

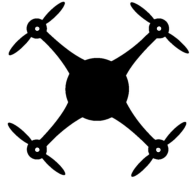
Car-Snow Clearing Drone



Major Qualifying Project

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Advisors: Mehul Bhatia (ME), Nicholas Bertozzi (RBE/ME)

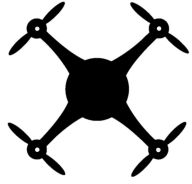


Need

Winter Weather Creates Challenges
for Wheelchair Users
Clearing Snow off Car Roof



Girl Injured After Large Piece of Ice
Flies Off Tractor Trailer on Interstate
495 in Andover, Massachusetts



Current Related Applications



Drones clearing wind turbines

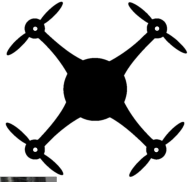


Agriculture spraying drones



De-icing spraying similar to airplanes

Project Overview

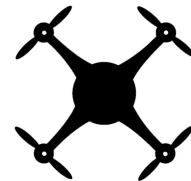


- X4 configuration
- ~1200 mm diagonal
- 711.2 mm (28") propeller
- ~20 min flight time
- ~11.3 kg total weight



- 3 spray nozzles, ~1.7 L/min
- 2 DOF spraybar, 5L tank
- Homemade de-icing solution of isopropyl alcohol & water

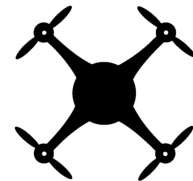
Methods & Approach



Project Objectives

Design, Manufacture, and Implement a Drone to Aid in the Removal of Snow and Ice Off of Cars

- 1 **Case Study Data and Research on Drone Designs and Applications**
- 2 **Design Drone to Fly in Mild Weather Conditions**
- 3 **Test and Evaluate the Accuracy, Repeatability, and Precision of Cleaning Front and Rear Windshields**
- 4 **Present a Comprehensive Design Summary with Compelling Vision for the Future**
- 5 **Suggest Future Iterations or MQPs**



Project Goals



**Performance
Metrics**

**Clear the front
and rear
windshield**



**Design
Metrics**

**Do not
damage car**



**Operate in
mild weather
conditions**



**Operate
around 15°F**



**Carry one
gallon
spraying fluid**



**Maneuver
smoothly with
payload**



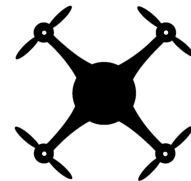
**Ensure
windshield is
fully clear**



**Identify snow
on a
windshield**

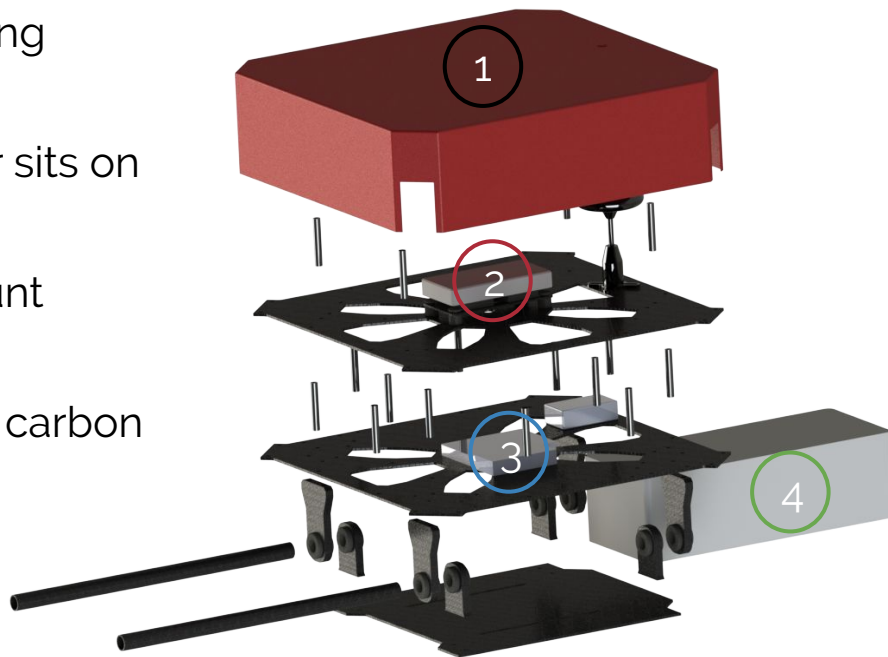
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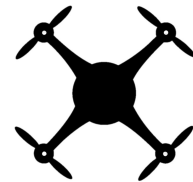
Design



