UNIVERSITY OF CENTRAL FLORIDA

College of Engineering and Computer Science

Knight's Intelligent Reconnaissance Copters (KIRC)

EEL 4914 Senior Design 1

Initial Project and Group Identification Document

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Team #14

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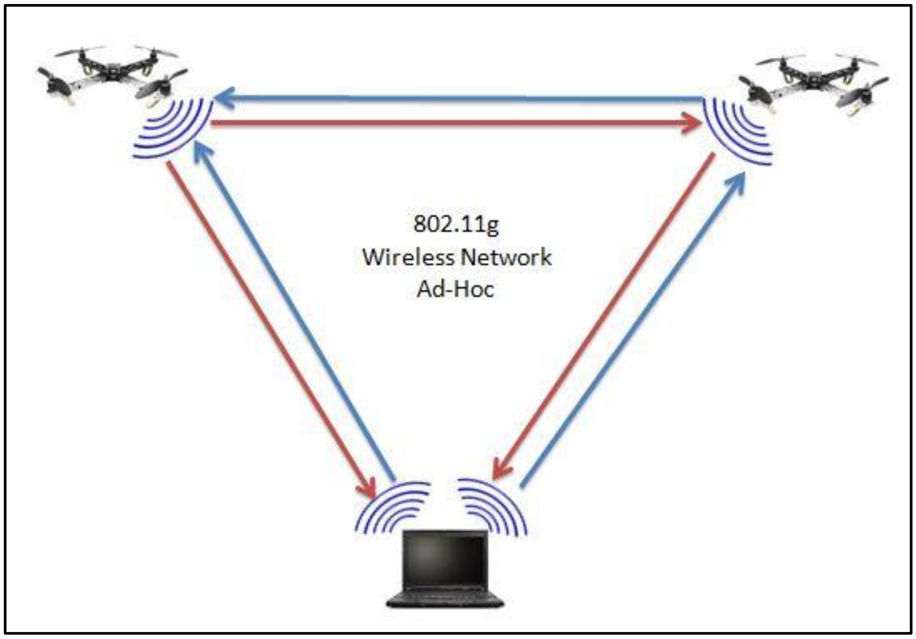
Sponsor: NASA

Introduction& Description

KIRC (Knight's Intelligent Reconnaissance Copter) is a NASA funded project that includes two quadcopters that will have the task of imaging an area for NASA earth science missions. Each copter will be autonomous and communicate via wireless mesh network. These copters will be re-configurable on a mission-by-mission basis, as mission flexibility is important to our sponsor. The copters should have ample flight time to cover moderate distances on a single charge. There will be a ground station with a user interface that can give commands to the copters. Commands include: hover, go-to coordinate, image an area, land copter, and return home. Each copter will have the ability to switch into a manual flight mode in which the user can use a traditional RC controller to control the copter(s).

This project is intended test Disruption Tolerant Networking (DTN) in an active field setting scenario for a group of engineers at the Kennedy Space Center. DTN is a special networking protocol that is optimized for environments where disruptions or delays in the line of communication frequently occur. DTN will be an integrated part of the software, and it will facilitate all communications on each copter. These quad-copters will be used during some 2014 NASA missions like the Pavilion Lake Research Project (PLRP), in Canada.



System Overview Diagram

Specifications & Requirements

The KIRC project is going to be split into three prototyping phases. Ultimately, we are planning to have two completely autonomous reconnaissance quadcopters. The first phase will be to create a remote controlled prototype in order to refine our flight stability algorithms before moving toward autonomous flight. The second phase will be to convert the prototype quadcopter into KIRC, a completely autonomous reconnaissance copter. Phase three will be to replicate the KIRC, naming it SPOK (Secondary Partner of KIRK). In the final presentation, we are planning to have both KIRC and SPOK working cooperatively.

