Drone Lookout: Thermal Perimeter Surveillance Drone for Prescribed Burns

By Anav Apparaju

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Intro

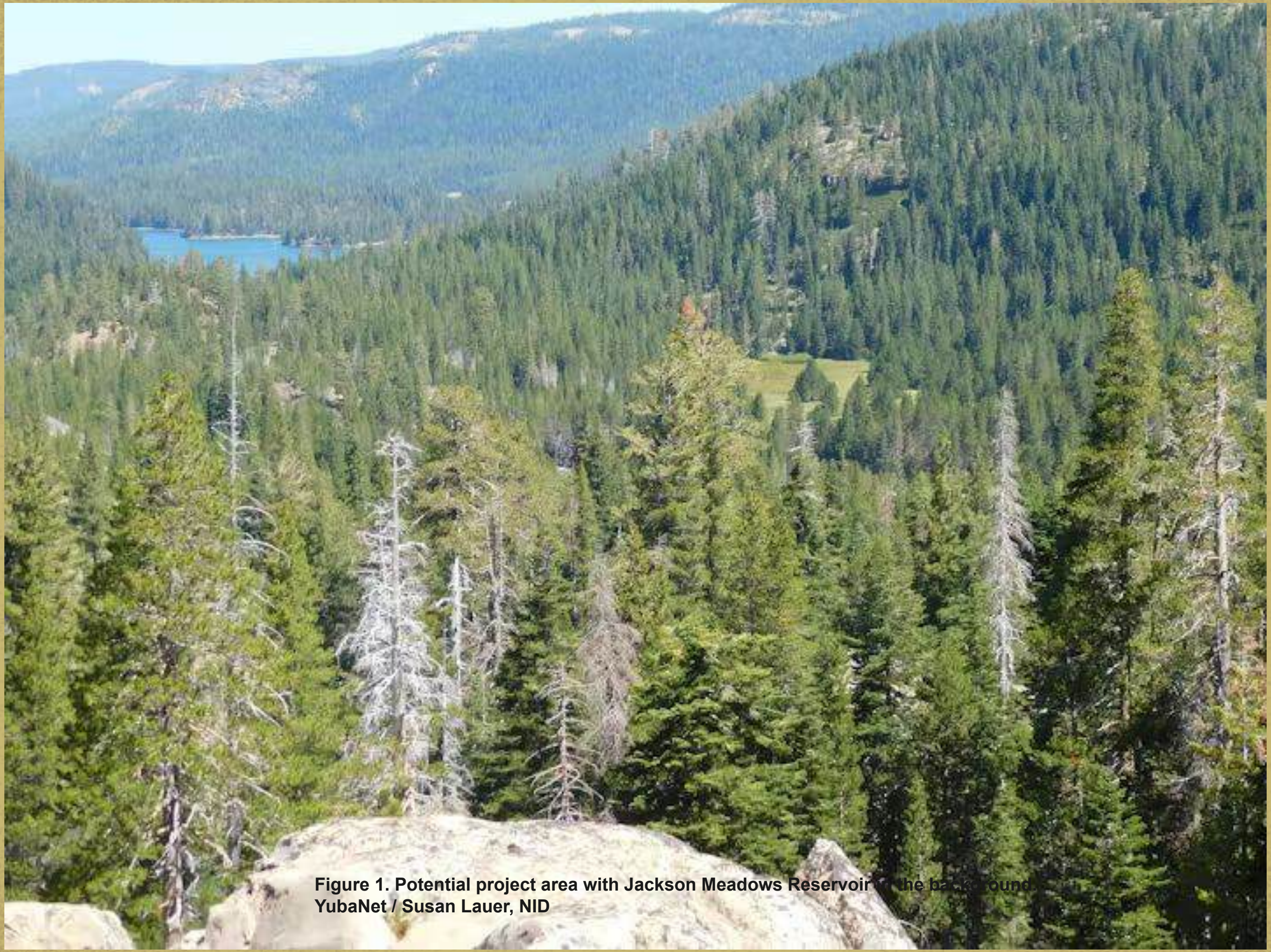
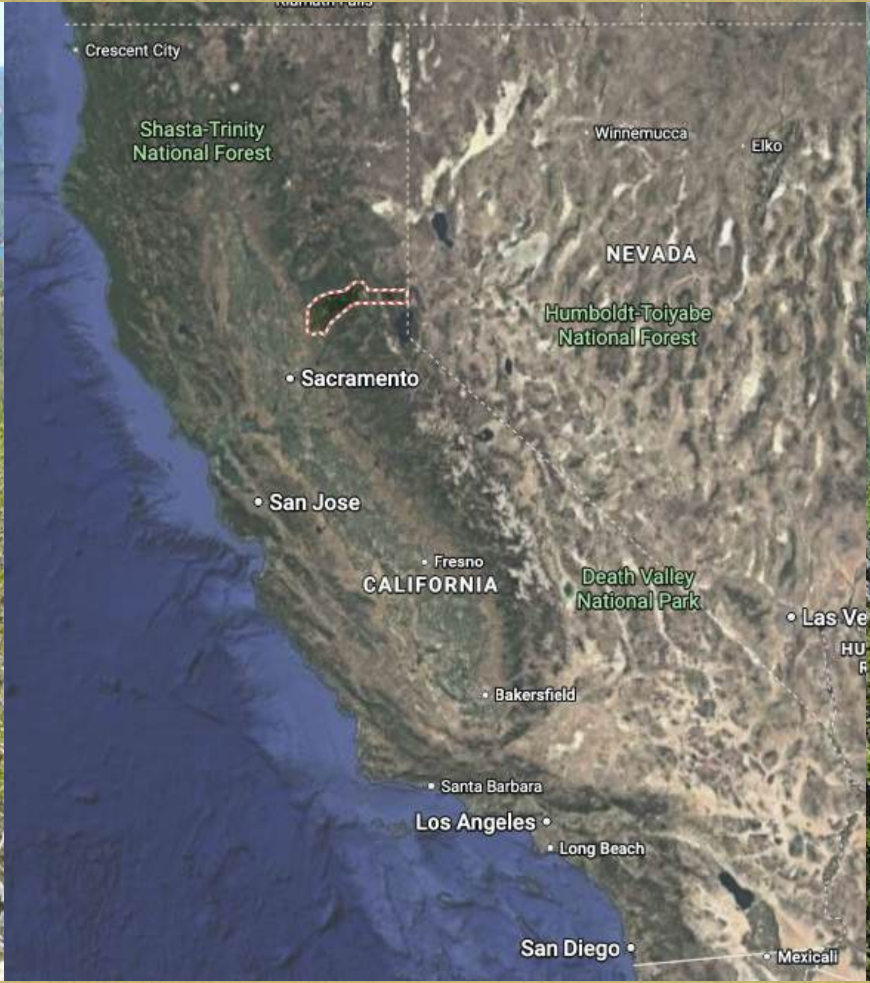


