









Website: craftandtheoryllc.com
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Pixhawk to FrSky Telemetry Cable and User Interface MANUAL



The system described in this manual allows an operator to display Pixhawk flight and safety information on the Taranis controller.

1. Prerequisites

Equipment needed		Comments
Pixhawk autopilot		<p>Must</p> <p>(1) flash Pixhawk with modified ArduCopter firmware (see instructions below)</p> <p>(2) configure Pixhawk by calibrating voltage/current measurements for the power module used: http://ardupilot.org/copter/docs/common-power-module-configuration-in-mission-planner.html</p>
Pixhawk power module		Supplies power and provides voltage/current measurements to the Pixhawk.
FrSky Taranis (X9D, X9D Plus, or X9E)		<p>Must</p> <p>(1) update Taranis firmware to OpenTX 2.1.x</p> <p>(2) copy script files onto Taranis SD card</p> <p>(3) configure Taranis to discover sensors and execute scripts (see instructions below).</p>
FrSky Smart Port X4R, X4RSB, X6R X8R or XSR receiver		The X8R receiver usually comes with the Taranis. All FrSky Smart Port receivers are compatible.
Pixhawk to FrSky telemetry cable		Needed to connect your Pixhawk to your FrSky Smart Port equipment. Telemetry cable available from craftandtheoryllc.com
USB A to micro-B USB cable		Needed to connect the Pixhawk to the computer (for flashing and configuration of the Pixhawk via Mission Planner)
USB A to mini-B USB cable		Needed to connect the Taranis to the computer (for flashing and configuration of the Taranis via OpenTX companion)
OPTIONAL FrSky FLVSS Smart Port LiPo voltage sensor	 (OPTIONAL)	System compatible with the FrSky FLVSS sensor (also known as SP-FLVS). To install, connect the FLVSS sensor between the telemetry cable and your Smart Port receiver (see instructions below).



2. Installation instructions

A zip file containing the following files is provided for download along with your purchase:

File/folder name	Description
CraftandTheory_FrSkyCableUI_Manual.pdf	This installation and user manual
ArduCopter-v2.px4 (for quad frames)	A modified ArduCopter firmware which must be flashed onto your Pixhawk.
"SDcard" folder	The contents of this folder must be copied to the root directory of the Taranis SD card.
Taranis_settings.eepe	EEPROM file containing customized settings for the Taranis to enable FrSky telemetry.

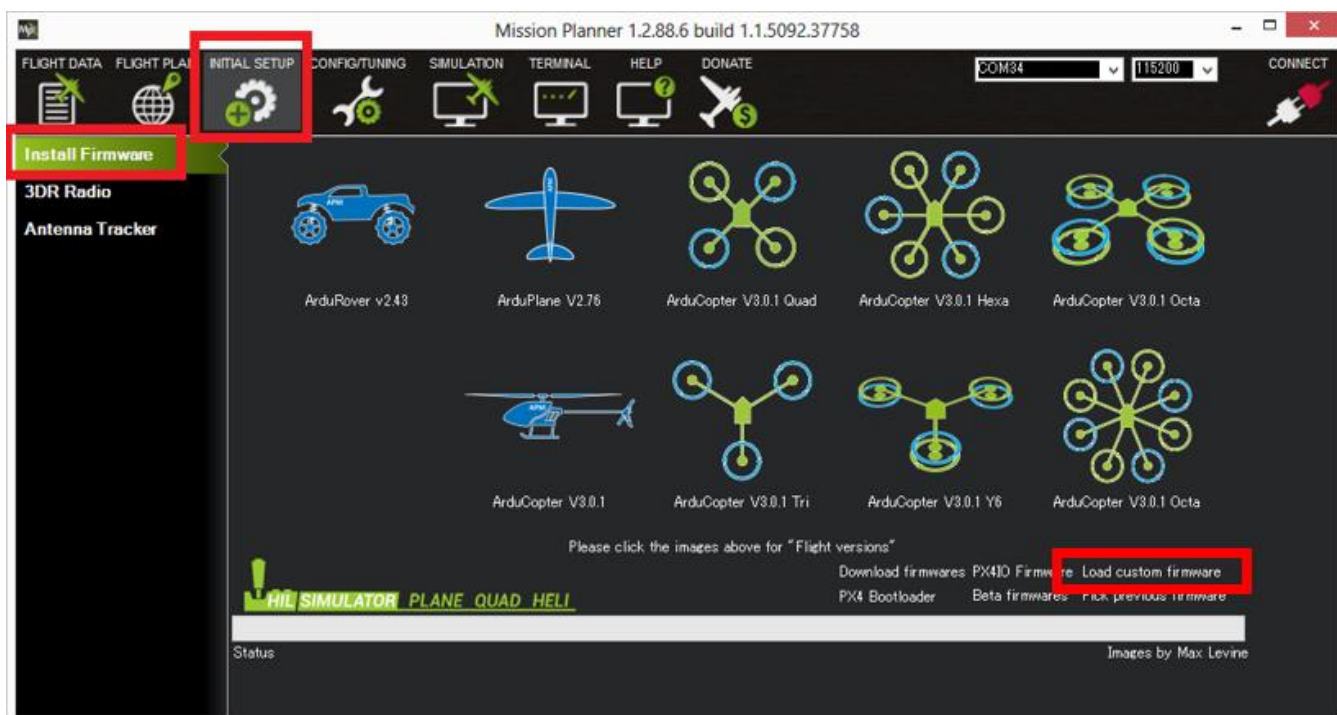
The contents of the "SDcard" folder are supplied when purchasing the user interface and cannot be published or distributed. No derivative work may be prepared based upon this work without prior approval from Craft and Theory.



