

QUADCOPTERS: BEST PRACTICES FOR PILOTED AND AUTONOMOUS FLIGHT

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NEB 444

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Nonlinear Controls and Robotics (NCR) Lab
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OUR QUADCOPTERS

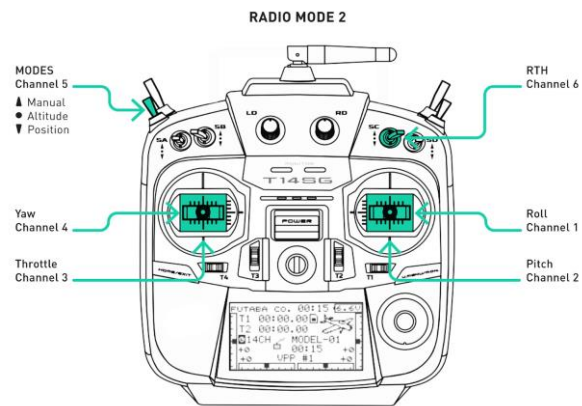


- 3x Freefly Astro
 - Radio to Herelink remote control
 - WiFi to onboard computer
 - 1,500g payload
- 1x Freefly Alta X
 - Radio to Futaba remote control
 - Radio to ground station (computer)
 - WiFi to Jetson Orin
 - 15,000g payload
- ~20x “Homebrew”
 - WiFi to Jetson Orin
- ~10x Parrot Bebop 2
 - WiFi to onboard processor

PILOTED VS. AUTONOMOUS FLIGHT

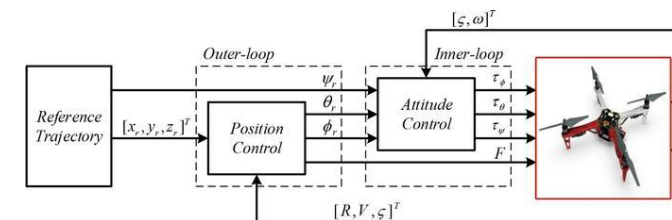
PILOTED FLIGHT

- Conducted by a human pilot
- Signals are sent via radio/over the air to off-the-shelf control algorithms



AUTONOMOUS FLIGHT

- Any flight requiring “offboard” state
- Any flight which uses ROS or another middleware to send commands
- User-developed controllers



FLY WITH PURPOSE

- All flights should be for either research or supervised training
- No recreational flights
- No aerobatics
- No flying outside of the net or indoor lab



MISSION PLANNING

Before ANY quadcopter operation, indoor or outdoor, fill out the [pre-flight form](#)

- Date of flight:
- Flight duration:
- Quadcopter(s) in use:
- Purpose of flight:
- Person operating controls (POC)/
Remote pilot in command (RPIC):
- Visual observer (VO):



FLIGHT PREP



Every successful flight requires...

1. Proper PPE
2. At least 2 charged batteries (or equivalently, a charged set and a backup set if your quadcopter requires more than 1 battery for flight)

- Closed-toed shoes, long pants, eye protection, and long hair tied back are **REQUIRED!**
- Refer to [LiPo SOP](#) for best practice w.r.t charging batteries

WEATHER

Current conditions at
Gainesville, Gainesville Regional Airport (KGNV)
Lat: 29.69°N Lon: 82.28°W Elev: 151ft.



Fair
88°F
31°C

Humidity	68%
Wind Speed	W 16 G 25 mph
Barometer	30.01 in
Dewpoint	76°F (24°C)
Visibility	10.00 mi
Heat Index	99°F (37°C)
Last update	14 Jun 3:53 pm EDT



- Big variable in Florida
- FAA says you shouldn't fly in precipitation – we agree. Our drones are not waterproof
- Cease operations above sustained winds of ~15mph (~7 m/s)
- Get wind speed from our anemometer (Home Assistant), or from [KGNV](#)
- [METAR and TAF](#)

FLIGHT SETUP, QUADCOPTER MANAGEMENT

- NEVER POWER ON A QUADCOPTER OUTSIDE OF A NETTED FACILITY WITHOUT FIRST REMOVING THE PROPELLERS
- Move quadcopter into netted facility, bring a walkie talkie
- Unfold arms and lock them out
- Only give drone power when you have a clear path to the exit
- POWER IT ON AND GET OUT!



