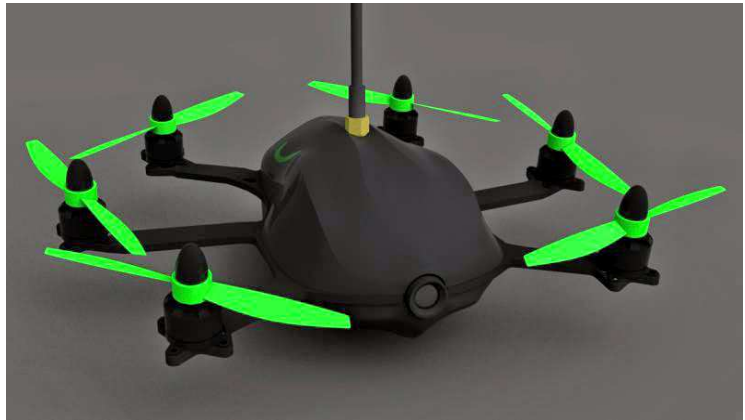

TBS GEMINI Mini FPV Hex

*Miniature hexacopter for fast
FPV flight and multirotor racing*

Revision 2015-02-16

The TBS GEMINI is the latest generation of mini racer multirotors. Its revolutionary design with forward tilting motors and aerodynamic canopy as well as fully



integrated yet modular electronics turn it into a beast that will dominate any race event.

Optimize your setup for HD filming with a Mobius or as the ultimate racer. Both setups are capable of operating on 3S and 4S setups, depending on your skill level and speed requirements. It is versatile enough to become your take-anywhere, fly-anytime multi rotor and at the same time rip through trees and leave the competition in the dust at races.

The frame is based on a design by award-winning pilot and one of the leading innovators in multi rotor design, William Thielicke (aka Shrediquette). TBS added its own secret-sauce with a fully-modular, crash friendly ESC and flight control installation. We get the best of both worlds: a tightly integrated component layout that optimizes weight efficiency, but also repair-friendliness in case of crashes. And let's face it, these things are made for crashing.

Assembly takes a few minutes as you add props, choose between the race and film setup and secure the canopy. A full slew of spare parts are available to repair the hex after a crash.

Key features

- Aerodynamic canopy for stability in forward-flight
- Forward-tilting motors for efficient, high speed flight
- Built-in FPV camera
- Optional Mobius HD camera (film canopy)
- CORE OSD/power supply with integrated current sensor
- Ready for long range FPV
- Stacked modular TBS 4A ESCs
- High-quality T-motors with vibration dampening
- 4-inch propellers
- TauLabs Quanton-based flight control
- Crash-friendly, yet integrated layout



Before we begin

Thank you for buying a TBS product! The TBS GEMINI is a new racing multirotor aircraft from Team BlackSheep (TBS). It features the best design practices available on the market to date, providing a great flying experience and incredible FPV characteristics.

Please read this manual carefully before assembling and flying your new TBS GEMINI hexacopter. Keep this manual for future reference regarding tuning and maintenance.

Disclaimer

Our request to you; the aircraft may not be used to infringe on people's right to privacy. We have designed a toy with mind blowing capabilities. It is your responsibility to use it reasonably and according to your experience level. Use common sense. Fly safe. You are on your own. TBS has no liability for use of this aircraft.

- Locate an appropriate flying location
- Obtain the assistance of an experienced pilot
- Practice safe and responsible operation
- Always be aware of the rotating blades
- Prevent moisture
- Keep away from heat or excessive amounts of sunlight



Specifications

Type:	FPV racer hexacopter
Power:	3S 1700mAh or 4S 1050mAh Lithium-ion Polymer battery, JST-connector
Motors:	6x 1806 class, 2100kV, 96W, 22x22 mm mount, M4 shaft, 10° forward tilt
Propellers:	6x 4x4.5-inch, 2-blade propellers (3xCW, 3xCCW)
Speed controllers:	TBS 4A Bulletproof ESCs, stacked modular configuration
Flight controller:	TBS COLIBRI flight controller, powered by TauLab codebase
RC receiver:	5-channel minimum, PPM, S-BUS, D-BUS or PWM
FPV camera:	32x32mm board camera, 2.8 mm lens, TBS CHIPCHIP V2
FPV transmitter:	TBS 2.4 Ghz or 5.8 GHz A/V transmitter, TBS UNIFY 5G8 200mW
HD camera:	Mobius HD ActionCam (available separately), vibration dampened
Canopy:	Racing (aerodynamic, light) or Film (protects camera, extra battery space)
Flight time:	Approx. 10 minutes
Speed:	Max. speed 80 km/h
Distance:	up to 2km range (and return)
Working temperature:	0 - 40°C
Size:	315 mm / 8.5-inch, diagonally
Battery spec:	25C+, max. 48(W) x 70(L) x 19(H) mm, 110 grams
All-up-weight:	340 to 370 grams, fully loaded
Kit contents: (base kit)	<ul style="list-style-type: none"> 1x Assembled TBS GEMINI main frame 6x TBS BULLETPROOF 4A ESCs 1x TBS COLIBRI Flight controller 1x TBS CORE PNP25, pre-configured 1x TBS CHIPCHIP V2 camera 1x TBS UNIFY 5G8 200mW video transmitter 1x TBS 3S 1700 mAh LiPo battery 1x Racing camera mount 1x Racing VTX mount 1x VTX extension antenna holder 1x Racing canopy set 1x Film canopy set 1x Bag of light-weight nylon motor screws 6x TBS T-motor 2100kV Brushless motors 8x 4x4.5-inch propellers with adapter rings (4 pairs)



The TBS GEMINI

On the GEMINI hexacopter, the motors are tilted 10° forward in order to decrease the angle of attack of the body in forward flight. The whole arm is deformed in order to achieve the desired forward tilt. This decreases the net aerodynamic drag in fast translational flight. In a hover the body will lean backwards but it will level out as it moves into forward flight. Additionally, the canopies help to reduce the drag coefficient of the copter. The effects has been measured in a wind tunnel using a two-axes force balance, and the results show that the drag is reduced by something around 30%.

The handling of the copter is not affected as long as the IMU is aligned parallel to the propellers (you can also rotate the IMU by software via calibration).

The flight controller is based on the TauLabs Quanton platform and TBS contributes back to the project. The controller has two modes. In "stabilize" mode (angle control) is auto levels and stabilized itself in flight, while in "heading hold" (angular velocity control) it will stay in a particular angle until the pilot makes corrections, very much like "manual" mode. There are a lot of other interesting features.










The TBS GEMINI has a two part canopy with a larger volume. This allows for using large batteries, a broader range of video transmitters and larger receivers (hence people can install the gear they want). We selected to include some very nice and light custom T-motors, these are made to precision with high quality bearings. The ESCs were also developed specially for the GEMINI. They are located centrally on the frame in a stacked rib formation for cooling and easy access. There are no LEDs on the canopy as of writing, but LEDs can easily be added to facilitate LOS flight.

Maybe one of the most important factors is the 3S to 4S capability. The ESCs are able to handle both with ease to cater for long fight time or high speed. When using the custom TBS ESCs on 4S, expect an exceptionally fast forward flight and a rocket in ascend.



IN PACKAGE

The following is included in the base TBS GEMINI kit. Replacement parts are available online, if needed.

 <p>1x Assembled GEMINI frame</p>	 <p>1x Set of film canopy - top/bott.</p>	 <p>1x Set of racing canopy - top/bott.</p>
 <p>8x 4x4.5-in propellers (CW, CCW)</p>	 <p>2x Canopy metal strips</p>	 <p>1x Set of racing carriage kit</p>
 <p>1x VTX cable extension holder</p>	 <p>1x PPM header cable for RX pwr and PPM/S-BUS/D-BUS</p>	 <p>1x Bag of light-weight M2 nylon screws for motor mounts</p>
 <p>1x TBS LiPo pack - 3S or 4S</p>	 <p>1x SpiroNet Grey RHCP RP-SMA antenna</p>	 <p>1x Cement glue ("goeey") to lock parts and electronics for racing</p>
 <p>1x Carrying case (preorder)</p>	 <p>1x Sheet of GEMINI stickers</p>	<p>-</p>



Quick Start Guide - BNF set

The following steps will get you setup and ready to fly quickly. It is a condensed version intended for experienced pilots. Each step is elaborated in more detail in this manual if you are new to this.

You will need to install a R/C receiver, configure the COLIBRI flight control, potentially adjust VTX frequency, insert the battery and install the propellers.

This section requires the following equipment.

- Desktop or laptop computer for configuration (OS X/Win/Linux)
- 5-ch R/C Radio transmitter and receiver with PPM/S-BUS/D-BUS
- 5G8 FPV receiver system or FPV goggles
- Optional, Mobius HD camera (when using the film canopy)

Let's go!

1. Connect the supplied PPM cable to the R/C receiver and the other end to the header on the I/O board marked "PPM/CH1/UART2RX" - configure the receiver to output PPM/S-BUS/D-BUS
2. Depending on the R/C receiver, install it under the I/O board or over the CORE PNP25 - apply the supplied glue to the bottom of the I/O pin header on the I/O board, install board on frame
3. Install the latest [TauLabs GCS configuration software](#) and connect a micro-USB cable to the COLIBRI flight controller
4. (for S-BUS receivers only!) Open TauLabs GCS, open "Configuration", go to the "Hardware" view, change "RcvrPort" to "Disabled" and "UART2" to "S.BUS" - unplug all power to reboot
5. Turn on the radio, create a new model preset, attach the video transmitter antenna, connect a LiPo battery to the frame, bind the receiver, open the "Input" view (in Taulabs GCS, under the "Configurations" tab) and run through the "Configuration Wizard" to map the controls and switches, go to "Arming Settings" and change it to "Yaw Right", flip the flight mode switch to "Pos. 1 Leveling"
6. Now, cut the metal strips to 10 mm pieces and bend two of the ends to form a half-triangle, key the location of the magnets on the side of the canopy and glue in place using superglue (see p15 for details)
7. Cut away a small window on the video transmitter for the configuration switches and set it to [one of the supported frequencies](#) for your video goggles
8. Mount the Mobius HD camera on the bottom of the frame using the velcro pad and rubber bands or black tape, [configure picture orientation](#) to be upside-down
9. Insert the LiPo battery using the preinstalled elastic band, with the connectors facing forward
10. Prepare the propellers with the correct M4 adapter rings and install them with the text facing up, rotating in the direction shown on the frame arms
11. Put on the canopy and antenna, connect the LiPo battery, start the Mobius recording and go fly!



R/C receiver

Install R/C receiver

A small or micro R/C receiver will fit underneath the I/O board, with the antennae feeding down the rear arms. If the receiver is too big, mount it in the front section on top of the CORE PNP25 unit or under the frame. Try to get as much separation between the R/C receiver- and VTX antenna as possible.

A short list of TBS recommended PPM/S-BUS/D-BUS receivers:

- **FrSky D4R-II:** Enable CPPM by shorting/jumping signal pin ch3 and ch4, now ch1 will output PPM, ch2 will also output RSSI



- **EzUHF 4ch Lite:** Use the ImmersionRC Tools to make ch1 output PPM, the unit barely fits under the I/O board and might require extending the SMA connector 10-15 mm



- **DJI Phantom 2, DJI DR16 Rx:** To use a DJI receiver, simply connect the supplied cable on the D-BUS header and configure TauLabs GCS to use S-BUS - *Note that Phantom Vision/FC40 uses 5G8 control and are thus not compatible with 5G8 video systems. All other DJI systems are on 2G4*

For all other receivers, inspect the manufacturers instructions to identify the supported protocols, dimensions and layout of output header(s). Traditional PWM channels for all controls is possible but requires some planning, see section later in the manual.

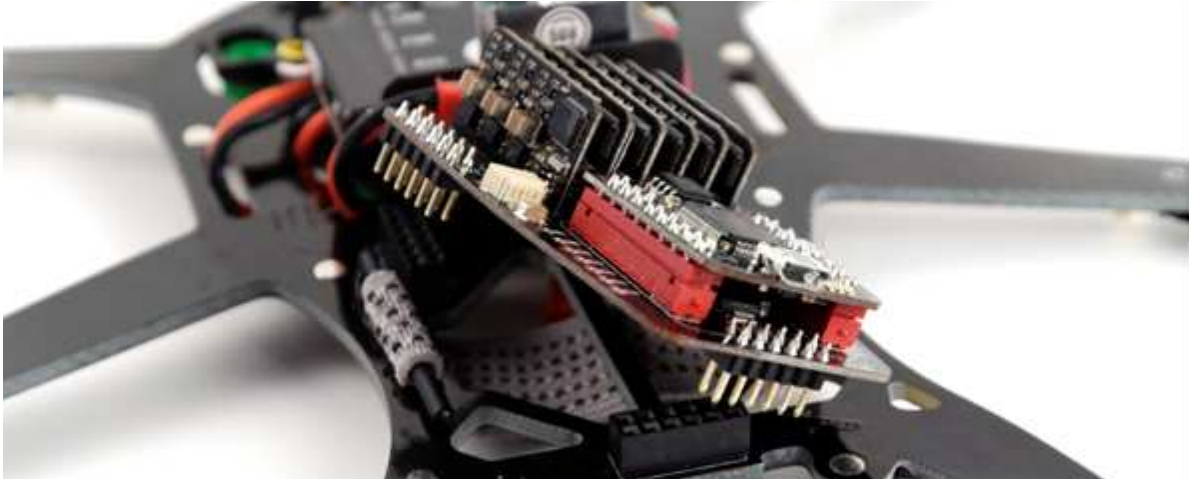
Power is provided by a 5V regulator on the frame. Use the supplied PPM cable to connect power to the R/C receiver. If you consider using a Spektrum satellite receiver, see the installation section later in the manual.