Pixhawk autopilot setup

➤ Load C&T's modified ArduCopter firmware onto the Pixhawk:

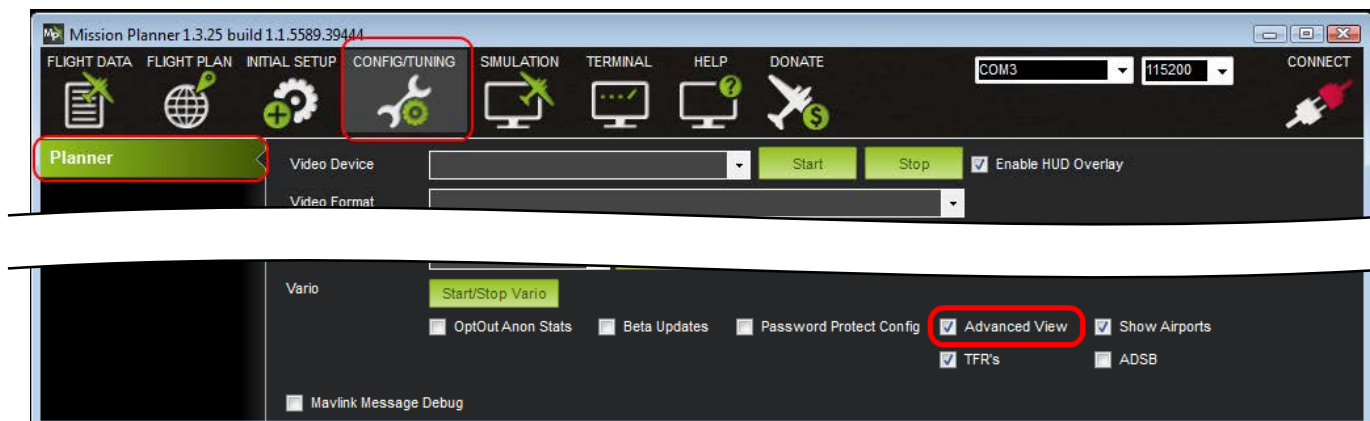
1. Retrieve ArduCopter-v2.px4 (for quad frames) from the zip file provided with your purchase or download from <http://github.com/craftandtheory/FrSkyTelemetry>. Firmwares for other frames (e.g., heli, tri, hexa, Y6, octa) can be found on that GitHub repository. **Make sure to follow these instructions to download a firmware file from GitHub:** click on the name to the corresponding .px4 file (e.g., ArduCopter-v2-hexa.px4). You should now see the contents of the file in a new page. Right-click on the "Raw" button and save the link as a file. Alternatively, you can select and copy the content of the file as displayed in GitHub, paste it to a new file, and save it with a ".px4" extension.
2. Download and install the latest Mission Planner from <http://firmware.ardupilot.org/Tools/MissionPlanner/MissionPlanner-latest.msi>
3. Start Mission Planner and connect the Pixhawk to the computer using a USB cable.
4. In Mission Planner, click on the "INITIAL SETUP" top menu icon. In the "Install Firmware" tab, click on "Load custom firmware," locate and select the firmware to flash (.px4 file), and follow the instructions provided by Mission Planner.



Use Mission Planner to backup your Pixhawk settings before flashing, as flashing may reset them to default! Once flashed, restore your settings using the .param file.



If the “Load custom firmware” option cannot be found, enable it by clicking on the “CONFIG/TUNING” menu icon and checking “Advanced View” in the “Planner” tab.



Mission Planner interface showing how to enable the advanced view.

The modified firmware offers enhanced performance and notable improvements in capabilities (HUD, MAVLink messages, failsafes, etc.). For more details on how to flash a firmware onto the Pixhawk, please consult:

<http://ardupilot.org/copter/docs/common-loading-firmware-onto-pixhawk.html>



The .px4 firmware file MUST be one that is provided by Craft and Theory. Any other firmware will not work properly with the user interface for the Taranis.

➤ **Configure the Pixhawk’s serial port used for FrSky telemetry:**

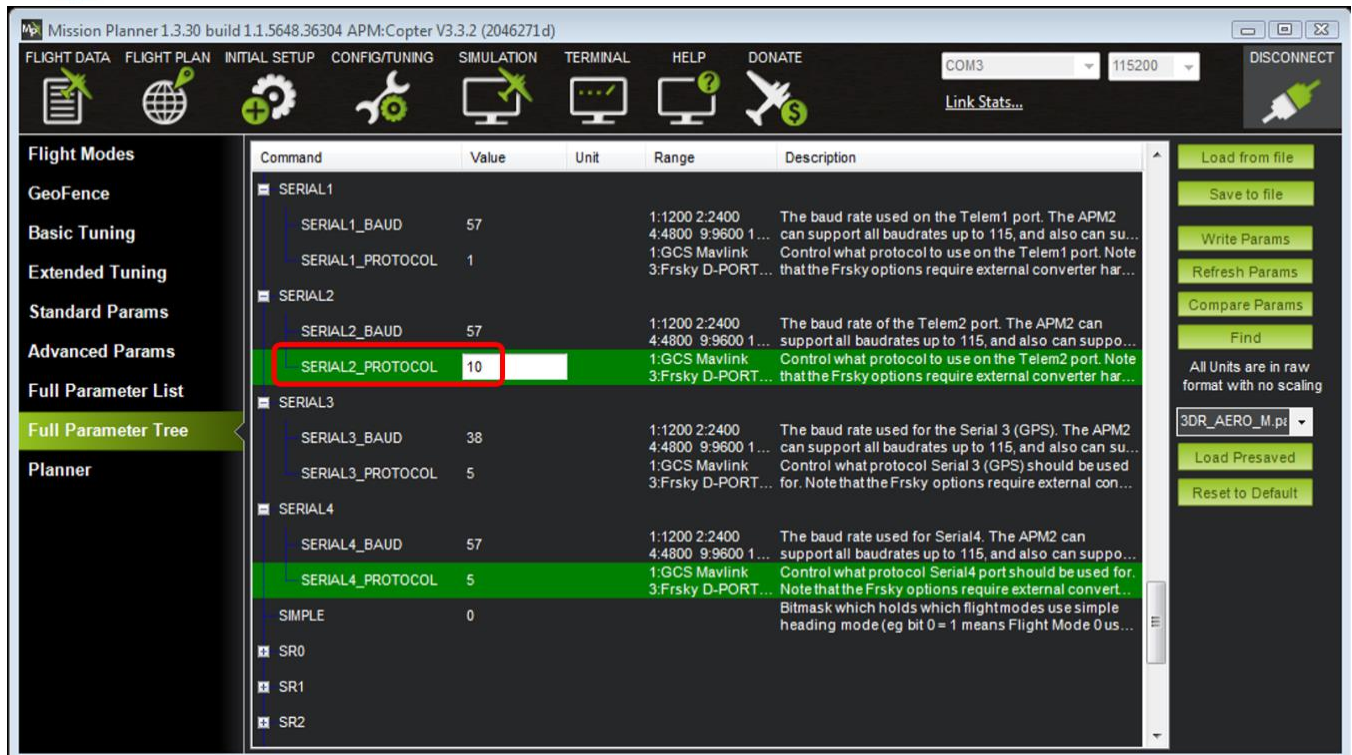
1. While the modified firmware should automatically configure your Pixhawk for operation on the SERIAL 4/5 port (please verify the parameters), you can alternatively connect the telemetry cable to the TELEM1, TELEM2, or GPS port. Depending on the port used, set the corresponding parameter to the value “10” in Mission Planner:

