Developing Pest Management Applications With Unmanned Aerial Systems

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Helicopter Operations

- Due to terrain helicopters are necessary for surveillance and management

Photos Courtesy Hawaii DLNR.

Herbicide Ballistic Technology (HBT)

- Herbicide containing projectiles
- Aerially-deployed

Leary, 2013

Unmanned Aerial Systems

- Aircraft and associated systems operated with no pilot on board

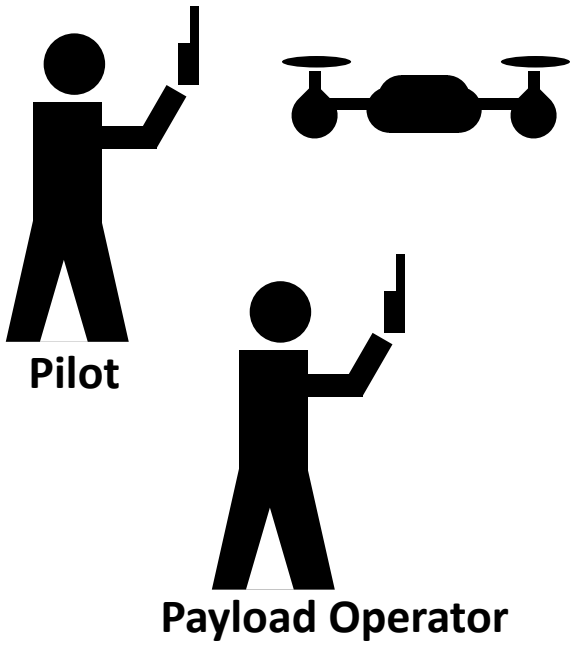
eBee (SenseFly)

Spreading Wings S1000+ (DJI)

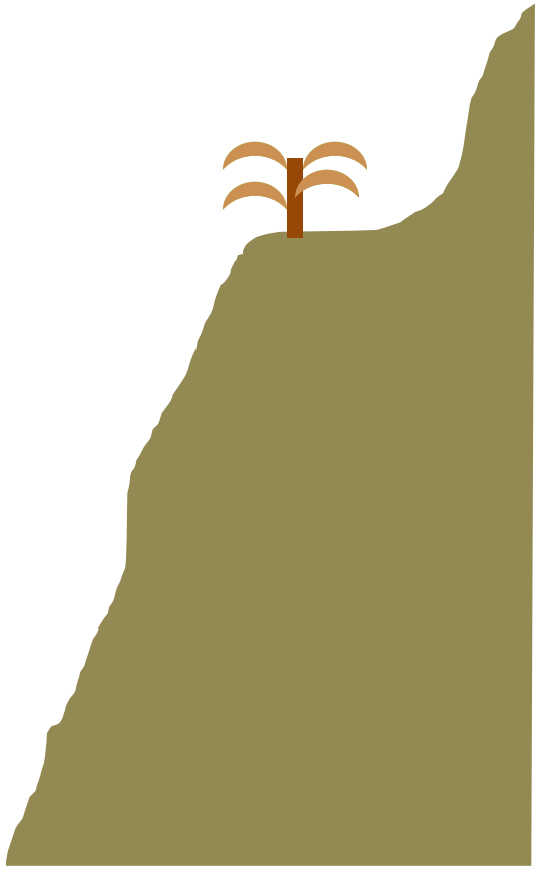
RMAX (Yamaha)

Agras MG-1S (DJI)

Concept



HBT-UAS
Fly To Target
Treat
Fly Back



Aircraft

DJI S1000+

- Payload:
  - 6 kg
- HT (max):
  - 15 min

Yamaha RMAX

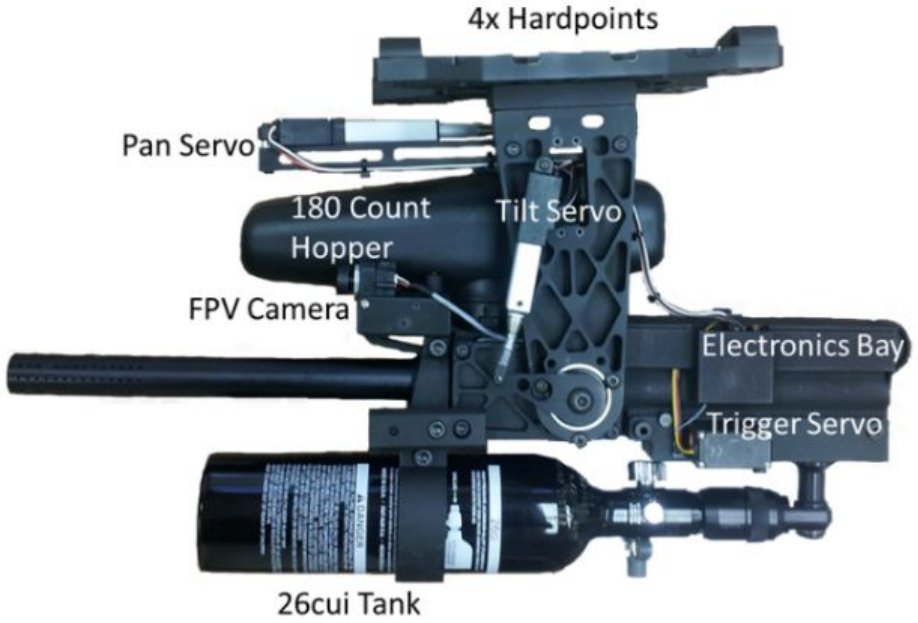
- Payload:
  - 28 kg
- HT (max):
  - 60 min