Receiver under I/O board

Be careful to cover up any exposed metal if there is a chance of short-circuiting anything on the I/O board.

1. Disconnect the red JST battery connector to the I/O board
2. Gently wiggle the front and back of the board to remove it from the sockets, be sure not to bend the pins

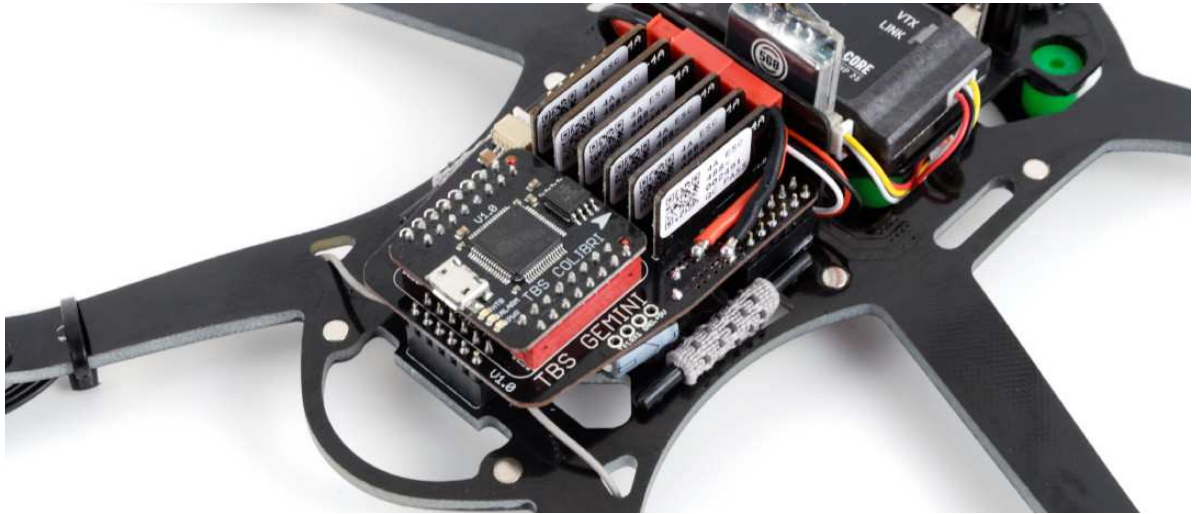


3. Place the receiver between the three header sockets on the GEMINI board with antennae facing the rear



4. Apply a small amount of the supplied glue on the bottom of the pin header base on the I/O board, reposition the board over the sockets and press firmly to ensure all the sides are properly installed. It is important that all the headers fit tightly into the sockets - no bulging/pushing. The glue keeps them in place during flight. Check that the pins has not been misaligned. Connect the other end of the PPM cable to the I/O board.



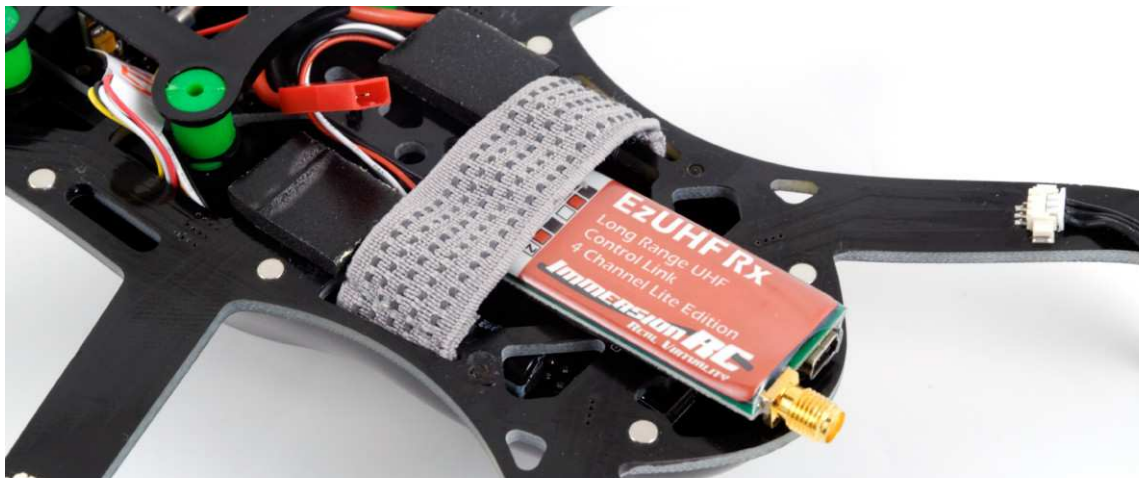


5. Strip the antenna to the arms, cut a slot in the top canopy to avoid the cable from being sheared off

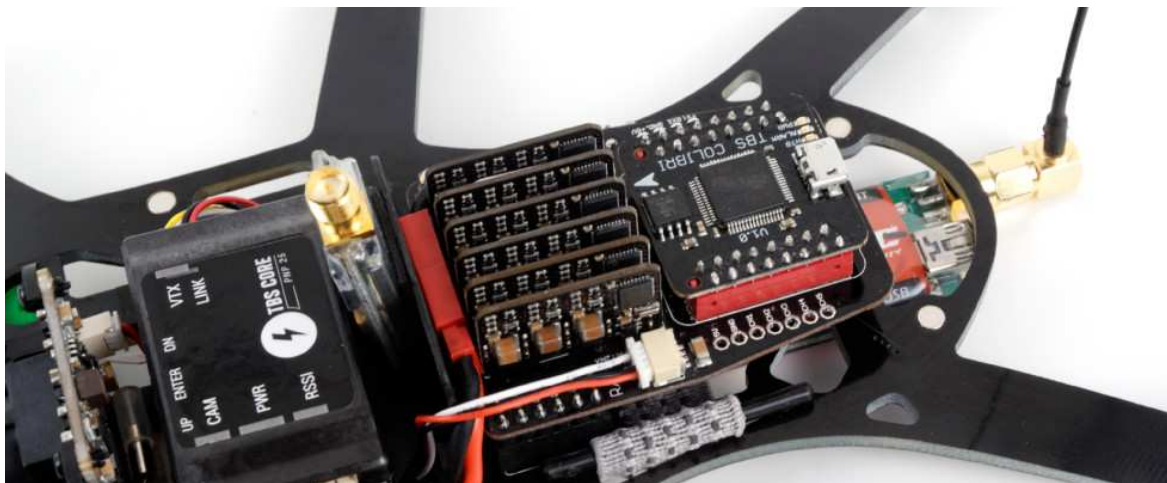
Receiver under the frame

If the receiver is long and has a slim profile (<8 mm), it will fit between the battery and the the frame.

1. Connect the PPM cable to the receiver and it it through to the top side
2. Add a piece of adhesive foam tape to the receiver and position it on the rear end of the frame



3. Align the antenna connector to the edge of the frame and connect the PPM cable to the I/O board



4. Add two foam pads and a foam sheet between the battery for protection and cushioning



5. Cut a notch in the bottom canopy for the antenna connector and antenna

An alternative way to install the EzUHF Lite, is to install it under the I/O board and modify the VTX plastic support to let the PPM cable through. This lets the receiver sit tightly and with a SMA extension adapter will put the antenna connector out on left-rear side.

Bind radio and receiver

Create a new model for the GEMINI if your radio supports presets. Pair your R/C radio and receiver as instructed for your particular setup (FrSky, Futaba, Spektrum, DJI, EzUHF).

The following is a quick binding summary of the most popular radio system.

- **FrSky Taranis:** On radio, open Model Setup, select D8 (D4R-II) or D16 (X4R-SB) and enter Bind mode - On the receiver hold the R/S button while applying power - rapid flashing indicates bind complete
- **Futaba:** Turn on the radio, when the RF signal LED is solid, press the "ID SET" button on the receiver for two seconds - the LED on the receiver should turn solid when done
- **Spektrum:** Insert the binding plug on the receiver, on the radio hold the bind button on the back while turning on the radio or use the bind menu - the receiver LED should stop flashing continuously
- **DJI:** Power the receiver, press the bind button, turn on the transmitter - the receiver LED should turn off when complete
- **EzUHF:** Toggle the transmitter power switch to Low, hold the bind button while turning on the transmitter, turn on the receiver and hold the bind button on the receiver for 5 seconds - the transmitter should stop beeping



Configure COLIBRI flight control

Install drivers and software

Download the TauLabs configuration software and driver for the TBS COLIBRI flight controller, from <https://github.com/TauLabs/TauLabs/releases/> (OS X/Win/Linux), links at the end of the latest post.

Open the TauLabs GCS software and connect a micro-USB cable to the COLIBRI board. GCS will detect the board and at the bottom of the view it should indicate that the controller is connected. Open "Configuration" and in the "Hardware" view it should recognized the GEMINI frame.

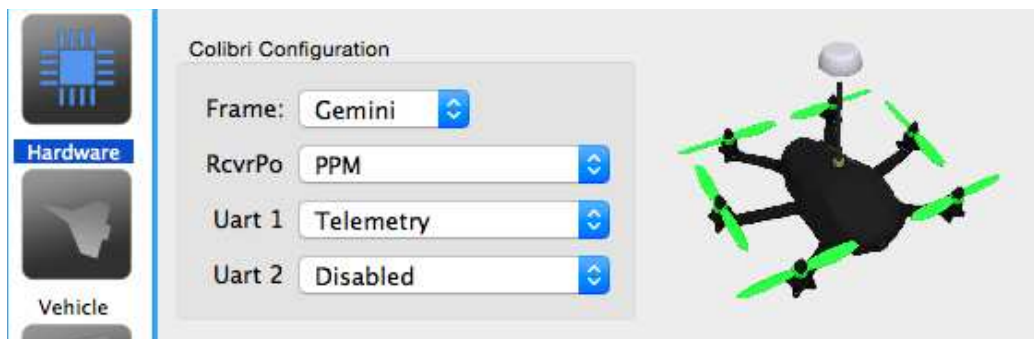
The TBS tuned settings will automatically be loaded from the board and shown. Resetting back to TBS settings is described later in the manual.

Setup inputs and outputs

Open the "Hardware" view, and depending on the R/C receiver used, configure for PPM or S-BUS/D-BUS/DSM. These are protocols to make sense of the received R/C signal.

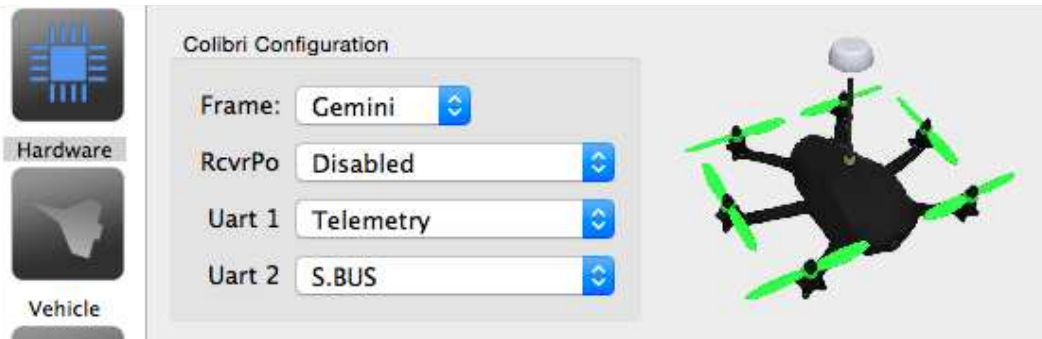
Note that the CH1 and UART2 ports are joined on the same signal lane, meaning that "RcvrPort" and "UART2" in GCS can NOT be both be enabled at the same time.

For **PPM** compatible receivers, under "RcvrPort" select "PPM", click "Save" and remove power to reboot the controller with the new settings.



For **S-BUS/D-BUS/DSM**, set "RcvrPort" to "Disabled" and under "UART2" select "S.BUS" for S-BUS/D-BUS (Futaba or DJI) or "DSM2" (DX7) / "DSMX (10 or 11bit)" (DX8, DX9) for Spektrum satellites - detailed later in the manual.

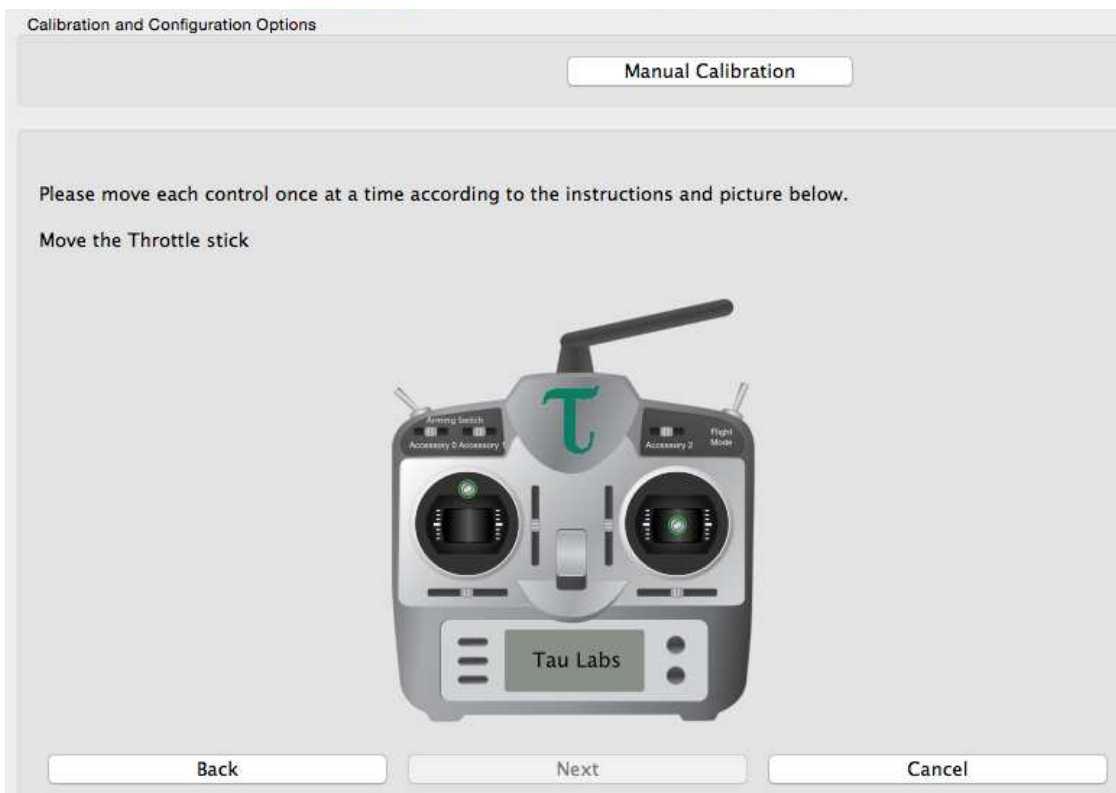




Next, with a new model set up on the radio and the receiver bound to the transmitter, attach the video transmitter antenna and connect a LiPo battery to the GEMINI to power the R/C receiver (USB will not provide power to the receiver).

