











Website: craftandtheoryllc.com
Email: info@craftandtheoryllc.com

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 for the power module used: copter.ardupilot.com/wiki/common-3dr-power-module/</p>
Pixhawk power module		This is the official method of supplying power and providing 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 or X8R receiver		The X8R receiver usually comes with the Taranis.
Pixhawk to FrSky telemetry cable		Needed to connect the Pixhawk to the FrSky Smart Port receiver. Telemetry cable available from craftandtheoryllc.com
USB A to micro-B USB cable		Needed to connect the Pixhawk to the computer (for Mission Planner)
USB A to mini-B USB cable		Needed to connect the Taranis to the computer
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 was provided for download along with your purchase:

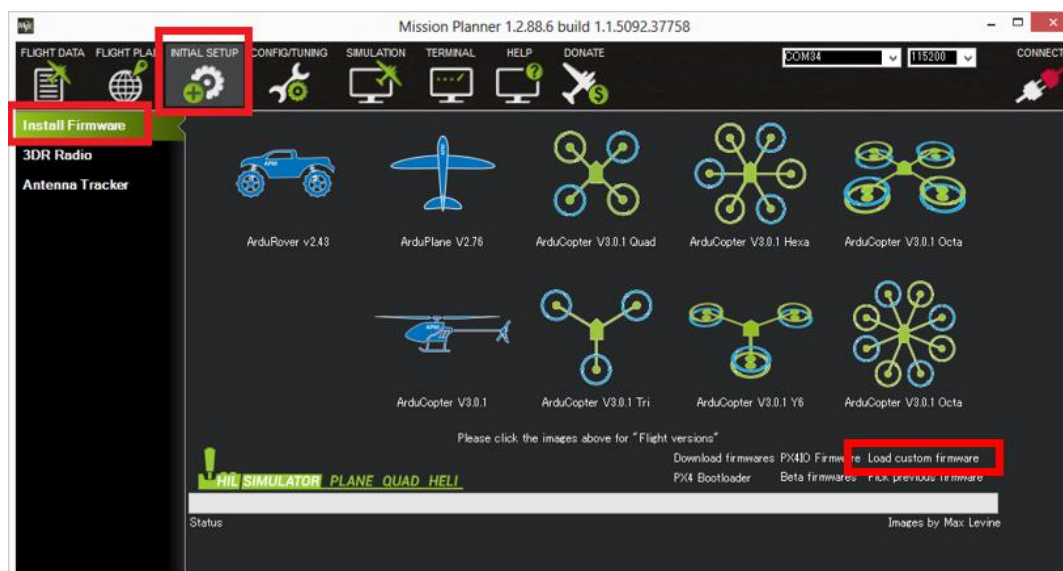
File/folder name	Description
CraftandTheory_FrSkyCableUI_Manual.pdf	This installation and user manual
ArduCopter-v2.px4 (for quad frames)	A modified ArduCopter firmware which must be flashed onto your Pixhawk.
"SDcard" folder	The contents of this folder must be copied to the root directory of the Taranis 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.

Pixhawk autopilot setup

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

1. Retrieve ArduCopter-v2.px4 from the zip file provided with your purchase or download the latest version from github.com/craftandtheory/FrSkyTelemetry. Firmwares for other frames (e.g., heli, tri, hexa, Y6, octa) can be found there.
2. Download and install Mission Planner from ardupilot.com/downloads/?did=82. Connect the Pixhawk to the computer via USB. Start Mission Planner.
3. 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 (ArduCopter-v2.px4), and follow the rest of the flashing instructions.



Mission Planner interface showing how to load a custom firmware.

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.