- Place quadcopter ~9 ft (3 m) from any net outdoors, ~3 ft (1 m) from any net indoors

PILOTED FLIGHT NON-NEGOTIABLES

1. The RPIC should always have their hands on the controller when flying a quadcopter.
2. The RPIC must have the quadcopter within their VLOS at all times.
3. The RPIC must never perform aerobatics with the quadcopter.
4. NO QUADCOPTER OPERATIONS MAY EVER BE CONDUCTED WHILE A PERSON IS INSIDE OF THE NETTED FACILITY.

KNOW YOUR MODES

MANUAL

- Throttle controls thrust directly (constant application of thrust needed to keep quadcopter in-air)
- Pitch and roll sticks send angle commands
- Yaw sends yaw rate command
- Quadcopter drifts in wind

POSITION

- Quadcopter uses GPS and other sensors to maintain position over a point on the ground, hold altitude
- Throttle sends **ADDITIONAL** vertical velocity
- Pitch and roll sticks send velocity commands

ALTITUDE

- Similar to position mode
- Quadcopter will maintain its orientation and hold vertical position using barometer
- Quadcopter will drift in the wind

AUTONOMOUS FLIGHT 101

OFFBOARD MODE

- EXTREME PRECAUTIONS MUST BE TAKEN IN THIS MODE
- Quadcopter accepts arbitrary velocity/acceleration commands
- All use of this mode must be thoroughly vetted in our simulation environment before flight

RETURN TO HOME MODE

- Quadcopter shoots up to predefined altitude, flies back to takeoff GPS coord, and lands
- No obstacle avoidance
- PX4 default RTH height is ~196 ft (60 m). Should be changed to ~8 ft (2.5 m) on all quadcopters to avoid net collisions

ROS 2 CODE

- Do not “roll your own” flight stack (e.g. takeoff, land, mode switching, coordinate transforms)
- The [aero-common](#) package has been carefully designed to ensure consistency across quadcopter flights at the Autonomy Park

GENERAL TIPS

- Only take off when the netted facility is completely clear of people and is properly secured
- Don't take off or land in position or altitude mode
 - Quadcopter can tip over in this state
- Override offboard mode by sending an RC command
- Land on a flat, debris-free area and gently bring throttle to zero
- **DISARM QUAD AFTER EVERY FLIGHT!**

