Autonomous Health Monitoring of Transportation Infrastructure Using Unmanned Aerial Vehicle (UAV)

Team 25: Isaac Bries, Kevin Yen, Quade Spellman, Rishab Sharma, Molly Hayes, Nathan Conroy

Client: Halil Ceylan **Advisor**: Halil Ceylan, Shuo Yang

Introduction/Motivation:

What drives this project is the need to provide cost-effective and efficient health monitoring management of transportation infrastructure systems. One of the benefits of this project is that this is a quick way to make sure all bridges, construction work, and roads are functioning properly so that civilians are safe when they are traveling. Some other benefits include capturing traffic movement, making sure contractors are safe, and minimizing traffic accidents. The ability to collect data with an unmanned aircraft incorporates many software and hardware challenges that can help strengthen the team. The future potential of learning these skills and applying to other industries is tremendous.

Functional requirements

- Video Recording
  - Thermal camera
  - HD Camera
- 45+ min flight time
- Fly in 30 mph winds, light rain
- Line of sight flight
- Scan bridges, roads, and windmills

Operating environment

- Outdoor flight year round
  - -20 to 45 degree celsius
  - Possible light rain
  - Winds up to 40 mph
- Fly up to 400 ft above ground level
- Underneath bridges and around other infrastructure

Problem Summary

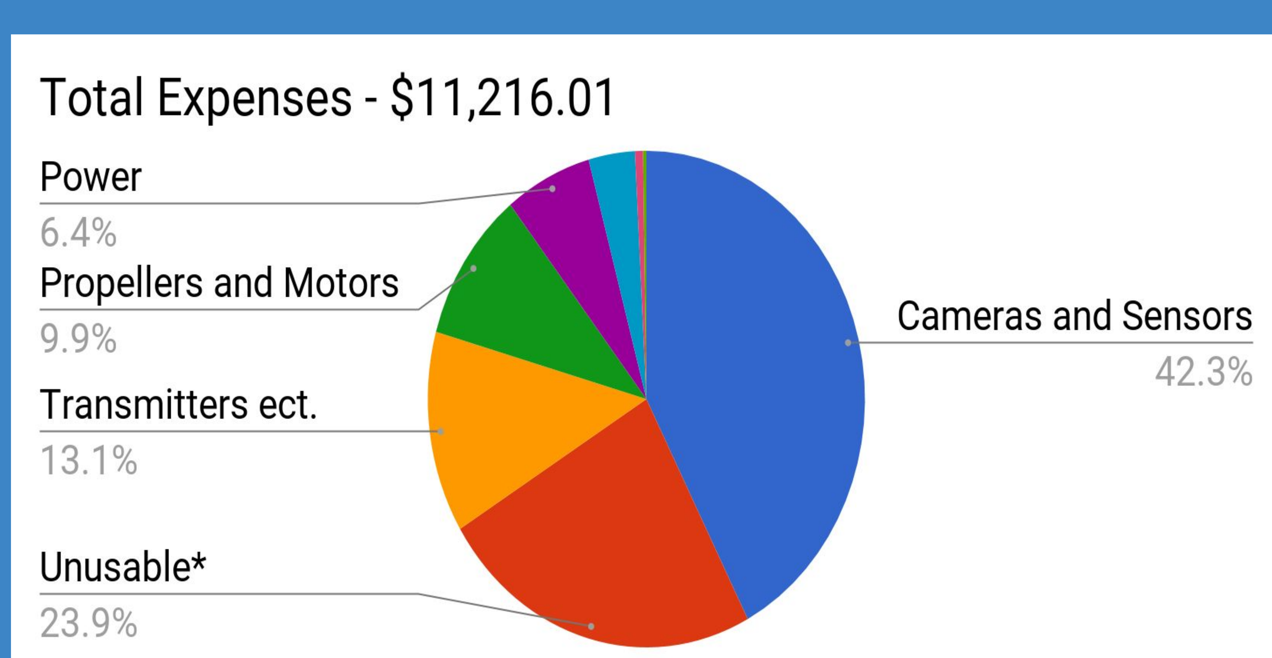
- Aging infrastructure causes potential safety hazards
  - Bridges, Roads, Buildings
- Monitoring the health is an expensive and labor intensive process
  - Requires moving and setting up heavy and expensive equipment multiple times in order to gather significant data