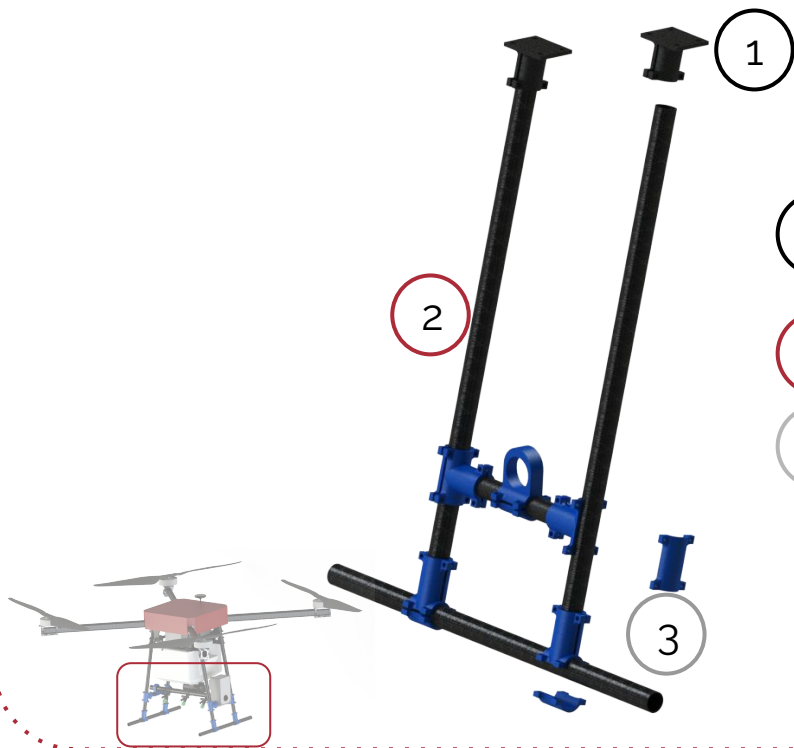
Center Frame

1. Vacuum-formed ABS plastic housing covers electronics
2. Sensitive Pixhawk4 flight controller sits on anti-vibration mount
3. 2mm thick carbon fiber plates mount electronics
4. Battery sits below center frame on carbon fiber tray

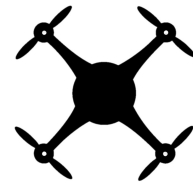




Landing Gear

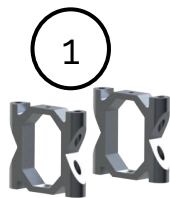


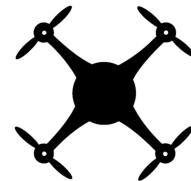
1. 3D printed carbon fiber fixtures that mount to center frame
2. 16mm OD carbon fiber tube
3. 3D printed ABS plastic tube clamps hold tubes together with compression



Rotor Arms

1. Compressive aluminum collars fixture to center frame
2. Octagonal carbon fiber arm in 0.5m length
3. Machined 6061-Al motor mounts sandwich arm



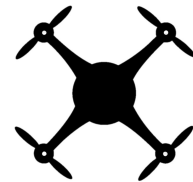


Components

- **Power unit:**

- 190 kV motor
- 50 amp ESC
- 28 inch propeller
- 22,000 mAh LiPo battery

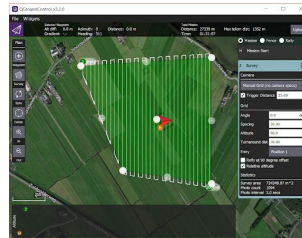




Components

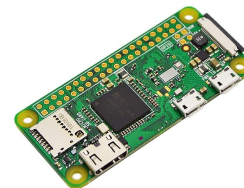
- **Flight Management Unit:**

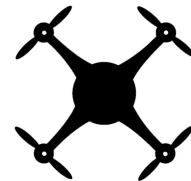
- Pixhawk Flight Controller (running PX4)
- Ground Station (QGroundControl)
- FrSky Taranis XgD



- **Auxiliary Units**

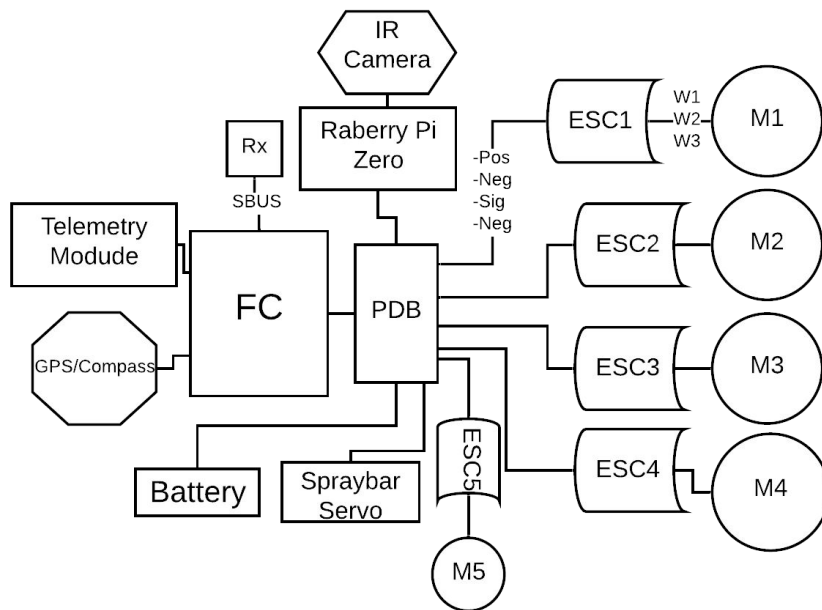
- 32 x 24 Pixel Thermal IR Camera
- Raspberry Pi Zero W
- Diaphragm Pump





