UAS Tool 12.9

FPV Configuration

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FPV Situational Awareness

Description (5W's)

- **Who**: *sUAS Operators*
- **What**: *FPV TAK UAS Tool v12.9*
- **When**: *15DEC23*
- **Where**: tak.gov
- **Why**: *IOT provide friendly sUAS operators with situational awareness of Organically Built Drones (OBD) during mixed sUAS operations.*

Build Requirements

- TAK Device with 5.0.0 or 4.10.0
- FPV drone w/TBS Crossfire RX, compatible VTX (eg: Analog, Caddx Walksnail, or HDZero)and **GPS* with I2C compass****
- RC with a compatible CRSF TX (eg: TBS Tango 2, Radiomaster Zorro, etc)

*requirements for Betaflight aircraft
**requirements for Arducopter aircraft

Employment Plan

- The TAK device requires both telemetry in (via Wifi) and video (via UVC or network).
- IOT share the aircraft position with other TAK users, the pilot must first connect their TX to an existing wifi connection (eg: Trellisware Wifi AP).
- The simplified Betaflight integration emulates, to the GCS, but **does not send bidirectional MAVLink to the aircraft**. Full control via TAK UAS Tool requires an Arducopter.

Amplifying Information

The Big 3 Firmwares

***Betaflight for Responsive Flight*:**
- Recreational FPV pilots often use Betaflight firmware and it
- Commonly flashed to RTF and BNF configurations.
- Limited integration of sensors and no autopilot features.
- Supports one-way MAVLink telemetry to the RC.

***Transition to Inav for Basic Autonomy*:**
- Inav, based on Cleanflight, is a user-friendly autopilot.
- Combines Betaflight's UI with advanced sensor integration.
- Enables pre-planned routes and sophisticated behavior.
- Supports one-way MAVLink telemetry to the RC.

***Strive for Ardupilot to Unlock Potential*:**
- Ardupilot now supports more hardware targets including FPV flight controllers
- Suitable for RC and autonomous flying.
- Interactive but requires detailed setup.
- Not available as widely in RTF or BNF configurations.

Work Flow

Hardware

FPV with GPS and I2C Compass

TX with Wifi AP or Serial Telemetry Output

Aircraft Firmware

Betaflight
iNav

Ardupilot

RC Input Telemetry

Crossfire RC Input
1-Way MAVLink Emulation
Track 1

ELRS
MAVLink Telem
2-Way MAV Full
Track 2

TBS Crossfire
MAVLink Telem
2-Way MAV Full
Track 2

Host

Android EUD
TAK
UAS Tool 12.9

Android EUD
TAK
UAS Tool 12.9

Android EUD
TAK
UAS Tool 12.9

Network

CoT Multicast via UAS Tool

Video via Multicast or RTSP Server

CoT Multicast via UAS Tool

Video via Multicast or RTSP Server

CoT Multicast via UAS Tool

Video via Multicast or RTSP Server

What is UAS Tool Going to Do?

UAS Integration:
•Enables real-time tracking and management of unmanned aircraft by broadcasting MAVLink location data as CoT.
•Muxes video with telemetry to provide Sensor Point of Interest (SPI) and other metadata.
•Reflects video as multicast for a local network or RTSP/SRT.
•Broadcasts UAS data at 1 update/second for network hosts.
•Enhances teamwork by enabling observers to assist with navigation.

Situational Awareness:
•Provides a comprehensive top-down view of UAS operations.
•Enables remote users to monitor FPV drone locations and orientation.
•Integrates UAS sensor data for a complete situational awareness picture.

Flight Path Monitoring:
•Tracks UAS flight paths and support waypoint mission planning.
•Ensures safety of sensitive payloads by showing lat/lon/alt of the aircraft to the network.
•Enhances mission planning, especially for altitude limits and protecting other air players.

Multi-Platform Support:
•Compatible with various UAS platforms for operational flexibility.
•Enables interoperability among different UAS types including Augmented Reality viewing of SPI within a drone camera field of view.

