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Disaster Response Observation Network (DRON)

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J. Shouba, O. Bhatt, O. Thomas, S. Ahn, T. Francis

Introduction to DRON

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Problem Definition

- The Disaster Response Observation Network (DRON) is a proof-of-concept initiative that aims to leverage unmanned aerial vehicles (UAVs) to gather intelligence during structural fires to aide first responders in scene assessment and emergency response.

Methodology

- Autonomous swarm functionality allows DRON to assist in emergency situations with minimal required human input. DRON is designed around ease of use, speed of deployment, and quality of data gathered and presented.

Relevant Literature (1/2)

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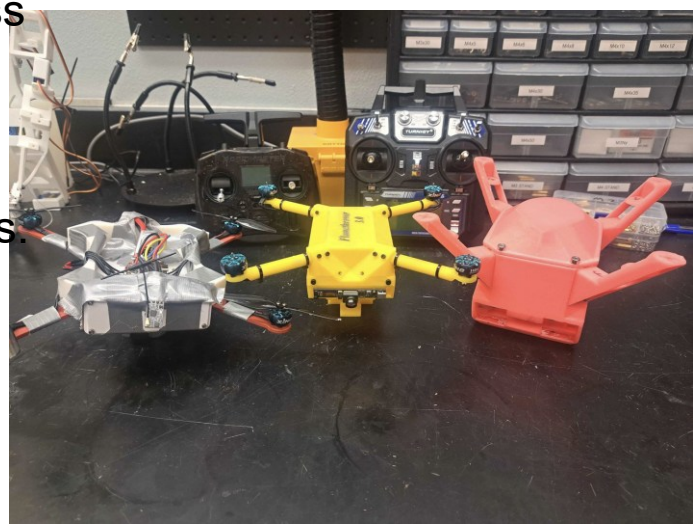
UAVs for Disaster Response

- UAVs provide rapid, low-risk situational awareness in fires and disasters using RGB, thermal, and LiDAR sensors.
- Recent reviews highlight improved detection, mapping, and decision support for first responders. (Gupta & Fernando, 2022; NASA, 2024)



SLAM & Multimodal Mapping

- Simultaneous Localization and Mapping (SLAM) enables autonomous navigation without GPS.
- Multimodal fusion of camera, IMU, LiDAR, and optical-flow data improves robustness in low-visibility environments. (Gupta & Fernando, 2022; Li et al., 2024)

Relevant Literature (2/2)

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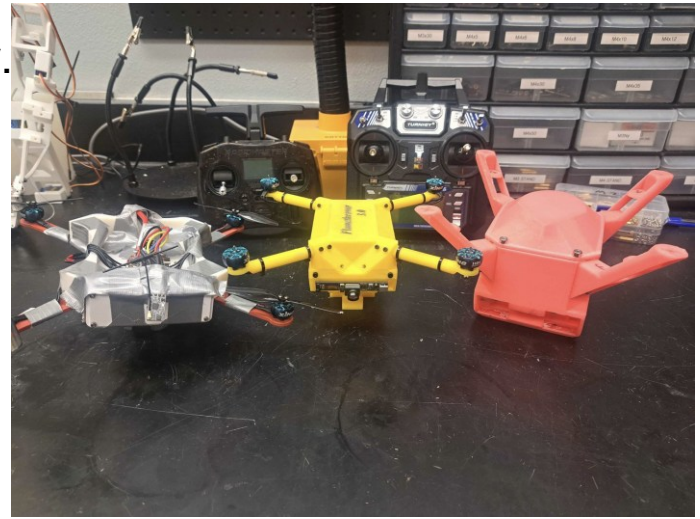
Collaborative & Swarm Mapping

- Multi-UAV collaborative SLAM (C-SLAM) allows agents to share local maps for global consistency.
- SwarmMap and related studies demonstrate scalable, real-time mapping across teams of lightweight drones. (Xu et al., 2022; Friess et al., 2023; Niculescu et al., 2024)

Dynamic & Real-World Environments

- Dynamic-object SLAM systems integrate object detection for reliable mapping in changing environments.
- Field datasets and active-SLAM methods inform DRON's approach to large-scale, uncertain scenes. (Li et al., 2024; Viana et al., 2023)



