System Architecture

Senior Design I

Kristopher Kenney
Kostya Kravchenko
Ryan Maroney
Gavin Swietnicki

Introduction:

This section of the report will explain the system architecture for the wildlife tracking system. All the interfaces will be explained and broken down into mechanical, electrical, wireless, and human interfaces. The design is depicted by a drawing and flow diagram that will depict a visual understanding of the product's operation. The sub-system interfaces will break down the initial flow diagram into more detail. Lastly, the user interfaces are explained. This will entail all the human factors the design considers.

System Architecture Plan:

Figure 6.1 below shows high-level system architecture plan and how various components interface with one another. The schematic is visually divided into 3 groups: Quadcopter, Ground Control and Tracked animal. All of these are equally important to the overall goal of the design. The most important aspect of the design is how the signal from the tracked animal reaches the end-user and all components that support this process. In short: the signal from VHF collar propagates through space and reaches the VHF directional antenna; if the signal is in the main lobe of the antenna, where it is the strongest, the receiver can pick it up and demodulate the audio carried by the signal; afterwards using the 'Audio Out' port on the receiver we modulate the audio onto 5.8GHz carrier (in 5.8GHz transmitter), which then propagates through space and reaches the 5.8GHz receiver, which then demodulates the signal and the audio can be heard in the headphones by the end user. The VHF link between the animal and the quadcopter was chosen due to great propagation characteristics and inexpensive collar trackers. The 5.8GHz link between the quadcopter and the user was chosen due to it being least susceptible to interference from other system components.

The supporting components of the process described above are:

1) The quadcopter, which supports the Directional antenna, battery power supply, 5.8GHz Tx and VHF Rx. Due to it being able to fly at significant altitudes, the VHF signal can be heard a greater range
2) The battery power supply #2, which powers the 5.8GHz Tx. The VHF Rx is a handheld receiver which has an internal battery. The quadcopter is powered from the main battery pack #1.
3) GoPro camera which feeds video into the 5.8GHz relay and allows the user to see which way the quadcopter is facing and allows easier tracking of the animal.