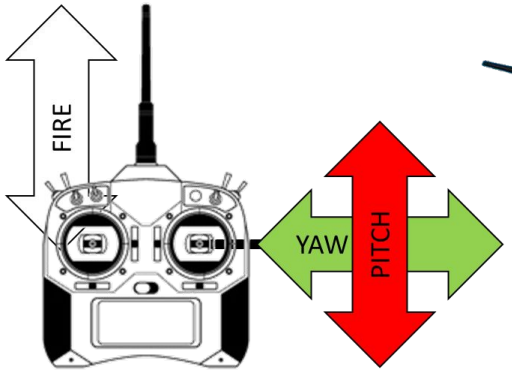
DJI Matrice 600 Pro

- Payload:
  - 5.5 kg
- HT (max):
  - 38 min

Payload

Component	Mass (kg)
Battery	2.53
Gimbal-Marker	3.97
Total	5.50

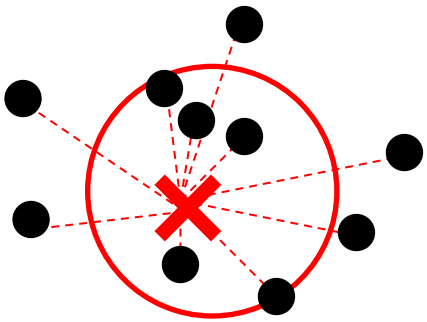




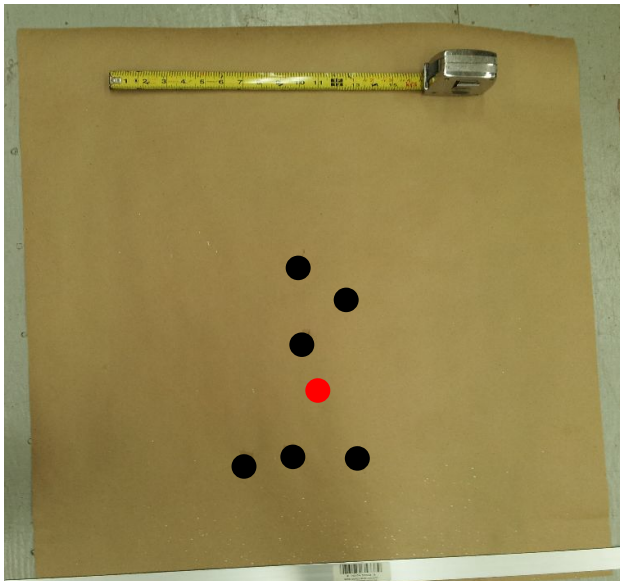
Payload

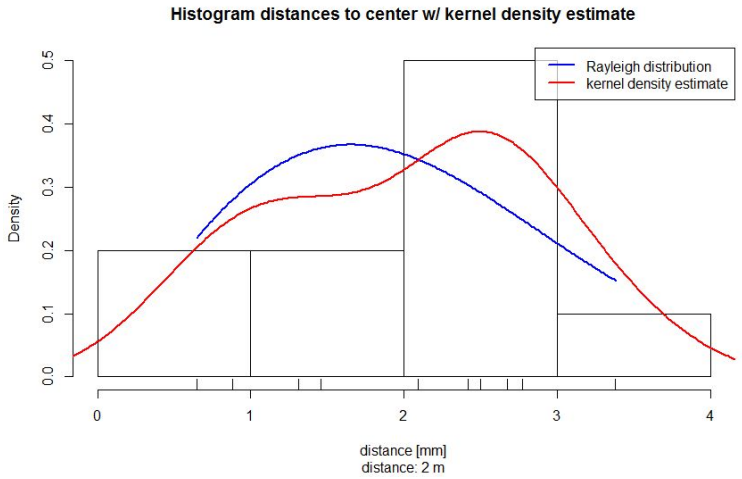
Methods: Treatment Statistics

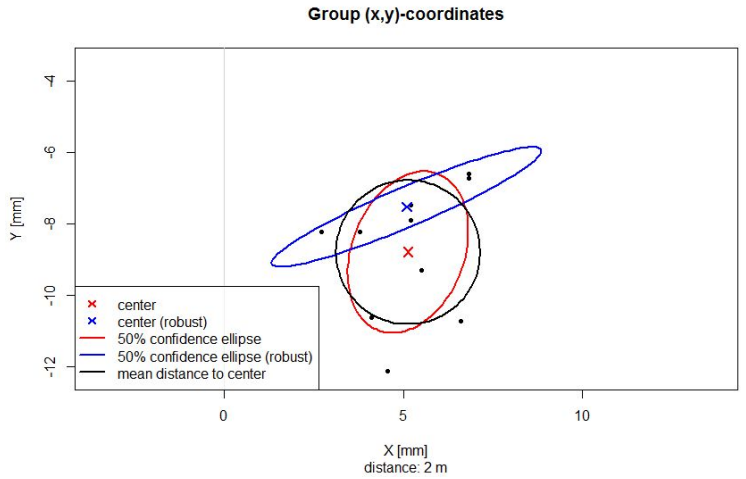
- Circular Error Probable (CEP)
  - Radius of circle containing 50% of points of impact
- Root Mean Squared Deviation
  - Difference between aiming point and points of impact



Methods: Treatment Statistics







Results: Treatment

Distance (m)	CEP (cm)	RMSD (cm)
2	1.87	10.41
4	3.81	12.89
6	4.87	6.40
8	5.58	12.11
10	5.05	10.08

