Autonomous health monitoring of transportation infrastructure using unmanned aerial vehicle (UAV)

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Client: Halil Ceylan

Advisor: Halil Ceylan, Shuo Yang

Isaac Bries

Kevin Yen

Quade Spellman

Rishab Sharma

Molly Hayes

Nathan Conroy

Project Plan

Problem Statement

- Cost-effective health monitoring

- Safety of:
  - Bridges
  - Construction work
  - Roads

Solution

- UAV
- Collecting Data
- Evaluate health of infrastructure

Functional Requirements

- Live feed and on board storage
  - Thermal camera
  - HD Camera
- 45+ min flight time
- Fly in 30 mph winds, light rain
- Line of sight flight
- Scan bridges, roads, and windmills

Non-Functional Requirements

- Easy to use
  - Clear documentation
- Cost effective
  - Limited budget
- Reliable
- Easy to maintain
- Drone pilot license

Other Constraints and Considerations

- Lots of research needed
  - Parts are expensive
  - No prior UAV experience
  - No civil engineering knowledge
- Avoid crashing the drone
  - Parts are still expensive
  - Delivery time
- FCC and FAA regulations

Potential Risks and Mitigation

- Drone Failure
  - Mechanical failure
    - Hexacopter design, allowing for 2 motors to fail
  - Flight system hardware failure
    - Redundant sensors and speed controllers
  - Low power
    - Multiple battery monitors and warnings
  - Communication Failure

Potential Risks and Mitigation (cont.)

- Unfavorable flight conditions
  - Bridges
  - Rain
    - IP water and dust resistant rated components
    - Housing for electronics
  - High Wind
    - Large wing span of drone
    - Powerful motors

Market Survey

- TerraHawk CW-30
  - Hybrid Vertical take and fixed wing
  - Phoenix Lidar Systems
  - Lidar Only
- Flir Aerial thermal imaging kits
  - Flir Thermal cameras + DJI drone systems
- InfraDrone
  - Iowa State Startup
  - 3D mapping and analysis

Resource/Cost Estimate

System Costs	
Flight System	$4,981
Imaging System (Projected)	$5,598
Total Cost	$10,579

Resource Costs	
Total Weight	8.8 kg / 19.3 lb
Thrust (60% Throttle)	35.4 kg / 78.0 lb
Battery Life (60% Throttle)	30-40 minutes

Project Milestone

- What we've done
  - Increased knowledge base
  - Experienced setbacks
  - Created a solid design

- Schedule of tasks for this semester
  - Order parts by November
  - Drone flight by end of semester

System Design

Imaging System
Hardware Flight System
Software Flight System

Imaging System

Original Plan:

- GoPro Hero 4 or 5
  - 4K video
  - Lots of available gimbals
  - Little to no zoom
- Flir Vue
  - Discontinued
- Velodyne LiDAR Puck
  - Not precise enough
  - $8,000 (cheapest we found)

Current Plan:

- DJI Zenmuse Z3
  - 7x zoom
  - Designed for industrial applications
  - Haven’t gotten approval yet
- Flir Vue Pro R
- No LiDAR
  - For now

Video Transmission

- Frequency
  - 5GHz
    - Signal offers better data rate
- Range
  - Maximum range is line of sight
- Interference
  - Radio
  - Other devices on the drone
- 3 Channel Switch
  - Allows switching between 3 cameras using 1 output

Hardware Flight System

- Frame decision
  - Very limited market for drone frame
  - Wind resistance
  - Storage Space
- Motor & Propellers
  - Allows heavy loads
  - Power efficient
- Electronic Speed Controller
  - Need to regulate motor speed

Hardware Flight System (cont.)