Port used	Parameter
TELEM1	SERIAL1_PROTOCOL
TELEM2	SERIAL2_PROTOCOL
GPS	SERIAL3_PROTOCOL
SERIAL 4/5	SERIAL4_PROTOCOL

The Pixhawk parameters are found by clicking on the “CONFIG/TUNING” menu icon and clicking on the CONNECT button in the upper left. Then, select either the “Full Parameter List” or “Full Parameter Tree.”



Make sure to set only one SERIAL#_PROTOCOL parameter to “10” and the other SERIAL#_PROTOCOL parameters to their default values or at least to something other than 3, 4, or 10, as only one port can be used for FrSky telemetry at a time!



Example Pixhawk configuration where the telemetry cable is connected to TELEM2.

2. Connect the telemetry cable to either the TELEM1, TELEM2, GPS, or SERIAL 4/5 port of your Pixhawk and the other end to the Smart Port of your X-receiver (i.e., X4R, X4RSB, X6R, X8R, or XSR) or FLVSS sensor.



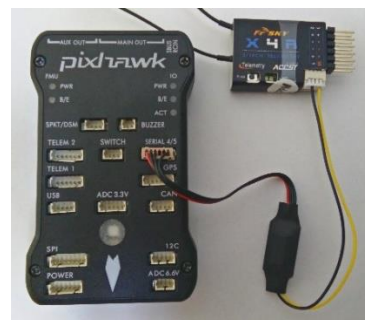
DO NOT PLUG THE TELEMETRY CABLE TO THE PIXHAWK WHILE THE PIXHAWK IS ON! IT MAY CAUSE THE CABLE TO OVERHEAT WHICH COULD RESULT IN SERIOUS BURNS!



Once plugged in, the setup should look like this (other connections between Pixhawk and X-receiver not shown):



Setup with X8R



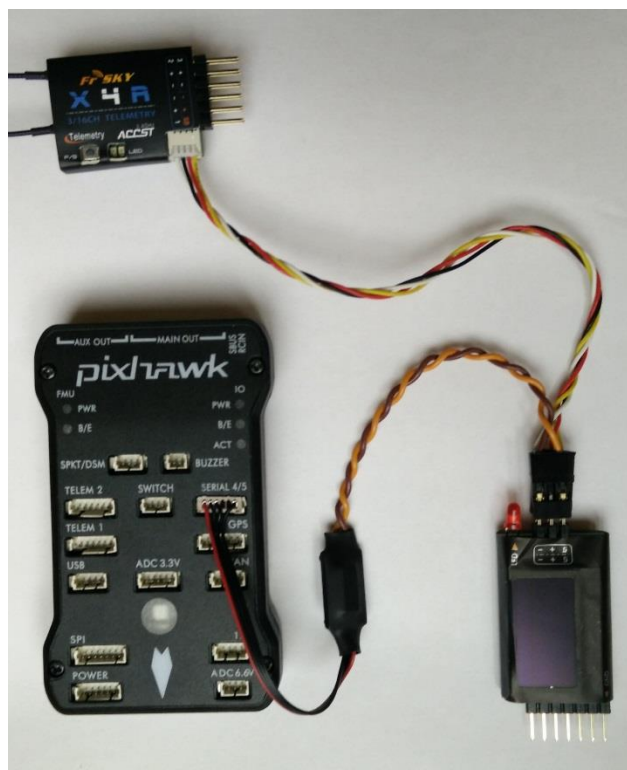
Setup with X4RSB

➤ **Configure the FrSky FLVSS Smart Port LiPo voltage sensor (optional; if used):**

The system is compatible with the FrSky FLVSS Smart Port LiPo voltage sensor (also known as SP-FLVS). To install, connect the telemetry cable between the Pixhawk and the FLVSS sensor, then use the cable supplied with your receiver or supplied with the FLVSS sensor to connect the FLVSS sensor to the Smart Port connector of your X-receiver, as shown here:



Setup with X8R
(other connections between Pixhawk and receiver not shown).