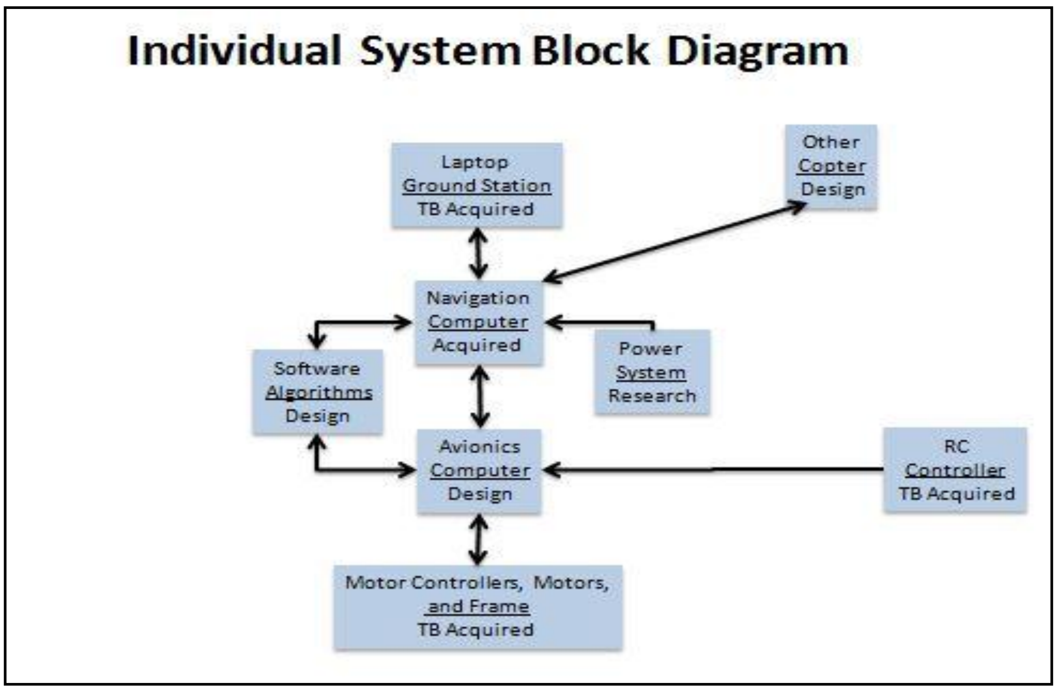
We are aiming for 10 to 15 minutes of flight time per charge with an average height of 150 to 200 feet off the ground. In order to simplify image stitching run time limitations, our stitched image will consist of a series of GPS stamped still images taken at interval locations rather than streaming video. These interval locations will be determined by an algorithm that computes the locations based on the horizon of the camera and the height of the copter. The area to survey will be defined as four GPS coordinates representing a boundary to be mapped. We are planning to use an 802.11g wireless network for external communication in Ad-Hoc mode for our physical communication layer, and DTN for our network layer.

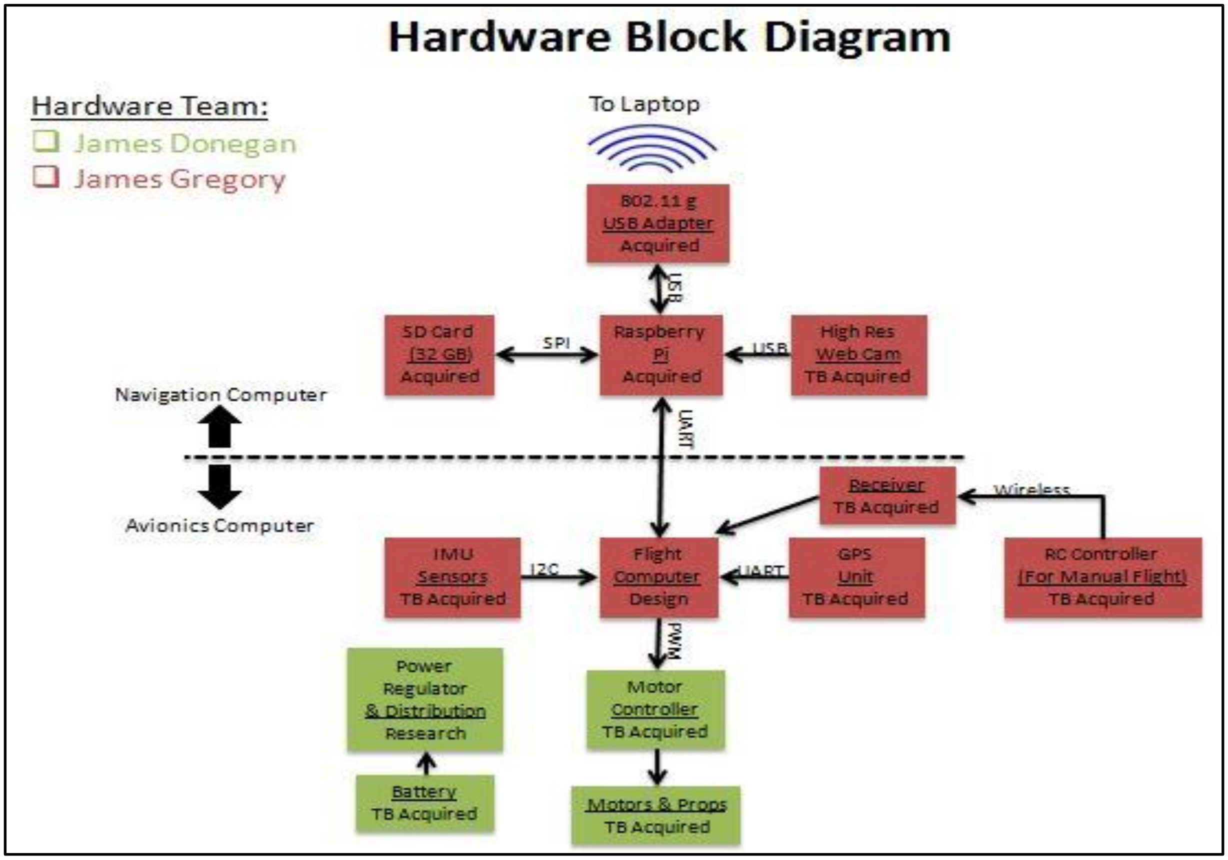
We will be using a Raspberry Pi model A which is a very powerful computing platform that has an embedded Linux operating system. This will give it plenty of ability to test NASA's DTN software while also handling imaging and flight path determination. We will also have a separate microcontroller an ARM processor that has an 80 MHz clock rate, 32KB SRAM, and 128KB Flash. This microcontroller will also have several UART, I2C, SPI, A/D and PWM ports. In order to achieve full state feedback, we will be using digital sensors such as an accelerometer, gyroscope, magnetometer, GPS, and an altimeter to determine attitude and absolute position. We will be using a real-time operating system (RTOS) on the microcontroller in order to achieve a deterministic processing pattern. The Raspberry Pi and the microcontroller will also be communicating via serial port operating at 115200 baud.