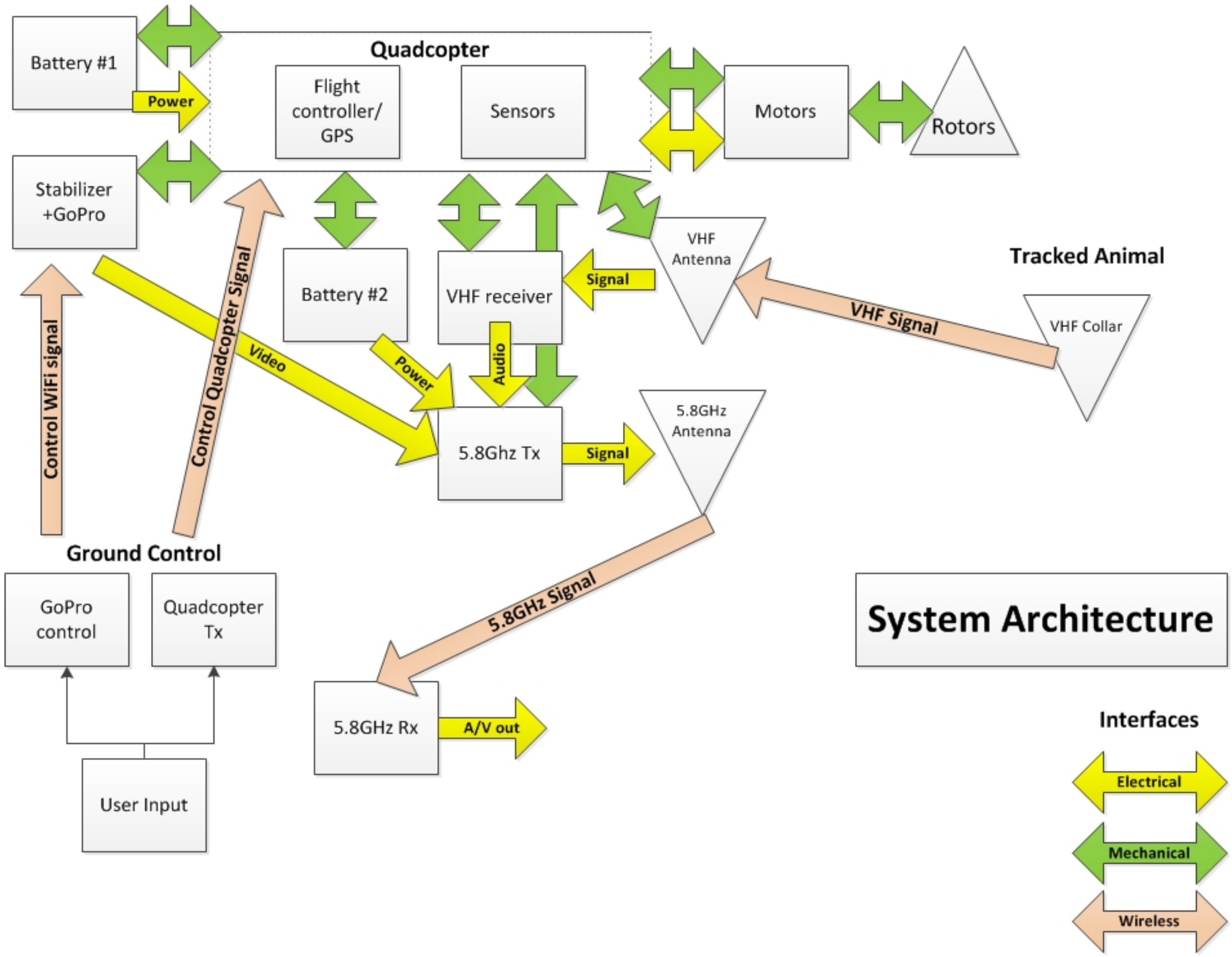

Figure 6.1: High-level system architecture plan

Wireless Interfaces:

- Long distance quadcopter Tx to quadcopter
- VHF collar signal to VHF receiver on the quadcopter
- Wi-Fi GoPro control
- 5.8Ghz link between Tx on the quadcopter and Rx on the ground

Mechanical Interfaces:

- Rotors to motors (screw)

- GoPro attached to the quadcopter through gyro-stabilizer
- 5.8GHz Tx attached to the quadcopter (screws)
- VHF receiver attached to the quadcopter (velcro)
- H-antenna attached to the quadcopter (velcro)

Electrical Interfaces:

- 5.8GHz Rx with a 5.8GHz Omni/dipole antenna through a SMA/BNC cable. Current choices are:
    - Duo5800 v3 Diversity A/V Rx (powered on the ground)
    - SpiroNET Omni - 5.8Ghz CP Antenna
    - SMA cable
- 5.8GHz Tx with a 5.8GHz Omni/dipole antenna through a SMA/BNC cable. Current choices are:
    - ImmersionRC 5.8Ghz 600mW A/V Tx
    - SpiroNET Omni - 5.8Ghz CP Antenna
    - SMA cable
- VHF (~150MHz) Rx with a directional antenna through a BNC cable.Current choices are:
    - H-shaped directional antenna
    - R-1000 telemetry receiver(internal battery powered)
    - BNC cable
- VHF Rx Audio Output to 5.8GHz Tx
    - 5-pin Molex SL audio/video (remove audio wire from GoPro, instead connect to VHF Rx Audio Output)

- GoPro to 5.8GHz Tx
    - 5-pin Molex SL audio/video (remove audio)
- Power Supply to 5.8GHz Tx
    - 2-pin Molex SL, battery input (6-25V DC)
- Quadcopter Matrix S-FPV interfaces (details can be found on the manufacturer website)
    - Battery power supply
    - Flight controller/Multi-rotor stabilization
    - GPS chip
    - Motors
    - Internal electronics

