	IR	UHF	Bluetooth	
Relay	Wi-Fi	IR	VHF	UHF	SHF	
Vehicle	Quad-copter	Hexa-copter	RC Airplane	Balloon	Piloted Aircraft	Octo-copter
Remote Control	Handheld Tx	Truck-mount Tx				
Video	HiDef	LowDef	Still shot			Satellite PC
Antenna	Omni	Directional	Dipole			
Power	Solar	Solid State Battery	Fission	Fusion	Fuel Cell	

This design draws influences from multiple ideas and combines them together to get the best of several worlds. The vehicle of choice is the quadcopter, chosen as a cheap, easy, and reusable way to get a directional antenna in the air for better range. The quadcopter offers a much less expensive option when compared to an airplane ride, and is also much more durable, faster, and easier to use than a balloon option. The collar and receiver would use VHF frequency, which is more common and is something the ecology department is already familiar with. The relay would use SHF as the frequency, incorporating a 5.8GHz frequency available for industrial, scientific and medical (ISM) purposes. The quadcopter would utilize a handheld remote control operated by the user on the ground. The video feed from the GoPro camera would be in high definition. There is really no reason to not incorporate HD video given the opportunity and small price difference. A directional antenna would be mounted on the quadcopter, in order to pinpoint the location of the collared animal. This is really the only option for an antenna in this design. As for power, a solid state battery would provide the best solution for the quadcopter and the subsystems. A battery is reliable, cheap, and able to provide constant power when compared to other options. Overall, this design certainly provides the best option, and will be used unless unforeseen issues cannot be overcome.

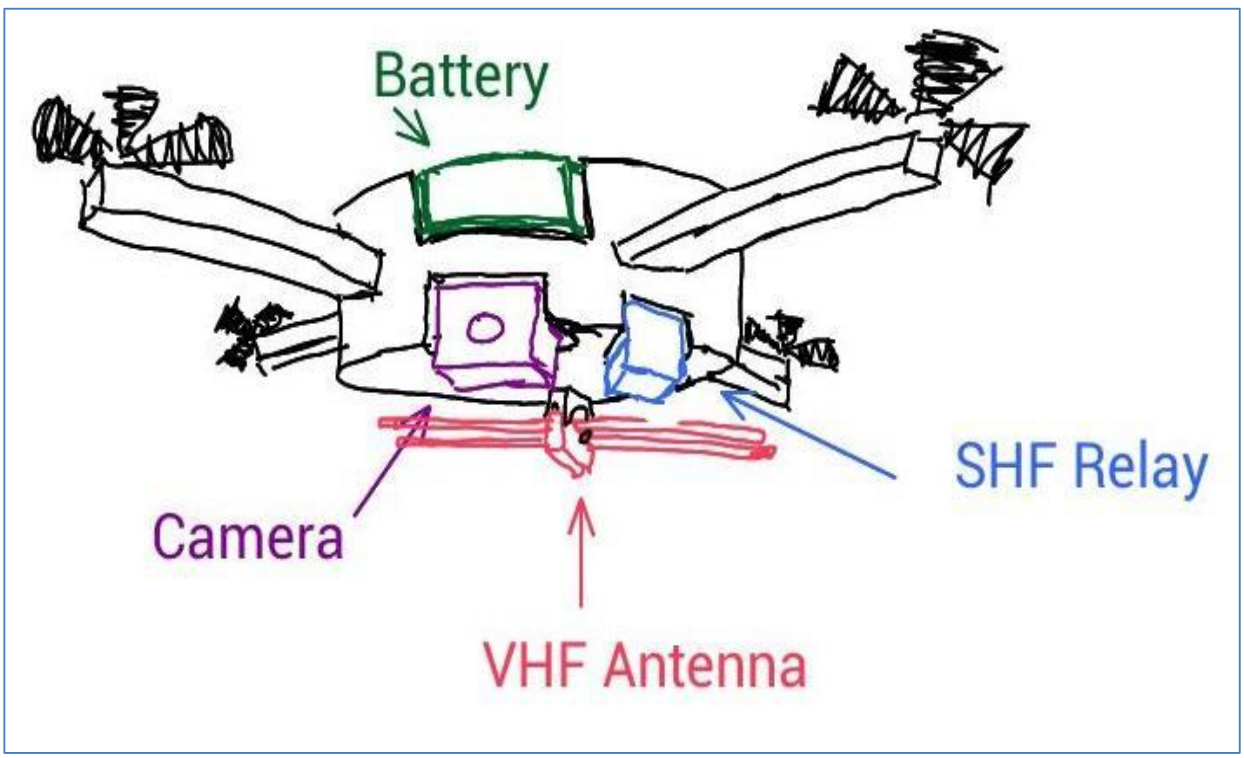

Figure 3.1: Sketch of quadcopter with all of the required components.