Figure 1. Potential project area with Jackson Meadows Reservoir in the background.
YubaNet / Susan Lauer, NID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Shasta-Trinity National Forest
Winnemucca
Elko
NEVADA
Humboldt-Toiyabe National Forest
Sacramento
San Jose
Fresno
CALIFORNIA
Death Valley National Park
Bakersfield
Santa Barbara
Los Angeles
Long Beach
San Diego
Mexicali

Figure 2. Fall forest floor. NPS / Billy Flynn.

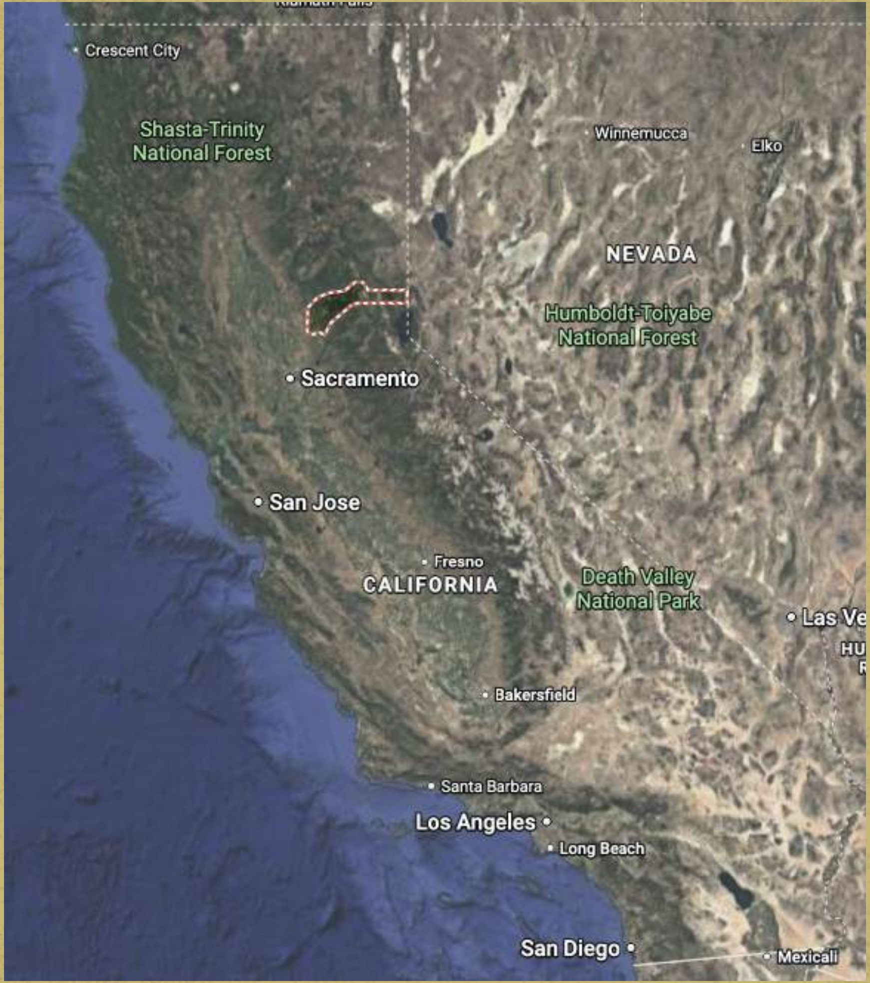

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Figure 3. Diana Almendariz sets fire to a redbud pile. Alysha Beck / UC Davis