System Interfaces:

The system interface can be seen below in Figure 6.2 which is broken down into various colors for each sub-system. Shown in black is the quadcopter system this is the platform that the tracking system will be build upon. In red is the in-flight stabilization system that will auto-pilot the quadcopter in windy conditions and help the pilot controlling the system to have ease of use. Shown in green is the camera stabilization mount and in purple is the camera, though these systems are not essential for animal tracking they will aid in the determination of approach as the animals are located. The VHF receiver and antenna shown in orange will be mounted to the underside of the quadcopter to help prevent interference from other systems and allow maximum line of sight in locating a collar signal. Shown in blue is the 5.8 GHz relay that will transmit the audio and video signals from the quadcopter to the pilot to aid in triangularization. Finally shown in pink is the wireless transmitter that is used in the piloting of the quadcopter.

Figure 6.2: Wildlife tracking system broken into individual sub-systems.

Figure 6.3 below shows the flow diagram for the wildlife tracking system. The pilot control interface will control the movement of the quadcopter simultaneously with the assistance of the flight stabilization system shown in the flowchart. The camera and VHF receiver will be connected to the 5.8 GHz video and audio relay which will be sent to the pilot on the ground to determine direction and distance to the animal being tracked. It can be seen in the flowchart that the camera is connected to the quadcopter with a auto-stabilization mount which will help balance the video. It can also be seen that the VHF receiver is connected to an H-antenna which are commonly used in the wildlife tracking fields of study.

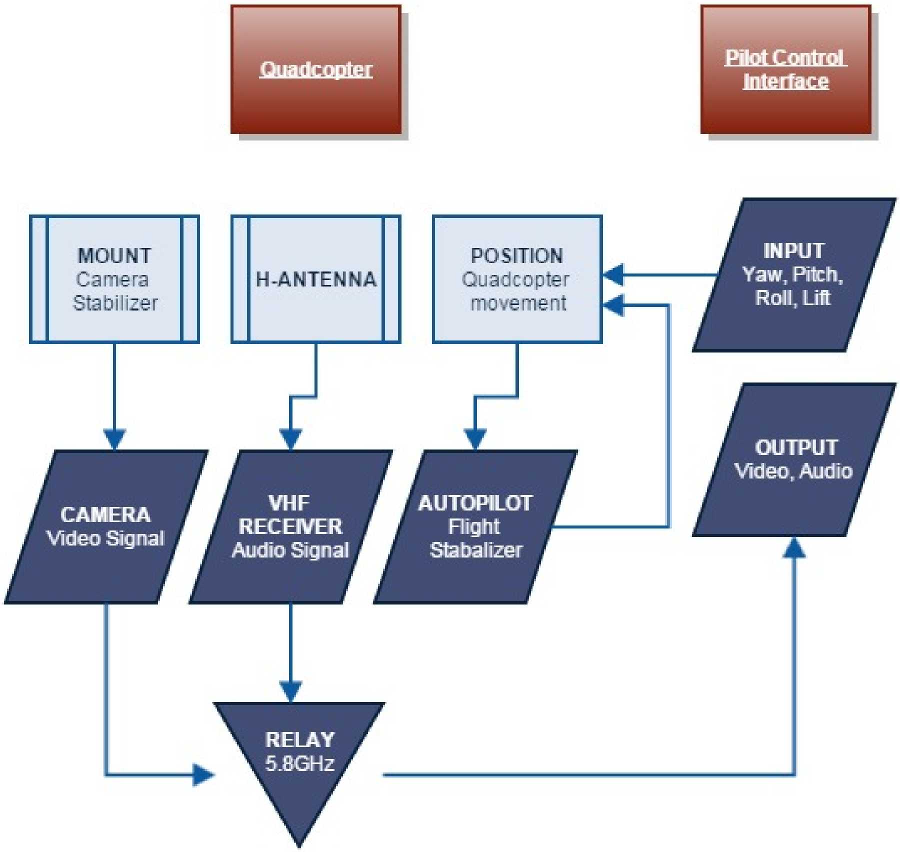

Figure 6.3: Shows the system architecture flowchart for the wildlife tracking system.