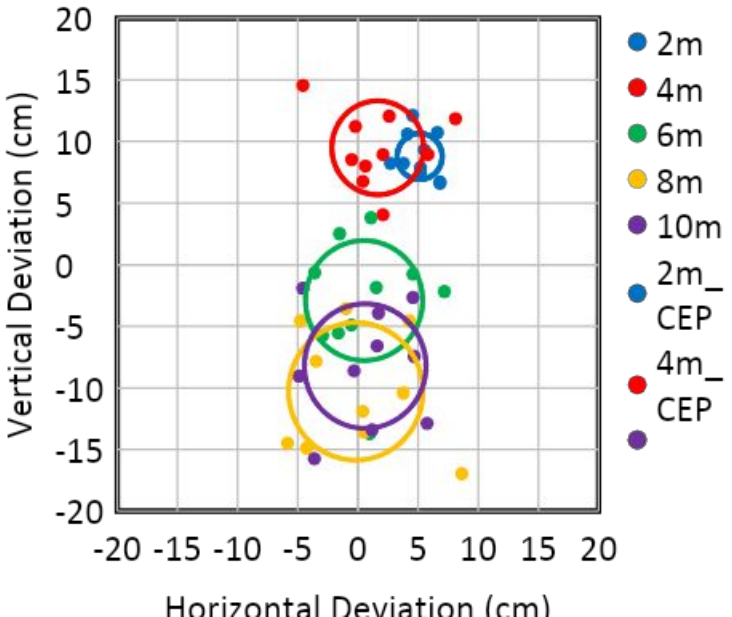
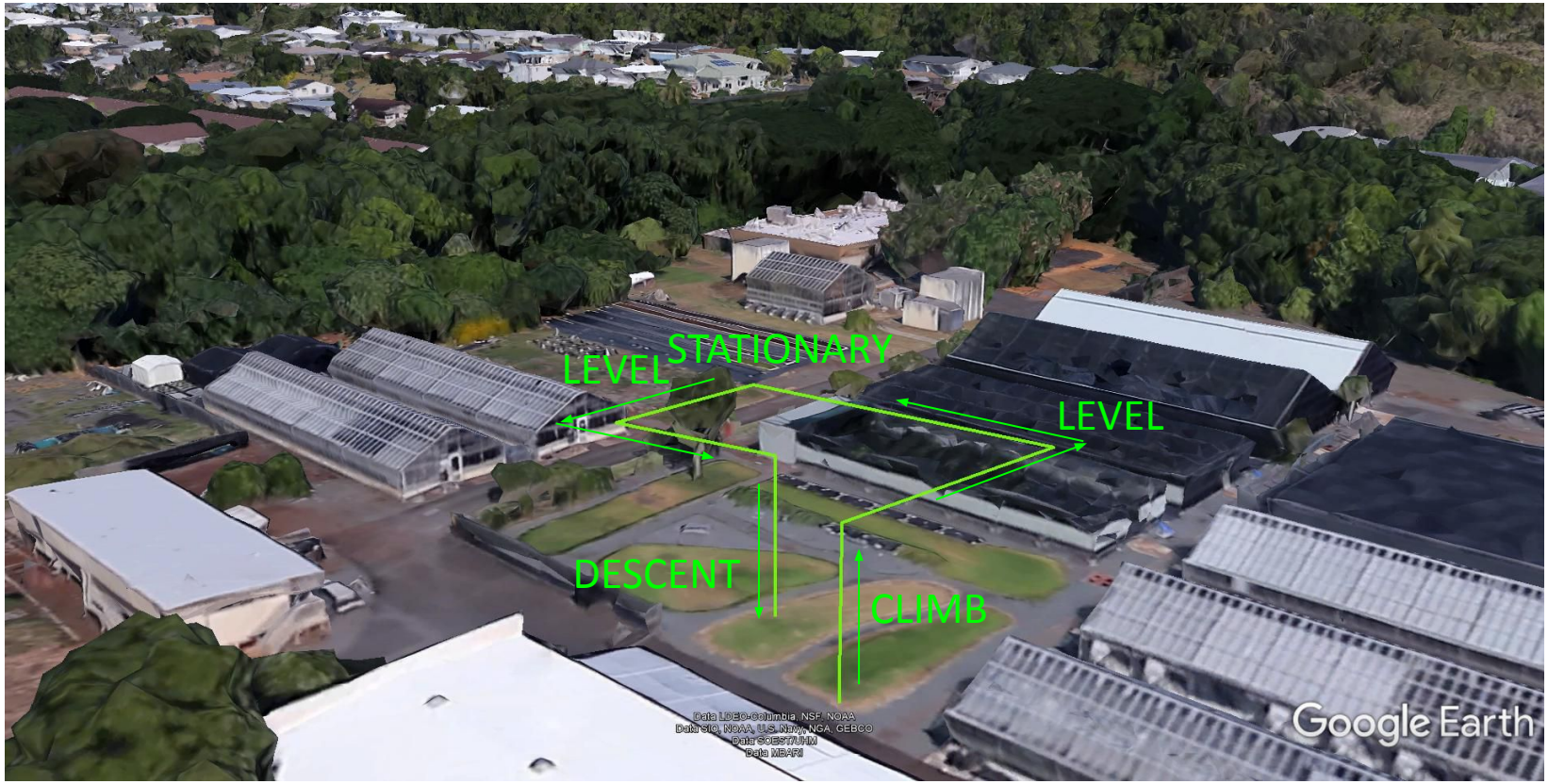