Preparing the GCS

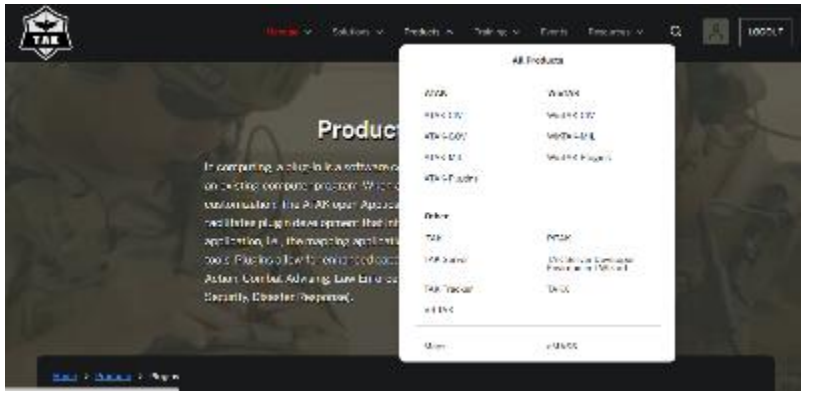
Requirements for Best Functionality:
•Use TAK UAS Tool 12.9 with TAK 4.10.0 or 5.0.0.
•Both CIVTAK and ATAK are compatible with the Core TAK plugin and UAS Tool.

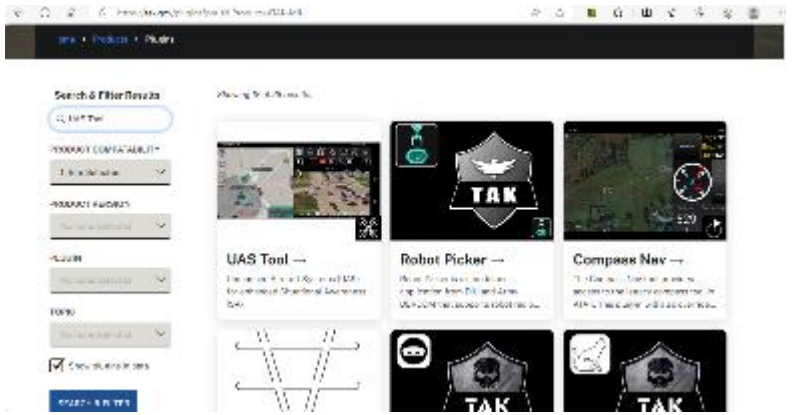
Distribution A Approved:
•CIVTAK and UAS Tool have unrestricted public release approval.

Control Your Versions:
•Download CIVTAK and UAS Tool GCS plugins from tak.gov for version control.
•Avoid automatic updates for TAK 5.0.0 from the Play Store to maintain UAS Tool compatibility.

Access and Highlights:
•Anyone can create a tak.gov account.
•The TAK Product Center promotes Commercial and Outdoor Recreation applications of the toolset.

Getting UAS Tool:
•Visit the TAK website's products tab and go to the plugins page.
•Search for "UAS Tool" and select the version (4.10.0 or 5.0.0).
•Ensure you choose "TAK for Android."
•The correct version will include "12.9" in the file title.





Preparing the TX

Historical Support:
•UAS Tool has historically supported Ardupilot and Pixhawk autopilots for drones.
•Existing FPV drones using Arducopter and a compatible telemetry radio can connect to legacy UAS Tool without modification.

Integrating FPV Telemetry:
•FPV pilots inject RC telemetry into TAK through their RC Controller with CRSF TX. If the TX isn't compatible, it won't reach the EUD.
•Preferred methods include Team Blacksheep's (TBS) Crossfire and the open-source ExpressLRS protocols.

Crossfire Protocol:
•With full MAVLink, a Crossfire TX is capable of bi-directional MAVLink messages as a telemetry rado.
•With emulated MAVLink, Crossfire tx offer one-way receive-only MAVLink packets but maintain interoperability with alternative FW like Betaflight.
•The Crossfire TX's Wifi AP allows connection between the TX and the EUD.

ExpressLRS Protocol:
•Requires flashing TX and RX with mavlink-rc branch of ELRS.
•Connects GCS to TX via USB or ELRS Backpack for telemetry.

Crossfire Settings

Telemetry Options:

•Team Blacksheep (TBS) TX offers BLE and WiFi AP telemetry output.

•This guide focuses on using the WiFi AP for the fastest and most reliable connection.