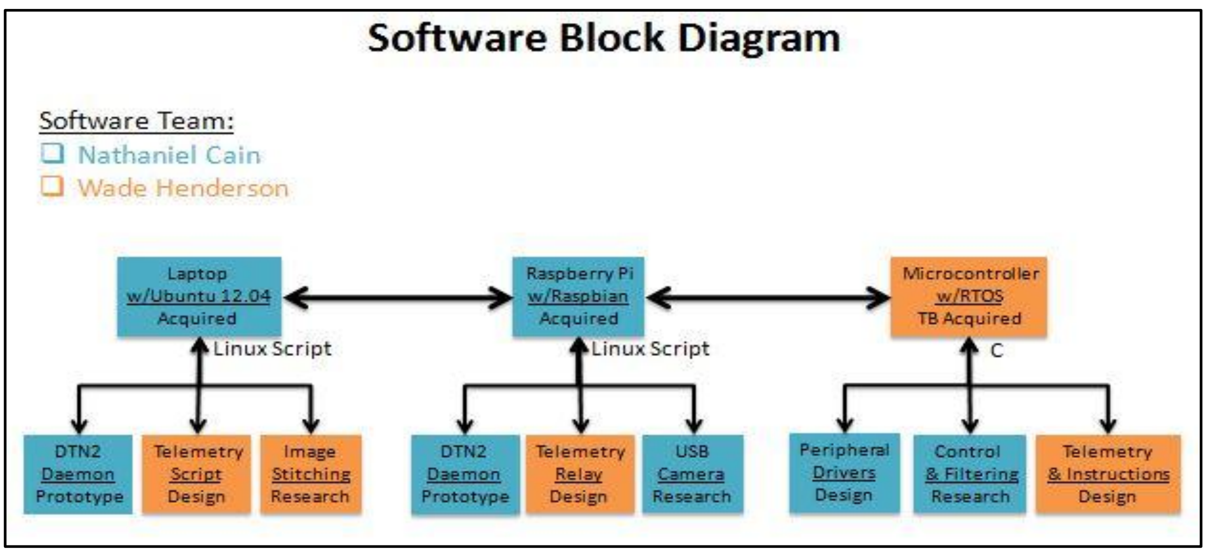
Our power source will be two separate lithium polymer batteries. The first battery will be used to power the motors, the microcontroller, and the IMU and will have a capacity between 2000-4000mAh. Our choice for this battery will be based on weight carrying capacity of our motors and the power drain that they will have for real flight. The second battery will be used to power the Raspberry Pi, 802.11g transmitter, and camera systems. This battery will be between 500-1000mAh since these components use less power.