Photo courtesy Ryo Kubota

Methods: Flight Stability & Battery Draw

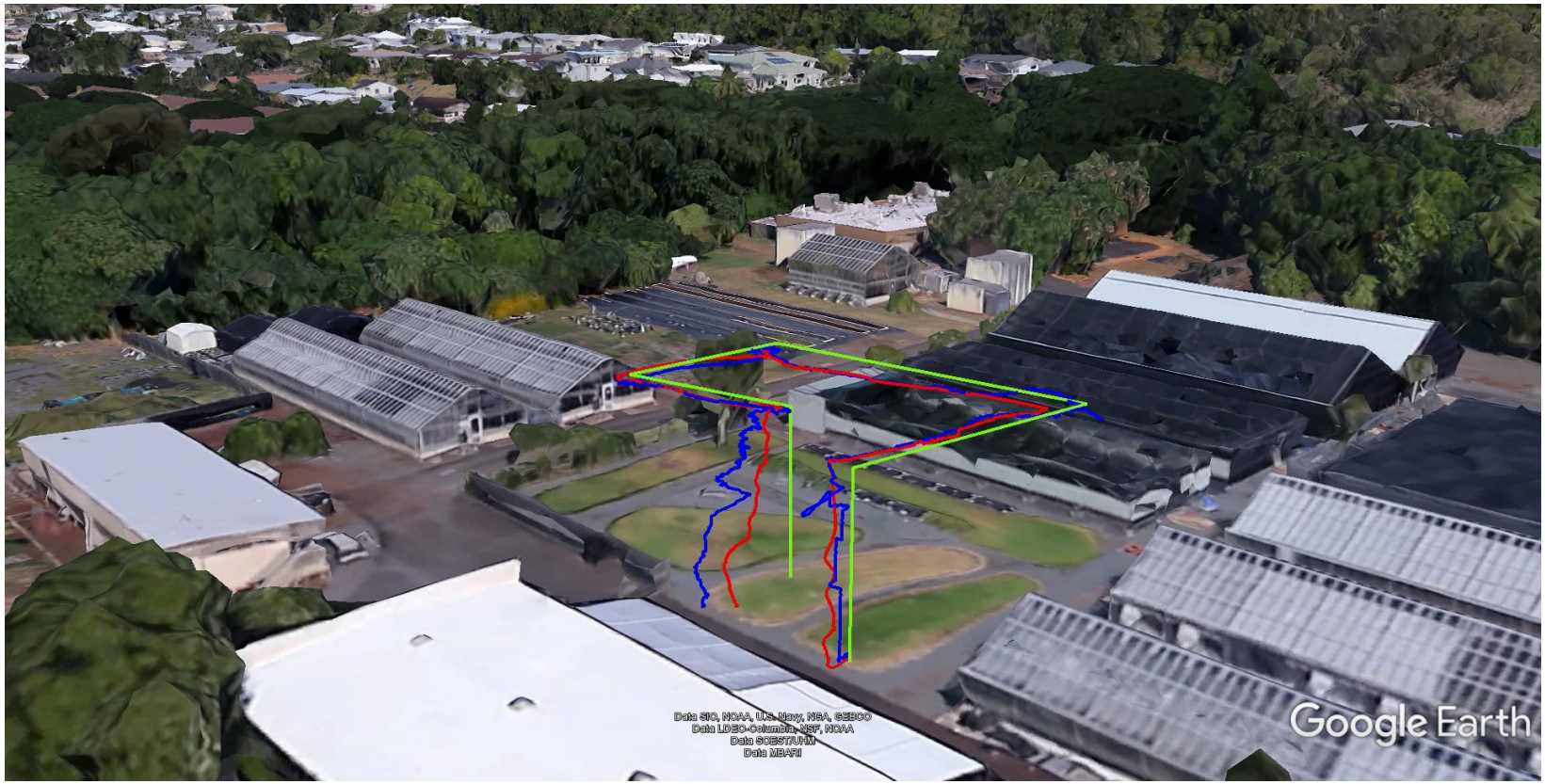
- Automated rectangular flight path with stop to simulate target treatment (UgCS)
- Root Mean Squared Deviation
  - Horizontal and 3D difference between unencumbered (control) and HBT equipped aircraft flight path based on flight records
  - Measured for four stages of flight: Climb, Level, Stationary, Descent
- Battery Capacity
  - Battery capacity as measured by onboard flight computer

Methods: Flight Stability & Battery Draw (S1000+)



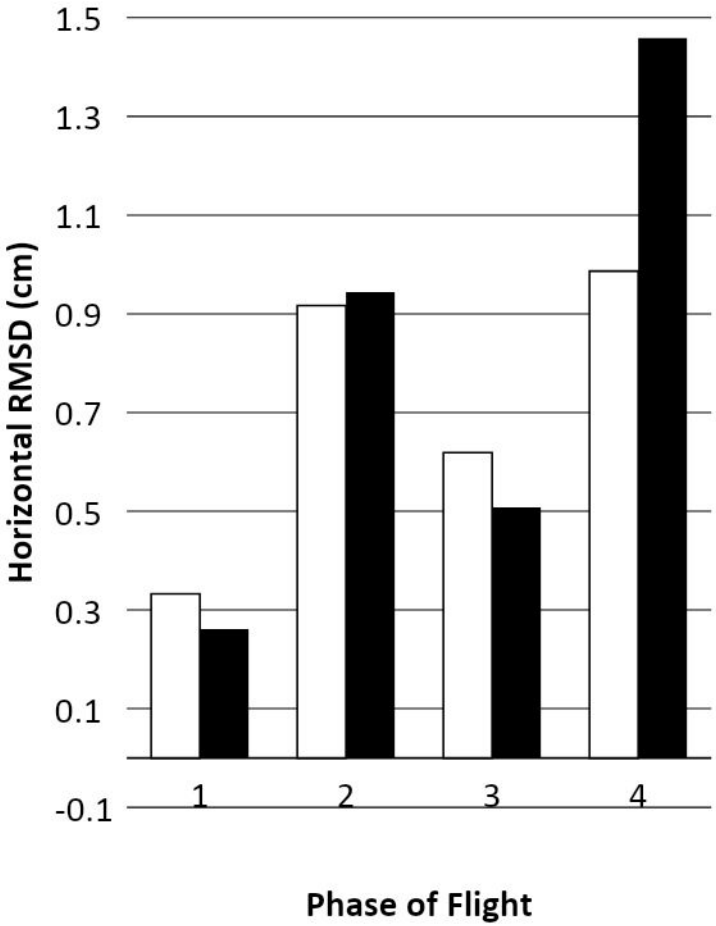
Planned Flight Path

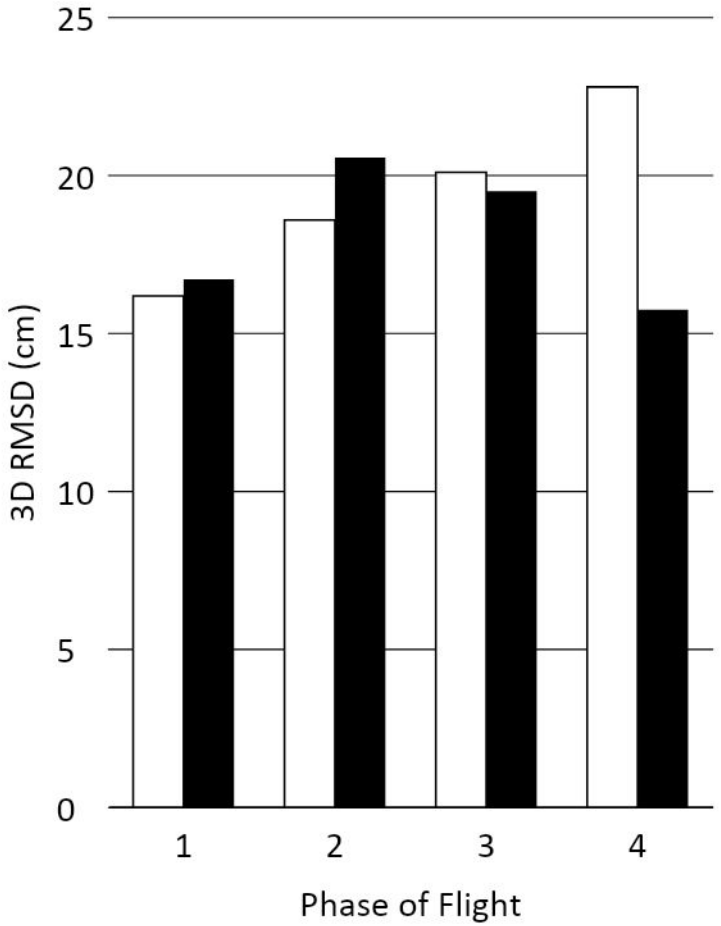
Results: Flight Stability (S1000+)