Setup with X4RSB



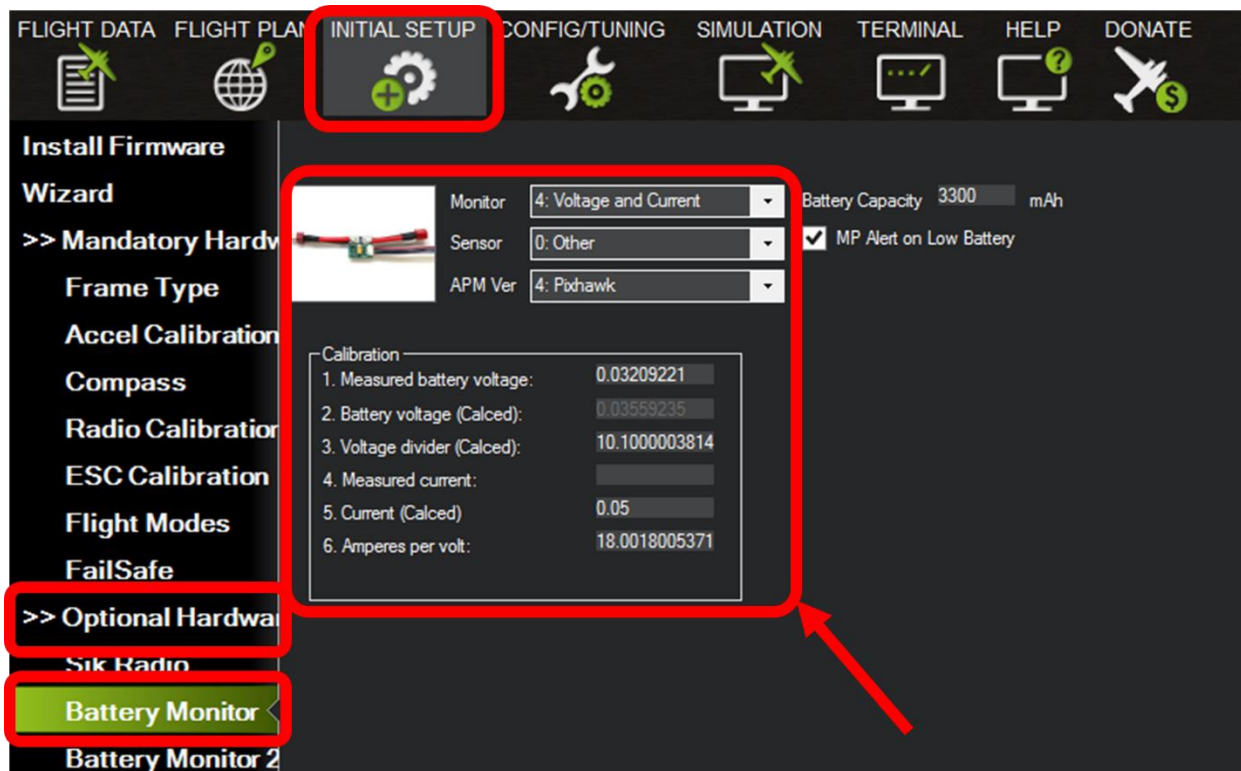
The same telemetry cable (model for X6R, X8R, FLVSS) is connected to the 3 pin 0.1" servo connector of the FLVSS sensor, regardless of which X-receiver is used.

The user interface supports the use of LiPo batteries up to 12 cells (12S) if your Pixhawk power module also supports that voltage. In addition, two FLVSS sensors can be connected simultaneously on the Smart Port bus if setup with different Sensor IDs. Setup of dual FLVSS sensors is beyond the scope of this manual and requires additional equipment, but the general steps are as follows:

- Change the Sensor ID of one of the two FLVSS sensors to "3" using either a FrSky Servo Channel Changer or the FrSky "S.Port Tool" program available for download from the FrSky website. Using the "S.Port Tool," change "PhyID from "2" to "3."
- Also, make sure both FLVSS sensors are discovered, and replace the name of the second one from "Cels" to "Cel2."

➤ **Configure the Pixhawk for the power module used:**

1. After connecting your Pixhawk using Mission Planner, click on the “INITIAL SETUP” top menu icon. In the “Optional Hardware” tab, verify the power module configuration.



For a complete tutorial on power module configuration, visit:

<http://ardupilot.org/copter/docs/common-power-module-configuration-in-mission-planner.html>

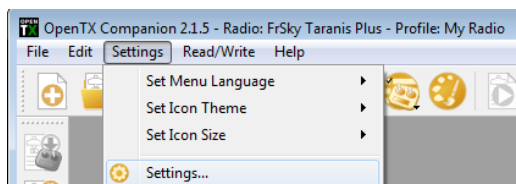


It is highly recommended to configure the power module (both voltage and current) according to the tutorial above, otherwise the voltage, current, battery consumption and battery percentage reported by the user interface will not be accurate!!!

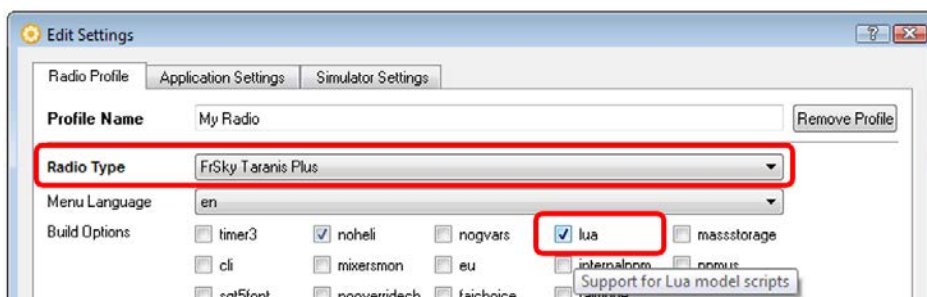
Taranis setup

➤ Update Taranis firmware to OpenTX 2.1.x

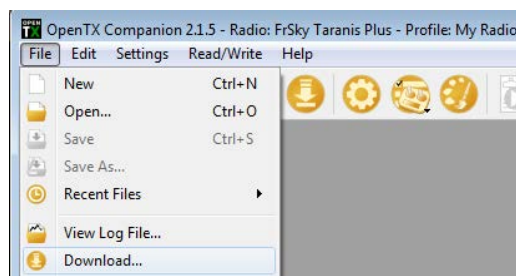
1. Download and install the latest version of OpenTX Companion from www.open-tx.org/downloads.html. Open the OpenTX Companion program, then go to Settings >> Settings



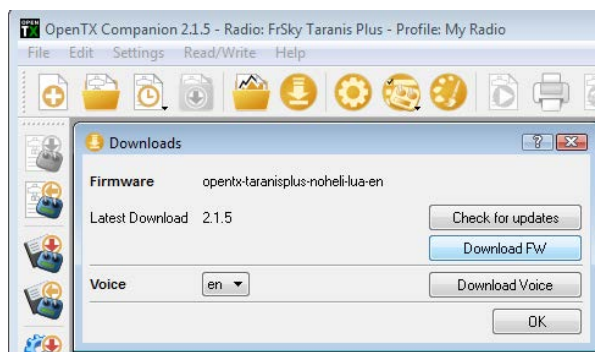
2. Select your "Radio Type" (Taranis, Taranis Plus, or Taranis X9E), make sure the "lua" build option is checked, then press OK.