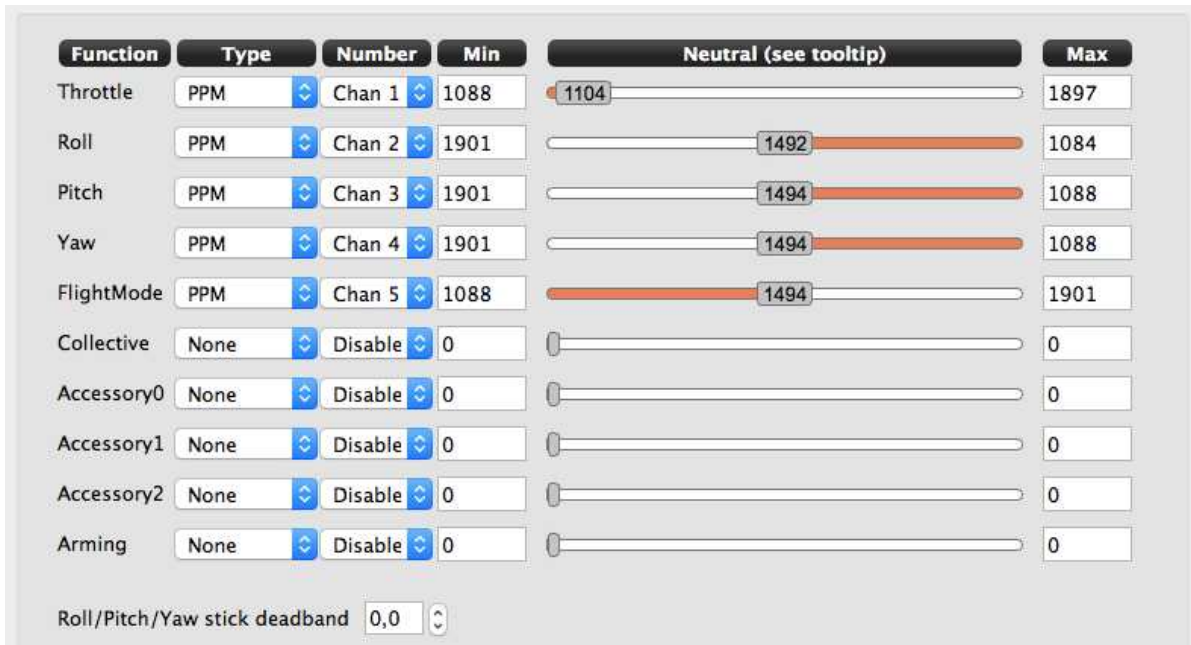
Open the "Input" view and click "Start Configuration Wizard" to initiate the stick-to-channel recognition process. Also complete the failsafe stage. You can skip the last auxiliary accessory switch steps.

If the controls are not recognized, check that the receiver outputs the right signal and trace the signal wire to ensure a proper connection.



The final mapping will be shown in the main view, you can fine adjust and tweak settings if needed. Your setup will differ from what is shown in the following image.

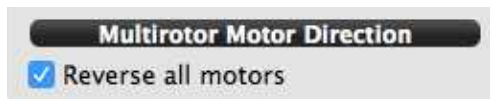




You should be able to see all the stick inputs “live” and the current position of the flight mode switch under the “Flight Mode Switch Settings” tab.

Because of the way the flight controller is implemented, the motors are run in reverse. This requires the mixer settings to have “reverse all motors” checked. The motors are reversed by default, so you do not need to change anything. If your Gemini spins when taking off, however, you can fix the problem as follows:

1. Open the “Vehicle” view, navigate to the bottom section of “Mixer settings”
2. Make sure “Reverse all motors” is ticked, click “Save”



Flight modes

For auto-leveling and an easy first flight, make sure the toggle switch on your radio is set to “Pos. 1 - Leveling”.

The default GEMINI flight modes are set up as follows.

- **Postition 1 “Leveling”** - Uses the gyrosopic sensor to self-level when you let go of the sticks. Move the pitch or roll stick and the aircraft will tilt and hold the angle as long as you keep the stick pushed. This mode is also known as “Attitude”.
- **Postition 2 “Stabilized2”** - Manual rate mode but with pitch and roll lock. This uses the gyro to help maintain zero rotation. Push the sticks to change the angle of the aircraft, e.g. you have to do all the work to fly true and level. Once you are confident in “Leveling”, switch to this mode.
- **Postition 3 “Stabilized3”** - Full manual rate mode with no help from the gyro, can be less locked in than “Stabilized2”.



See <https://github.com/TauLabs/TauLabs/wiki/Flightmode-Settings> for further details how the different flight modes behave.



Set failsafe

When the flight controller detects a failsafe (caused by equipment or range failure) it will turn off all the motors (sets throttle to zero). This is the safest behavior compared to potentially having settings that cause it to float off or even climb higher.

The failsafe setup is a two stage procedure.

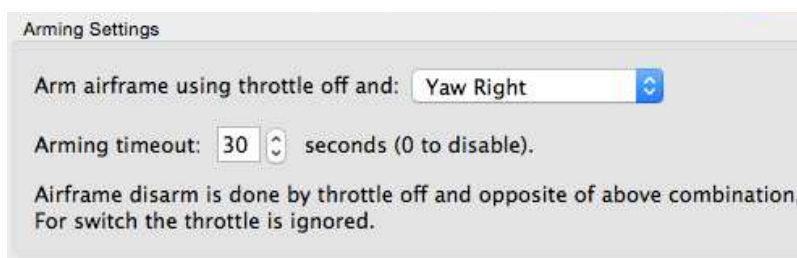
1. Set up failsafe on the R/C receiver (per manufacturer instructions), normally by pressing a F/S button to not output any pulses on the PPM/control cable, or more traditionally to preset the desired stick position in a failsafe situation (e.g. low throttle) - the former option is highly preferred
2. Run the TauLabs GCS wizard to let the flight controller know what constitutes a receiver operating in failsafe mode

Setting up arming

Caution: Always remove the propellers before setup or doing a reconfiguration!

The controller is by default set to disarm/disabled controls for safety after running the setup wizard.

1. Open "Input" and go the "Arming Settings" tab
2. Change "Always Disarmed" to "Yaw Right" (or your stick or switch preference)



To arm and fly, hold the throttle stick low and at the same time move the yaw stick to the right for two seconds. The motors will automatically engage and start to spin if a battery is connected - this is to ensure that the motors always keep spinning in flight even when the throttle stick is low (takes time to spin up the props).

Raising the throttle stick will increase the power to the motors. Increase the throttle further and it will start to hover. To disarm, lower the throttle to zero and move the stick to the left (opposite side of arming).



Upgrading flight controller firmware

Upgrading the software on the flight controller fixes faults and bugs which improves the overall experience using the controller - it is highly recommended upgrading to the latest official version.

Preparation

- Make a note of all your working settings and configuration options (i.e. screenshots, exports, etc.)
- Reset all your transmitter model settings, should be free of expo, trim, dual-rates, or other tweaks
- Unplug your VTx just to make sure
- Remove props - just in case

Installation GCS

- Uninstall your old TauLabs GCS to start from a clean slate
- Download the latest version from <https://github.com/TauLabs/TauLabs/releases/>

Upgrading the firmware

1. Start the new GCS, plug in your GEMINI to the USB port (no battery required)
2. Go into the FIRMWARE tab, click on HALT. Wait for it to shut down (about 15 seconds)
3. Select OPEN FILE, select the file fw_colibri-xx-xx.tfw from the file selection window. If you are not by default in the firmware folder, it is located at C:\Program Files (x86)\TauLabs\firmware (Windows)
4. Click FLASH and wait for the flash to finish
5. Click BOOT to start up the flight control software

Loading Gemini settings

1. Download the default GEMINI settings from our support page at <http://team-blacksheep.freshdesk.com/support/solutions/folders/4000007579> or search for "tbs gemini files software"
2. In GCS, click FILE -> IMPORT UAV Settings, select the file downloaded earlier
3. Click "Save to flash"
4. Proceed to CONFIGURATION tab, click "SAVE"
5. Unplug your GEMINI from USB, and unplug the battery in case you have connected it
6. Reconnect the USB cable
7. Click FILE -> IMPORT UAV Settings again. Once more, select the file you downloaded earlier.
8. Click "Save to flash"
9. Now plug in the battery, select your receiver type in CONFIGURATION view, under the HARDWARE tab
10. Unplug the USB and battery, wait 2-3 seconds to ensure a clean reboot, re-plug both cables
11. Proceed to the CONFIGURATION view, under the INPUT tab
12. Click START CONFIGURATION WIZARD
13. From here on out follow the standard setup procedure outlined in this manual. Enjoy and fly!



Install canopy brackets

The frame has six embedded magnets to lock the top and bottom canopy in place. The kit includes a two metal strips which needs to be cut to length and installed with superglue (not the supplied cement glue).

The final bracket should resemble a half-triangle. The inner tab prevents scratches and wires from catching.

1. Start with the bottom canopy and position it over the frame, make key markings with a pencil on the side of the canopy where there are magnets located
2. Use a cutting plier or scissor to cut length of 10 mm, total 24 pieces (for four canopy halves)



3. Make two bends, the first approx. 3 mm in from the end without adhesive and another approx. 6 mm from the other end. Use a small plier to hold the piece to get a sharp bend.



-
4. Add a drop of superglue to one bracket at a time. Align it with the key markings and adjust so it is flush to the trim of the canopy. If the bracket stands out, bend it some more to minimize canopy gaps.



5. Perform this for all the metal brackets and repeat for the top canopy and the second set.



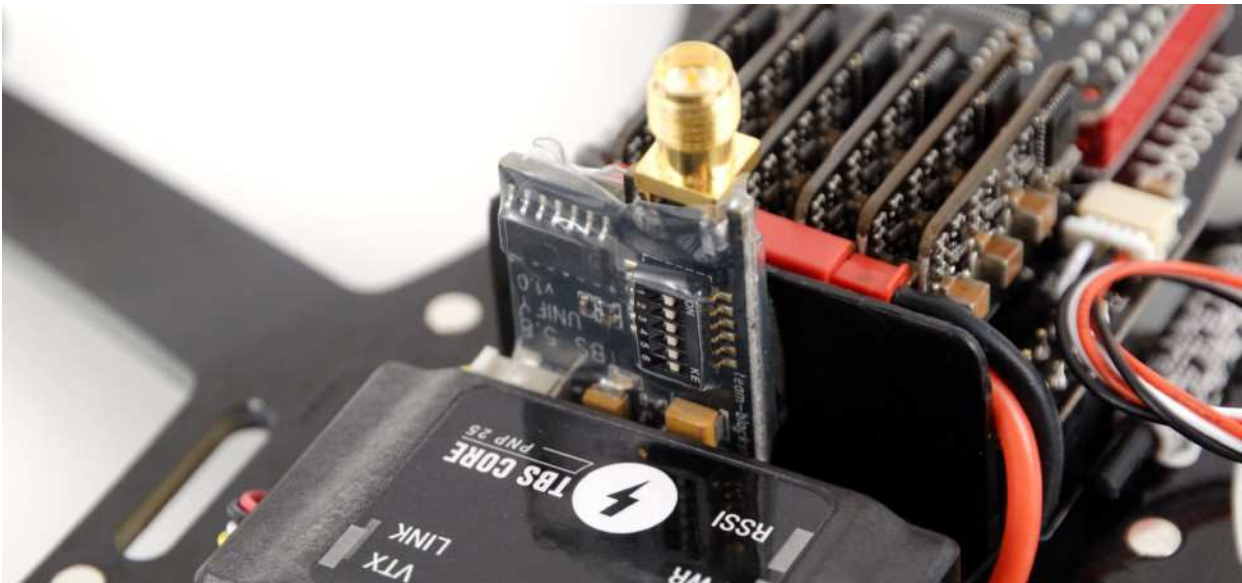
Set-up video transmitter

The included TBS UNIFY 5G8 200mW video transmitter and encased cloverleaf antenna provides great range (up to 1km line-of-sight) and supports 32-channels (compatibility with Fatshark, IRC, DJI and all other brands). The 5G8 frequency band means no interference when using a 2G4 R/C transmitter.

The kit comes with a VTX extension cable holder if you want to replace and use a larger VTX which does not fit the standard VTX spot.

See the official manual to find the frequency switch combination for your FPV receiver/goggles, www.team-blacksheep.com/tbs-unify5g8-manual.pdf. Make sure no-one else is using the same frequency in your proximity before turning on your transmitter.

