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October 14, 2014

Dr. Andrew Rawicz
School Of Engineering Science
Simon Fraser University
Burnaby, British Columbia
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Re: ENSC 440 Functional Specification for Search and Rescue Quadcopter

Dear Dr. Rawicz,

Enclosed in this document is our functional specification for quadcopter design for search and rescue operation. The Unmanned Aerial Vehicle (UAV) is capable of autonomous flight and can be used in many applications, videography, geological surveys and security. Our project focuses on search and rescue to survey a particular area for a missing person with minimal human intervention. We aim to assist with search and rescue operations particularly paying attention to geographical areas that are not safe and also assist with night search, which ensures safety, saves time and money.

This functional specification document contains requirements that the quadcopter has to fulfill as a proof-of-concept model. All hardware and software components of our product are examined to meet the standard requirements including functional requirements, safety considerations and test plan. We will refer to this document throughout the development phases of our product.

Searcue comprises of five well-varied and dedicated engineering students: Lekabari Nghana, Hesam Fatahi, Avi Gill, Gurjeet Matharu and Mehrdad Ahmari. Should you have any questions or comments on this proposal, please feel free to contact Hesam Fatahi at 778-773-4681 or by email at hfatahi@sfu.ca.

Sincerely,

LekabariNghana
CEO
Searcue

Enclosed: Functional Specification for Search and Rescue Quadcopter

SEARCUE

# Functional Specification for Search and Rescue Quadcopter

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# EXECUTIVE SUMMARY

The need for a quicker response time during an emergency rescue operation is important to sustain lives and ensure safety of individuals. In provinces like British Columbia where there are lots of mountains and rivers most of which are available for sightseeing, there have been reports of deaths and missing persons. In British Columbia, the amount of search and rescue teams and members we have is almost more than double any other province in Canada (BCSARA, 2011). The amount of search and rescue operations in 2011 in British Columbia was 1 304, this is almost nine times more than the province of Nunavut which had 163 (BCSARA, 2011). From the volume of searches required in BC, it is evident search and rescue in British Columbia is an issue that can't be ignored.

With the major goal of saving lives by minimizing the time required for a search operation, our company Searcue uses quadcopter not only to speed up the process but also to search areas that may pose dangerous thereby overcoming environmental constraints and ensuring safety. The quadcopters could fly to these hard to reach places to search for an individual, thus giving search and rescue members enough notice to get well equipped for such areas. There are two modes of operation of quadcopter, automatic and manual. These modes allow for versatility, allowing the operator to fly the quadcopter closer for a better view of the situation.

Development of the quadcopter will occur in three phases. In the first stage of development, we will be focusing on getting the quadcopter to fly. Upon completion, we will have the following functionality:

- The quadcopter should be able to take off and land
- Manual flight using the transmitter to control speed and direction of flight and automatic flight using open source software
- The quadcopter should be able to fly for 15 – 20 mins

The second phase of development focuses on communication system between the receiver and transmitter.

Finally, embedding software for proper digital imaging processing with the use of a GoPro camera to find an object in a field and send its location. Once the proof of concept model is complete, we would continue with improving the design. Furthermore, our quadcopter will conform to all standards and regulations, including those of the CSA.

The detailed functional specifications are outlined in this document and would be used during the development phases, serving as a reference.

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# Glossary

UAV - Unmanned Aerial Vehicle, aircraft without human pilot

GPS - Global Positioning System that provides location and time information

Arduino - single-board microcontroller

IMU - Inertial Measurement Unit

DOF - Degrees of Freedom

# 1. Introduction

The search and rescue quadcopter is a four-rotor, small-scale system. It is a low cost prototype of a more advanced technology and it is designed with video streaming. It is capable of lifting off the ground, travelling a specified distance and searching for objects in its location and then land which requires sensors as well as gyroscope, accelerometer, GPS, batteries and a good camera. The system requires the use of Arduino board and Razor IMU to allow for 9 degrees of freedom therefore providing stability during flight.

## 1.1 Scope

This document contains information on functional specification and requirements which will be used as a guide throughout the development phases. The high priority requirements must be met while the medium and low priority requirement are add-ons but not necessary.

## 1.2 Intended Audience

This document is intended to be used by all members of Searcue during the design and development phases of the search and rescue quadcopter. It would serve as a reference document and would allow tracking the progress of the both the hardware and software groups. It will also serve as a standard for testing to determine the success of the final product.

## 1.3 Classification

For the functional requirements listed in this document, the following convention would be used.

R[n - p] Functional requirements

Where ***n*** represents the functional requirement number and ***p*** denotes the priority level of the functional requirement and is classified as follows:

A. High Priority - requirements that must be finished at the end of the project for proof-of-concept
B. Medium Priority - requirements that are not necessary but will enhance the design and functionality
C. Low Priority - additional requirements after product completion

# 2. System Requirements/Overview

General system guidelines and system requirements are presented in this section.

The Searcue system, an autonomous system utilized for search and rescue missions with minimal human intervention, or input. An onboard UAV flight controller and the use of digital imaging techniques to help identify possible search tokens accomplish this.