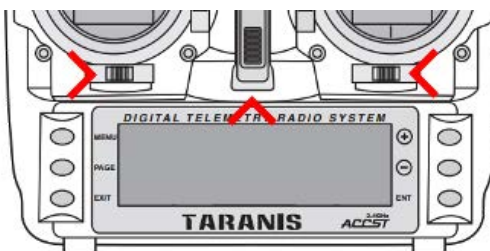
3. Click on File >> Download...



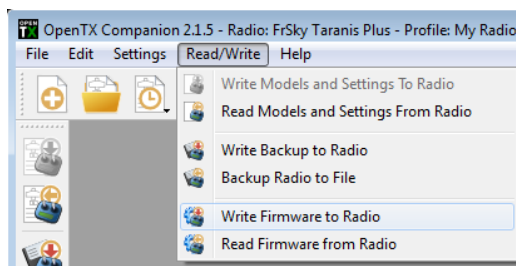
4. Click on the "Download FW" button and save the resulting .bin file. Once the firmware is downloaded, press OK.



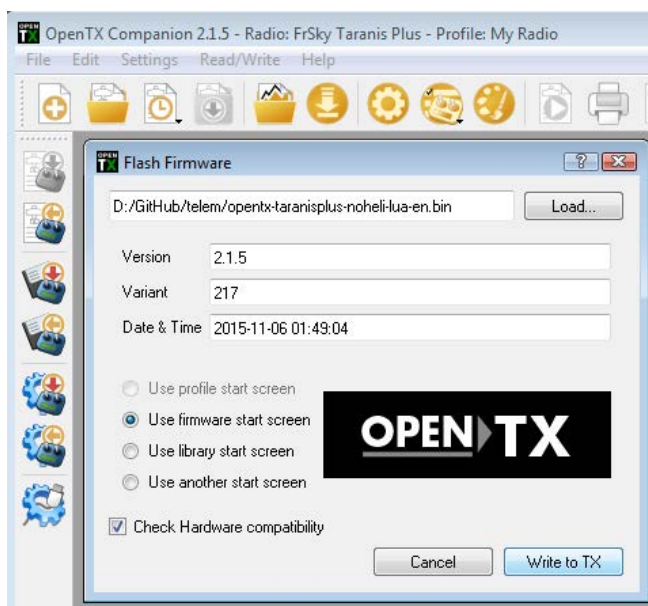
5. Enter bootloader mode on the Taranis by sliding both horizontal trims, each under the main sticks, towards the center and then turning the Taranis on. The top of the Taranis LCD screen should now display “Taranis Bootloader.”



6. Connect a USB cable between the Taranis and the computer. “USB Connected” should appear in the center of the Taranis LCD screen. Click on Read/Write >> Write Firmware to Radio.

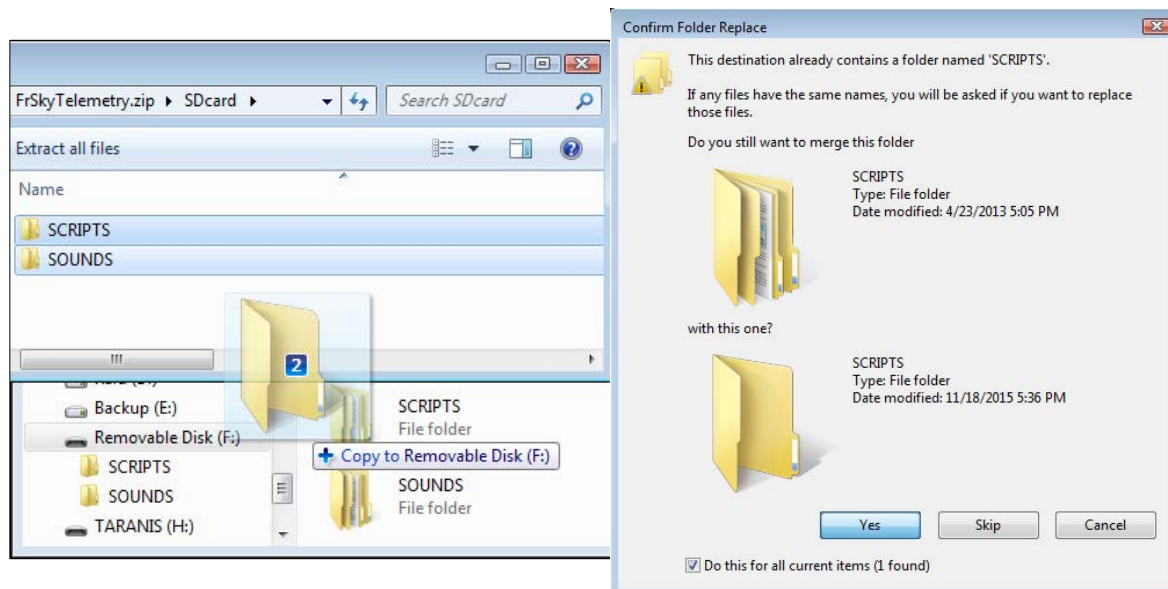


7. Locate/load the firmware (.bin) which was downloaded earlier, then click on the “Write to TX” button. A popup window should display a progress bar which will eventually reach 100%. If flashing is successful, “Flashing done” will appear. Click on the “Close” button to close the popup window.