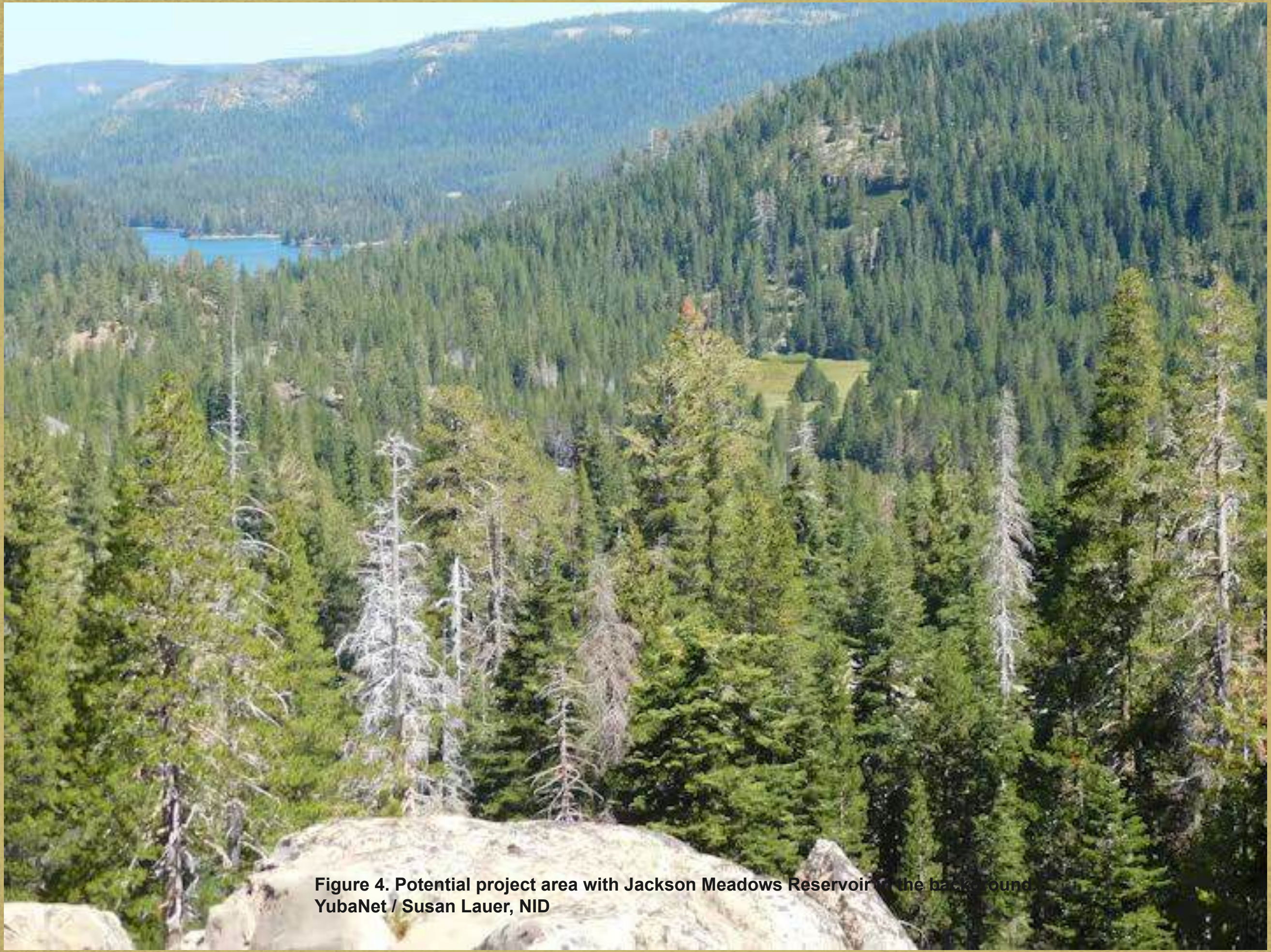


Figure 4. Potential project area with Jackson Meadows Reservoir in the background.
YubaNet / Susan Lauer, NID

Figure 5. Broadcast Burn 1. Image courtesy of Terra Fuego Resource Foundation.

Figure 6. Broadcast Burn 2. Image courtesy of Terra Fuego Resource Foundation.

Figure 7. Broadcast Burn 3. Image courtesy of Terra Fuego Resource Foundation.

Prescribed Burning

Land management strategy that applies controlled fire to meet an ecosystem's management goals

Research Question

Is it possible to develop a low-cost hexacopter with thermal vision and perimeter surveillance capabilities for applications in prescribed burning?

My Use Case

Figure 8. Sample Burn Perimeter. Image courtesy of Terra Fuego Resource Foundation.

Currently Available Alternatives

- IGNIS II Aerial Ignition System
  - Full-stack wildland prescribed fire solution
  - Ignition
  - Autonomous perimeter tracking
  - Flame management
  - $90,000

My Use Case

Figure 1. Nightime Smoke Plume. Image courtesy of Terra Fuego Resource Foundation.

Background

Figure 9. Pile burn site. Image courtesy of Terra Fuego Resource Foundation.

Design Process

Hardware Stack: Components

9 Key Components:

1. Frame
2. Flight Controller (FC) — the brain
3. Motors
4. Electronic Speed Controllers (ESCs)
5. Propellers
6. Battery
7. Power Distribution Board (PDB)
8. RC Receiver
9. Compute / payload (everything mission-specific)

Hardware Stack: Total Weight

Component	Weight
Tarot 680 Pro frame	728g
Motors × 6 (SunnySky X3508S)	~600g
ESCs × 6 (60A BLHeli32)	~132g
Props × 6 (T-Motor 13×4.4)	~90g
Pixhawk 6C + PM07	~120g
Battery (Zeee 6S 8000mAh)	~744g
Pi 5 + cooler	~55g
Thermal (Lepton + PureThermal)	~9g
RunCam Spotter V2	~28g
AKK VTX + SiK radio	~20g
HDMI-AV converter + cables	~35g
GPS + wiring/misc	~80g
Total AUW	**~3,705g**

Hardware Stack: Motor Selection

- Slower motor → can swing larger props → more efficient (generates more thrust)
- 8,400 RPM at full throttle = ~1,300 thrust/motor
- 6 motors × 1,300g = ~7,800g total thrust
- Actual T:W achieved: 7,800 / 3,705 ≈ 2.06:1 ✓