1. Cut a small window in the heat-shrink around the DIP switch using a precision knife
2. Flip the right switches (up is toward "ON") and attach the antenna
3. Connect the LiPo battery to test the frequency and video feed (remember to remove the lens cap!)



Important: Keep the antenna mounted at all times while the VTX is powered on, otherwise the unit could heat up and burn out over time. Forgetting it for a few minutes is normally not a problem.

Note that the TBS UNIFY uses RP-SMA (reverse polarity) connectors, this means that the female connector body (outside threads) has a center pin not an inner receptacle. It makes no difference on the receiving end/goggles, just the connection is reversed. If you replace the antenna, the connector has to be of the same type.



Pilot camera

The TBS CHIPHIP V2 600 TVL PAL pilot camera comes with a 2.8 mm lens and pre-configured to capture a bright and crisp image. No configuration required.



If the image turns out to be out of focus, loosen the phillips set/grub screw on the top and turn the lens. The lens is also exchangeable to get a narrower or wider viewing angle, e.g. 3.6 mm (90°) or 2.1 mm (150°) focal length. The stock 2.8 mm lens provides a 115° view, which is a good all-around angle of view.

Mount battery

The frame comes with a durable elastic band on the bottom side. This keeps the LiPo battery tightly mounted. Insert the battery with the connectors facing forward.



To power the GEMINI, connect the battery lead with the corresponding connector from the CORE PNP25 which sticks out through the frame slots. The GEMINI carrying case can hold up to six to eight batteries plus one strapped to the frame.



Mount Mobius HD camera - film canopy

The stock setup comes prepared with a carriage for a Mobius HD camera (available separately), but it can be swapped out for a much lighter carriage to only hold the pilot camera. Coupling this with the streamlined racing canopy, makes for a serious rocket, especially on 4S! See section later in the manual for conversion specifics.

Configuration of the Mobius is necessary to get the picture orientation right. Download the manual and software from <https://www.mobius-actioncam.com/softwareuser-guide/>

1. Use either rubber bands, black tape or apply the supplied adhesive velcro pad over the center of the Mobius carriage



2. Position the Mobius camera a bit off center and straight with the body aligned to the frame edge



3. Use the bottom film canopy to help line up the camera lens all the way forward. Secure it with a few rounds of rubber bands or black tape.





4. When properly positioned, the footage should not show the propellers in view (neither normal or wide-angle B lens). If you do see the propellers, ensure that the camera is fully straight and move it towards the front by a bit.



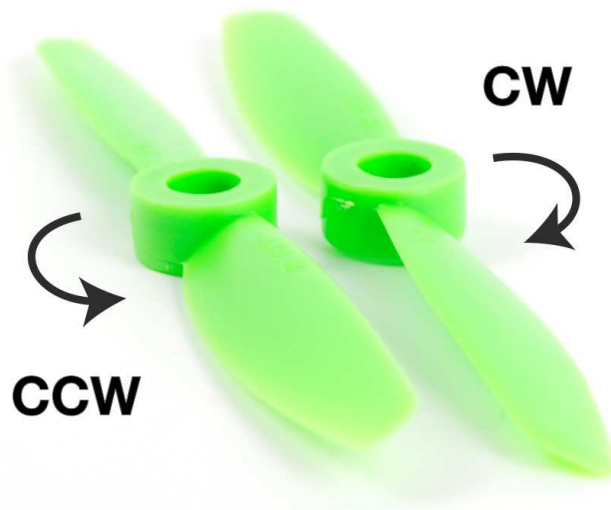
Note: Since the camera now is mounted upside-down to allow access to the control buttons, enable 180° picture rotation in the Mobius configuration to get easy-to-manage footage. Assigning one of the two modes with picture orientation enabled or keeping a separate SD card for the GEMINI makes it easy to swap the camera between platforms in the field (also disable the date code once you are at it).



Install propellers

There are two kinds of 4x4.5-inch propellers in the kit, clockwise rotation (3x CW) and counter-clockwise rotation (3x CCW). Mounting them in the proper manner is paramount for a safe first flight.

On the GEMINI arms, there are indicators showing the rotational direction for each motor and propeller. The propellers also need to be mounted with the side with the text and small prop hole facing up. Failing this will cause the aircraft to act erratic and flip over.



Begin by preparing the propellers and then install them onto the motor bell.

1. Snap off the correct M4 adapter ring from the provided set (see photo below)
2. Trim off excess plastic stubs and firmly press the ring *all* the way into the propeller receptacle



3. Use the indicators on the arms as guidance to install the propellers on the motors. Notice how the rounded tip faces into rotation and the small prop hole is facing up.





4. Secure the propellers using the provided M4 spinners - use an Allen wrench through the small hole on the cone to tighten them properly



Make sure the base of the propeller is evenly pressed against the motor bell for perfect tracking and minimum vibrations.

To further reduce weight, consider replacing the prop spinners with black flanged M4 nylon lock-nuts.



Finishing up

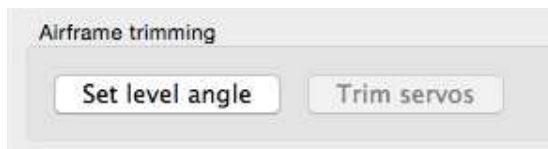
When everything setup and configured, perform this short procedure to get into a hover.

1. Turn on the radio and video goggles
2. Put on the top canopy and attach the antenna
3. Connect the LiPo battery
4. Start the Mobius recording
5. Put on the bottom canopy and check all propellers
6. Put the flight mode switch to position 1 and arm the aircraft to zero the gyros
7. Move the throttle stick to start hovering!

Hover drift fix / level angle trim

If the hex drifts in flight ("Leveling" or "Attitude" mode), perform the following procedure to set the pitch and roll offset trim angles to get a stationary hover.

1. Takeoff without the top canopy but with the VTX antenna (to get access to the flight controller later)
2. Counter the drift using the trims on your radio
3. Land and disarm the aircraft, do not power off either the GEMINI or your radio
4. Connect the flight controller to TauLabs GCS, open "Configuration", go to the "Vehicle" view and at the bottom click "Set level angle"



5. Now, reset/re-center your trims on your radio



TBS CORE



The TBS CORE PNP25 included in the kit is mounted behind the pilot camera and provides voltage regulation to the video transmitter and pilot camera, in addition to an On-Screen Display (OSD) overlay for crucial flight data (mAh current consumption, battery voltage, flight timer, receiver signal).

An optional TBS PNP PRO upgrade can provide additional details such as home direction, speed and location.

Menu configuration

The CORE PNP25 has a configuration menu which can be entered by holding down the ENTER button on the front side of the unit for 3 seconds - use the UP and DN buttons to toggle between the options. Use a plastic spudger to reach the buttons if needed.

The setup menu allows you to configure several aspects (recommended settings highlighted in **bold**):

- **RSSI** - Received signal strength - **off**, analog, digital or link (EzUHF), set min. and max. signal level
- **CURR. TYPE** - Current sensor - **25A** or 50A
- **CAM. TYPE** - Camera type - **FPV** or GoPro (avoids OSD overlapping)
- **BATT ADJUST** - Battery voltage adjust - tune the OSD battery voltage reading
- **OSD** - On-Screen Display - **on** or off for a completely immersive experience
- **EXIT** - Exit out of the menu

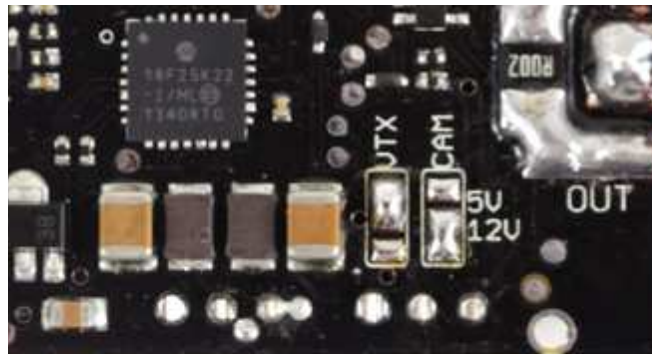


Custom VTX and Camera voltages

The CORE PNP comes pre-setup with 5V and 12V on the VTX and CAM ports, respectively, to support the included equipment. If you install different equipment requiring different voltages, you need to open the CORE PNP25 case and bridge the correct voltage. Failing to set the correct voltage can damage your equipment.

- **VTX:** 5V (**TBS UNIFY 2G4/5G8**, TBS ROOKIE, TBS BOSS, TBS GREENHORN, Lawmate 2G4)
- **CAM:** 12V (**TBS CHIPCHIP**, TBS 59)

Remove the four phillips screws on the bottom and remove the shells. In the center section you will see two solder bridges, one for CAM and the other for VTX. Labels for 5V and 12V show the right bridge to solder.



RSSI telemetry

RSSI (Received signal strength indication) is used to gauge the signal strength at the GEMINI-end of the R/C link, giving you an idea of the RF environment and usable range in percentages (0% no signal, 100% top signal). It is a good rule of thumb to return when the figure approaches 60% to ensure good operational conditions.

The CORE PNP25 (and CORE PRO) has a dedicated RSSI input port. Use a 3-pin Molex PicoBlade cable to connect your R/C receiver (available separately).



In the photo above, the cable connected on the right side on the CORE PNP25 is the RSSI signal from the R/C receiver. The pin-out is as follows.



Wire	Function
Black	GND
Red	+5V (leave unconnected)
White	RSSI signal



Next, enter the CORE configuration menu and select the correct RSSI protocol type for your receiver (ANALOG or DIGITAL). The configuration will also ask you to turn on and off the transmitter to record the min. (0%) and max. signal level (100%).

You can even connect an EzUHF receiver using a LINK cable (available separately) to get extended telemetry data. No configuration needed other than selecting LINK protocol on the RSSI menu.

Audio downlink

The CORE PNP25 comes configured with an on-board microphone and feeds this to the video transmitter (camera cable audio input is unconnected).

To adjust the gain, open the case and turn the trimpot next to the mic.



If you want to feed a different audio source or telemetry instead, change the AUDIO bridge from MIC to EXT. Connect an audio signal to the **white** lead on the CAM input.



Upgrade to CORE PRO

While the CORE PNP25 is plenty fine for the type of close range and proximity flight the GEMINI is designed for, the CORE PRO provides additional flight stats and helps you maintain a sense of direction.

Upgrading to the CORE PRO requires replacing the CORE PNP25 unit, installing the current sensor and optional GPS module.

1. Disconnect the JST connector to the I/O board and untangle the battery cables
2. Also disconnect the VTX and CAM cables and release the CORE PNP25 unit from the adhesive foam tape
3. Prepare the current sensor and GPS module by removing the plastic casing (to save space)
4. Replace the current sensor XT60 connectors with JST wire leads and apply piece of heat-shrink over the sensor board to protect it
5. Mount the main CORE PRO unit in the original CORE PNP25 spot and install the GPS on top of the COLIBRI flight controller
6. The current sensor can go over the ESCs or on the bottom side of the frame
7. Perform the normal configuration and calibration laid out in the CORE PRO manual, www.team-blacksheep.com/tbs-core-pro-manual.pdf

If you are using the GPS module and Mobius HD camera in combination, consider copper shielding the inside of the HD camera to attenuate radiated EMI noise. This keeps the noise level down and helps the GPS get and maintain a lock.



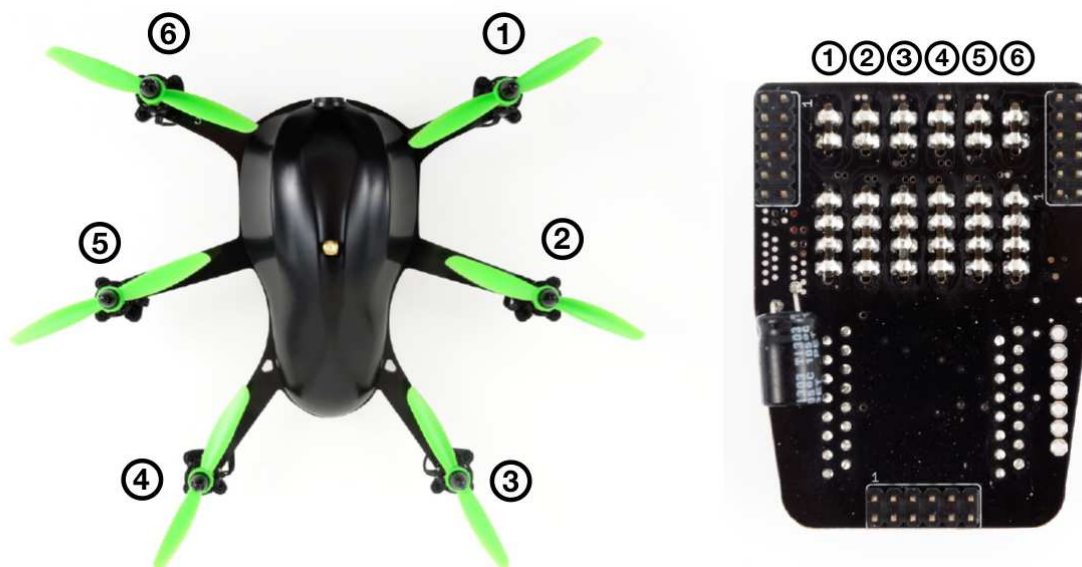
Repair and maintenance

Replace ESC

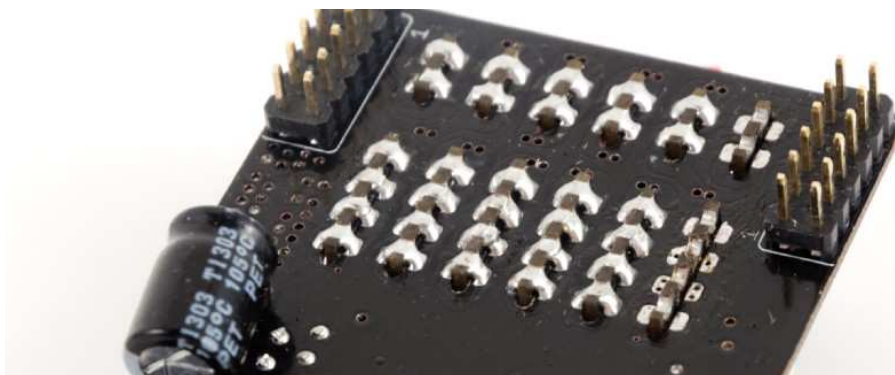
1. Remove the canopy and lift the I/O board out of its sockets