➤ Copy script files onto Taranis SD card

With the Taranis still in bootloader mode and connected to the computer via USB, extract the contents of the “SDcard” folder found in the zip file provided with your purchase to the root directory of Taranis SD card (the SD card should appear as a computer drive and contains multiple folders, including one named SCRIPTS). When extracting, make sure to “merge” the contents and replace/overwrite any file already on the SD card when prompted. Do not delete the folders already on the SD card before copying the SCRIPTS and SOUNDS folders to the root directory of the SD card.



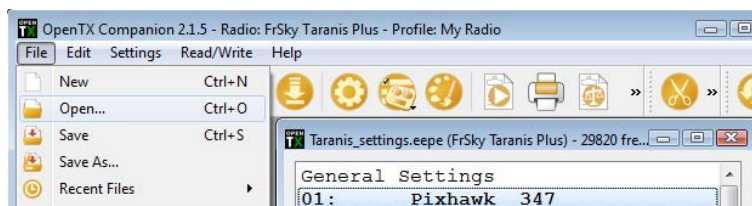
➤ Configure Taranis to discover sensors and execute scripts

Two options (A or B) are offered depending on whether your Taranis already has a model configured for your multicopter which you want to keep.

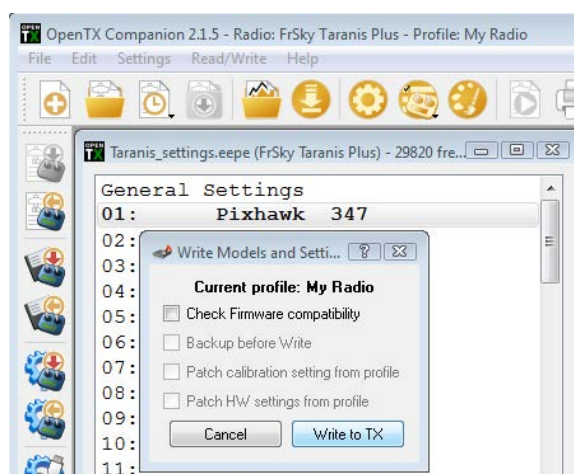
Option A. If you are willing to start with a new Taranis configuration (simple method):

For convenience, a Taranis settings file is provided, which alleviates the need for any of the steps shown in Option B. The drawback is that you will lose any settings currently on your Taranis (which can be backed up using OpenTX Companion before overwriting them).

1. Retrieve Taranis_settings.eepe from the zip file provided with your purchase or download it from github.com/craftandtheory/FrSkyTelemetry
2. In OpenTX Companion, click on File >> Open... Locate and select the Taranis_settings.eepe file and press the “Open” button. A window showing the “Pixhawk” model should appear in OpenTX Companion.



3. With the Taranis still connected in bootloader mode to the computer via USB, click on Read/Write >> Write Models and Settings To Radio. Click on the “Write to TX” button. A popup window should display a progress bar which will eventually reach 100%. Once complete, click on the “Close” button to close the popup window. Unplug the USB cable and turn off the Taranis.



4. You may need to bind your Smart Port receiver to your Taranis again since the Taranis settings have been overwritten. Other settings may differ from your previous configuration, so you are advised to check all settings before any flight!



Option B. If you want to keep your Taranis configuration/models (advanced method):

1. The Pixhawk emulates FrSky sensors and OpenTX 2.1.x requires the emulated sensors to be discovered. To discover, unplug the USB cable, turn off the Taranis, then turn it back on (not in bootloader mode). Repeat the following steps for each model with which you want to use the FrSky Telemetry capability:
2. Press the MENU button, then long press the PAGE button to get to the TELEMETRY page. Press the - button until "Discover new sensors" is highlighted and press ENTER. The Taranis LCD screen should display "Stop discovery."

```
TELEMETRY 13/13
RSSI
Low Alarm 45
Critical Alarm 42
Sensors Value ID
Discover new sensors
Add a new sensor...
Delete all sensors
```

3. Power on the Pixhawk and FrSky receiver. Wait 15 seconds. The Taranis should discover the emulated sensors based on the data from the Pixhawk. The sensors must all be properly discovered for the scripts to run. The Taranis LCD screen should show at least the following sensors as discovered (order not important):

```
TELEMETRY 13/13
Sensors Value ID
1: RSSI [75dB] 25
2: 1000 --- 28
3: 1001 --- 28
4: 1002 --- 28
5: 1003 --- 28
6: 1004 --- 28
7: 1005 --- 28
8: 1006 --- 28
9: 1007 --- 28
10: GPS --- 28
11: Alt --- 28
12: USpd --- 28
13: VFAS --- 28
Discover new sensors
```

If you use a FrSky FLVSS Smart Port LiPo voltage sensor, make sure the FLVSS sensor (named "Cels") gets discovered too.

4. Once the sensors are discovered, scroll down using the - button, and highlight the "none" entry next to "Screen 1." Once "none" is highlighted, press ENT, then navigate the choices with the +/- buttons until "Script" appears. Press ENT to validate, then press - to move to the right (highlighting "- - -"). Press ENT and select "screens" using the +/- buttons, then press ENT to validate. The "screens" script handles the display capabilities. The Taranis LCD display should then look like this:

```
TELEMETRY 13/13
Top Bar
Voltage Source ---
Altitude
Screen 1 Script screens
Screen 2 None
Screen 3 None
Screen 4 None
```



5. Press EXIT once, long press PAGE to get to the CUSTOM SCRIPT page, then press ENT to edit LUA1. On the LUA1 page, press ENT and select “telem” using the +/- buttons, then press ENT to validate. The “telem” script handles the data parsing and sounds.