Hardware Stack: Battery Selection

- 22.2V nominal (matches motor/ESC voltage rating)
- 8,000mAh — larger capacity, but weighs ~1kg. (~25% of total AUW)
- Estimated flight time: ~24 minutes
- Bigger battery → more flight time
- More weight → higher throttle → faster discharge

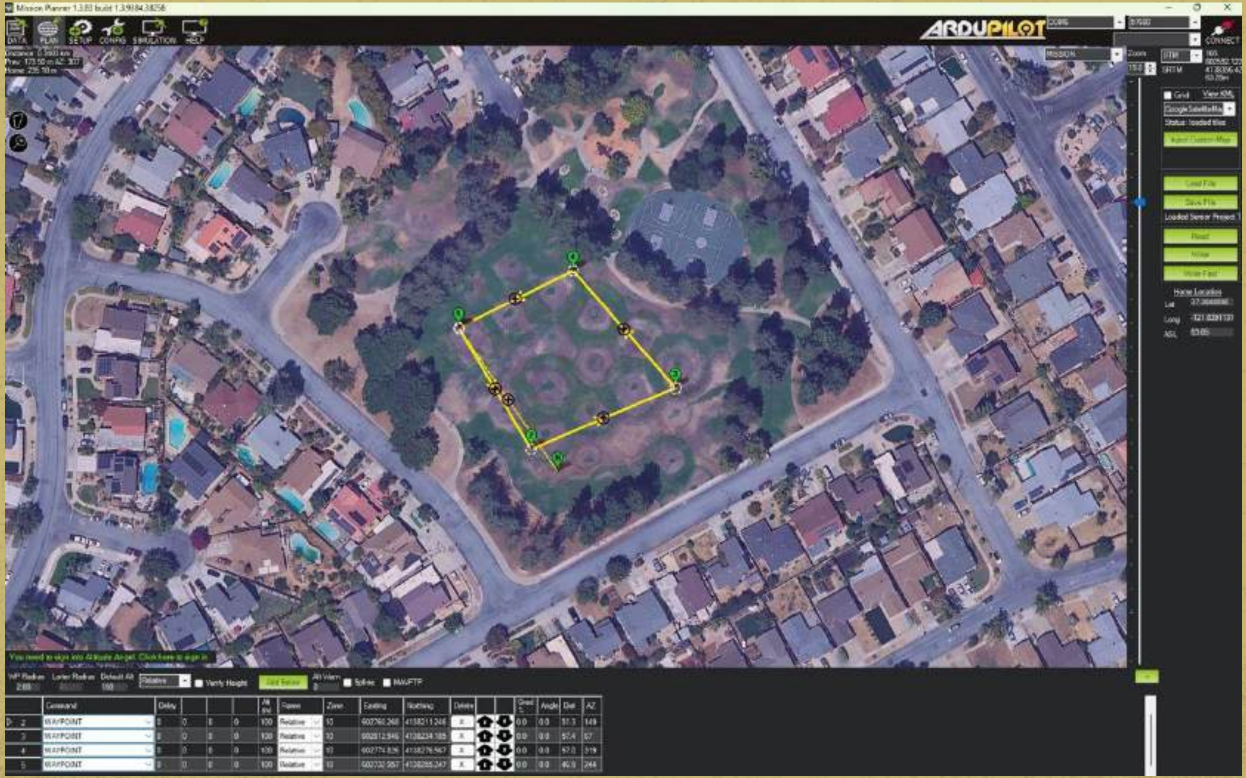
Software Stack: Raspberry Pi 5

- Extendable
- Provides USB-A connection for thermal camera
- Able to run dronekit and connect to Pixhawk (flight controller)
- OpenCV and NumPy