2) Stripped-down Quadcopter

Table 3.2: Marked in orange are the options that were chosen for design two.

Stripped-down Quad-copter	**1**	**2**	**3**	**4**	**5**	**6**
Collar/Receiver	VHF	GPS	IR	UHF	Bluetooth	
Relay	Wi-Fi	IR	VHF	UHF	SHF	
Vehicle	Quadcopter	Hexacopter	RC Airplane	Baloon	Piloted Aircraft	Octocopter
Remote Control	Handheld Tx	Truck-mount Tx				
Video	HiDef	LowDef	Still shot	none		
Antenna	Omni	Directional	Dipole			
Power	Solar	Solid State Battery	Fission	Fusion	Fuel Cell	

This solution consists of the same main components that were chosen in design 1. The difference in this design is that only the absolutely essential components would be included. The GoPro video would be taken off of the quadcopter. The client has expressed that this option is not essential, and can be removed if deemed unnecessary or found to be interfering with the main audio signal. Any stabilization system included on the quadcopter could also be removed in this design option. The reason for this would be if the stabilization system was found to be an interfering device. This would make the quadcopter slightly harder to control and use, but the end goal could still be achieved. The quadcopter could still be taken up into flight to find the location and bearing to an animal. In short, this design solution would consist of removing any unnecessary components if they were found to be a hinder to the overall system. Only the bare essential parts required to achieve the level one requirements would remain.

3) Balloon solution

Table 3.3: Marked in blue are the options that were chosen for design three.

Balloon Solution	1	2	3	4	5	6	7
Collar/Receiver	VHF	GPS	IR	UHF	Bluetooth		
Relay	Wi-Fi	IR	VHF	UHF	SHF	Cable	
Vehicle	Quad-copter	Hexa-copter	RC Airplane	Balloon	Piloted Aircraft	Octo-copter	
Remote Control	Handheld Tx	Truck-mount Tx	Tether				
Video	HiDef	LowDef	Still shot				Satellite PC
Antenna	Omni	Directional	Dipole				
Power	Solar	Solid State Battery	Fission	Fusion	Fuel Cell	Cable	

The Balloon Solution design was constructed entirely for the purpose of cost effectiveness and elimination of noise between the components used. However, there are multiple flaws that come with using a simple design as this. The vehicle used would be a balloon that would carry the weight of the devices explained. The collar uses VHF, which is commonly preferred and is already used by the Ecology Department. The relay from the balloon to the ground would use a hard wire instead of a GHz link to eliminate noise and create an improved signal to the user. To control the vehicle, a tether would be used. The tether is not ideal, but is certainly cost effective. The video will be gathered by a GoPro on the balloon. The video will be HiDef since resources that could be used elsewhere (i.e. GHz link, Quadcopter

Drone, or manned aircraft) can be used for video capture. The antennas used on this design would be three directional antennas organized radially around the balloon. Since the balloon cannot be controlled, the bearing to the collar would have to be gathered by recognizing which antenna picks up the strongest signal. Lastly, to power the design, a cable from the ground will be used to power the components. Indubitably, the largest flaw of this design comes from the factor of cost effectiveness. This design is not durable or easily operated in non-ideal weather conditions. This design would best be used as a critical last resort. If other designs become too expensive, or noise cannot be overcome, then this design can be considered and improved upon.