Sub-System Interfaces:

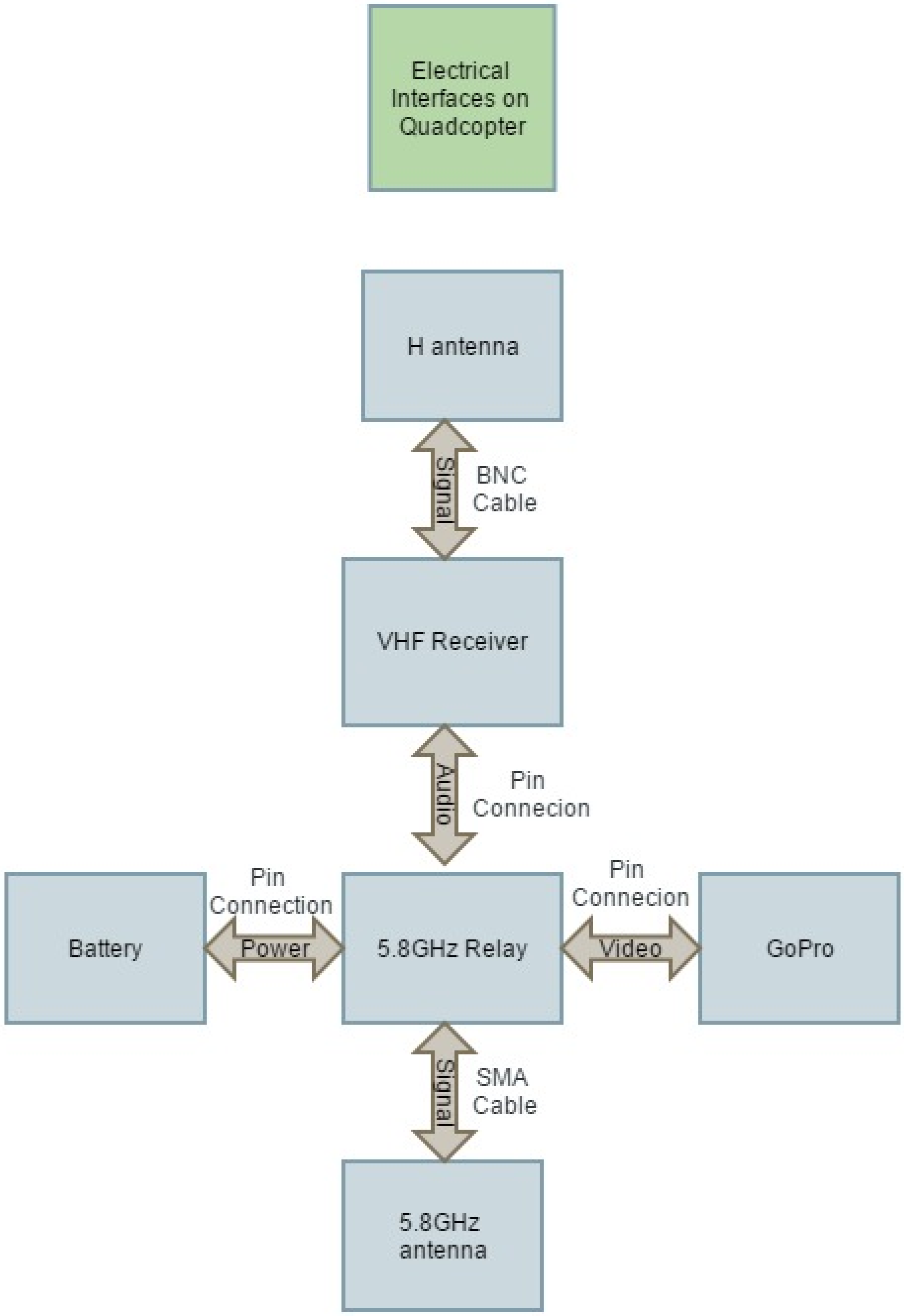

Figure 6.4: Electrical Subsystem Interface for the components on the quadcopter.