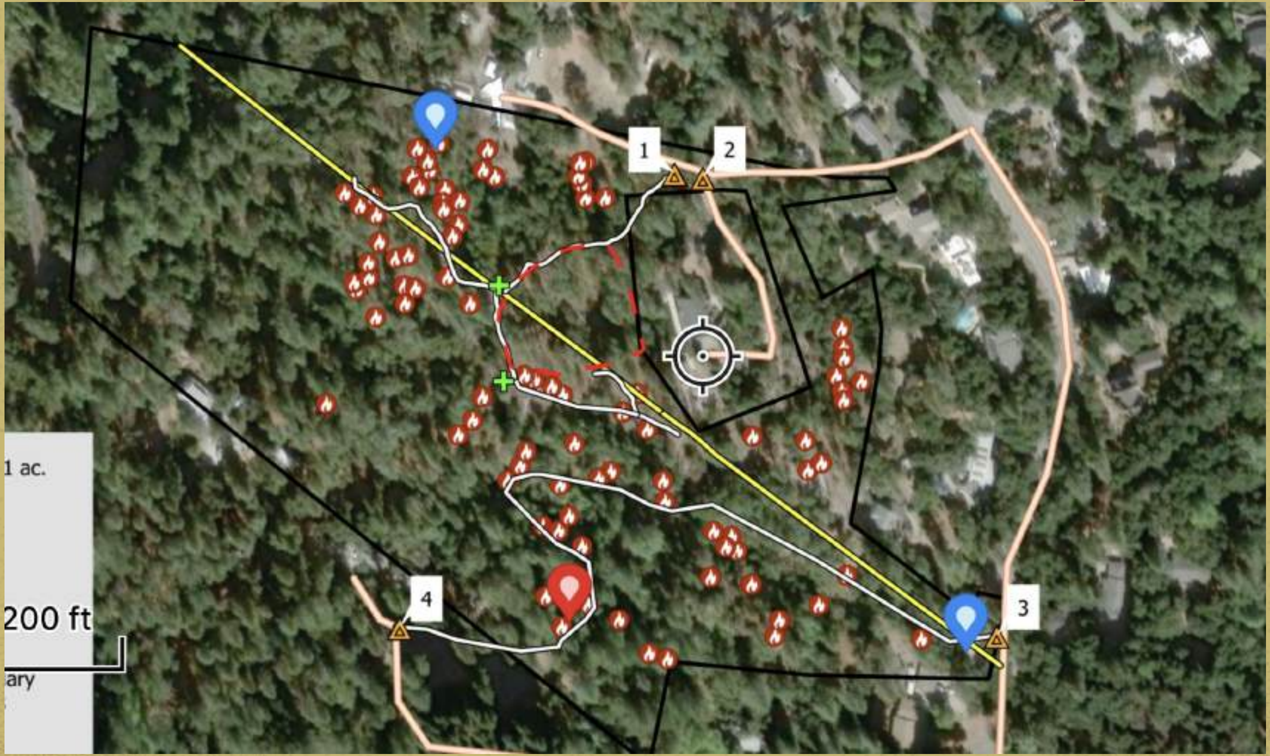
Software Stack: SiK Telemetry Module

- Transmits flight controller and GPS info via radio waves
- Interfaces with Mission Planner