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Mechanical Systems

Chassis

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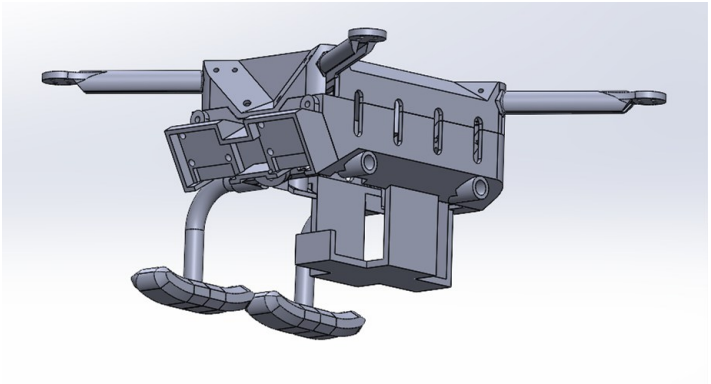
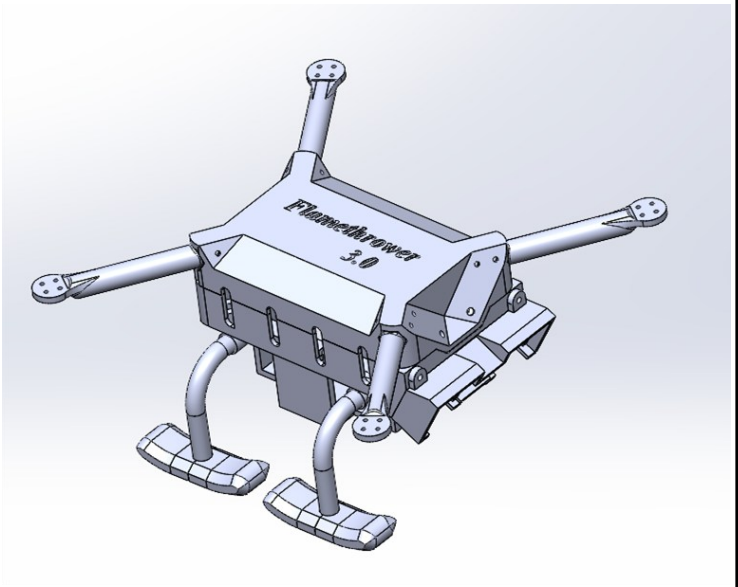
Production UAVs must house internal elements to protect the electronics and sensors from occlusions and





Material Selection

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Stiffer materials tolerate higher excitation frequencies; which is more relevant than ultimate strength in this case

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Electrical Systems

Electrical Diagram

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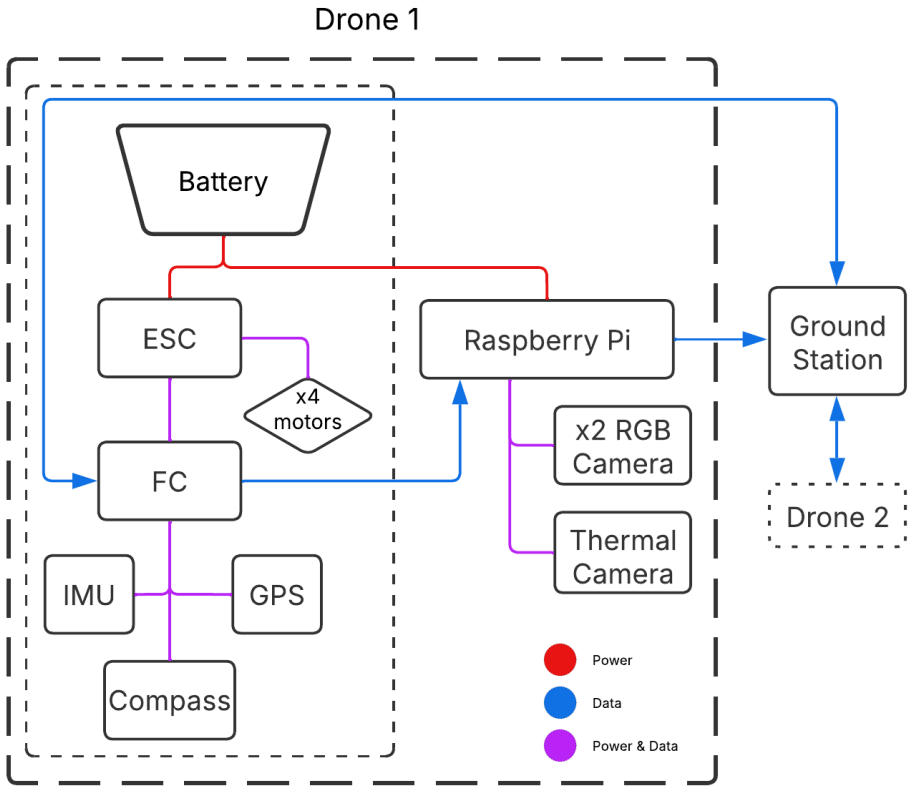
- A COTS FC/ESC stack will be used to ensure compatibility
- Ground station will send commands to each drone through the Pi (PX4 autopilot)
- FC will send navigational data to the Raspberry Pi (PX4 ROS)
- Raspberry Pi will transmit sensor data to the ground station (wifi ros -> unity)