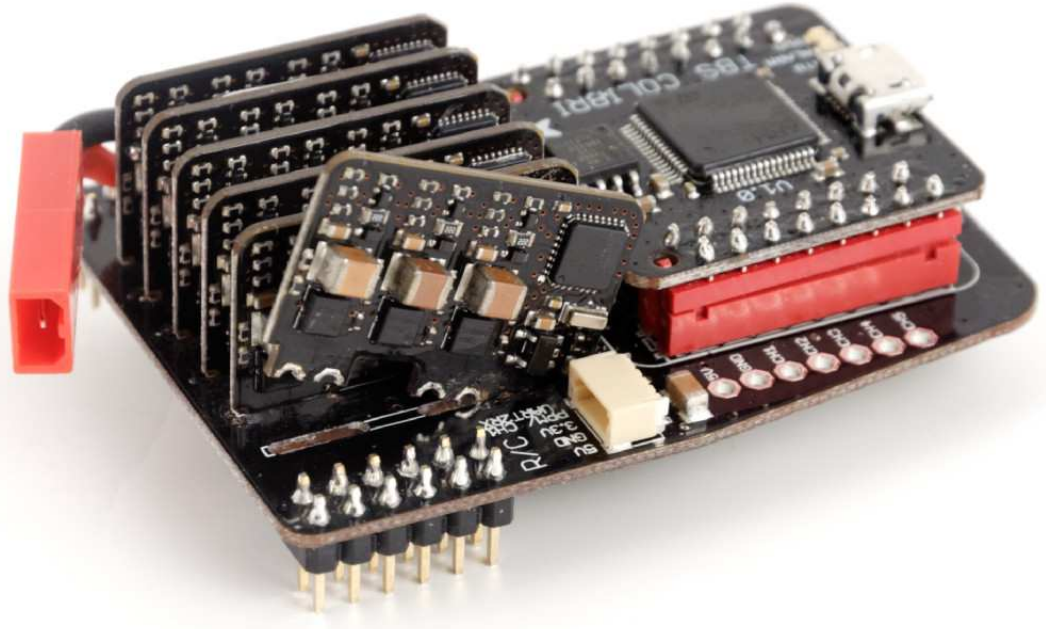
2. At the bottom of the board, there are six rows, each with six solder joints (for control, power and motor). Use the diagram below to determine the correct ESC to remove.



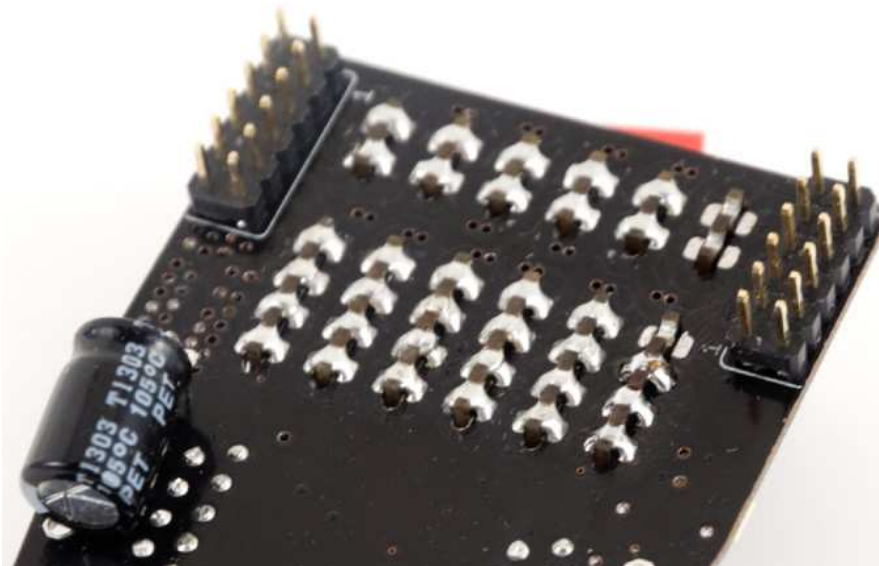
3. Use a soldering iron and desoldering braid to remove the solder joints on both sides of the ESC. Avoid applying heat for too long at once. Reflow/add solder if they are hard to remove at first.



-
- Carefully remove the ESC from its slot and replace with a new unit



- Once the ESC is well seated, hold the ESC to be parallel to the others and re-apply solder to both sides of the ESC slot

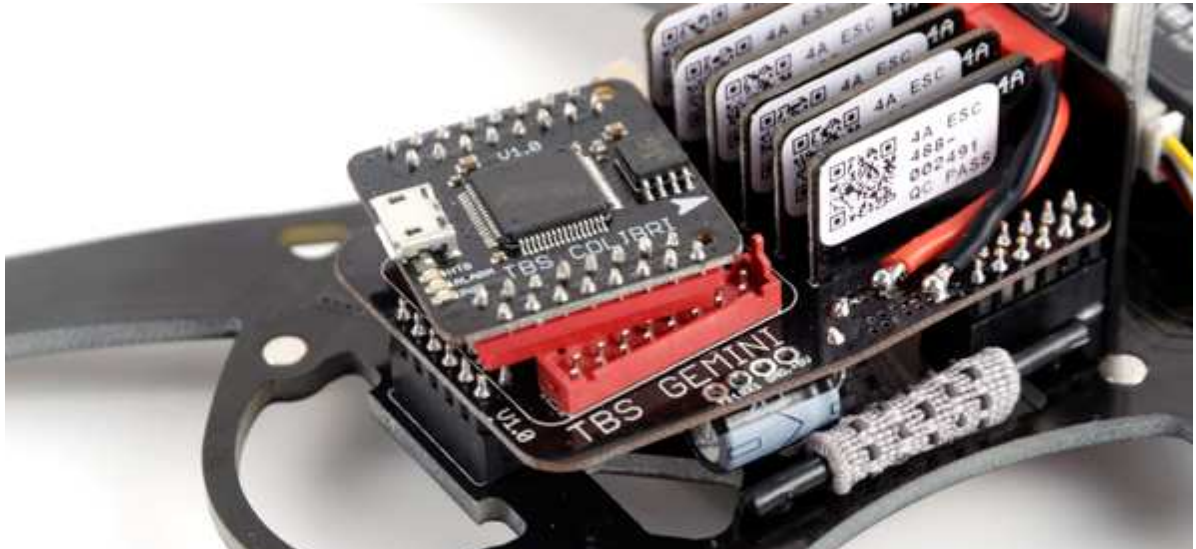


- The TBS BULLETPROOF 4A for multirotors comes pre-configured and does not require to be calibrated or set-up prior to use



Replace flight controller

1. Remove the canopy and lift the TBS COLIBRI flight controller from its sockets on the rear end of the GEMINI
2. Wiggle it slightly on both ends to avoid popping it off and bending the pins



3. Replace the controller and put it back on the sockets - ensure the controller is seated properly
4. Use TauLabs GCS to configure the controller with the default TBS GEMINI settings (see below for links to the files)

GEMINI configuration

The default TBS GEMINI configuration setup (which comes pre-stored on the FC) can be downloaded from <http://team-blacksheep.freshdesk.com/support/solutions/articles/4000034918-files-software>, in case you need to re-configure or reset the controller. Right-click, "Save as" and load the settings by selecting "File" and "Import UAV settings" in the TauLabs GCS software.

- PPM receiver protocol, UART1 Telemetry, UART2 disabled
- Frame style set to X-style hexacopter
- Reverse all motors
- Yaw right to arm
- Neutral throttle to spin all motors
- Board orientation pitch set to +10 degrees
- Tuned PID control gains
- TxPID tuning possible but unassigned

Check the site to get our latest tuned TBS GEMINI configuration.



Replace motor

The design of the motor mount is made to handle a hard crash without sacrificing other parts of the frame. This means that the motor screw will break away when you have a hard crash. Additionally, the included rubber dampeners help to isolate vibrations from the propellers from the rest of the frame.

1. Remove the four nylon screws



2. Disconnect the motor from the Molex connector header on the frame



3. Install a new motor and put vibration reduction rubber pads on both sides of the motor mount/screw holes. Use the supplied set of light-weight M2 nylon screws to fasten it - not overly tight but sufficiently for the vibration damping to work. Melt the ends or apply glue to keep the nut locked



4. Wrap the cable around the arm and connect it to the Molex header on the frame



5. For extra protection from dirt and gravel, add a piece of black tape around the connector

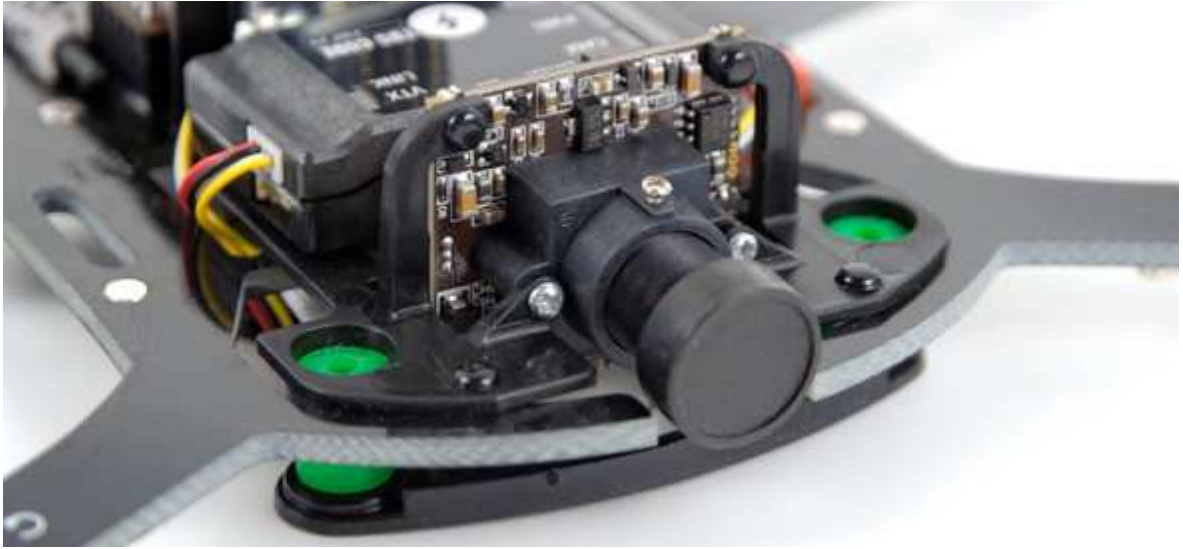
Replace propeller

1. Hold the motor by the bell while using an Allen wrench to remove the prop spinner
2. Install a new 4x4.5-inch propeller with the same profile (clockwise or counter-clockwise rotation) with the text facing up - refer to the picture in the beginning of the manual
3. Re-tighten the prop spinner using the Allen wrench, making sure the propeller is well seated for perfect tracking



Replace camera

1. But back the lens cap to protect against scratches during the repair (to reuse the lens)



2. The flight camera is held in place with two plastic locking pins and two screws, use a screwdriver to push the center pin then the rivet on the top corners and remove the two screws on the lens



3. Lift the camera straight up and out of the camera mount



4. Replace with a new camera, break away the edge tabs if needed - reverse the process

Replace video transmitter

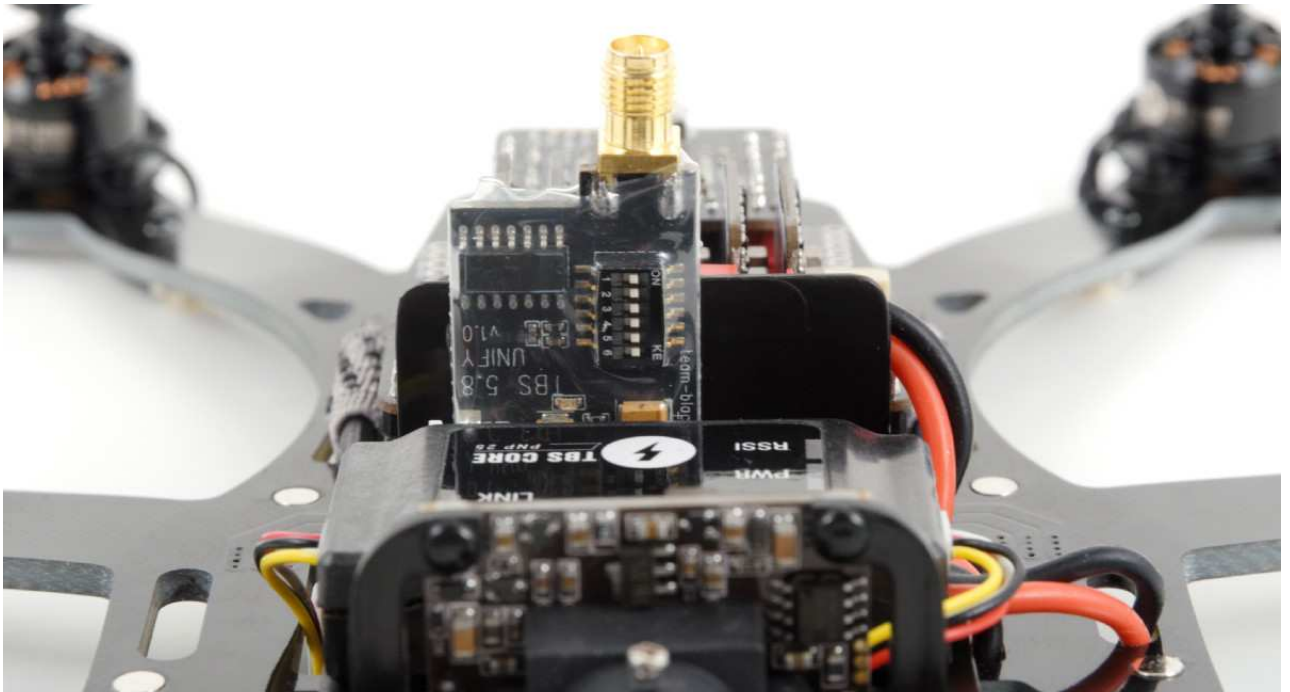
1. Remove the antenna and lift off the canopy. The stock VTX is attached to the VTX mounting bracket with double-sided adhesive foam tape.
2. Slightly tug on the VTX body (not the SMA connector) until the adhesive gives. If needed, heat up the adhesive with a hairdryer or use a plastic spudger to ease the removal.