General instructions on how to flash a firmware onto the Pixhawk are available here: copter.ardupilot.com/wiki/common-loading-firmware-onto-pixhawk/

The modified firmware offers enhanced performance and notable improvements in capabilities (HUD, MAVLink messages, failsafes, etc.). **The ArduCopter-v2.px4 firmware file MUST be the one provided by Craft and Theory. Any other firmware differs in content and will not enable a proper working user interface on the Taranis.**

➤ Pixhawk serial port configuration:

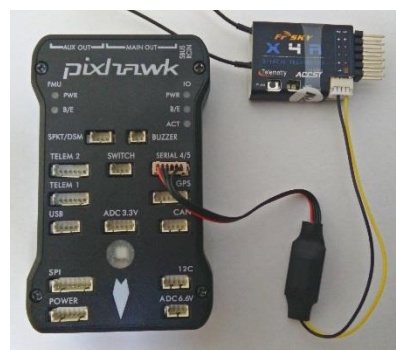
1. Connect the telemetry cable to either the TELEM1, TELEM2, GPS, or SERIAL 4/5 port of your Pixhawk and the other end your Smart Port equipment (X4R, X4RSB, X6R, X8R, or FLVSS sensor).



Once plugged in, the setup should look like this:



Setup with X8R



Setup with X4RSB

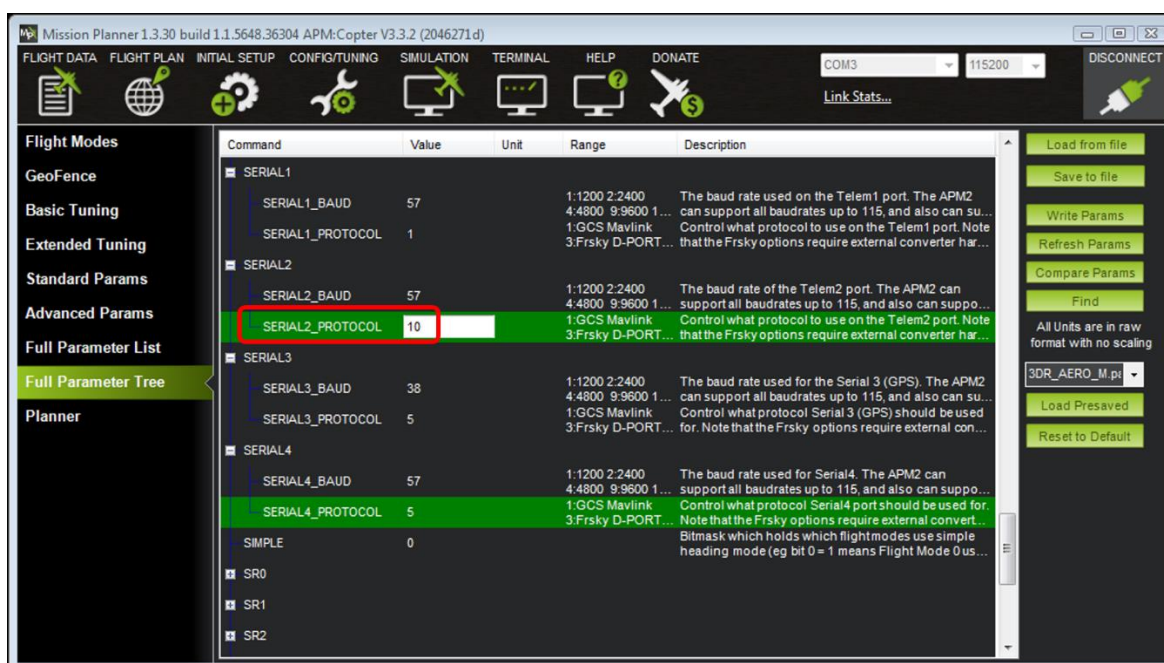
(other connections between Pixhawk and receiver not shown).

- While the modified firmware should automatically configure your Pixhawk for operation on the SERIAL 4/5 port, you can alternatively connect the telemetry cable to the TELEM1, TELEM2, or GPS ports. If you so choose, 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



Make sure to set only one SERIAL#_PROTOCOL parameter to "10" and the others to their default values as only one port can be used for FrSky telemetry at a time!