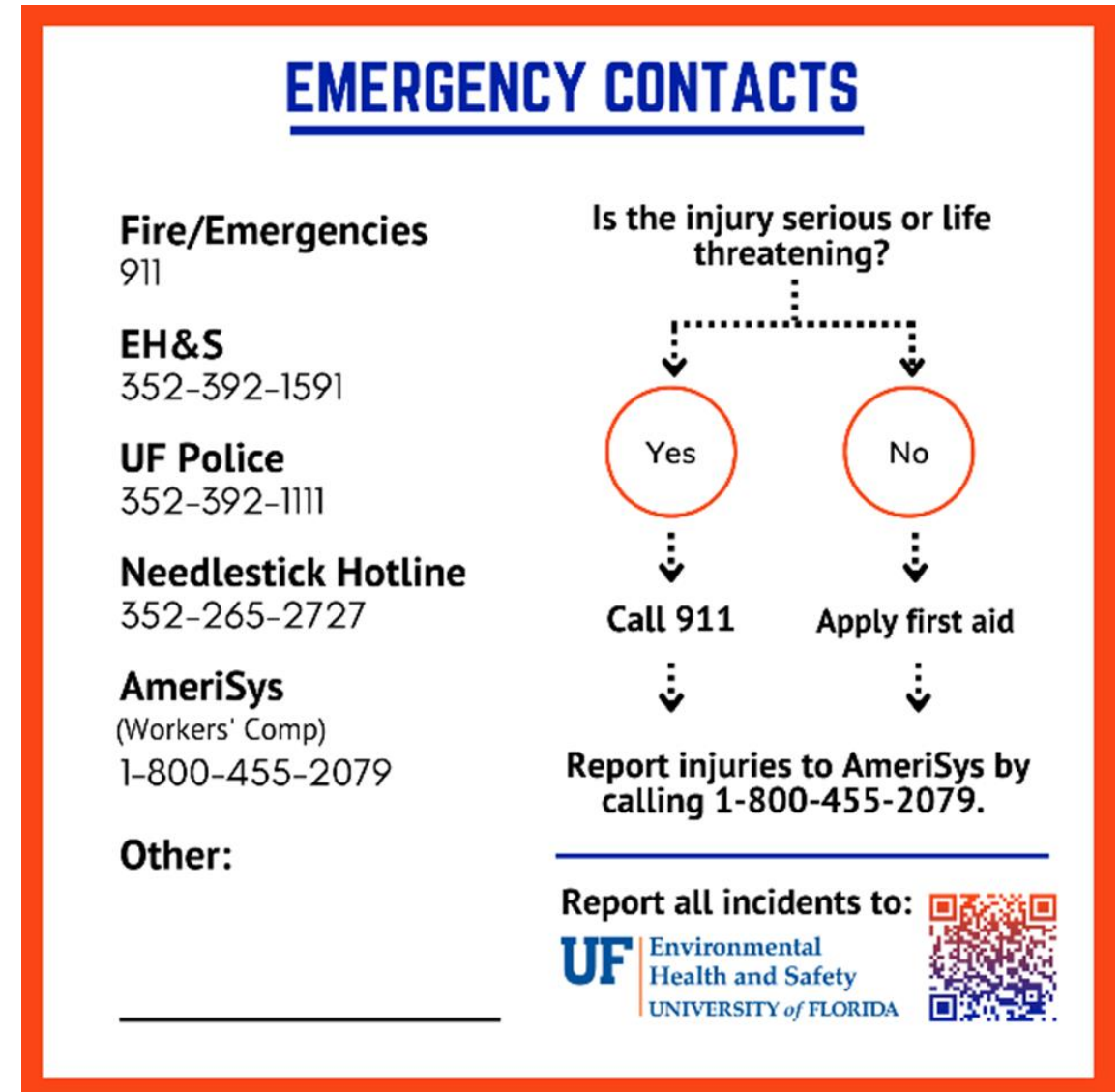


EMERGENCY PROCEDURES

- Disarm quadcopter after every flight
- If you lose feedback in air **and drone is in safe hover state**, try to reconnect via ROS or radio
 - If this is not possible, wait it out. PX4 parameter will cause quadcopter to land at low battery. This should take 25 mins max
 - DO NOT TAKE EYES OFF QUADCOPTER OR HANDS OFF REMOTE CONTROL
- Full-blown crash is the worst case
 - Never approach a drone that has not been confirmed to be fully disarmed
 - Never enter netted facility while quadcopter in flight
 - Approach quadcopter carefully and quickly while wearing full PPE
 - Do not attempt to diagnose hardware. JUST UNPLUG THE BATTERY

ACCIDENTS AND INJURIES

- If serious or life-threatening, CALL 911 ASAP
- Get medical attention as necessary
- If not, apply first aid and then consider next steps
 - Call PI
 - Call AmeriSys at 1-800-455-2079
 - Report accident on [EH&S website](#)
- Fire extinguisher and first aid kit are in both facilities. Know where they are!



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— LEADING THE CHARGE, CHARGING AHEAD —