Software Stack: Mission Planner

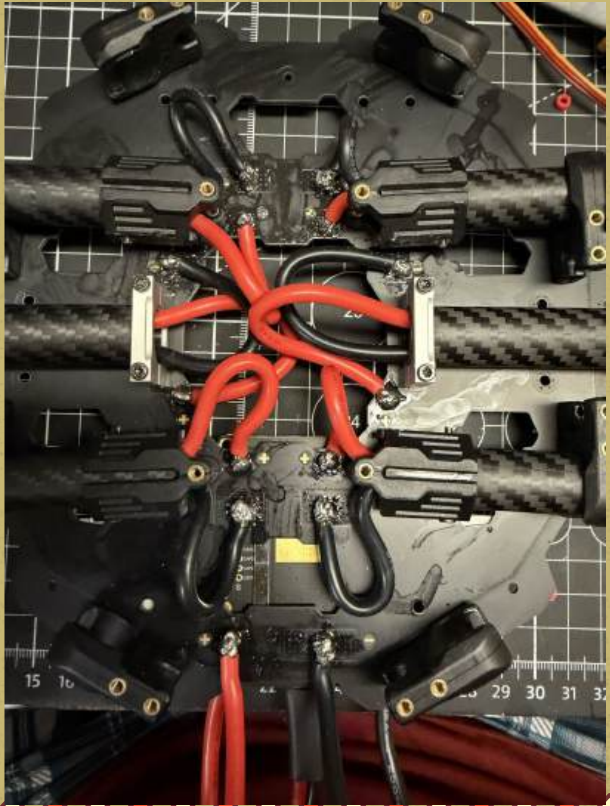


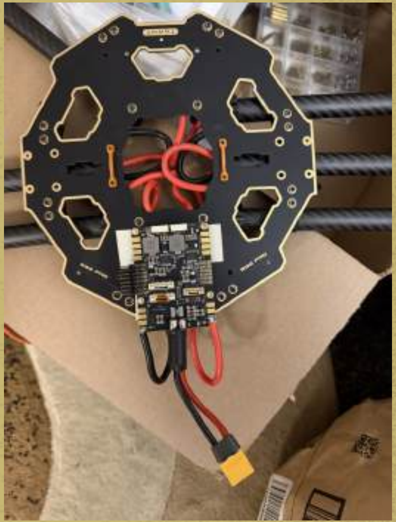
Software Stack: Avenza Maps



Assembly Process

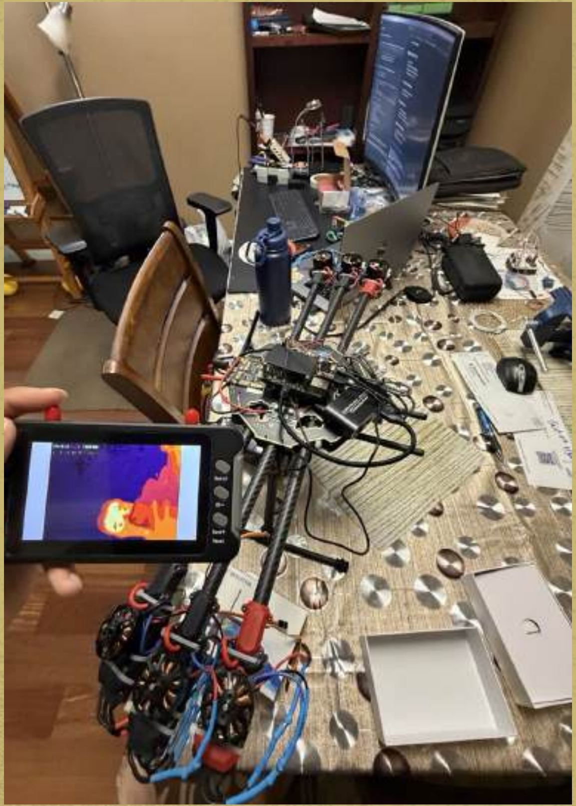
Phase 1 – Mechanical and Power System





Phase 2 – Flight Electronics and Compute

Phase 3 — Thermal Video Chain



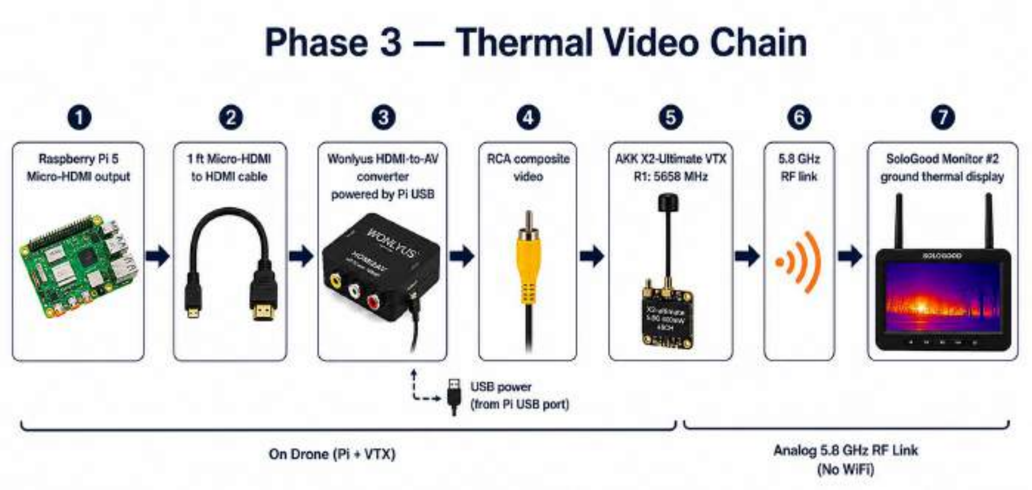


Figure 10. Thermal video chain diagram. Image generated with OpenAI Codex, 15 May 2026.