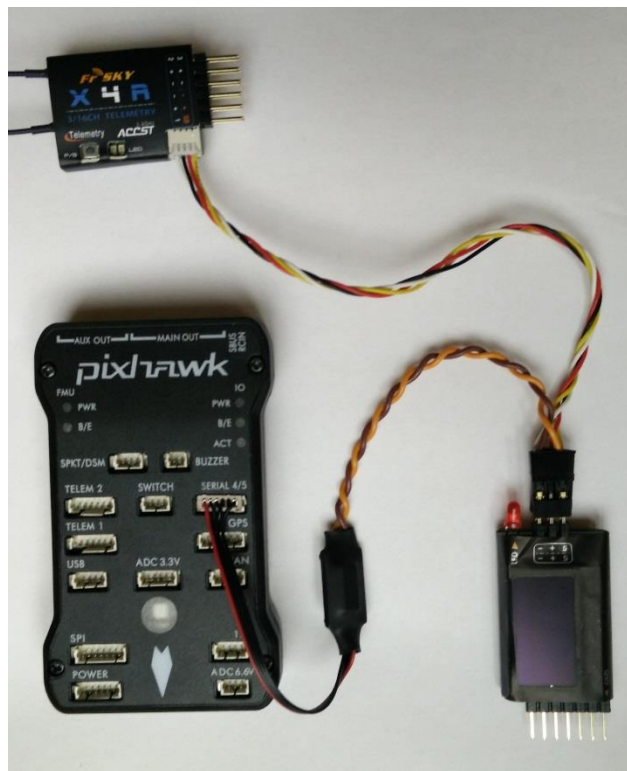
Example Pixhawk configuration where the telemetry cable is connected to TELEM2.

➤ FrSky FLVSS Smart Port LiPo voltage sensor configuration:

The system is compatible with the FrSky FLVSS Smart Port LiPo voltage sensor (also known as SP-FLVS). To install, connect the FLVSS sensor between the telemetry cable and your Smart Port receiver, as shown here:



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



Setup with X4RSB



Regardless of the X-receiver, the telemetry cable is the same model (the X6R, X8R, FLVSS version), connected to the 3 pin 0.1" servo connector of the FLVSS sensor.

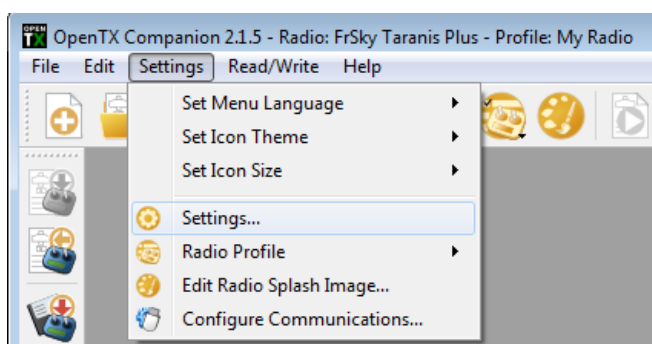
The user interface supports the use of LiPo batteries up to 12 cells (12S) if the Pixhawk power module also supports it. In addition, two FLVSS sensors can be connected simultaneously on the Smart Port bus if properly setup. Setup of dual FLVSS sensors is beyond the scope of this manual and requires 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 one of them (preferably the second one) from "Cels" to "Cel2."