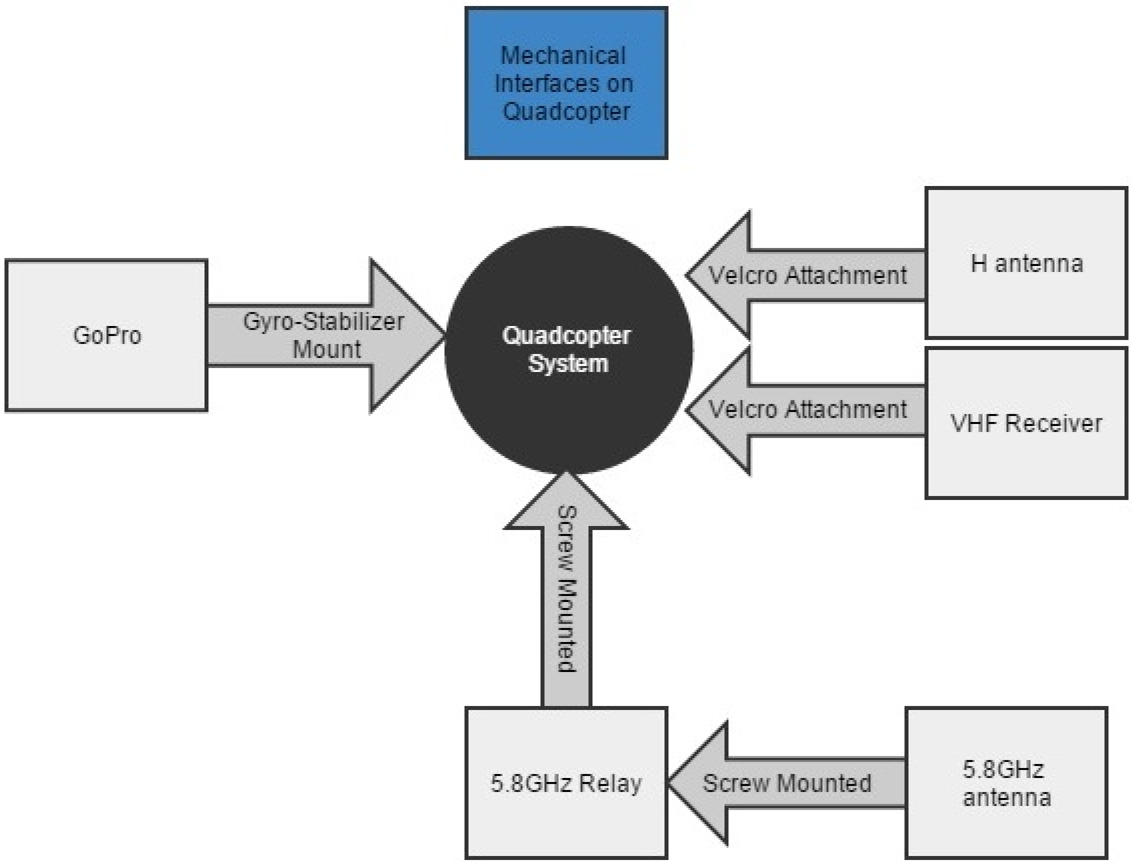

Figure 6.5: Mechanical Subsystem Interfaces for the components on the quadcopter.