The Searcue UAV system is composed of two integrated stages, the first being the UAV and it's capability of stable flight, and the second being the image processing capable of providing adequate feedback to the system.

**FLIGHT**

The flight of the controller can be modeled at a high level by the following block diagram.

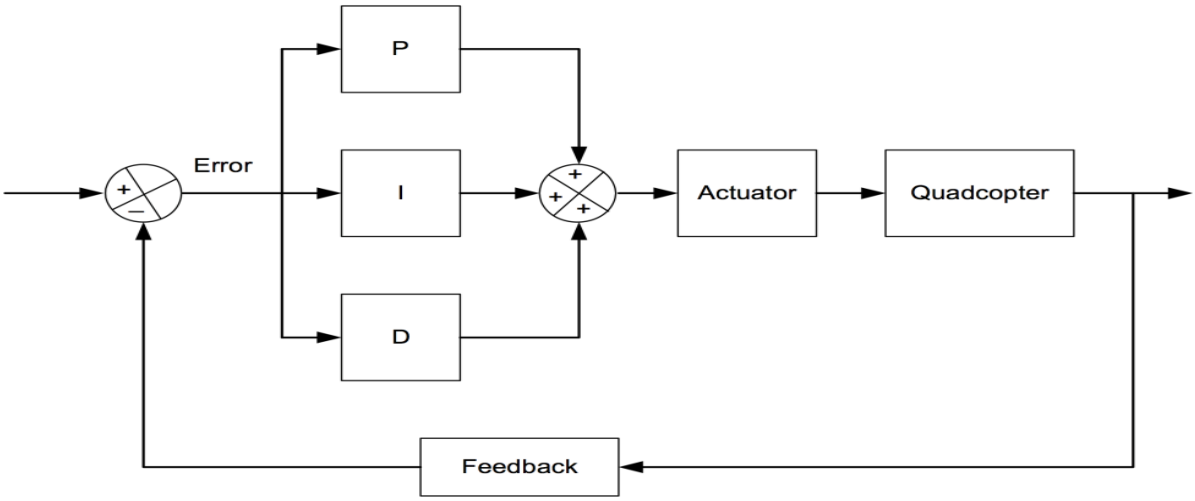


**Figure 1** – Block Diagram for controller flight

Where the feedback of the system is the respective yaw pitch and roll of the UAV, and the respective motor thrust is the output as demonstrated by figure X.

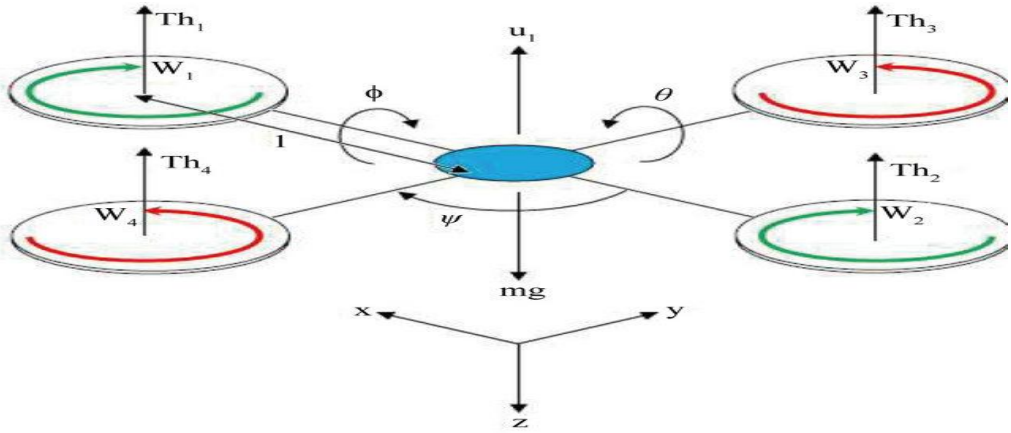


**Figure 2** – Figure showing yah, pitch, roll and thrust of system

This PID control mechanism is handled by an arduino based flight controller, which takes the feedback of the yaw pitch and roll in real time allowing for stable flight. Furthermore, the thrust of the system is dependent on the motors chosen and the overall weight of the integrated system.
Due to budget and time constraints we have limited our selection of parts trying to achieve an optimal cost to performance ratio. This greatly impacts the performance of the UAV including flight time.

Digital Image Processing – Identification

The image processing integrated into the system provides the following control system.

This will allow for a separate unit to be able to handle the image processing and update the UAV with proper information. The sensor in this case will be a camera and once the system detects a positive match the gps coordinates along with an image will be sent to the user.
Due to time constraints the image-processing algorithm developed will be a much simplified version, indicating a proof of concept. The algorithm will be able to identify unique objects in an unobstructed field. Additionally the equipment required to find a person is expensive and exceeds our budget. Nevertheless, this algorithm can be further developed with the necessary equipment to effectively find people through various terrains.