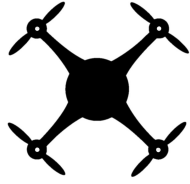
Wiring Overview

- Flight Controller (FC)
- Power Distribution Board (PDB)
- Receiver (Rx)
- Electronic Speed Controller (ESC)
- Motors (M1...M5)



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Analysis

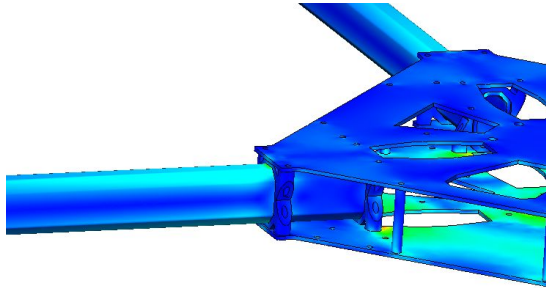


Finite Element Analysis

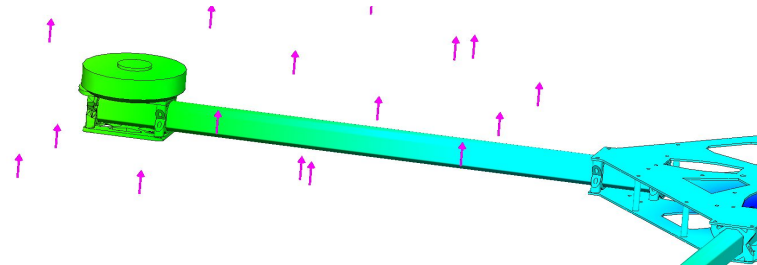
- FEA analyzed stress and deformation on center frame and arms
- Applied thrust force of 66.25N per rotor assembly (propeller & motor)
- FEA shows minimal stress on arms during flight

von Mises (N/m²)

3.832e+07
3.512e+07
3.193e+07
2.874e+07
2.555e+07
2.235e+07
1.916e+07
1.597e+07
1.277e+07
9.579e+06
6.386e+06
3.193e+06
0.000e+00



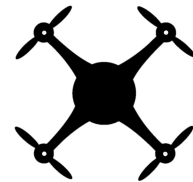
Stress Analysis



Deflection test

URES (mm)

6.642e-01
6.089e-01
5.535e-01
4.982e-01
4.428e-01
3.875e-01
3.321e-01
2.768e-01
2.214e-01
1.661e-01
1.107e-01
5.535e-02
1.000e-30



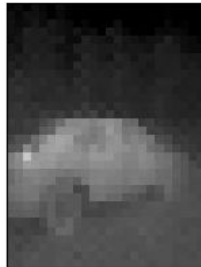
Computer Vision

- Infrared camera images processed with OpenCV
- Thresholded image opened to remove noise
- Target determined by drone trajectory
- Centroids of each object calculated, marked as on- or off-target

visible light



infrared



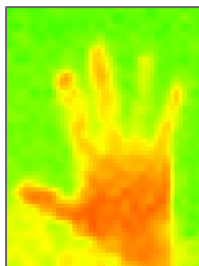
binarized



labeled



false color IR



infrared



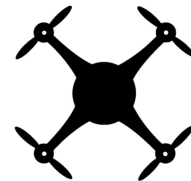
binarized



labeled



Conclusion



Results & Recommendations

Results:

- Drone built and all motors working
- Plan to fly by the end of D-Term



Recommendations:

Electrical:

- Investigate other sensors and radio

Mechanical:

- Redesign spraybar for easier movement

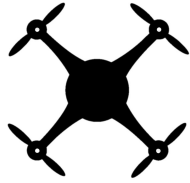
Software:

- Investigate computer vision and machine learning solutions

Other:

- Test different deicing fluids
- Complete tests and revise designs as needed

Societal Applications



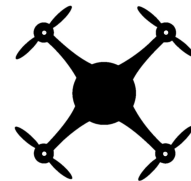
Employ drones to
clean house roofs



Drones clearing car
dealerships



De-icing top of
semi-truck trailers



Thanks!

Thank you to our advisors and
WPI for supporting this project.



WPI Tinkerbox