CUSTOM SCRIPT LUA1	
Script	telem
Name	
Inputs	
mAhx100	0
ShowAh	0
LowVx10	35
CritVx10	34
SoundON?	1
RepeatT	10
Language	0

From this screen, several parameters can also be configured:

- mAhx100 Defines the battery capacity in units of hundreds of mAh (e.g., 50 corresponds to a 5000mAh battery). The value is used to calculate/display the battery bar and % left. Set this parameter if you are out flying and forgot to set the correct battery capacity in Mission Planner (as it overrides the parameter set on the Pixhawk). Set to 0 (default) if you want the value stored in the Pixhawk to be used instead.
- ShowAh Defines whether to show the Ah consumed and battery capacity to the right of the battery bar (default: OFF; set to 1 to turn on).
- LowVx10 Defines the cell voltage level at which the low voltage alarm will blink and sound (default: 3.5V).
- CritVx10 Defines the cell voltage level at which the critical voltage alarm will blink and sound (default: 3.4V).
- SoundON? Defines whether the sound alarms are on (default: ON; set to 0 to turn off).
- RepeatT Defines the period in seconds at which the following alarms will sound: critical cell voltage, battery failsafe, and EKF failsafe.
- Language Defines which language to use for the texts and sounds of the user interface (default: 0 for English, 1 for French, 2 for German).



6. Battery pack voltage, altitude, and vertical speed are transmitted by the Pixhawk and can be used natively in OpenTX. The following example configuration enables their use:

```
TELEMETRY 13/13
Variometer
Source USpd
Range -10 10
Center -0.5 0.5 Silent
Top Bar
Voltage Source VFAS
Altitude Alt
```

The Top Bar display of the voltage and altitude is found in the center, at the top of the main menu screen. In the following example, voltage is 12.31 Volts and the altitude is 125 meters:

```
0.2V 12.31V ^ 125m 06:00
Pixhawk
SA↑ SE↑
SB↑ SF↑
SC↑ SG↑
SD↑ SH↑
FT SKY
OPEN TX
```

Variometer sounds are played if a special function is configured for the use of the Vario, as in the following example where the SF switch will enable/disable the variometer sounds:

```
SPECIAL FUNCTIONS 11/13
SF1 SF4 Vario
SF2 ---
SF3 ---
SF4 ---
SF5 ---
SF6 ---
SF7 ---
```

7. You can additionally setup the display of the latest transmitted latitude and longitude information; for instance, in case of a crash or fly away, to locate your copter. To setup, go back to the TELEMETRY page, scroll down using the - button, and highlight the "none" entry next to "Screen 2." Once "none" is highlighted, press ENT, then navigate the choices with the +/- buttons until "Nums" appears. Press ENT to validate, then press - to move down (highlighting the first "- -" in the table). Press ENT and select "GPS" using the +/- buttons, then press ENT to validate.

```
TELEMETRY 13/13
Screen 1 Script screens
Screen 2 Nums
GPS ---
--- ---
--- ---
--- ---
Screen 3 None
```

Once configuration is complete, turn off the Taranis. The display is ready!

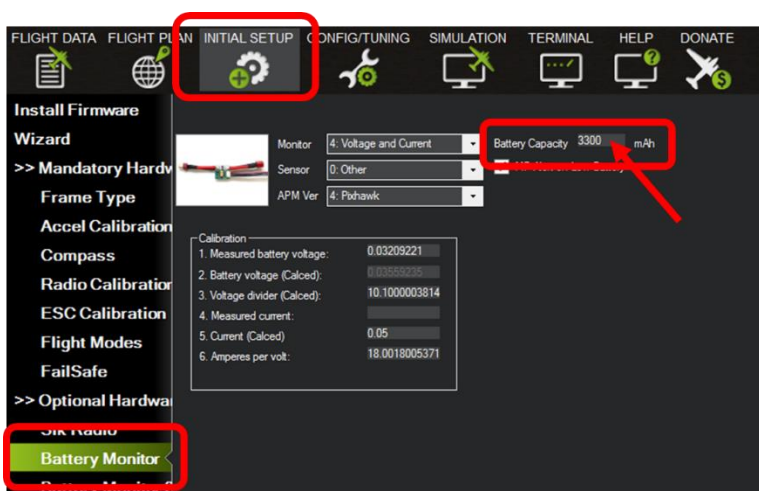
3. Usage and display description

- Configure the Pixhawk for the battery capacity and battery failsafe levels:



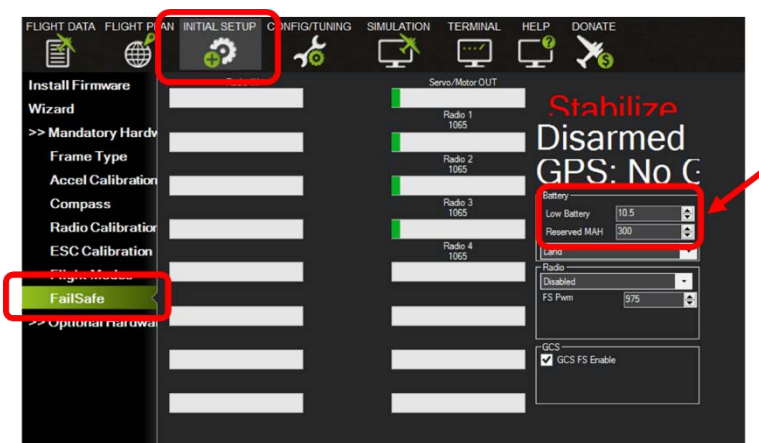
Before turning on your Taranis, verify your Pixhawk's battery configuration, especially when using a battery of different capacity (mAh) or number of cells (S).

1. After connecting your Pixhawk using Mission Planner, click on the "INITIAL SETUP" top menu icon. In the "Optional Hardware" tab, click on "Battery Monitor" and verify the power module configuration. For a complete tutorial on power module configuration, visit: <http://ardupilot.org/copter/docs/common-power-module-configuration-in-mission-planner.html>
2. Set Battery Capacity to your battery's capacity in mAh.



Battery capacity configuration

3. If battery failsafes are used, in the "Mandatory Hardware" tab, click on "Failsafe" and set the "Low Battery" voltage and the "Reserved mAh" capacity.