Thrust test result - Verification

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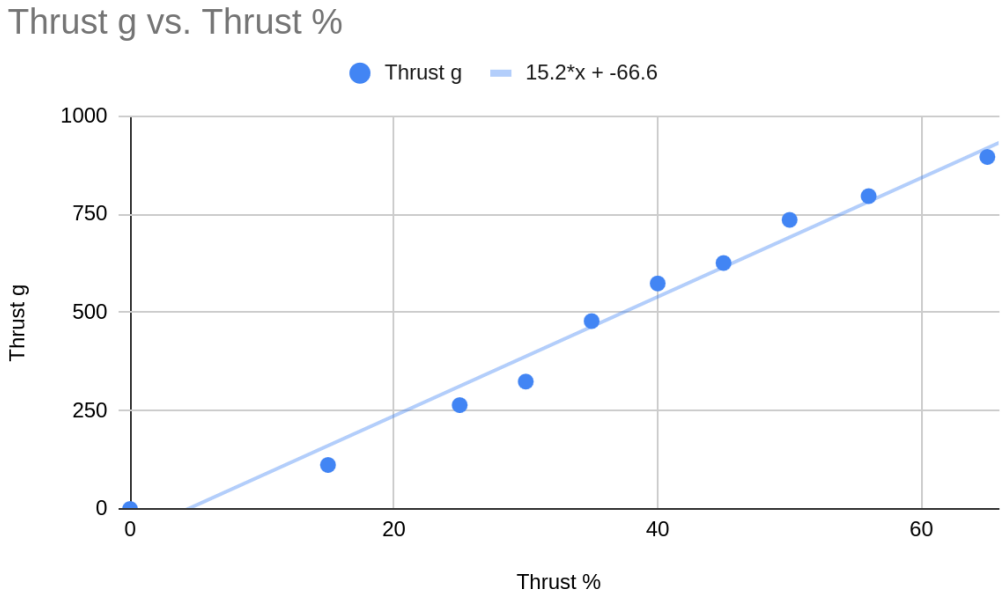
Proj. Max: 1453g

Est. Mass (from BOM): 462g

Thrust/Weight Ratio: 3.14

Appx. Thrust %	Force g	Thrust g
0	2766	0
15	2654	112
25	2502	264
30	2442	324
35	2288	478
40	2192	574
45	2140	626
50	2030	736
56	1970	796
65	1870	896