Planned Flight Path Control HBT Equipped

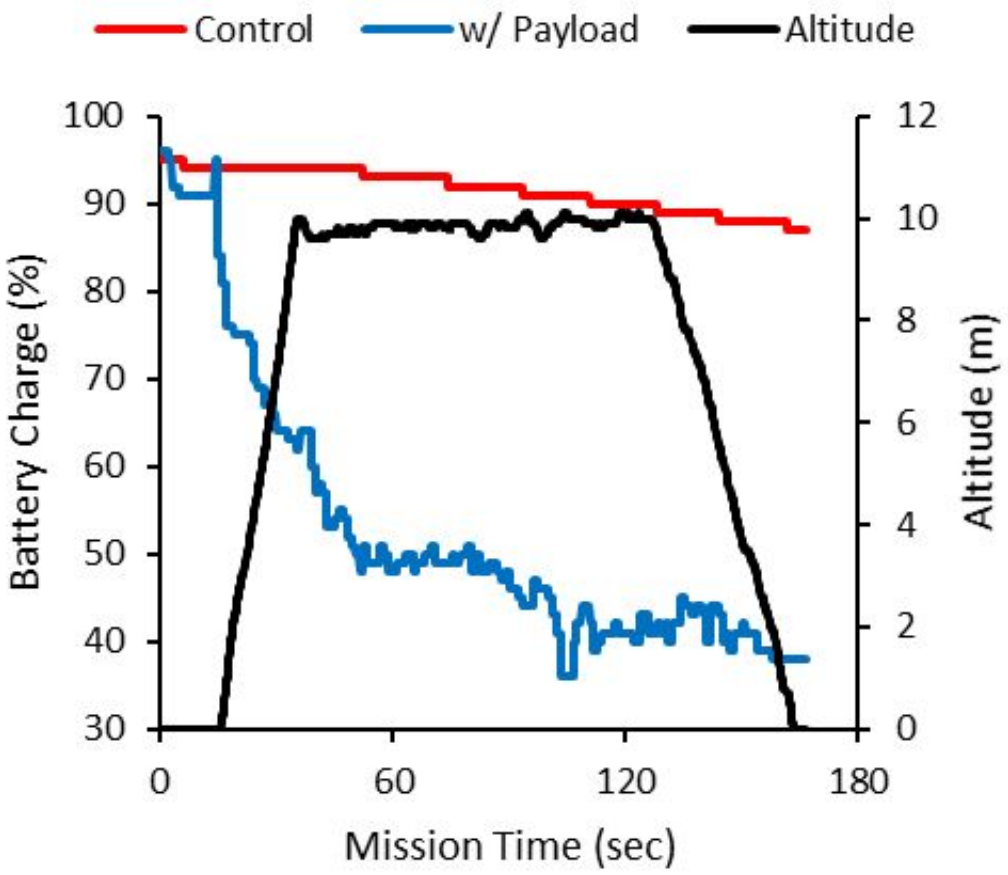
Results: Flight Stability (S1000+)