3. Disconnect the cable from the VTX and replace it with a new unit



4. Apply a new piece of adhesive foam tape to the VTX and align the antenna connector in the center of the frame/mounting bracket, positioned high enough for the connector to protrude through the top canopy



Common questions

- **Issue: The ESCs get hot while idle**

Solution: This is completely normal and is part of the design. When flying, the circulation will provide adequate cooling.

- **Issue: Motors not arming**

Solution: Can you go to the Flight Status page in GCS and check that the system health gadget does not show any errors.

- **Issue: One or two motors does not spin up**

Solution: Check that the flight controller board and I/O board are firmly seated on the sockets. To avoid this from happening, consider using the provided glue to lock the flight controller to the I/O board.

- **Issue: Yaws out of control in a clockwise direction**

Solution: Make sure all propellers are rotating in the right direction and with the small propeller hole/text facing up

- **Issue: CORE PRO GPS does not seem to lock**

Solution: Try to move the GPS module as far away from switching power regulators, UHF transmitters, pilot cameras and video transmitters. Leave the GPS to initialize for 30 seconds before moving the model.

Is your problem not listed? Please check our helpdesk for the latest information. Feel free to submit a support ticket if you can not find your issue and we will get back to you.

- <http://team-blacksheep.freshdesk.com/>



Custom Assembly

Select canopy

The difference between the top racing and film canopy is subtle, but noticeable. You can use the film canopy on the racing setup, but not the other way around.

Racing canopy



For racing and optimal aerodynamic flight, use the Race canopy. This drops down the pilot camera a notch and removes the Mobius HD camera carriage, making everything streamlined and light-weight with only the pilot camera and VTX antenna visible.



Convert to racing canopy

1. Remove the video transmitter by gently prying off the adhesive while holding onto the VTX body



2. Remove the pilot camera by pushing out the two top locking pins and removing the two screws on the lens



3. Disconnect the cables from the I/O board, video transmitter and pilot camera, and untangle the battery lead from the Mobius mount



4. Remove the CORE PNP25 unit, it is fastened with a adhesive foam tape



5. Use a screwdriver to unseat the four damping balls on the Mobius mounting plate

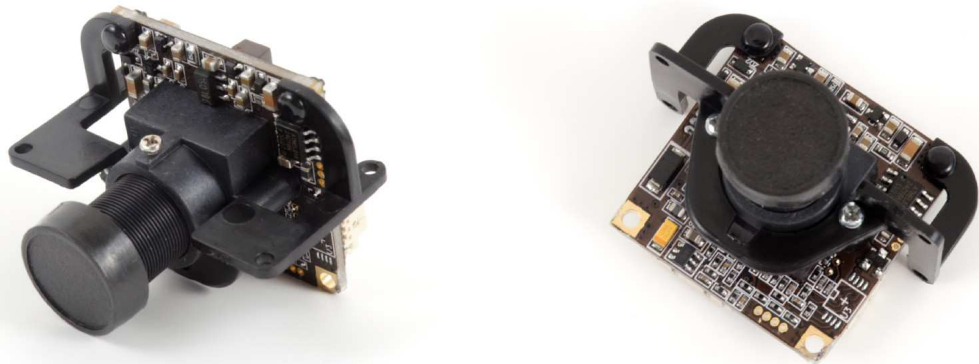


6. From the bottom side, push the five plastic locking pins and rivets of the the carriage to release it from the frame

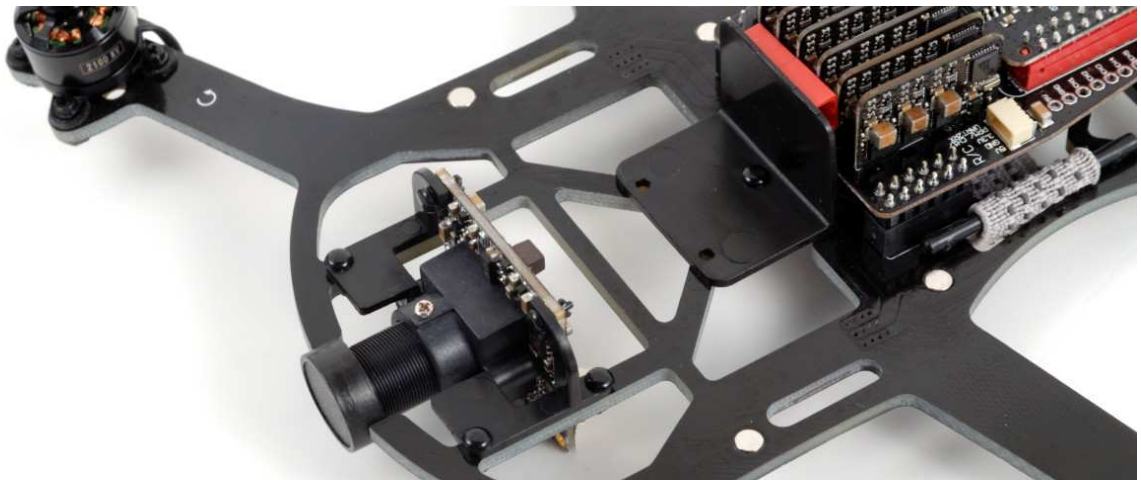




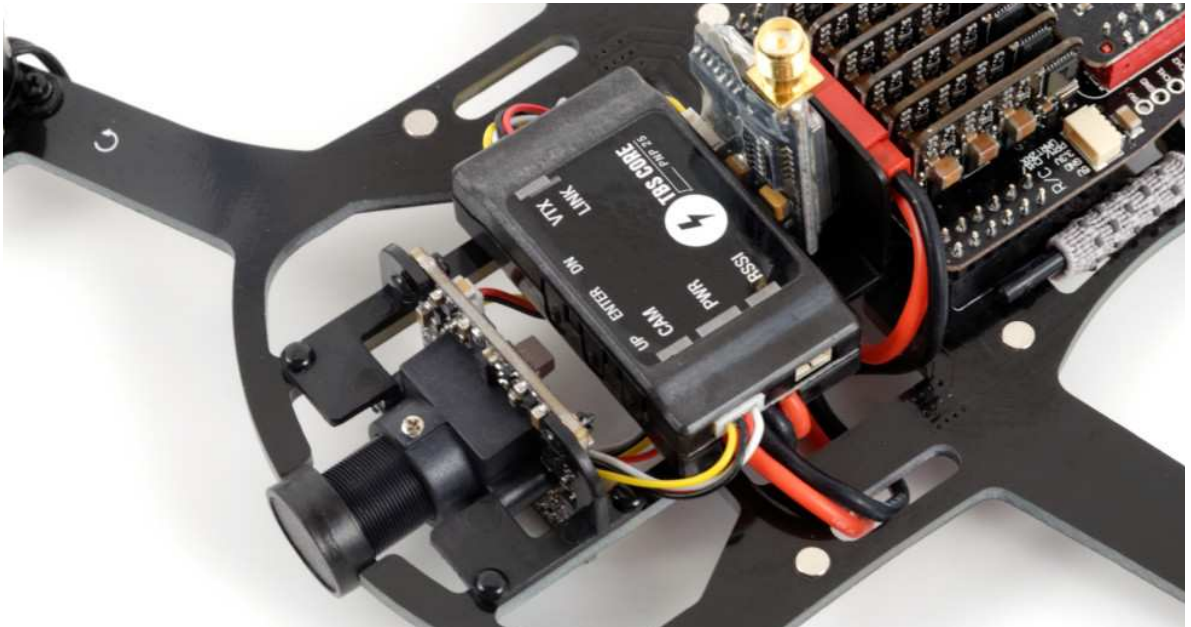
7. Continue by installing the racing camera mount to the pilot camera in the orientation shown, fasten using two locking pins and two screws, as shown



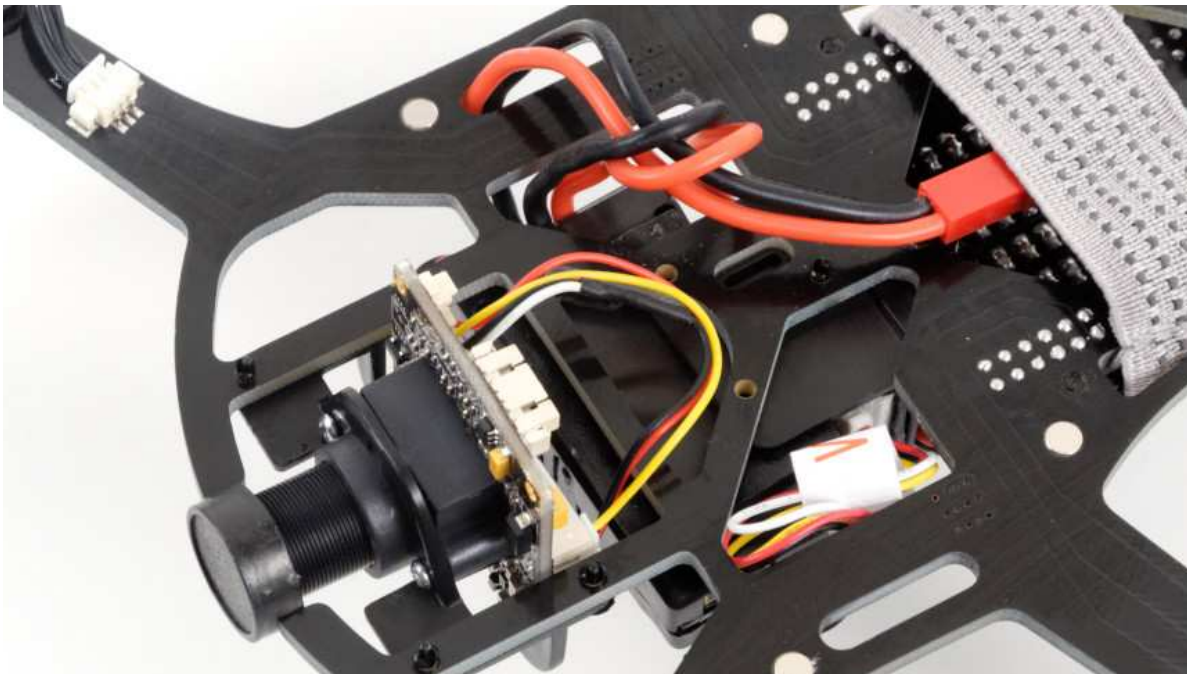
8. Position the camera over the front four holes on the frame and use four locking pins to install it - do the same for the VTX mount, use a single locking pin the fasten it



9. Install the video transmitter on the new mounting bracket. Loop the CORE PNP25 cables through the holes shown and connect up the pilot camera and video transmitter.



Bottom side of the frame:



10. With the new carriage installed, use the light and streamlined racing canopy to finish off the conversion!



Film canopy



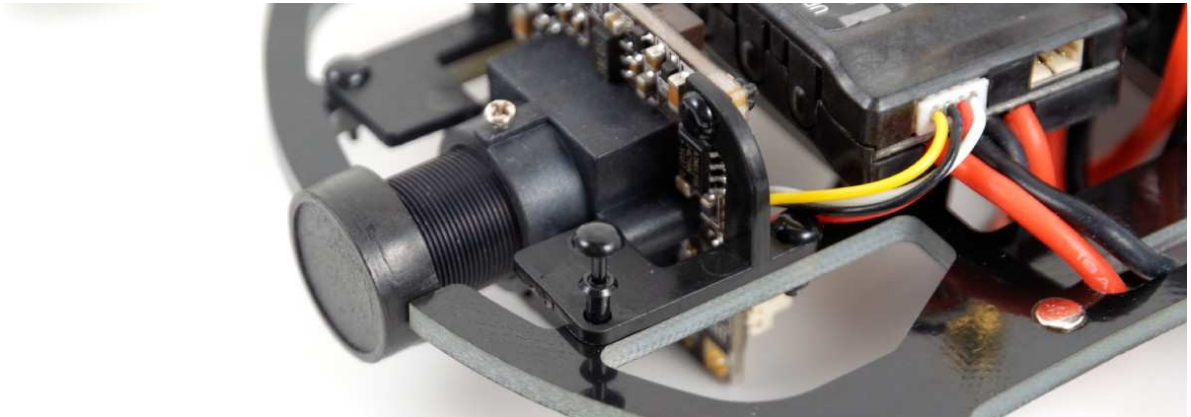
The included Film canopy provides additional bulkhead and volume on the bottom of the GEMINI to facilitate a Mobius HD ActionCam.