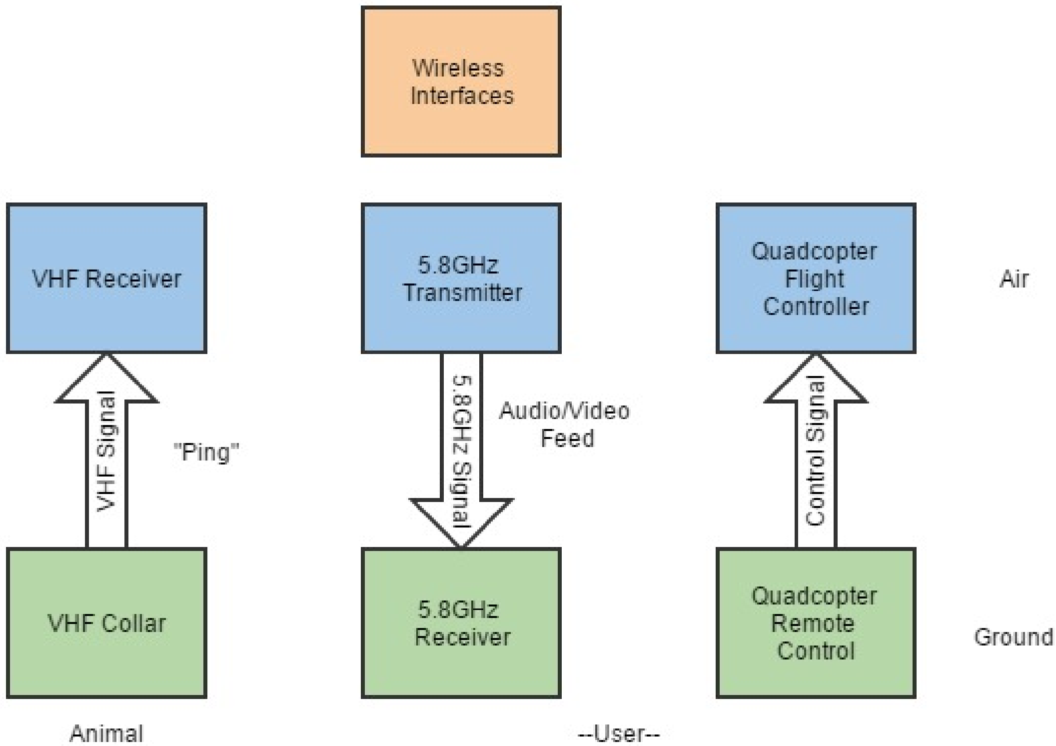

Figure 6.6: Wireless Subsystem Interfaces between components

User Interfaces:

The user interfaces will incorporate the human factors the user will have to consider when operating the design. Firstly, the user will have to deploy the assembled quadcopter. This entails taking it out of the designated carrying case, and rearranging the quadcopter from carrying mode to operating mode.

Secondly, the user will have to ensure that all the components' batteries are charged as well as turned on and operating before the quadcopter is powered. The components that correspond to this step are, the 5.8Ghz relay, the VHF receiver, the Hero3 GoPro camera, and the directional VHF H-antenna. This step contains a ground test to confirm that the audio and video are being transferred to the user clearly. A test run on the VHF receiver can be conducted by a collar held by the user. The quadcopter's GPS system will have to be enabled and confirmed that it is operating correctly. The GPS system will enable the quadcopter to return to the user automatically if something goes wrong, or if the quadcopter is not fully charged.

Once the previous steps have been conducted, the user will now operate the quadcopter. This entails a controller the user will handle, as well as a audio/video feed that the user can see on the ground transmitted from the quadcopter. The user will be able to control the quadcopter's elevation and bearing. The user will not have to compensate for an unexpected gust of wind that knocks the quadcopter off kilter since the GPS stabilization device will do this automatically for the user.

Finally, to fulfill the purpose of the design, the user will rotate the quadcopter at its operational height. The quadcopter will be rotated until an audible "beep" is heard on the A/V feed. This "beep" correlates to a collar. Therefore, the user will have a bearing on the direction of where the animal is located. With the elevation of the quadcopter at which the "beep" was heard, the user will be able to figure out the distance of the location of the animal. Indubitably, the location and bearing of the animal is achieved.

After all is done, the user will have to land the quadcopter, power down the components, and stow away the quadcopter into its designated carrying case.