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

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Flight System</td>
<td>$4,981</td>
</tr>
<tr>
<td>Imaging System (Projected)</td>
<td>$5,598</td>
</tr>
<tr>
<td><strong>Total Cost</strong></td>
<td><strong>$10,579</strong></td>
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## Resource Costs

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Total Weight</td>
<td>8.8 kg / 19.3 lb</td>
</tr>
<tr>
<td>Thrust (60% Throttle)</td>
<td>35.4 kg / 78.0 lb</td>
</tr>
<tr>
<td>Battery Life (60% Throttle)</td>
<td>30-40 minutes</td>
</tr>
</tbody>
</table>
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?
Ground Station Data Schematic

1. 5.8 GHz Analog Video Receiver
2. Analog to digital video converter
3. Laptop/Tablet
   - Video Feed
   - Autonomous Flight Planning
   - Heads Up display
4. 3DR Radio (Telemetry transmitter and receiver)
5. FrSky Transis QX7 (Radio Transmitter)
6. Pilot