Battery Failsafe Configuration



➤ **Start the user interface:**

Turn on the Taranis and your Pixhawk (in any order). From the main page, long press on the PAGE button. If the Taranis is configured properly, the LCD display should show one of these two introductory screens (version may vary):



If “Turn ON your Pixhawk” is displayed, you should be automatically redirected to the flight screen within 15 seconds of powering on your Pixhawk.

Flight screen

The first screen contains the following flight and safety information:

Top bar	
Flight mode + simple/super simple mode.	
Flight timer showing actual flight time based on landing detector.	
Radio link quality between Taranis and receiver (link starts to become unreliable at 2 or less bars).	
Taranis battery voltage.	

Left panel		
HUD showing vehicle attitude (each line is 10° pitch increments), horizontal speed (in meters per second) on left, altitude (in meters) on right, and heading with rotating compass bezel at the bottom.		Additionally, ARMED/DISARMED appears for five seconds in the HUD. Battery failsafe, EKF failsafe, and fence failsafe alerts are shown blinking in the HUD.



Right panel		
Battery pack voltage from power module (left) and lowest cell voltage (right) from FLVSS sensor or average from pack voltage. Lowest recorded voltage represented below in smaller font.		If ENT is pressed, the nominal voltage levels are displayed instead for reference, along with the number of cells in the battery pack (e.g., 3S for 3 cells in series).
Current or power draw from power module. Press ENT to toggle between current and power.		The highest recorded current or power draw is represented below in smaller font.
Battery bar with percentage remaining. Blinks below 25%. To be relevant, a fully charged battery is required when turning on the Pixhawk!		Pixhawk must be configured for the power module and the battery capacity (in mAh) used: http://ardupilot.org/copter/docs/common-power-module-configuration-in-mission-planner.html
Direction of home position relative to vehicle orientation (e.g., arrow pointing straight up means Copter facing home).		Home position is determined by the Pixhawk based on a reliable GPS signal, so good GPS is necessary for this feature to work properly.
Distance to home and rangefinder distance (in meters).		Rangefinder distance will be reported only if a rangefinder is connected and configured.
Left: Number of satellites or HDOP (in meters). Press ENT to toggle between the two.		Right: GPS fix status (no GPS, no fix, 2D fix, or 3D fix).



Message bar (bottom)	
Latest MAVLink message (of type statustext, system_status, or ekf_status_report) shown for 10 seconds (blinking for the first 3 seconds).	

MAVLink screen

A second screen is accessed by pressing the MENU button from the first screen. On the main panel of the MAVLink screen, the last five MAVLink messages are shown, in the order in which they were received (latest received message appears at the bottom):

MAVLink screen

This screen allows the user to see text messages usually displayed in Mission Planner, including:

statustext	system_status	ekf_status_report
GROUND START	Bad GPS Health	Error velocity variance
Arm: Safety Switch	Bad Gyro Health	Error compass variance
Arm: Mode not armable	Bad Accel Health	Error pos horiz variance
PreArm: inconsistent compasses	Bad Compass Health	Error compass variance
PreArm: RC not calibrated	Bad Baro Health	Error terrain alt variance
PreArm: Compass not calibrated	Bad LiDAR Health	
Locate Copter Alarm!	Bad OptFlow Health	
...	Bad or No Terrain Data	
	Geofence Breach	
	Bad AHRS	

Custom Telemetry screen

If you have configured “Screen 2” to show additional telemetry, this additional screen can be accessed by pressing “PAGE.” When configured to display “GPS,” the Custom Telemetry screen will show longitude/latitude value pairs as such:



Sounds

The “telem” script will play sounds regardless of which page the Taranis screen is displaying. These sound alarms can be disabled by setting SoundON? to 0 (in the CUSTOM SCRIPT menu). The audible alarms consist of:

- Flight mode (e.g., “stabilize,” “loiter”),
- “Normal/simple/super simple mode,”
- “Armed”/“disarmed,”
- “Landing complete” each time the copter lands (which pauses the flight timer)
- “Message received” each time a MAVLink message of the type shown in the table above is transmitted by the Pixhawk (but no more than once every 5 seconds),
- “Battery at 50%,”
- “Battery warning” when 25% is left,
- “Battery low” if the lowest cell voltage is below the LowVx10 value,
- “Battery critical” if the lowest cell voltage is below the CritVx10 value,
- “Battery failsafe” which repeats every RepeatT seconds if triggered,
- “EKF failsafe” which repeats every RepeatT seconds if triggered.
- “Altitude fence failsafe” or “Circular fence failsafe” which repeats every RepeatT seconds if triggered.



4. END USER AGREEMENT

PLEASE READ THIS AGREEMENT CAREFULLY AS IT CONTAINS IMPORTANT INFORMATION ABOUT YOUR RIGHTS AND OBLIGATIONS, AS WELL AS LIMITATIONS AND EXCLUSIONS THAT MAY APPLY TO YOU. THIS DOCUMENT CONTAINS A BINDING ARBITRATION CLAUSE.

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Craft and Theory warrants to the original retail purchaser that its product will be free from defects in materials and workmanship for ninety (90) days from the date of purchase, or such longer period as is required by applicable law. Products suffering from such defects will be repaired or replaced at the discretion of Craft and Theory, without charge for parts or labor directly related to the defects, provided that the problem has appeared during normal consumer usage and conditions.

The limited warranty extends only to consumers who purchase the product from Craft and Theory or an authorized distributor. This warranty does not apply to:

- (a) Product subjected to abnormal use or conditions, accident (including without limitation, collision, crash or fire), mishandling, neglect, alteration, misuse, improper installation or repair or improper storage;
- (b) Damage from exposure to moisture, humidity, excessive temperatures or extreme environmental conditions;
- (c) Damage from connection to, or use of any accessory, software, or other product not expressly approved or authorized by Craft and Theory;
- (d) Defects in appearance, cosmetic, decorative or structural items such as framing and non-operative parts;
- (e) Damage from external causes such as fire, flooding, dirt, sand, weather conditions, battery leakage, blown fuse, theft or improper usage of any electrical source.

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