Updating TX Firmware:

•Ensure your TX firmware is up to date.

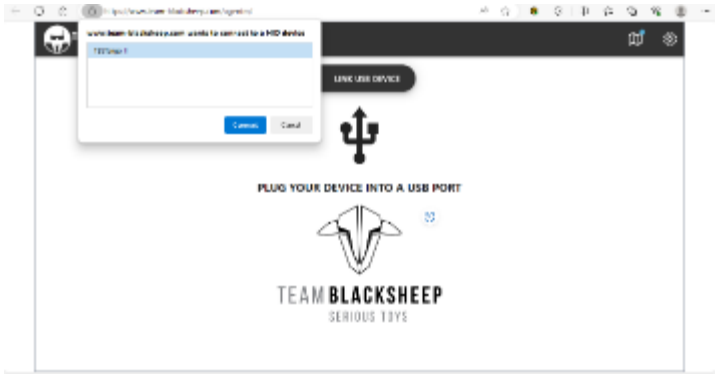
•Author used Tango WiFi v1.08 and updated it upon arrival.

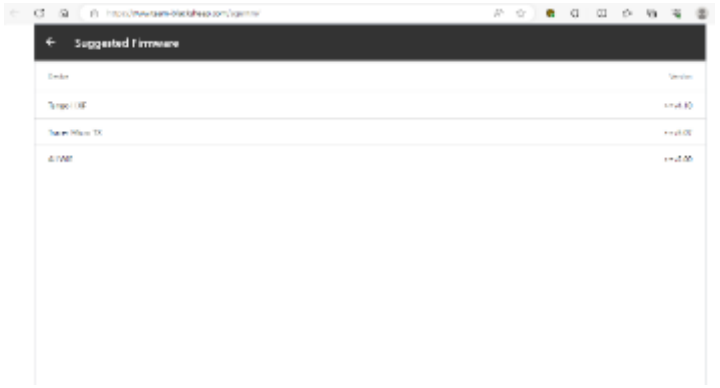
•End user can update fw via Agent Web or Agent Desktop. Once updated, the TX is configured via a LUA script within the FreedomTX, EdgeTX, or OpenTX firmware.

•The TBS WiFi AP by default will be named something like “TBS_XF_AP_xxxxxx” with a UI accessible on the default IP of 192.168.4.1

•Specifically, the user is looking for the TBS Agent Lite LUA script within the Tools menu of their RC. After an upgrade, the user will see a Tango WiFi option which has several useful submenus.

- •General: This is where the WiFi AP is enabled and the user can manually join an existing AP from the RC interface (eg: tactical radio WiFi dongle)
- •MAVLink: This is where the MAVLink server settings are controlled including the MAVLink format (UDP or TCP) and the Port. Author recommends using UDP packets with the default 14550 port.
- •WebUI: This is where the user can control the TX’s UI settings including password
- •Pro: This is where the user can change the power settings of the WiFi AP.
- •About: This menu has information on the WiFi AP FW and AP IP address if it has joined another network.





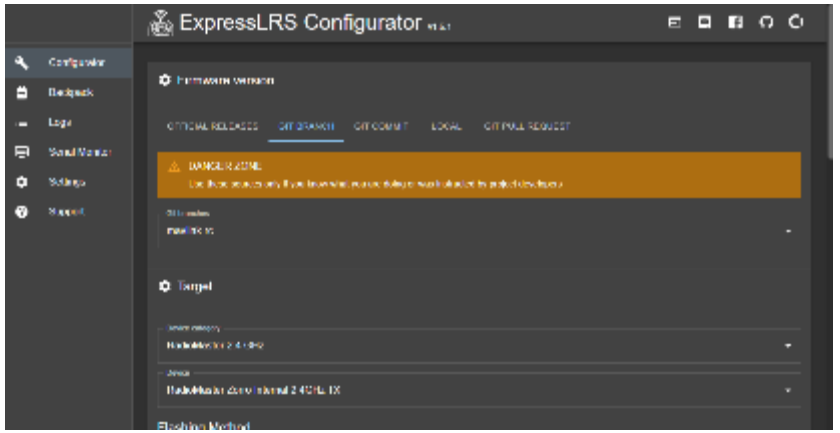
ELRS Settings

Hardware Compatibility Check:

- Verify if your TX supports a WiFi AP for telemetry using the ELRS hardware list.
- If not, use a USB cable between your TX and End User Device (EUD).
- Hardware List Reference

Downloading ELRS Configurator:

- Get the ELRS configurator for flashing TX firmware on your configuration computer.
- ELRS Configurator Download

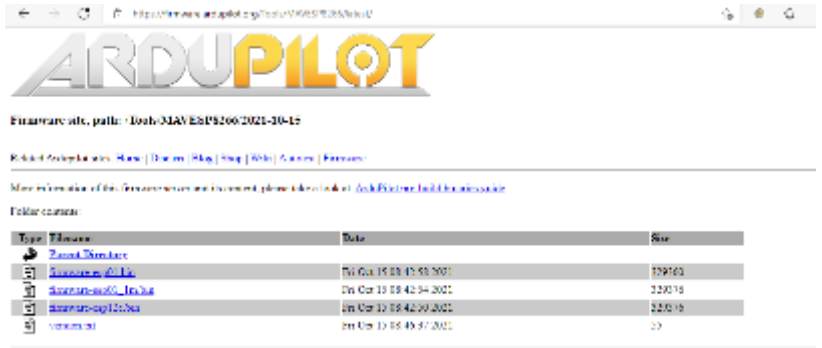


Firmware:

- Launch the ELRS Configurator and navigate to the Git Branch tab.
- Choose the "mavlink-rc" branch from the drop-down menu.
- Select the appropriate target and flash both RX and TX with the same firmware.

For Backpack-Enabled Hardware:

- Flash the backpack with MAVESP8266 FW (firmware-esp01_1m.bin) to create a WiFi AP named "Ardupilot."
- This configures the backpack to send MAVLink telemetry to your GCS (TAK UAS Tool) via UDP or TCP.
- Firmware Download



ELRS Settings

Enabling the Backpack:

•Access the ELRS Lua on your TX.

•Scroll down to the Backpack submenu and ensure it's turned on.

Flashing MAVESP8266:

•Join the AP that appears on your configuration computer and upload your firmware-esp01_1m.bin firmware. Just like other ELRS hardware, the Backpack has a captive portal with its UI, which resembles the ELRS RX/TX UI.

Accessing MAVLink WiFi Bridge:

•After reboot, the ELRS backpack now functions as an AP with SSID “ArduPilot" and password "ardupilot.“ The AP appears whether an aircraft is connected to the RC or not.

•Join the AP and enter the GUI at 192.168.4.1.

Updating Baudrate:

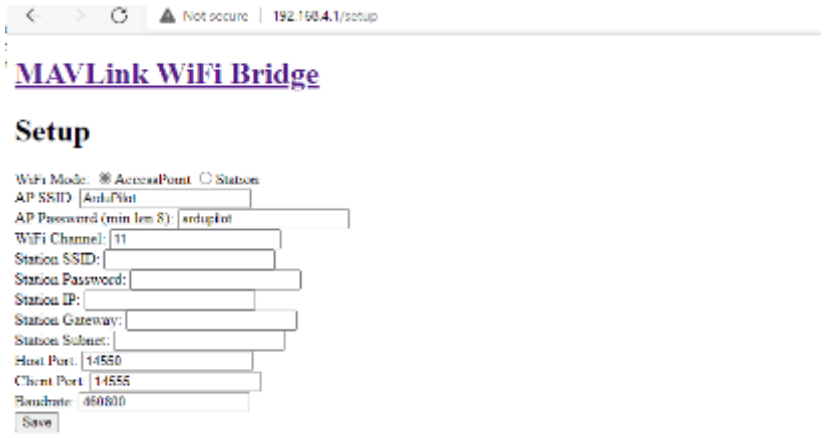
•From the GUI, select "Setup" and navigate to Baudrate.

•Update the BAUD rate to 460800 and save.

•Note: TAK UAS Tool defaults to 115200 BAUD, but users can manually override.

•Testing shows negligible difference in parameter loading times between both BAUD rates.

•Be aware that parameter download time exceeds the UAS Tool's 40-second timeout in v12.9.



Joining Existing AP:

•To connect to an existing AP (e.g., home WiFi or Tactical Radio WiFi dongle), change the Bridge from an Access Point to a Station.