Challenges and Surprises

1. Working with AI:
    a. Confidently lies
    b. Doesn’t have access to some websites (amazon and youtube)
    c. Context Rot
2. Shady Suppliers and Shipping:
    a. Slow response time
    b. Ghosted
    c. Extremely slow parts delivery
3. Tariffs:
    a. $300-$400 additional costs due to tariffs

Outcomes

1. Steady thermal camera stream
2. Steady RunCam camera stream
3. Motor test successful
4. Telemetry tests successful
5. Flight test successful
6. Stayed within budget
7. Stayed within weight limits

Limitations

1. Stationary cameras
2. Manual fire recognition
3. Manual Avenza Updates
4. Short battery life

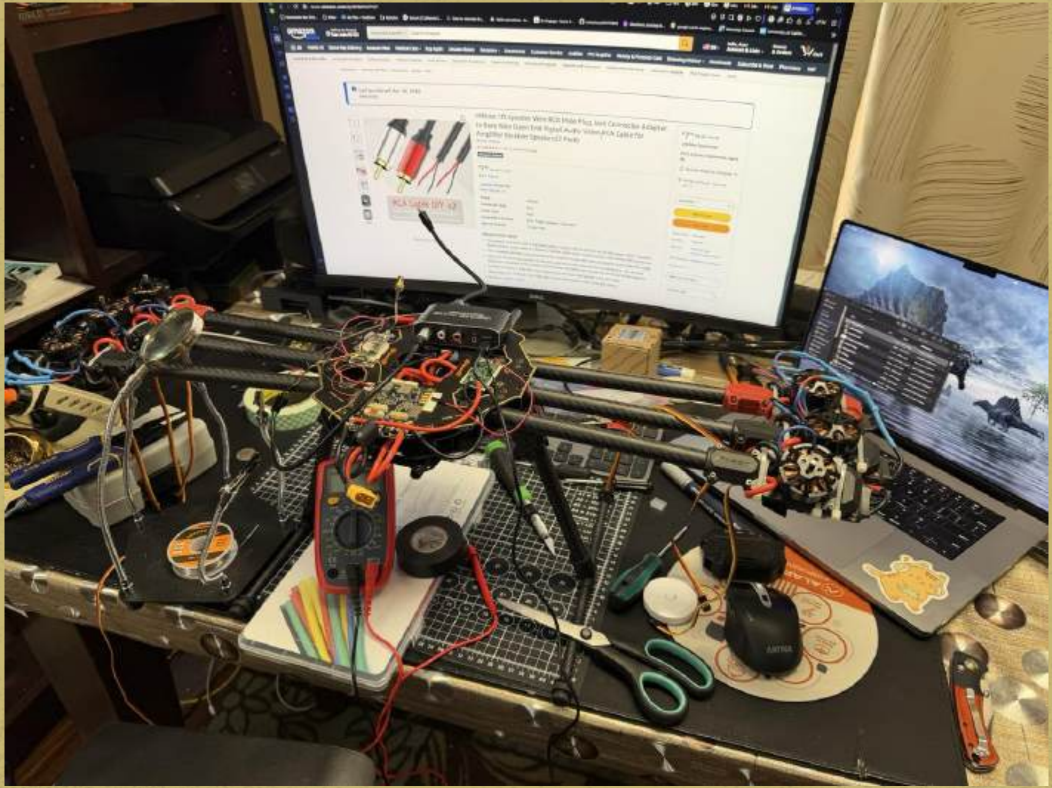
Next Steps

1. Install gimbal based cameras
2. AI-based fire detection
3. Live Avenza Updates
4. Extend battery life
5. Larger frame (Tarot T810)

Pros

Good real world experience

Do something with your hands



Talk to genuine people

Cons

1. Time
2. Space:
3. Money:
    a. Parts cost ~$2.5k

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