ETERNAL FLIGHT

Delivering Power In Flight

In-Flight Battery Switching for Unmanned Aerial Vehicles

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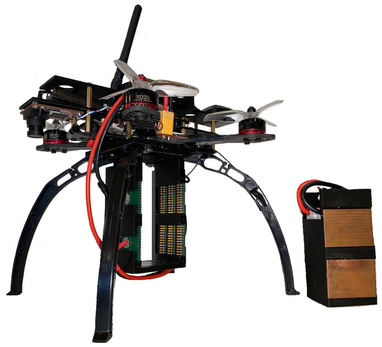
Abstract

As the applications of UAVs increase, restricted battery life continues to hinder the expansion of drones for numerous use-cases. Drones can typically remain in flight for 30 minutes, which limits both operating time and range. Eternal Flight aims to address this problem through a novel system called IFS (In-Flight Switching). Taking inspiration from jet aerial refueling, IFS consists of a large "tanker" hexacopter which replaces the battery of a smaller "receiver" quadcopter, effectively increasing the receiver's time in flight. The tanker replaces the receiver's battery while keeping the receiver's system alive, effectively performing a hot swap of the battery. Once the battery switching is complete, the receiver takes off with a full battery.

Overview

Receiver



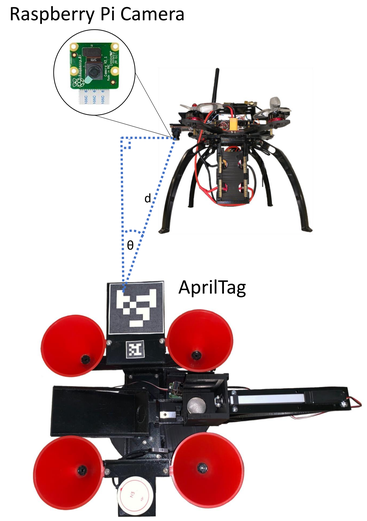
Key Hardware
- Pixracer Flight Controller
- Raspberry Pi Zero W
- U-Blox NEO-M8P GPS
- Pi Camera Module
- Weight: 1068 grams

Tanker

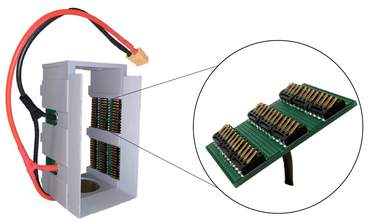
Key Hardware
- DJI N3 Flight Controller
- Raspberry Pi Zero W
- U-Blox NEO-M8P GPS
- Actuonix Linear Actuator
- Weight: 3679 grams

In-Flight Switching

Waypoint Navigation
The tanker communicates its coordinates to the receiver over WiFi. Using centimeter-level accurate Real-Time Kinematics present on both drones, the receiver drone navigates to and hovers 6 feet above the tanker.

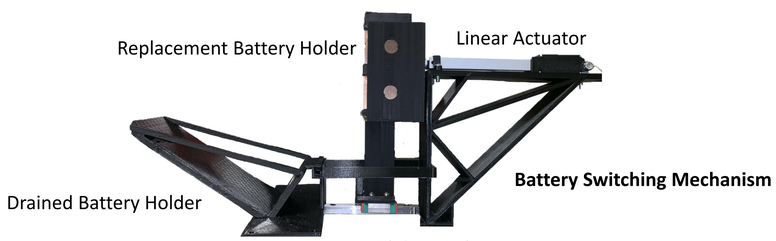


Control System for Landing
An AprilTag, a fiducial marker, present on the top of the tanker helps guide the receiver to land precisely. The Raspberry Pi Camera on the receiver can determine the x, y, z (linear) and roll, pitch, yaw (rotation) coordinates relative to the tanker. These coordinates are then passed to a fine-tuned controls algorithm to allow the receiver to land stably on the tanker.



Spring Compression Contacts
Interface with the Battery

Battery Hot-Swap
A linear actuator pushes in the replacement battery and simultaneously pushes out the drained battery. Spring compression contacts on the receiver ensure that during switching, the onboard system is kept alive when both batteries are temporarily in parallel.



Battery Switching Mechanism

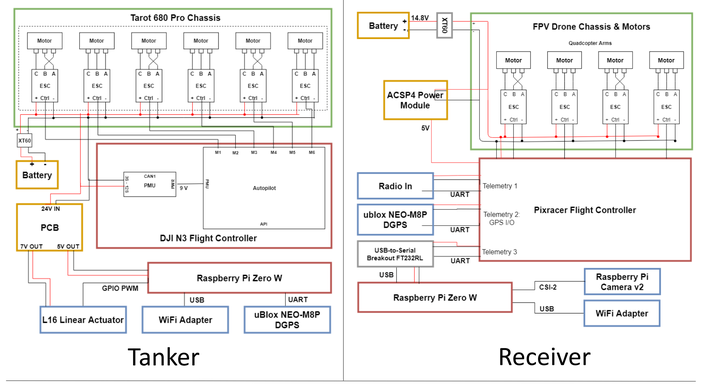
Challenges

Getting centimeter-level GPS accuracy
Sending GPS correction data allowed the receiver to fly closer and hover directly over the tanker drone

Developing the battery switching mechanism
The battery switching mounts were designed through rapid prototyping of CAD models using SolidWorks and 3D printing.

Landing precisely and accurately
A custom controls algorithm was designed to allow the drone to use AprilTag coordinates and descend slowly and land stably.

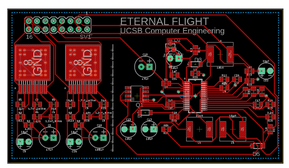
Electronics



Raspberry Pi Zero W
- 1 GHz, single core CPU, 512 MB RAM
- 802.11 b/g/n wireless LAN
- Onboard computer for receiver drone

Raspberry Pi Camera Module v2
- Sony IMX219 8-megapixel sensor
- Used to detect AprilTags

U-Blox NEO-M8P RTK DGPS Module
- Provide centimeter-level GPS positioning
- Integrated Real-Time Kinematics



Custom Power PCB
- Voltage conversion from 24V to 5V and 7V
- Power linear actuator and Pi onboard tanker

Acknowledgements

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