•Fill in Station information within the Setup tab.

•On boot, the ELRS Backpack will join the specified AP.

UVC Video

What is UVC Video?

- UVC (USB Video Class) is a standard for video capture and streaming via USB.
- Allows devices like webcams and camcorders to communicate with computers without specific drivers.

UVC Video in TAK UAS Tool (v12.9):

- TAK UAS Tool now supports UVC Video as a video input.
- Enables near real-time video integration into the TAK environment as well as video sharing via Observer Broadcast.
- Benefits include video for teammates, Object Recognition overlay, Augmented Reality overlay, and enhanced situational awareness.
- UAS Tool sends out your Sensor Point of Interest (SPI) across the network if four corners of telemetry are available (ie: user has set Camera Pitch Override to a positive value under Camera Preferences and the aircraft is flying in a generally nose-down angle).

This guide will cover:

- Analog 5.8G.
- Caddx Walksnail.
- HDZero.
- DJI Goggles V2.

UVC Video Analog

Using Standalone VRX (e.g., Skydroid):
•Analog VTX offers signal accessibility with the right VRX.
•Fastest method: Utilize a standalone VRX (e.g., Skydroid) supporting UVC video output.

Simple USB Connection:
•Connect VRX to Android End User Device (EUD) using a USB cable.
•Android recognizes Skydroid connection, prompting app selection for USB video. Select ATAK to avoid launching the wrong GCS.

The Only APK You Need:
•UAS Tool is the sole APK required to view Skydroid video in the TAK environment; the standalone Skydroid app is not necessary.
•Unlike the standalone app, no changes to EUD connections needed for video viewing.

Alternative Method with FPV Gear:
•Consider using AV out from FPV goggles or a standalone VRX with an analog to HDMI adapter.
•Note: Adapters may introduce latency and require separate power.

Make sure to give permission to the correct app

Note Double OSD from both VTX and UAS Tool

UVC Video Walksnail / HDZero

HDMI Out:

•Caddx Walksnail Avatar and Fat Shark Dominator HD goggles support HDMI out via a USB C port on the goggles.

•Caddx Avatar HD Goggles X, Caddx Walksnail Avatar VRX, HDZero Goggles, and HDZero VRX Modules all support HDMI out.

Cabling the EUD:

•In order to view the HDMI out video on the EUD, users need to connect the HDMI cable from their goggles or VRX to an HDMI USB Capture device. These capture cards work using the same UVC video input within the UAS Tool interface.

Digital Video Considerations:

•HDZero video allows users to use the same one to many approach as analog video. The VRX is just that, a receiver and will not transmit to the VTX.

•Caddx Walksnail, like the DJI FPV system, has a two-way data stream with the video transmitter. This means that the pilot and his VRX/goggles are the source of video within the system. Depending on your task organization, a team member can use the HDMI out of his goggles to cable an EUD and stand near him, or the pilot can run his own EUD and simply broadcast the video to the network.

•While it's still too early to reliably use, the Caddx Avatar HD Goggles X have a wifi access point and an RTSP server for video. This potentially allows for an alternate to UVC video in the near future as this capability is further developed by Caddx.

Make sure to give permission to the correct app

Note Double OSD from both VTX and UAS Tool

UVC Video DJI Goggles V2

Fake It Until You Make It:

•Video out has been a contention issue for the DJI FPV system since its inception. At this time, a few open source projects exist which spoof bits from the DJI SDK/APK that allow DJI Goggles V2 to stream video out via USB.

•When one of these systems is in use, the DVR function of the goggles will not work and the video will not include any OSD elements from the FC.

Hardware Requirements:

•The best solution the author has used for injecting DJI FPV video into the TAK environment is using Digiview's raspberry pi images, found here.

•Supported Pi's include 4, 3, Zero, and 2B.

•These images are headless and the service launches on boot. Once running, video comes out via the Pi's HDMI out port and can then be added to the EUD via UVC in or a network encoder.

Make sure to give permission to the correct app

Note the absence of VTX OSD from DJI Goggle V2 video out. Also, mix of telemetry from the Betaflight aircraft (eg: disarmed but in the air)

Connecting the Aircraft

Platform Configuration:

•From the UAS Tool ui, select the plus sign to access the platform menu.