Solution

- Creating a Hexacopter UAV
  - Hexacopters are more reliable than quadcopters
  - Hexacopters can also carry a bigger payload
- Gather data through mounted HD and Thermal cameras

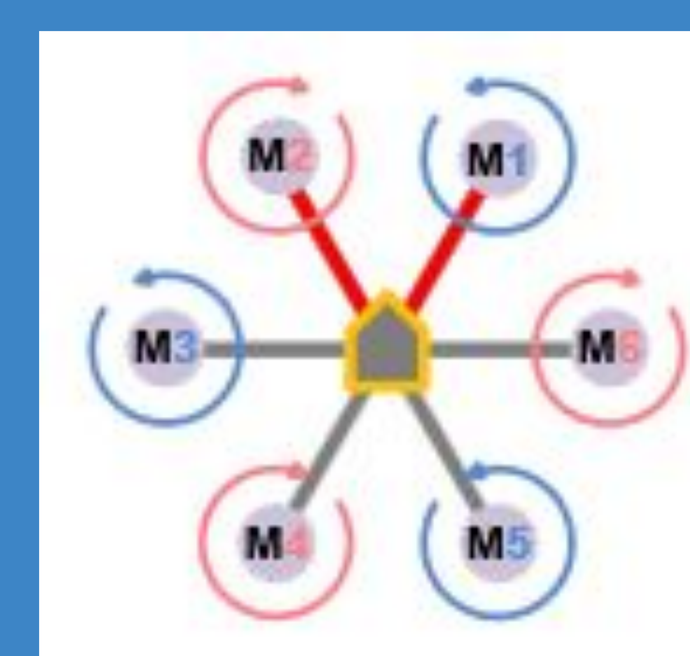
Non-functional requirements

- Easy to fly the drone
- Clear documentation on:
  - How to use drone
  - Drone maintenance
  - Drone parts used
- Cost effective
- Reliable to use
- Easy to maintain



Engineering constraints

- Limited space on the drone
  - Needing to fit all essential drone pieces
  - Mounting cameras
- Fail safes for motors dying
  - Crashing the drone costs a lot of money
  - Hexacopters are designed to allow for up to 2 motors to fail safely
    - Remaining 4 motors allow for a controlled emergency landing
- Heavier drone frame and power motors needed
  - Steadier flight in heavy winds for smoother video



Damien. Frame Type #3 Hexacopter How to Build a Drone - A Definitive Guide For Newbies. Electronic. http://beginnerflyer.com/wp-content/uploads/2015/08/rsz_1multi_rotor_configs.png

Intended Users and Uses

Users:

- Civil Engineers
  - Conducting research
  - Gathering information for maintenance
- Drone Pilots
  - Possibly flying the UAV for Civil Engineers

Use Cases:

- Collecting HD and thermal images of infrastructure
- The gathered information will be used for
  - Crack analysis
  - Thermal inspections

Standards

While flying and testing our UAV FAA drone regulations must be followed:

- Fly at or below 400 feet
- Be aware of airspace requirements and restrictions
- Stay away from surrounding obstacles
- Keep your UAS within sight
- Never fly near other aircraft, especially near airports
- Never fly over groups of people
- Never fly over stadiums or sports events
- Never fly near emergency response efforts such as fires
- Never fly under the influence of drugs or alcohol

Testing Strategy

- Pre-emptive testing to avoid future problems
- Test functionality as subsystems were completed
  - Assure success before connecting to other systems
- Adapt tests for each individual system
  - Each subsystem (power, control, etc.) has different requirements