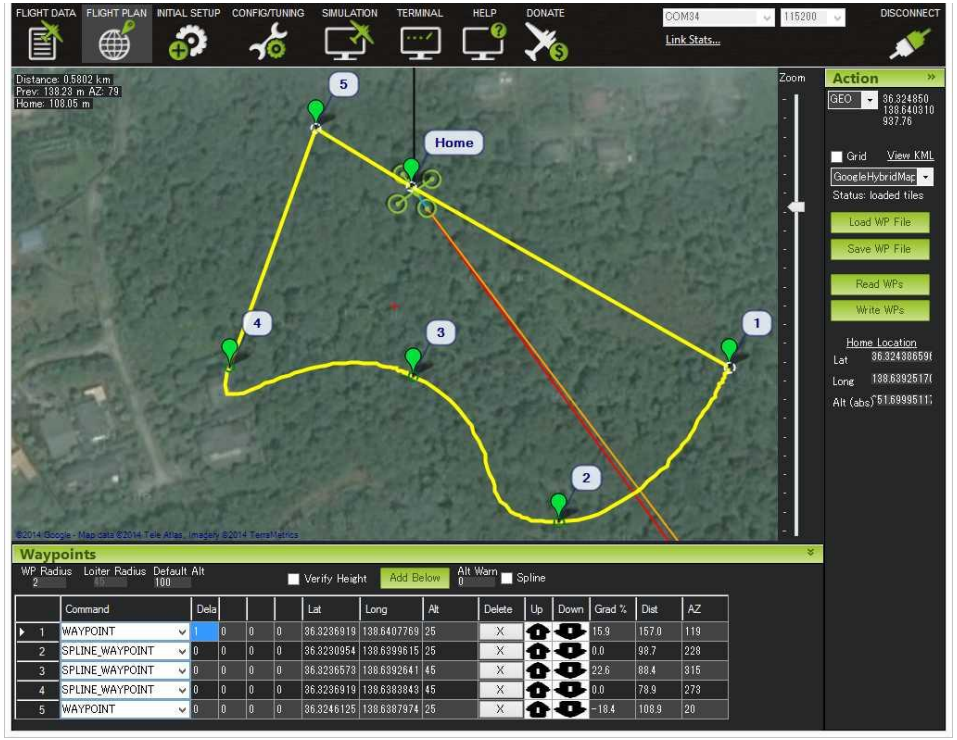
- Remote Controller
  - Status Bar
  - Easily programmable
  - Sufficient Channels
- Battery
  - Power output
  - Duration
  - Weight

Software Flight System

- ArduPilot
  - Open source
  - Autonomous flight capabilities
  - Mission Planning
  - Real time operating system
- Ground Station
  - Many options thanks to MavLink protocol
  - Windows, OS X, Linux, iOS and Android options
  - Mission Planning
  - Drone flight and camera control
  - Open source options

Test Plan

- Flight Simulations
  - ArduPilot
  - SITL Simulation
- Data Transfer
  - Video Transmission
  - Data Storage
- Battery Life/Flight Time
  - Field Tests



Prototype

- Fixed Wing vs hexacopter
  - Stability
  - Ease of build and operation
- Methods to store image data
- Streaming video devices
  - Laptop vs tablet
- Orientation of sensors
  - Where and how are they being put onto the drone (via frame, gimbal etc.)

Prototype (cont.)

- Hexcopter
  - Stability benefit
  - Ease of build and operation
- Data stream implementation
  - All current imaging devices have onboard storage.
- Stream video on tablet
  - Portability
- 3D print own gimbal
  - More customizability

Current Project Status

- In Progress
  - Camera model choice
  - Simulation Ardupilot
  - FAA Certification
    - Schedule
    - Practice test
  - Motor, esc, propellers - waiting on parts
  - Testing individual parts working condition.
  - Gimbal design
- Completed
  - Researched and ordered flight related hardware
  - Assembled drone frame