•Ensure MAVLink is set as your default platform. Verify that other settings match your configuration, especially Network Protocol and Local Port (consistent with TX setup).

Recognizing the Platform:

•Once a platform is recognized, Android notifications will appear about new Cursor on Target (CoT) players including an aircraft, a home location, and possible a SPI.

•A named UAS will appear in the Network UAS tab as UAS Tool begins downloading parameters.

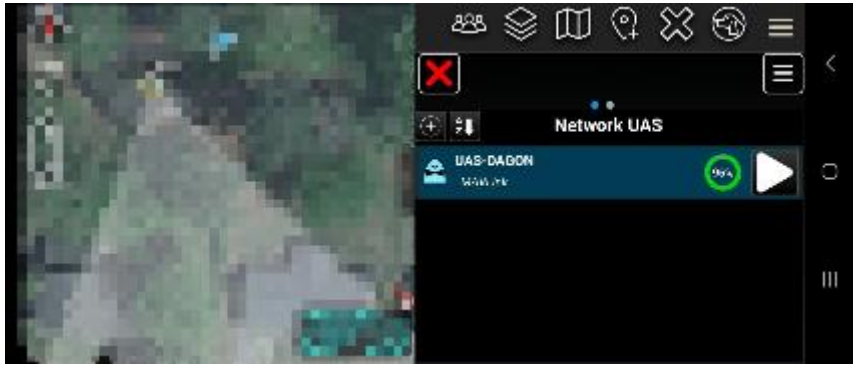
Understanding Notifications:

•Messages like "No GPS" may appear over the aircraft, and the battery meter may remain at 0% for an extended time. These errors are common with Betaflight aircraft.

•For Betaflight, expect the parameter download to time out and continue setup by hitting the play button as soon as its available.

•Expect incomplete params/telemetry during flight, as Betaflight reports limited fields.

•ELRS users may experience timeouts during parameter downloads, which may take up to 2 minutes on a laptop with a traditional Mission Planner GCS. This doesn't impact flying, and future builds may extend the timeout for full downloads.



UAS Tool Overlays

Full Overlay Compatibility:
•Every overlay available for traditional UAS in UAS Tool is also compatible with your FPV drone including Object Detection and Augmented Reality.

Object Detection:
•Object Detection utilizes streaming video from the drone and processes video on your End User Device (EUD) using preloaded tflite models.
•Users can import their own models in UAS Tool if needed.
•Customizable features of this overlay include the detection interval, mapshops, and automatic broadcast of detection objects to your network.

Augmented Reality:
•Augmented Reality allows live visualization of CoT players within the camera field of view including other TAK users and Sensor Point of Interest (SPI) from UAS or ISR on the network.
•Users need to manually set the camera pitch of their FPV from the Camera Preferences submenu of UAS Tool.

UAS Tool Route Planning

Familiar Interface:

•UAS Tool Route Planning remains familiar and user-friendly.

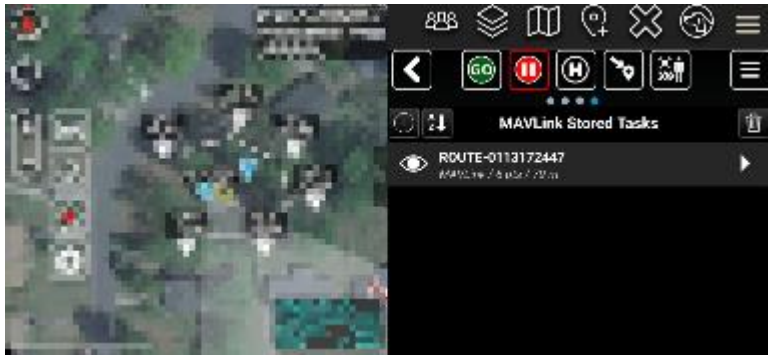
•If you have experience with drones like Mavic 2 Pro or R80D, you'll find the interface similar.