Block Diagrams & Descriptions

Below is the full system block diagram for the KIRC project. This block diagram represents the different subsystems and their current status. The individual tasks are depicted in the following diagrams, because we have divided our team into two sub-teams: Hardware and Software. The power system, PCB, and the physical layout will be designed by our hardware team. Our hardware team will have the task of mounting all the individual parts onto the quadcopter, and wiring the system. Most of the hardware will be purchased, but some of the parts will be integrated into a custom PCB. For the second generation quadcopter, the flight/avionics computer and the IMU sensors will be integrated on to a printed circuit board (PCB). The software for this project consists of different software for the Laptop, Raspberry Pi, and Microcontroller. The software for each computer will have important modules that must run with a certain priority at certain times. For this reason, each computer will have a form of operating system that will handle timing, priorities, and task switching. The software for each computer will act independently of the other computers, but be able to cooperate over some communication medium.




Hardware Block Diagram
Hardware Team:
James Donegan
James Gregory
To Laptop
802.11 g USB Adapter Acquired
USB
SD Card (32 GB) Acquired
SPI
Raspberry Pi Acquired
USB
High Res Web Cam TB Acquired
UART
Navigation Computer
Avionics Computer
Receiver TB Acquired
Wireless
IMU Sensors TB Acquired
I2C
Flight Computer Design
UART
GPS Unit TB Acquired
RC Controller (For Manual Flight) TB Acquired
PWM
Power Regulator & Distribution Research
Motor Controller TB Acquired
Battery TB Acquired
Motors & Props TB Acquired


Software Block Diagram
Software Team:
Nathaniel Cain
Wade Henderson
Laptop w/Ubuntu 12.04 Acquired
Raspberry Pi w/Raspbian Acquired
Microcontroller w/RTOS TB Acquired
Linux Script
Linux Script
C
DTN2 Daemon Prototype
Telemetry Script Design
Image Stitching Research
DTN2 Daemon Prototype
Telemetry Relay Design
USB Camera Research
Peripheral Drivers Design
Control & Filtering Research
Telemetry & Instructions Design

Project Budget & Financing

NASA is funding this project, and has offered to pay for all expenses. An unofficial budget was given that we would be funded up to $3000, but it would be preferred to stay under $1000. Our goal for the project is to keep costs under $1000 dollars for the whole project. Some items have already been acquired by NASA for our use in the project and have been noted on in the status column for each item on the list. The spreadsheet below lists all the generic items we need (specific parts are not listed here) for this project.

Category	Item	QTY	Price Ea. ($)	Total $	Need By Date	Status
Quad:ControlSys						
...	Microcontroller Launchpad	2	$15.00	$30.00	9/30/2013	To be acquired
...	IMU Sensor Unit	2	$25.00	$50.00	9/30/2013	To be acquired
...	GPS Unit	2	$50.00	$100.00	9/30/2013	To be acquired
Quad:FlightSys						
...	Motor Controller	2	$20.00	$40.00	11/4/2013	To be acquired
...	Motors	8	$20.00	$160.00	11/4/2013	To be acquired
...	Props	12	$4.00	$48.00	11/4/2013	To be acquired
...	Frame	2	$15.00	$30.00	11/4/2013	To be acquired
...	Li-Po Battery (4-5 A-h)	2	$40.00	$80.00	11/4/2013	To be acquired
...	RC Controller & Reciever	1	$300.00	$300.00	11/4/2013	To be acquired
Quad:GuidSys						
...	Embedded Linux Processor	2	N/A		N/A	Acquired
...	Power Cable	2	N/A		N/A	Acquired
...	SD Cards	2	N/A		N/A	Acquired
...	802.11G Wireless Card	2	N/A		N/A	Acquired
...	High Resolution Webcam	2	$50.00	$100.00	1/6/2014	To be acquired
Ground:GndStat						
...	Laptop	1	N/A		N/A	Acquired
Quad:PCBHardW						
...	Microcontroller Standalone	2	$10.00	$20.00	2/3/2014	To be acquired
...	Accelerometer	2	$5.00	$10.00	2/3/2014	To be acquired
...	Gyroscope	2	$5.00	$10.00	2/3/2014	To be acquired
...	Magnetometer	2	$5.00	$10.00	2/3/2014	To be acquired
...	Altimeter	2	$5.00	$10.00	2/3/2014	To be acquired
...	Passive Components		Free		N/A	Acquired
...	Active Components		Free		N/A	Acquired
TOTALS	**All**			**$998.00**	**N/A**	N/A

Milestone Chart

Below is the Gant-chart that outlines the milestones from Senior Design 1 to Senior Design 2. The project is broken up into phases (explained in the specifications section). This is a very aggressive schedule, because it is a large project. A working 1st generation prototype is the goal by the end of Senior Design 1, a working 2nd generation by March, and replication of the 2nd generation by mid April.