The Mobius camera is mounted on a separate camera plate which is suspended beneath the frame using damping balls. This provides separation from the main frame and reduces vibration from propagating to the camera, making the final HD video smooth and free from so called "jello"-effect in bright conditions.



Convert to film canopy

1. Disconnect the cables for the I/O board and video transmitter and untangle the battery leads from the bottom side



2. Lift out the CORE PNP25 unit from its spot. From the bottom side, use a screwdriver to push through the plastic locking pins and rivets for the camera- and video transmitter mounts



3. Continue by aligning the film carriage over the frame and pushing locking pins into the holes shown in the following photo

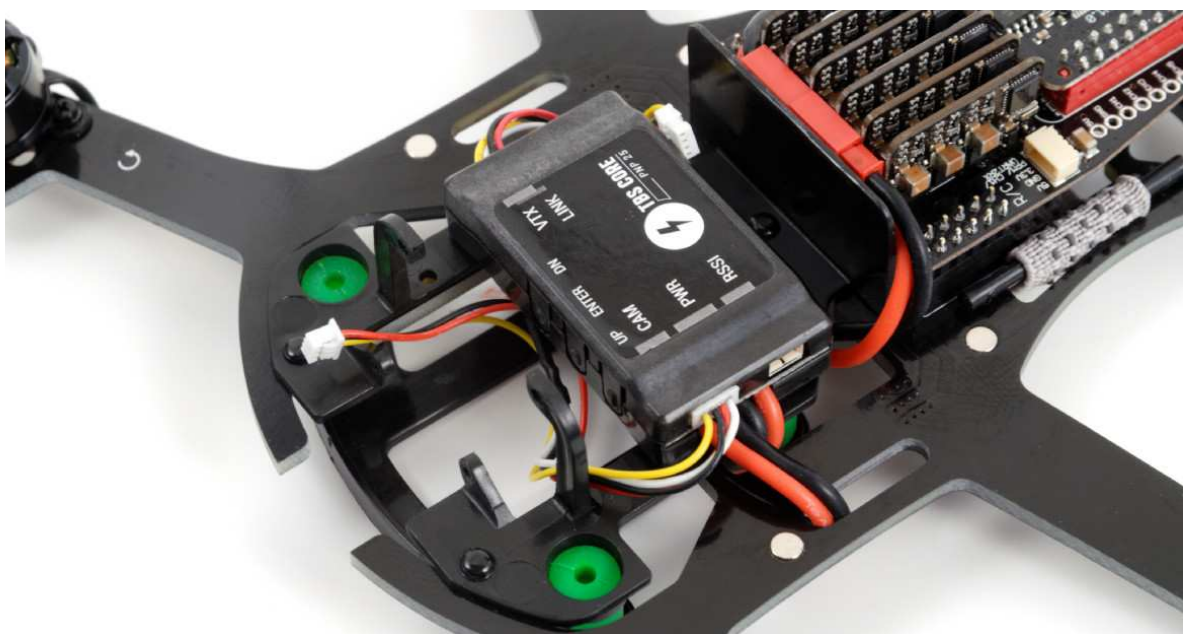




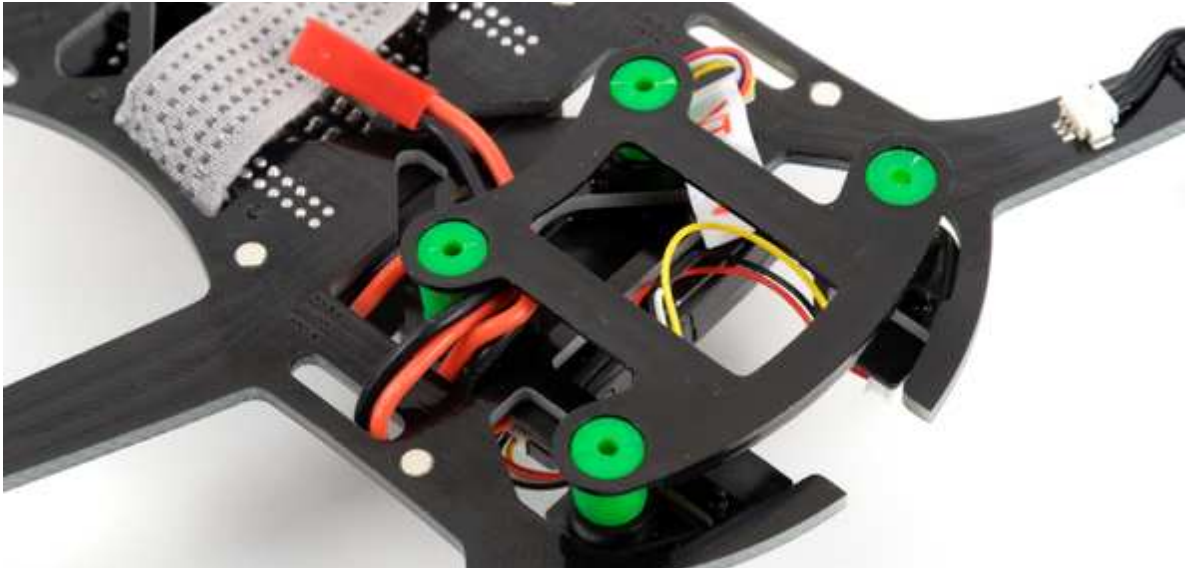
4. Turn the frame over and position the Mobius mounting plate over the dampening balls. Use a short loop of wire to hook through the hole and pull the end of the damping ball through.



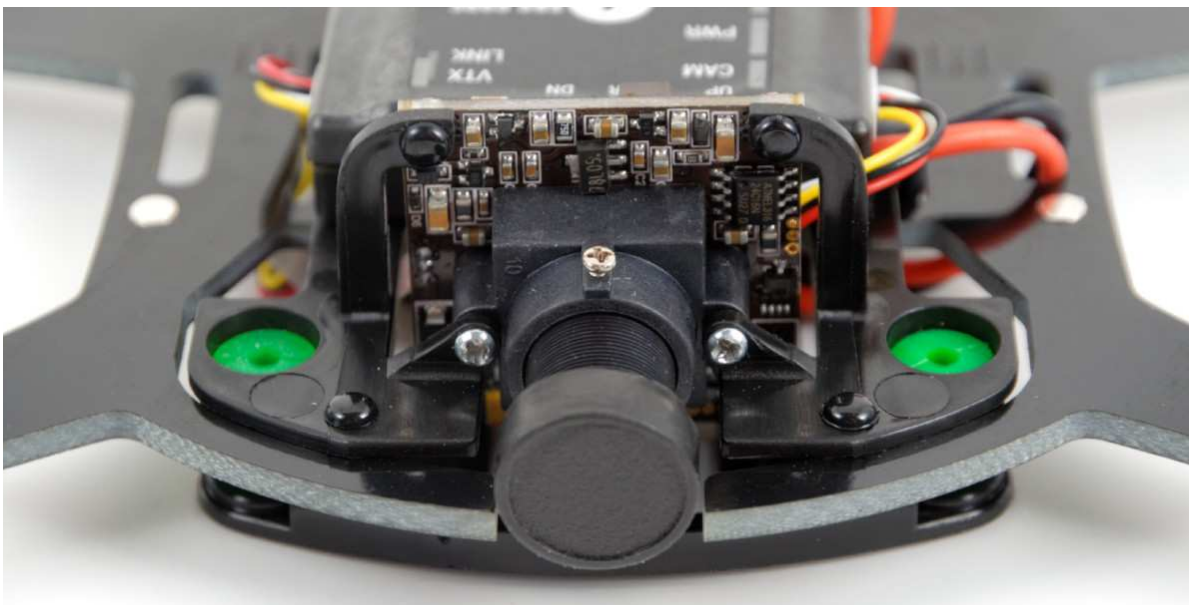
5. Put the CORE PNP25 back on the top of the frame while leaving space for the VTX and camera - route the cables as shown



Bottom side of the frame:

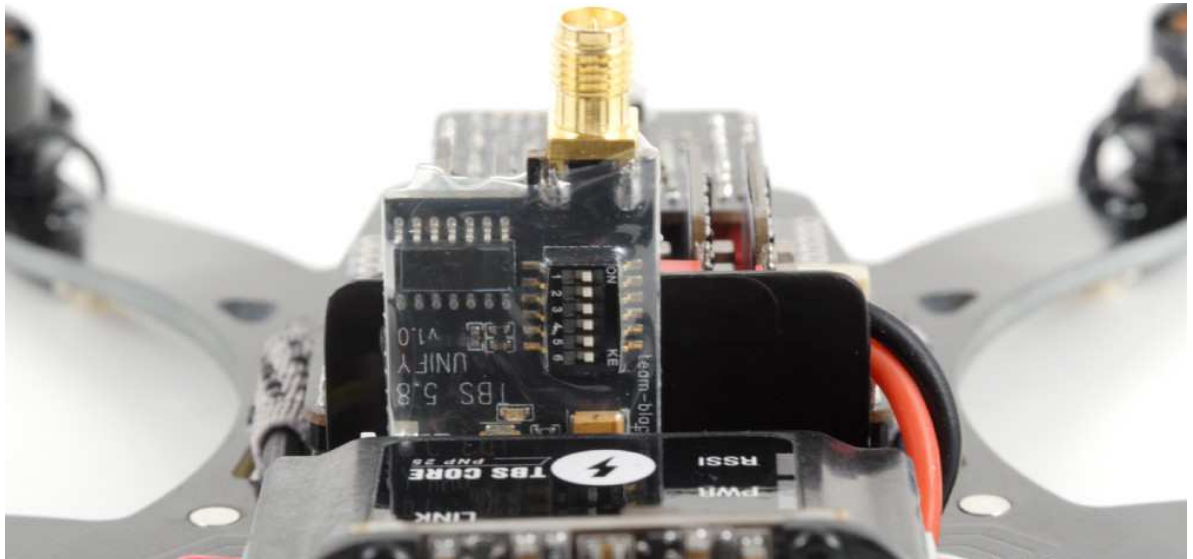


6. Connect the pilot camera and lock it in place using two locking pins on the top two corners and two screws on either side of the lens



7. Connect the VTX and mount it with a piece of strong adhesive foam tape. Position it with the antenna connector in the center of the VTX mount and high enough to reach through the canopy.





8. Finish off the conversion with the film canopy!



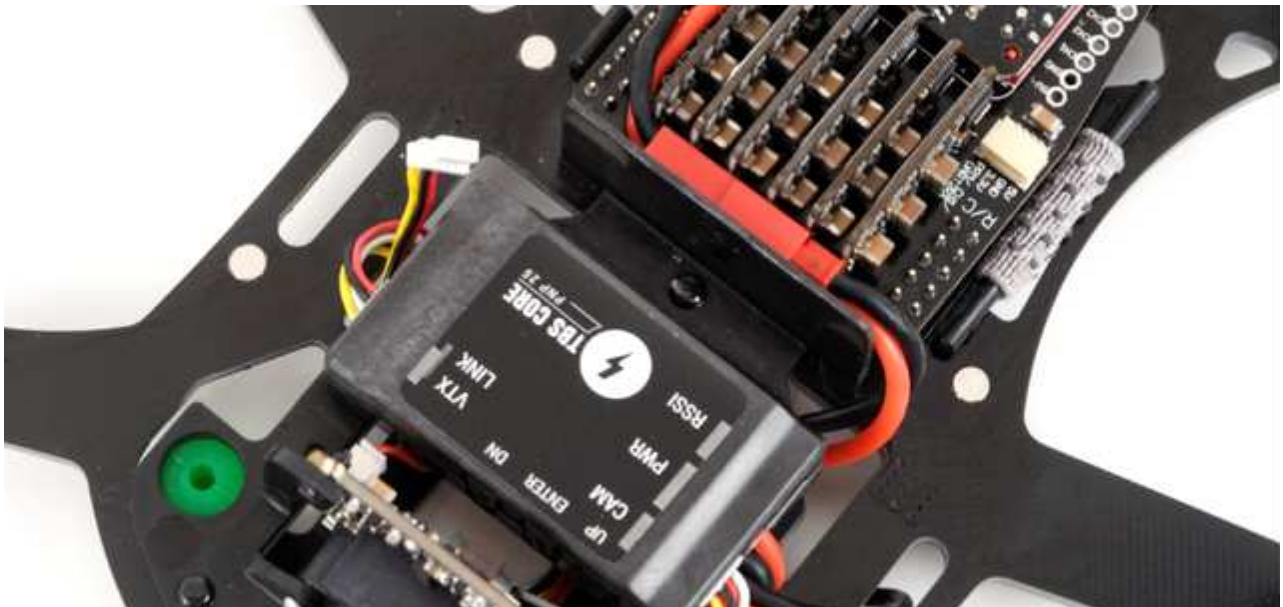
Video system

Change pilot camera

The supplied camera mounts supports standard 32x32 mm board cameras. There is a fair bit of depth behind the mount to allow thicker boards and cables to loop through.

Change video transmitter

Because of the limited space in the top canopy, you can only fit a small VTX on the allocated spot - max. dimensions can not exceed 40(H) x 35(W) x 10(D) mm. This means that only micro or small VTX will fit (e.g. TBS UNIFY, TBS BOSS, TBS ROOKIE, TBS GREENHORN, Lawmate 2G4).



For a larger VTX, the kit comes with a separate VTX shoulder to accommodate a SMA extension cable. This makes it possible to install a VTX elsewhere in the canopy while still mounting the antenna end of the extension cable in the allocated VTX spot - keeping the antenna fastened vertically through the canopy slot.



Drive system

Motors

Changing the motors to a different 1806 type requires that the mounting pattern and wire connection is compatible, or modified to fit. The mounting pattern on the arms will fit 22 x 22 mm motors.

R/C receiver

Traditional PWM receiver install

It is possible to install a 5-channel receiver using individual servo cables for each channel (instead of PPM/S-BUS/D-BUS).