Power

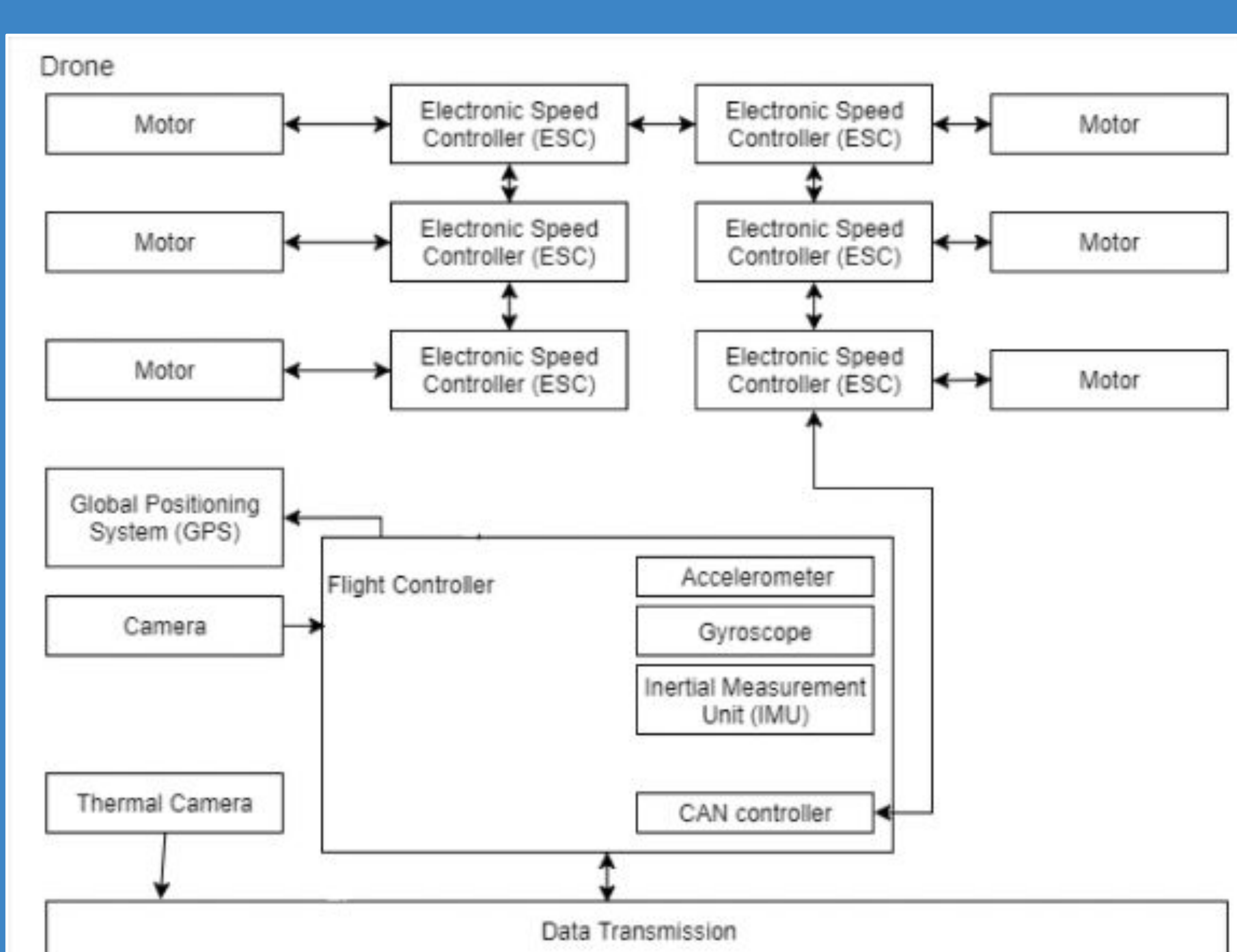
- Battery charging requirements
- Measure voltages/currents at critical points

Control

- Motor/ESC communication
- Camera operations
- Remote functions
- Flight controller functionality

Structure/Cable Management

- Limited space
- Volatile environment
- Ease of troubleshooting



Programming language, libraries dev tools, environments

- Flight related tasks are handled using ardupilot libraries
  - open-source autopilot, data-logging and simulation software
- Ardupilot SITL (Software in the loop) for simulation testing
  - Allows us to test our drone software configurations without hooking up the hardware
  - This helped minimize the risk of costly accidents
  - Simulations were run on a linux environment
  - For actual flights Ardupilot is ran on the UAV's Pixhawk flight controller
- All coding and configuration was written using C++