## 2.1 General system requirements

R[1 - C] - Cost is less than $750
R[2 - A] - Able to carry a gopro camera into stable flight
R[3 - A] - Have a flight time of at least 10 minutes
R[4 - A] - Find a unique object in an unobstructive field
R[5 - C] - The vibration should be minimal and does not affect the camera footage
R[6 - B] - The quadcopter should be able to fly manually and autonomously

## 2.2 Electrical Requirements

R[7 - A] - The power source must be able to adequately provide power for all the motors and flight controller/sensors
R[8 - A] - The esc circuit must be able to control the motors effectively
R[9 - B] - The wires will be well placed allowing for effective flight
R[10 - C] - The power source must be portable.

## 2.3 Physical Requirements

R[11 - A] - The product will not weigh more than 8lbs
R[12- A] -The product should be able to withstand some physical stress

## 2.4 Mechanical Requirements

R[13 - C] - The batteries need to be easily replaceable
R[14 - B] - The quadcopter should be portable
R[15 - B] - The Quadcopter must have landing gear

## 2.5 Environmental requirements

R[16 - C] - The Quadcopter must be able to operate under different weather conditions
R[17 - C] - The Quadcopter must be able to operate normally between 0°C to 45°C temperature
R[18 - C] -The Quadcopter must be able to operate in dark environments
R[19 - C] - The device should be able to land in all sorts of surfaces

## 2.6 Standards

R[20 - A]- All connections and cables should follow the CSA Canadian electrical Code in regards to safety
R[21 - B] - The device should comply with OSHA 1910.269 standards
R[22 - B] - The system should follow ISO 9001 and ISO 14001 standards

R[23 - B] - The systems should conform to EN 60950 safety requirements
R[24 - B] - The systems should conform to EN 300-328 standards
R[25 - B] - The systems should conform to EN 301 489-1 and EN 301 489-17

### 2.7 Reliability and Durability

R[26 - B] - The propellers must be easily replaceable
R[27 - B] - The Quadcopter must be able to sustain stable flight

### 2.8 Safety Requirements

R[28 - A] - The Quadcopter must avoid catastrophic crashes
R[29 - B] - The device should have failsafe protocols in place
R[30 - A] - Electrical circuits and wiring will follow safety protocols

### 2.9 Performance Requirements

R[31 - A] - The Searcue system must be able to identify the GPS coordinates of the person/token in question

### 2.10 Usability Requirements

R[32 - A]- The user must be alerted when a positive match is found

## 3. Frame Specifications

### 3.1 Physical Requirements

R[33 - A] - The frame will not exceed a diameter of 33cm without the propellers
R[34 - A] - The frame weight should not exceed 2lbs
R[35 - A] - The propellers should not exceed a diameter of 9 inches
R[36 - B] - The frame material should be sturdy, yet light in weight
R[37 - C] - The frame should be made of moisture resistant material

## 4. Motors

### 4.1 General Requirments

R[38 - B] - Motors should be easily replaceable
R[39 - A] - Motors should be able to create enough thrust to sustain flight
R[40 - A] - Motors should be brushless motors
R[41 - A] - 4× 53 grams Motors should be used

### 4.2 Electrical Requirements

R[42 - A] - Motors should be adequately wired controlled via ESCs
R[43 - A] - 920KV motors must operate in the range of 7V to 12V DC

## 5. Digital Image Processing

### 5.1 General Requirements

R[44 - B] - Must be able to identify a unique object autonomously
R[45 - A] - efficiently use digital imaging techniques to identify unique objects

### 5.2 Software Requirements

R[46 - A] - Code should be easy to read and easy to follow
R[47 - A] - Should use standard libraries and methodology

## 6. Flight Controller

### 6.1 General Requirements

R[48 - A] - Flight controller should read the inputs from the sensors and adjust the motors to allow for stable flight
R[49 - A] - The flight controller must allow for outside disturbances and correct for error

### 6.2 Physical Requirements

R[50 - A] - The components are secured properly to the frame
R[51 - A] - The components are efficiently connected and soldered together

## 7. Communications

### 7.1 General Requirements

R[52 - A] - The transmitter must be a minimum of 6 channels for transmitting and receiving
R[53 - A] - The gopro camera must be able to stream video and send pictures
R[54 - A] - Must not lose data, it must have stable communication
R[55 - B] - Data transmission must be on a secure channel

# 8. Conclusion

The functional specifications demonstrate the capabilities and requirements that will be held for this device and the accompanied software. Searcue is committed to provide an effective solution to improve the search and rescue operation. Our product will introduce a safer way of communication between the rescuers and the rescue. It also reduces the rescue operation time, cost, and fatality rate. Development has currently begun and we expect to see a complete working prototype by early December. Our team hopes to give the knowledge required for the product from these functional specifications.

# 9. References

BCSARA (2014). Rescue Techniques. Retrieved from http://www.bcsara.com/sar-groups/rescue-techniques/

Coptercraft Unmanned Aerial Robotic Systems(2014). Beginner Quadcopter for Aerial Photography. Retrieved from http://www.coptercraft.com/f450-beginner-quadcopter-aerial-photography/