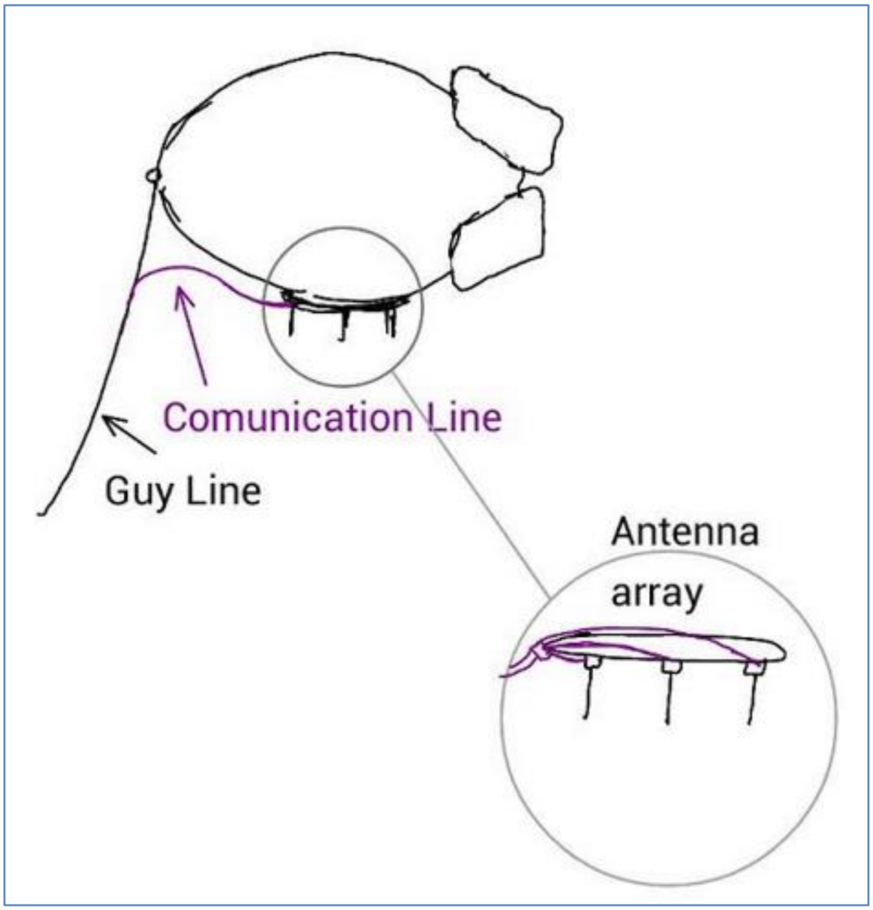

Figure 3.2: Sketch of balloon with antennas and ground tether.

Client/User Operation

Design one will be chosen because it best meets the client requirements which can be seen in the decision matrix below. The way this design will be implemented will be to fly the quadcopter from the ground. The signal will be relayed from the animal collar to the VHS antenna through the SHF relay to the ground operator. This will require the quadcopter to be portable which means that it must be assembled and disassembled in the field to increase portability. Once the quadcopter is in the field, assembled and ready to deploy, the user will need to turn on all of the components and test operation before lifting off the ground. This will involve ensuring batteries have sufficient charge for operation of each device and ensuring that all devices are working together. Once a ground test has been completed by ensuring the video and audio are being transmitted by the SHF relay, the quadcopter controls must be checked at low altitude. This can be done by slowly raising the vehicle off of the ground using lift via the remote control. Once lift has been established, yaw, pitch and roll can be tested. Once all flight controls are confirmed operational the device may be lifted to operational height and a 360 degree yaw (spin a full circle) will determine if a collar is in range. If a blip is heard via the SHF relay, the pilot will yaw left and right until the direction is determined. Once the direction is determined, then the lift may be adjusted to establish a distance. Using these two parameters, distance and direction, the researcher has the information they need to find the animals for research.

Decision Matrix

A decision matrix is a tool that is applied in an engineering design process and is used to select the most feasible project design. The idea is to score each design alternative across the design metrics discussed previously. Obviously every metric has a different importance factor which is determined based on the design goals. To account for this factor a weight system is used. Each design objective/metric is scored on a scale from 1 to 10. This determines the weight/importance of the metric. After the three alternatives are scored across each metric and using a formula that accounts for the weights, a total score is produced. For this project: cost-effectiveness, operational range and bearing accuracy were chosen to be the most crucial to the success of the design and received scores 9 to 10. Due to the quadcopter design scoring the most in these categories, this design got the highest overall score and was chosen to be the best solution.

Table 3.4: Design Matrix showing the scores of each selected design and the final totals.

Objective	Importance Score	Weight(%)	Quadcopter	Stripped-down Quad	Balloon Solution
Cost Effective	10	18.52	10	10	10
Durable	6	11.11	5	4	4
Flight time	3	5.56	5	5	7
Ease of Use	2	3.70	8	6	6
Safety	1	1.85	8	8	8
Range	9	16.67	8	8	8
Weight	3	5.56	8	9	5
Portability	5	9.26	9	9	6
Signal Interference/Noise	5	9.26	5	7	9
Bearing Accuracy	10	18.52	9	8	6
Total	54	100.00	7.87	7.74	7.16