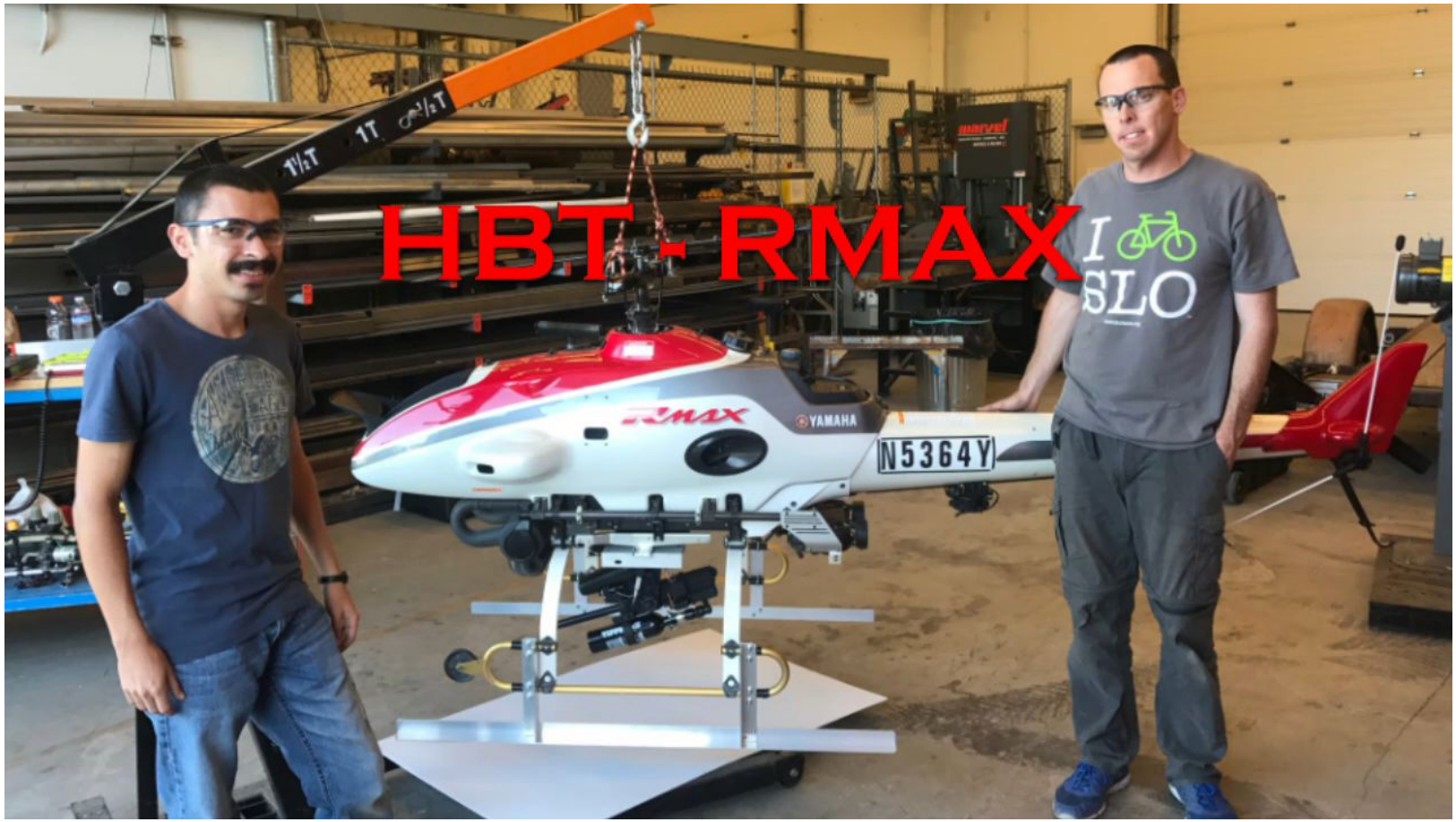


Control HBT Equipped

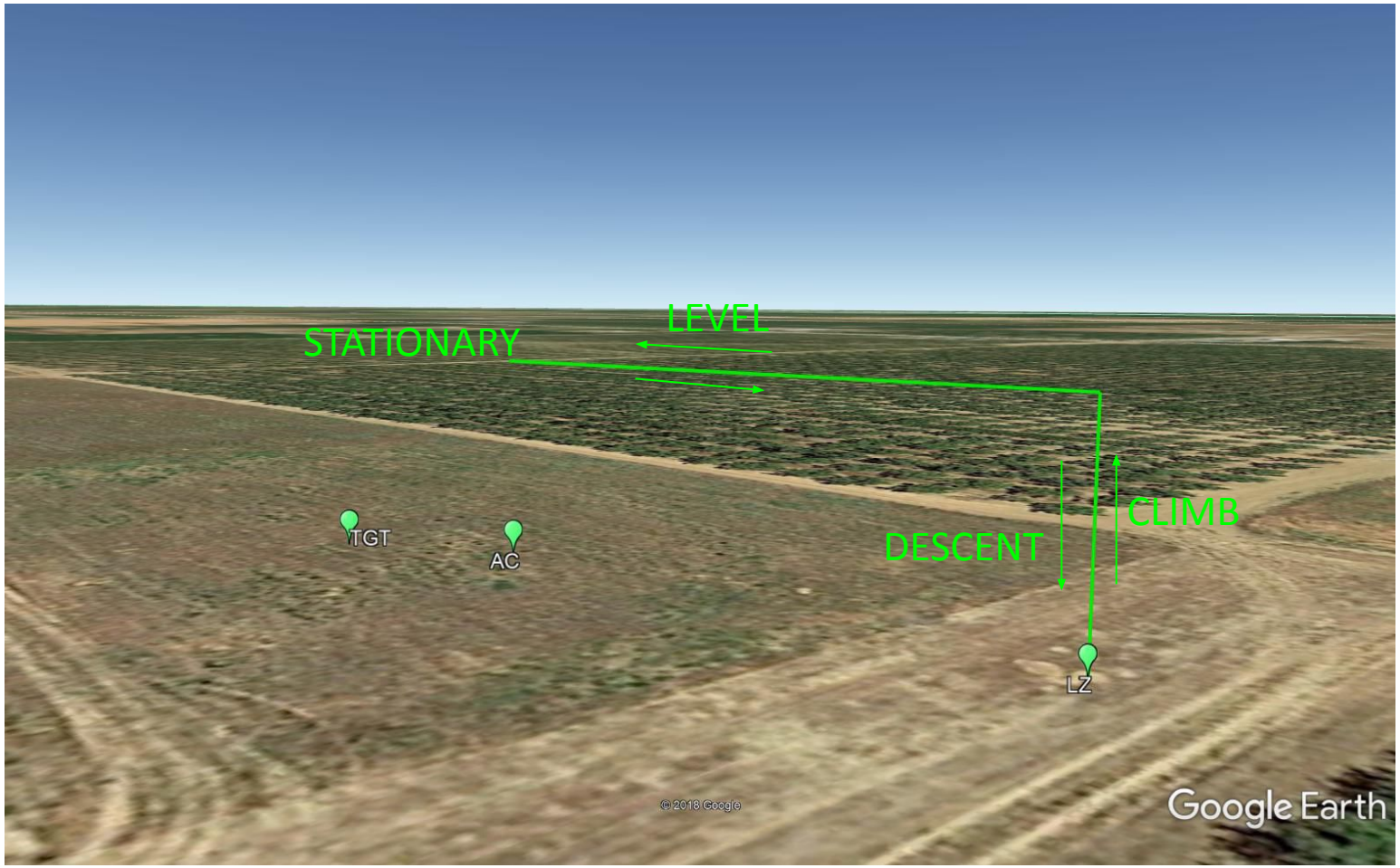
Results: Battery Draw (S1000+)