Task Responsibility of Each Project Member

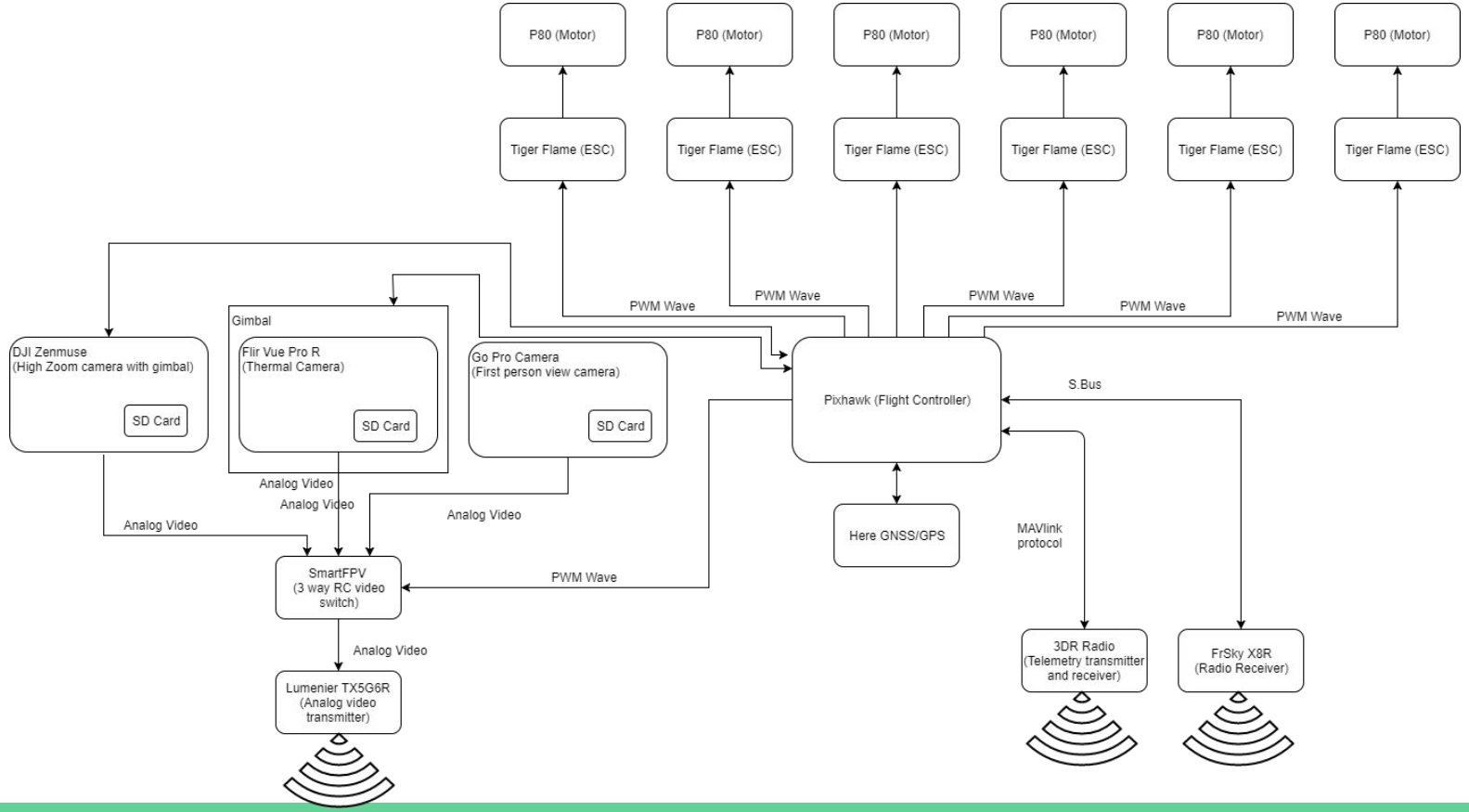
- **Nathan Conroy** - *Software Lead*: software library selection, flight hardware research
- **Kevin Yen** - *Hardware lead*: gimbal design, frame and signal transmission research
- **Quade Spellman** - *Meeting facilitator*: thermal research, helped with video transmission research
- **Rishab Sharma** - *Report Manager*, camera, battery research
- **Molly Hayes** - *Meeting Scribe*: camera and gimbal research
- **Isaac Bries** - *Test Engineer*: purchase proposal, test environment design

Plan for Next Semester

- Purchase all parts; HD Camera, Thermal, etc.
- Assign Software and Hardware jobs
- Finish building the drone; calibration, storing data, etc.
- Documentation - user manual
- Test, Test, Test!
- Have solution finished by mid-April

Questions?

Drone Data Schematic



Ground Station Data Schematic