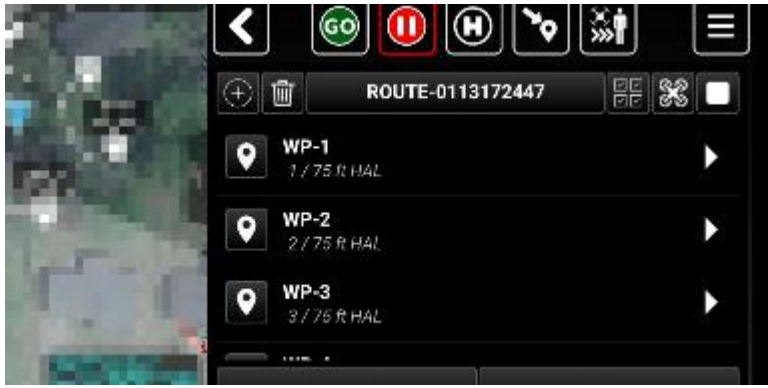
Key Considerations:

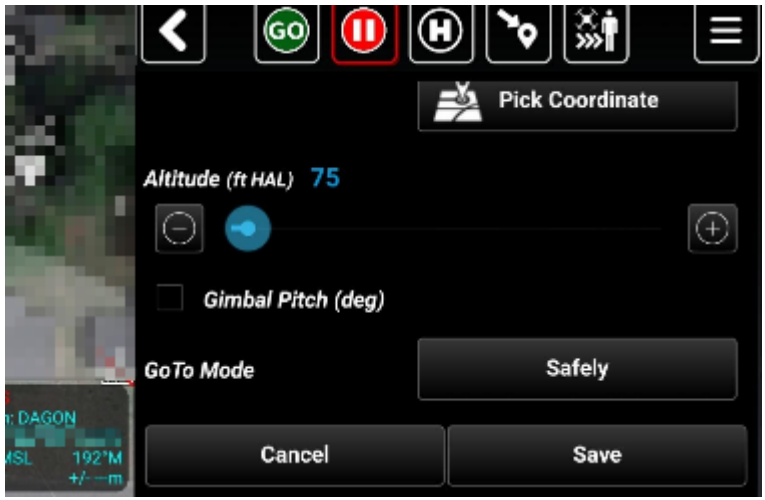
•When using Route Planning with FPV drones, consider your firmware and TX.

•The best-supported FPV drone configuration is a full arducopter with TBS Crossfire as a telemetry radio. This means setting the serial parameter as telemetry and not rcin. Make sure to also change other relevant params including setting the radio rssi to telem and not rc.

•With the above configuration, a pilot can take advantage of bidirectional MAVLink communication, including waypoints, fly-to points, orbits, etc.







Sample Configuration: Crossfire x Analog

- **EUD**: Samsung S23
  - Startech USB-C Hub
  - Wifi to TBS Wifi AP for Telemetry
  - USB A to Skydroid VRX for UVC Video
- **TX**: TBS Crossfire Tango 2
- **RX**: TBS Crossfire Diversity Nano
- **VTX**: TBS Unify Pro32
- **VRX**: Skydroid

Sample Configuration: ELRS x Walksnail

- **EUD**: Samsung S9+
  - Wifi to MAVLink WiFi Bridge on ELRS Backpack
  - USB C to HDMI Capture from UCB C to HDMI Out on Fat Shark Dominator HD Goggles (Walksnail) for UVC Video
- **TX**: Radiomaster Zorro with mavlink-rc branch fw
- **RX**: Happymodel EP2 with mavlink-rc branch fw
- **VTX**: Walksnail Avatar HD
- **VRX**: Fat Shark Dominator HD

Sample Configuration: Crossfire x Walksnail

- **EUD**: Samsung 23
  - Wifi to TBS Wifi AP for Telemetry
  - USB A to HDMI Capture from HDMI Out on Walksnail Avatar VRX for UVC Video
- **TX**: TBS Crossfire Tango 2
- **RX**: TBS Crossfire Nano Pro
- **VTX**: Walksnail Avatar HD
- **VRX**: Walksnail Avatar VRX

Sample Configuration: Crossfire x DJI

- **EUD**: Samsung 23
  - Wifi to TBS Wifi AP for Telemetry
  - USB C to HDMI Capture from HDMI Out on Raspberry Pi 3 (DigiView) for UVC Video
- **TX**: TBS Crossfire Tango 2
- **RX**: TBS Crossfire Nano
- **VTX**: DJI Air Unit
- **VRX**: DJI Goggles V2