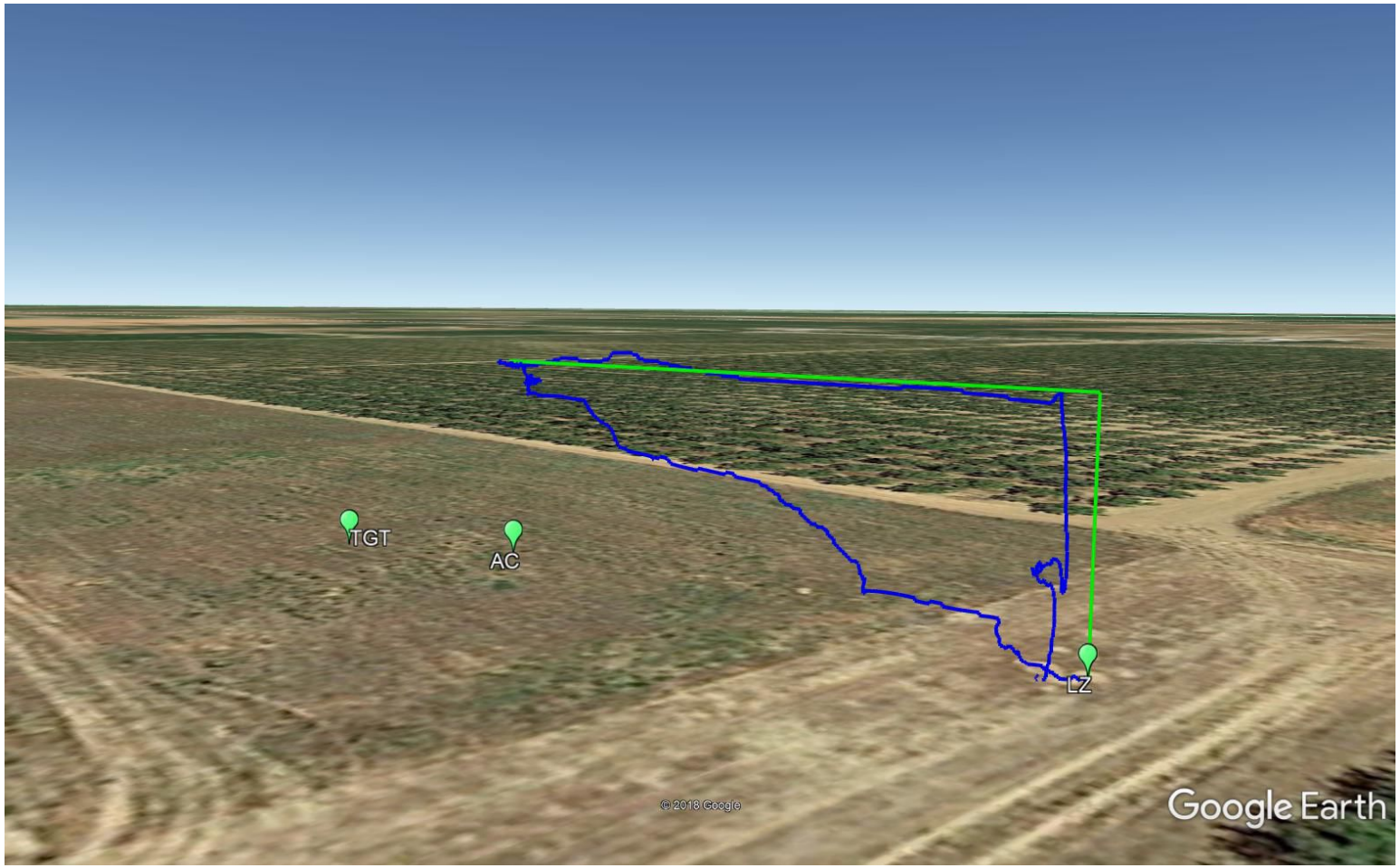
RMAX



Methods: Flight Stability & Battery Draw (M600P)



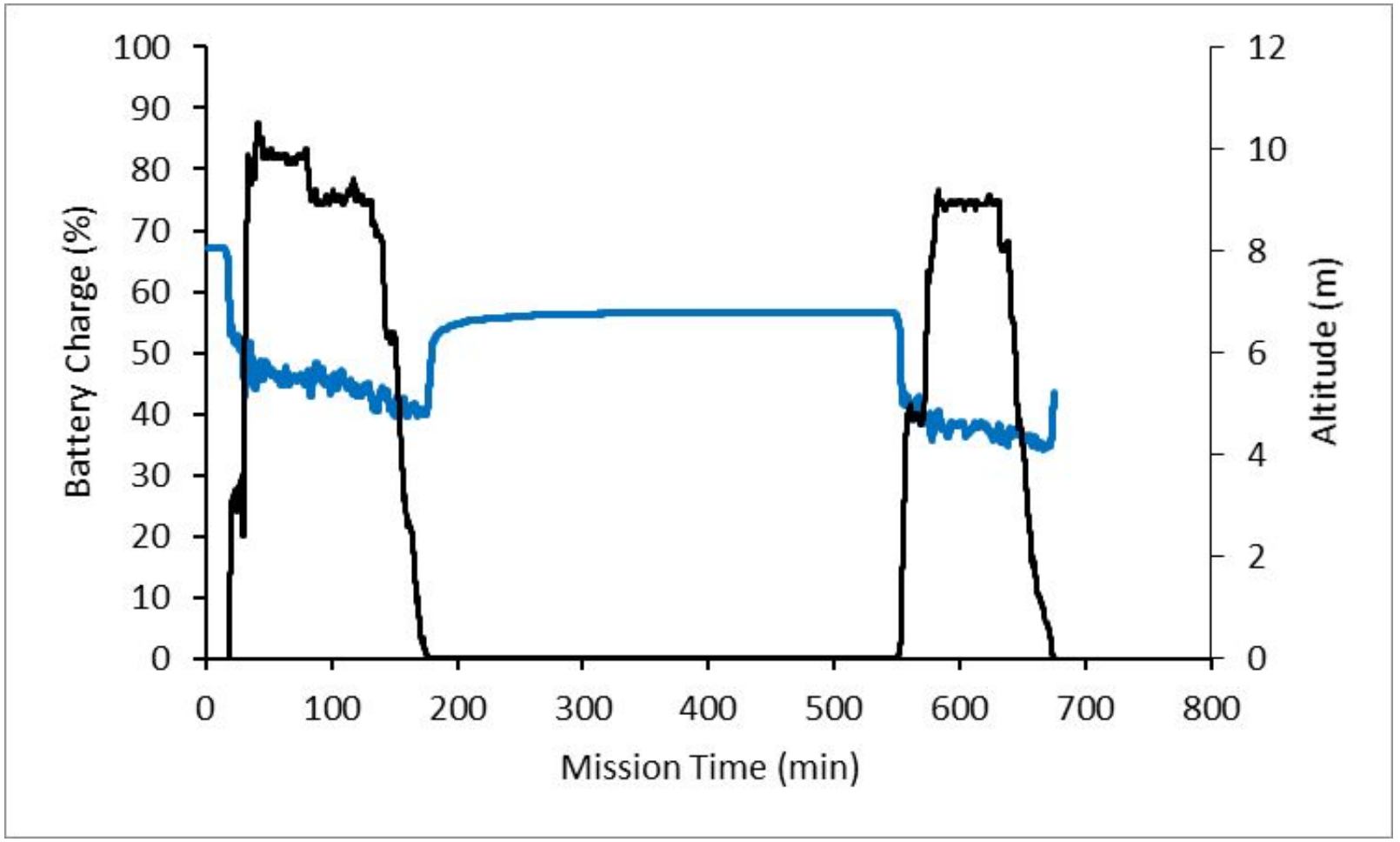
Results: Flight Stability (M600P)