Multirotor Calculator

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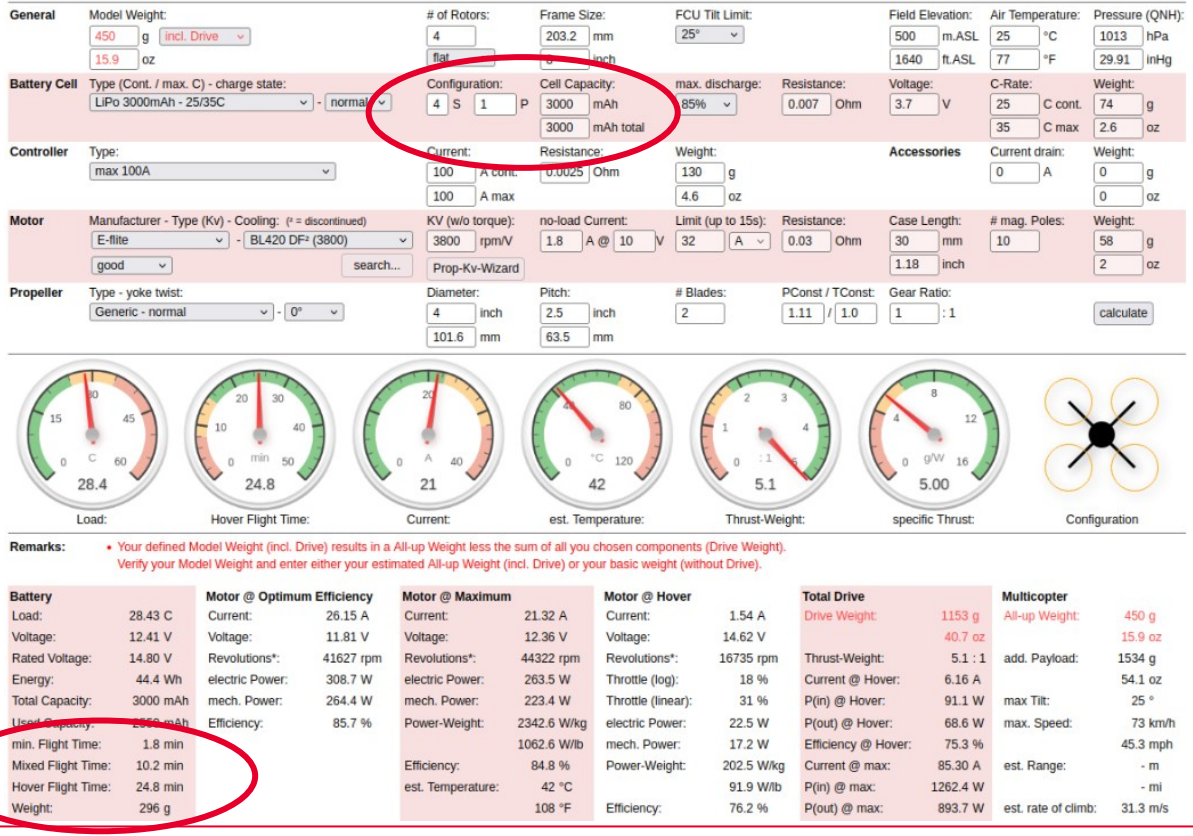

4S standard

3000 mAh ->

~10 min flight time

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Software Systems

Camera & IR Sensors

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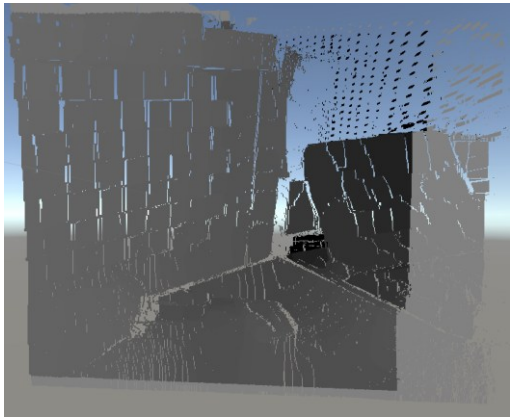
- CV Depth from Stereo
  - Two rbg cams in, point cloud out
  - Need pi 5 to process two cameras
- Senxor Library
  - IR cam usb serial driver/reader
- Publish point cloud
- “Paint” thermal data onto point cloud



PX4 Autopilot

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- Flight Controller Software
- Provides uorb topics as ros topics natively
- Substantial documentation

State & estimates
/fmu/out/vehicle_odometry
/fmu/out/vehicle_attitude
/fmu/out/vehicle_local_position
/fmu/out/vehicle_global_position
/fmu/out/home_position
/fmu/out/estimator_status_flags
/fmu/out/timesync_status
/fmu/out/vehicle_land_detected
/fmu/out/vtol_vehicle_status
/fmu/out/vehicle_status

Sensors
/fmu/out/sensor_combined
/fmu/out/vehicle_gps_position
/fmu/out/airspeed_validated
/fmu/out/collision_constraints (if configured)

Offboard control & setpoints
/fmu/in/offboard_control_mode
/fmu/in/trajectory_setpoint
/fmu/in/vehicle_attitude_setpoint
/fmu/in/vehicle_rates_setpoint
/fmu/in/vehicle_thrust_setpoint
/fmu/in/vehicle_torque_setpoint

Commands & status inputs
/fmu/in/vehicle_command
/fmu/in/onboard_computer_status
/fmu/in/telemetry_status
/fmu/in/manual_control_input (RC/joystick)

ROS-Unity Integration

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- Unity Ros# Plugin to subscribe to topics
- Update loop:
  - Accumulate & consolidate physical points (assuming static environment)
    - ICP-based Point Cloud cleaning methods
  - Decay & remove old temperature data

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Questions?