On the left side of the I/O board is a single row with seven ports (5V, GND, CH1 to 5). The first three ports are also directly connected to the PPM header.

1. Either solder a pin header to the ports or directly solder the servo wires. Use the two first ports to power your receiver and the rest to individually hook-up the control signals (thr, pit, rol, yaw, fm)



- Open TauLabs GCS, go to the “Hardware” view and change “RcvrPort” to “PWM” to enable the five inputs. Also be sure “UART2” is set to “Disabled”, as shown. Click “Save” and unplug power to reboot.



- Now, go to the “Input” view and change the “Type” to “PWM” for all the first five channels. Or run the configuration wizard to map the receiver signals to the right controls one by one.

Function	Type	Number	Min	Neutral (see tooltip)	Max
Throttle	PWM	Chan 1	1088	1104	1897
Roll	PWM	Chan 2	1901	1492	1084
Pitch	PWM	Chan 3	1901	1494	1088
Yaw	PWM	Chan 4	1901	1494	1088
FlightMode	PWM	Chan 5	1088	1494	1901
Collective	None	Disable	0		0
Accessory0	None	Disable	0		0
Accessory1	None	Disable	0		0
Accessory2	None	Disable	0		0
Arming	None	Disable	0		0

- Remove the receiver casing if it turns out that the it is difficult to seat the canopy properly



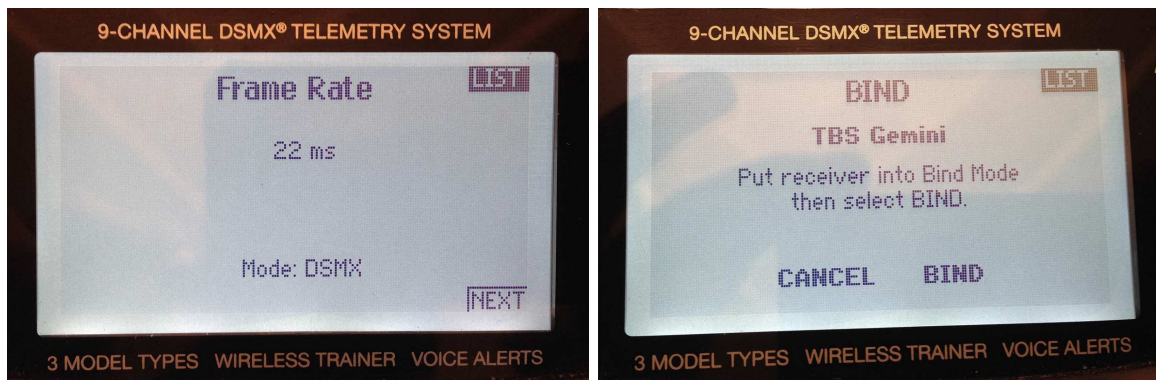
Spektrum Satellite install

Using a Spektrum Satellite as a receiver makes for a very compact and neat install.

- OrangeRx R100 DSM2 satellite
- Spektrum AR6200/AR6210 DSMX satellite
- Spektrum AR9000 DSM2 satellite
- Spektrum AR9010/AR9110 DSMX satellite

Binding the satellite to the transmitter

1. Connect the satellite to a regular Spektrum R/C receiver, as you normally would
2. On the radio, hold the roller button (DX8, DX9) while turn on the Tx to reach "System Setup"
3. Now scroll through and set "Frame Rate" to "22ms/DSMX" (DX8, DX9)



4. On the receiver, insert the bind-plug and apply power - LED on the receiver will be flashing
5. Power on the radio while holding the trainer button (DX8) or back button (DX7), or go into the "System Setup" and initiate "Bind" (DX9)
6. Within a few seconds the LED on the receiver will go solid indicating connection
7. The receiver and satellite is now bound to the transmitter and the satellite is ready to be installed

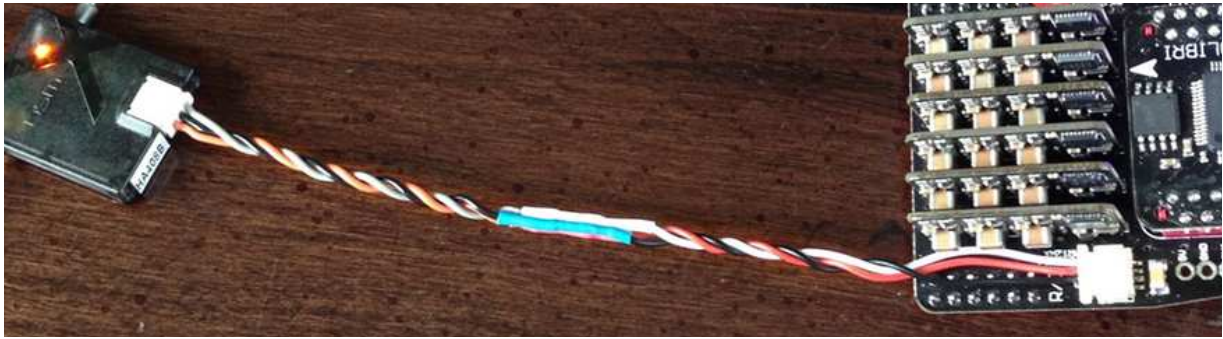
Prepare connection cable

The finished cable should look like the photo below. Lift the plastic tab with a precision knife to remove the red wire pin move it to position 2 and solder the corresponding wires for the satellite. 3.3V power is provided by the COLIBRI controller.

GEMINI PPM header			Satellite unit
1 - PPM/UART2 RX2	White	Grey	3 - TX
2 - 3.3V	Red	Orange	1 - 3.3V
3 - GND	Black	Black	2 - GND
4 - 5V	-	-	Not used

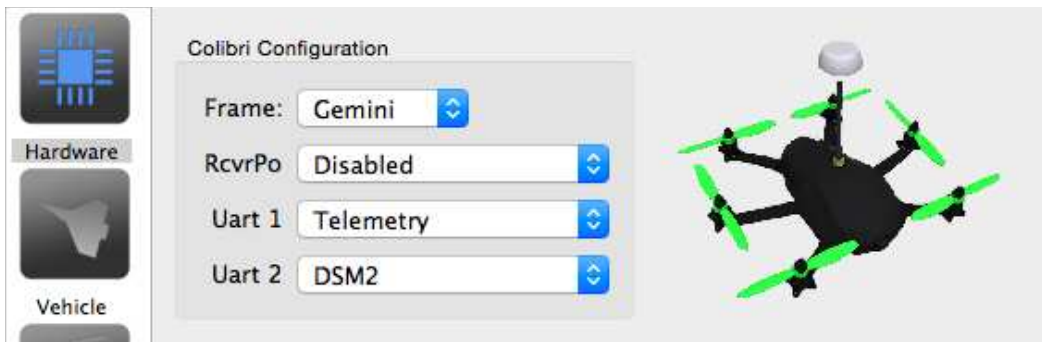


Important: The red 5V pin has been moved to the 3.3V pin - otherwise the satellite could be damaged.



Configure COLIBRI

Connect a LiPo battery to get power to the satellite, configure the COLIBRI to accept DSM2 (DX7) or DSMX 10 or 11bit (DX7S, DX8, DX9) on UART2 using TauLabs GCS, as shown. After changing hardware settings, unplug USB and the LiPo to reboot the COLIBRI controller. If one of the DSM stick selections does not work on the hardware tab, try a different DSM (10 or 11bit) selection and reboot. Then try the wizard again.



When everything is set up and powered, the satellite should have a solid orange LED light. In GCS "input" view, change the "Type" to "DSM" for channel 1 to 5 and 6 & 7. Adjust the "Channel number" accordingly. Or you can run the configuration wizard to perform the test of each channel.

Function	Type	Number	Min	Neutral (see tooltip)	Max
Throttle	DSM (Main)	Chan 1	342	369	1706
Roll	DSM (Main)	Chan 2	1705	1024	344
Pitch	DSM (Main)	Chan 3	1705	1024	343
Yaw	DSM (Main)	Chan 4	1705	1024	343
FlightMode	DSM (Main)	Chan 5	342	1024	1706
Collective	None	Disable	0		0
Accessory0	None	Disable	0		0
Accessory1	DSM (Main)	Chan 6	1024		1024
Accessory2	DSM (Main)	Chan 7	1024		1024
Arming	None	Disable	0		0



Flight controller

Tuned PID settings

To further improve how the GEMINI handles in the air you can tune the control loop which is the backbone in the flight controller.

Open “Configuration” and go to the “Stabilization” view. The second “Advanced” tab lets you tune the core parameters.

Rate Stabilization Coefficients (Inner Loop)			
<input type="checkbox"/> Link Roll and Pitch	Default		
	Roll	Pitch	Yaw
Proportional	0,00440	0,00360	0,01400
Integral	0,04600	0,04200	0,07800
Derivative	0,000025	0,000025	0,000000

Attitude Stabilization Coefficients (Outer Loop)			
<input type="checkbox"/> Link Roll and Pitch	Default		
	Roll	Pitch	Yaw
Proportional	6,015	6,015	8,000
Integral	0,000	0,000	10,000

Stick Range and Limits			
	Roll	Pitch	Yaw
Full stick angle (deg)	45	45	35
Full stick rate (deg/s)	360	360	220
Max rate attitude (deg/s)	300	300	300

Install GPS module

The TBS COLIBRI flight controller supports GPS input and UART1 (TX1, RX1, GND, +5V) on the right side of the I/O board allows you to connect a compatible module. This is not yet officially supported by TBS, but you can try it out using the steps laid out on this page,

<https://github.com/TauLabs/TauLabs/wiki/User-Guide:-Enable-GPS>

Configure the controller to use “GPS” under “UART1” in the “Hardware” view.

Any Ublox 8 or later (e.g. NEO-M8) GPS module will work directly. A short list of tested modules.

- RY825AI Ublox 18Hz UART GPS module



Using center sprung throttle stick

Using Altitude Hold in new firmware December 2014.





Altitude Hold

In this mode the controller will hold the current altitude by monitoring atmospheric pressure using the on-board barometer sensor. If your throttle stick is high the aircraft will climb and if it is low it will descend.

Before enabling this mode, be sure the "Altitude Hold" module is enabled under the "Modules" view in "Configuration". Click "Save" and reboot/unplug power to the GEMINI.

Go to the "Input" view and open the "Flight Mode Switch Settings". Change "Pos. 2" (or any other switch position) to "AltitudeHold". You can only enter Altitude Hold once you armed the aircraft, you can not takeoff in Altitude Hold mode, i.e. engage the motors and switch over to Altitude Hold.

There are a few parameters that need to be updated, described more in detail here

<https://github.com/TauLabs/TauLabs/wiki/Flightmode-Settings>. Open the object explorer on the right side of the GCS view, select "Settings" and then navigate to the following settings.

Parameter	GEMINI value
AltitudeHoldSettings.PositionKp	1
AltitudeHoldSettings.VelocityKp	0.3
AltitudeHoldSettings.VelocityKi	0.3
AltitudeHoldSettings.AttitudeComp	225%
AltitudeHoldSettings.MaxRate	2 m/s
AltitudeHoldSettings.Expo	40



Good practices

We have compiled a list of all of practices which have been tried and tested in countless environments and situations by the TBS crew and other experienced FPV pilots.

Follow these simple rules, even if rumors on the internet suggest otherwise, and you will have success in FPV.

- Start with the bare essentials and add equipment one step at a time, after each new equipment was added to proper range- and stress tests.
- Do not fly with a video system that is capable of outperforming your R/C system in terms of range.
- Do not fly with a R/C frequency higher than the video frequency (e.g. 2.4GHz R/C, 900MHz video).
- Monitor the vitals of your plane (R/C link and battery). Flying with a digital R/C link without RSSI is dangerous.
- Do not use 2.4GHz R/C unless you fly well within its range limits, in noise-free environments and always within LOS. Since this is most likely never the case, it is recommended to not use 2.4GHz R/C systems for longer range FPV.
- Do not fly at the limits of video, if you see noise in your picture, turn around and buy a higher-gain receiver antenna before going out further.
- Shielded wires or twisted cables only, anything else picks up RF noise and can cause problems.
- When using powerful R/C transmitters, make sure your groundstation equipment is properly shielded.
- Adding Return-To-Home (RTH) to an unreliable system does not increase the chances of getting your plane back. Work on making your system reliable without RTH first, then add RTH as an additional safety measure if you must.
- Avoid powering the VTx directly from battery, step-up or step-down the voltage and provide a constant level of power to your VTx. Make sure your VTx runs until your battery dies.
- Do not power your camera directly unless it works along the complete voltage range of your battery. Step-up or step-down the voltage and provide a constant level of power to your camera. Make sure your camera runs until your battery dies.
- A single battery system is safer than using two dedicated batteries for R/C and FPV. Two batteries in parallel even further mitigate sources of failure.
- For maximum video range and "law compatibility", use 2.4GHz video with high-gain antennas.
- When flying with R/C buddies that fly on 2.4GHz, or when flying in cities, it is perfectly possible to use 2.4GHz video provided you stick to the channels that do not lie in their band (CH5 to CH8 for Lawmate systems, available from TBS).
- Do not use diversity video receivers as a replacement for pointing your antennas, diversity should be used to mitigate polarization issues.
- Improving the antenna gain on the receiver end is better than increasing the output power (except in RF-noisy areas). More tx power causes more issues with RF on your plane. 500mW is plenty of power!



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- Try to achieve as much separation of the VTx and R/C receiver as possible to lower the RF noise floor and EMI interference.
 - Do not buy the cheapest equipment unless it is proven to work reliably (e.g. parts falling off, multitudes of bug fix firmware updates, community hacks and mods are a good indicator of poor quality and something you do NOT want to buy for a safe system). Do due diligence and some research before sending your aircraft skyward.

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