Planned Flight Path

HBT Equipped

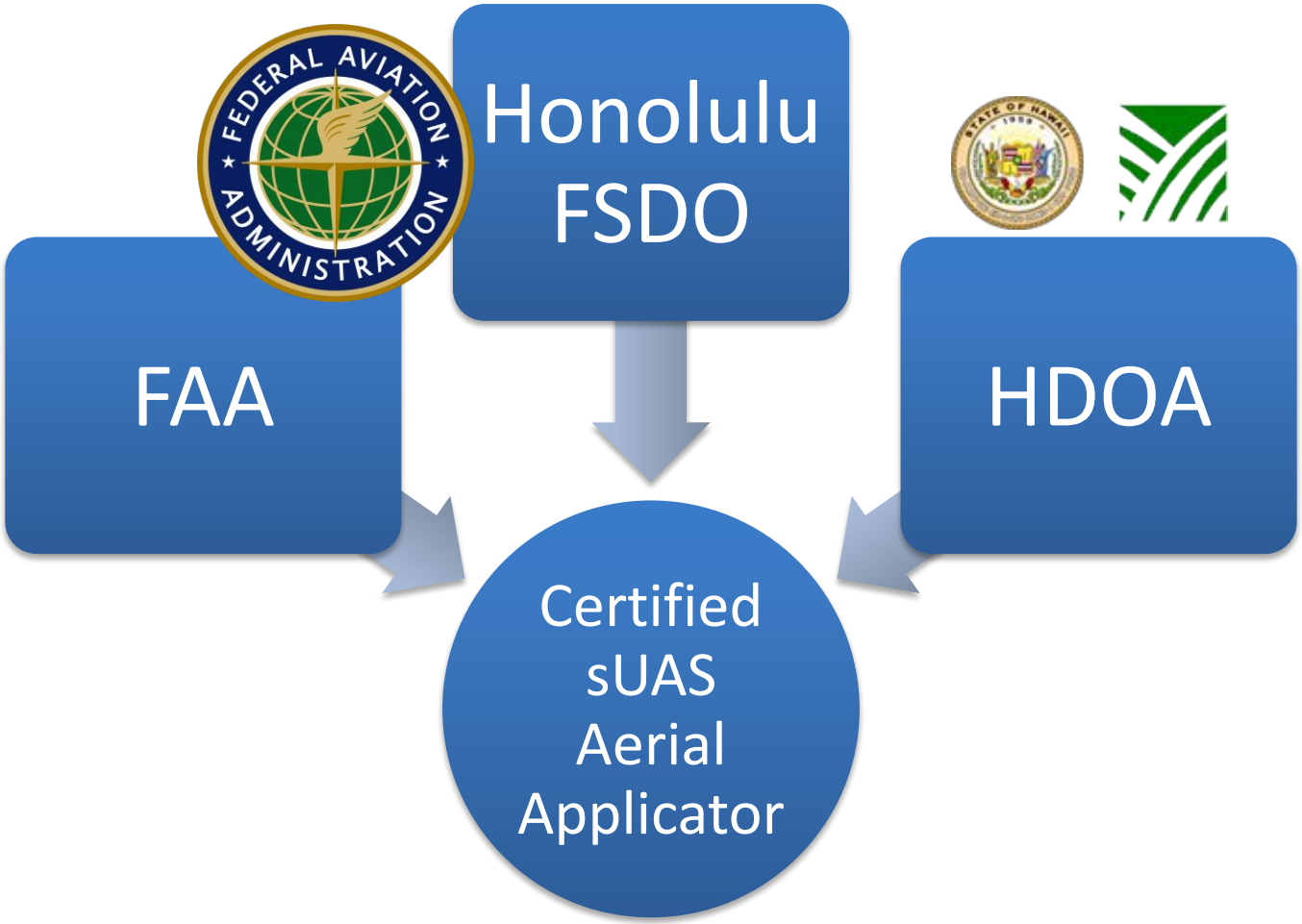
Results: Battery Draw (M600P)



Agricultural Aircraft Operations

- To operate a civil UAS for Agricultural Aircraft Operations
  - Must comply with 14CFR§137, 14CFR§107, and have an agricultural aircraft operator certificate
  - Requires a Section 333 Exemption for Agricultural Aircraft Operations to void 14CFR §107.36 and portions of 14CFR§137

Regulatory Framework



Documentation

- Aerial Pesticide Application Guide
- Aircraft User Manuals
- Petition for Exemption
- HBT-UAS Manual
- Supplement to Aerial Application Guide for Unmanned Aerial Systems - Multirotor

Conclusions

- Projectile dispersal is within limits to treat a juvenile miconia plant
- Effects of the gimbal-marker system on flight stability are minimal in autonomous flight
- Added weight substantially reduces available flight time on the S1000+ to one mission of 3 minutes
- RMAX is not compatible with envisioned application due to cost and lack of autonomous flight capabilities
- Matrice 600 Pro is capable of multiple missions on a single set of batteries
- Future Work
  - Secure 333 Exemption
  - Consider miniaturized system

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