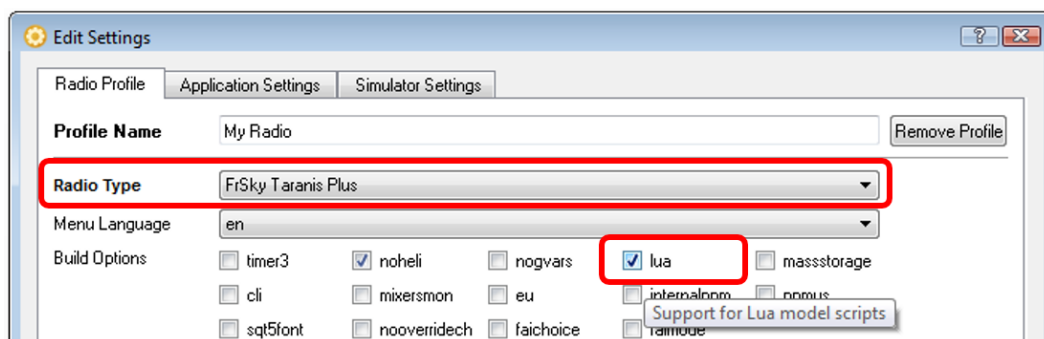
Taranis setup

➤ Update Taranis firmware to OpenTX 2.1.x

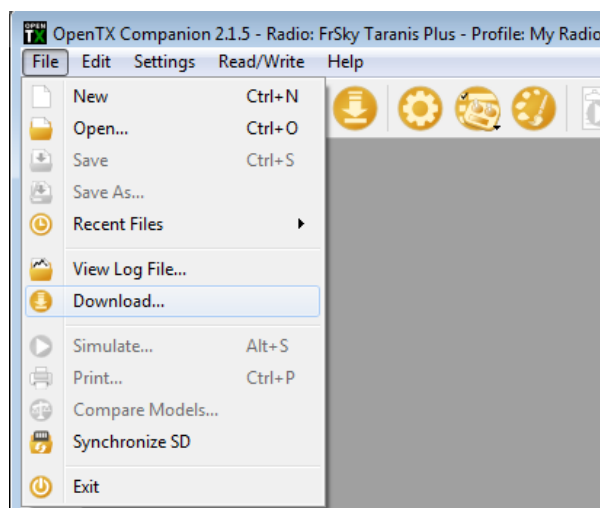
1. Download and install the latest version of OpenTX Companion from www.open-tx.org/downloads.html
2. Open the OpenTX Companion program, then go to Settings >> Settings



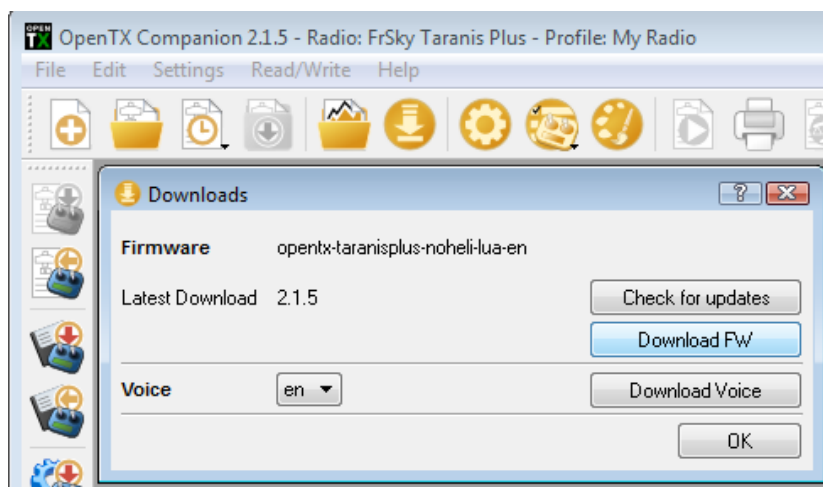
3. Select your "Radio Type" (Taranis, Taranis Plus, or Taranis X9E), make sure the "lua" build option is checked, then press OK.



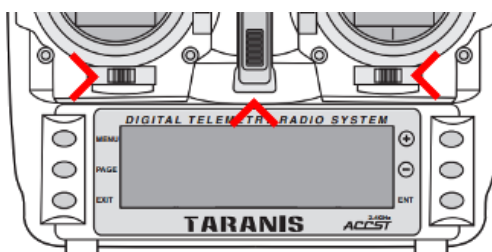
4. Click on File >> Download...



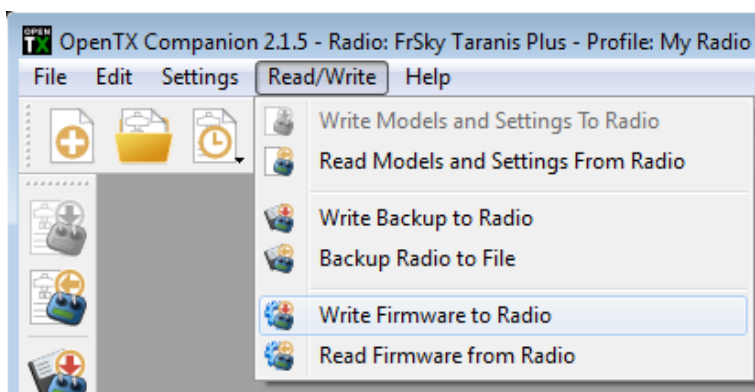
5. Click on the “Download FW” button and save the resulting .bin file. Once the firmware is downloaded, press OK.



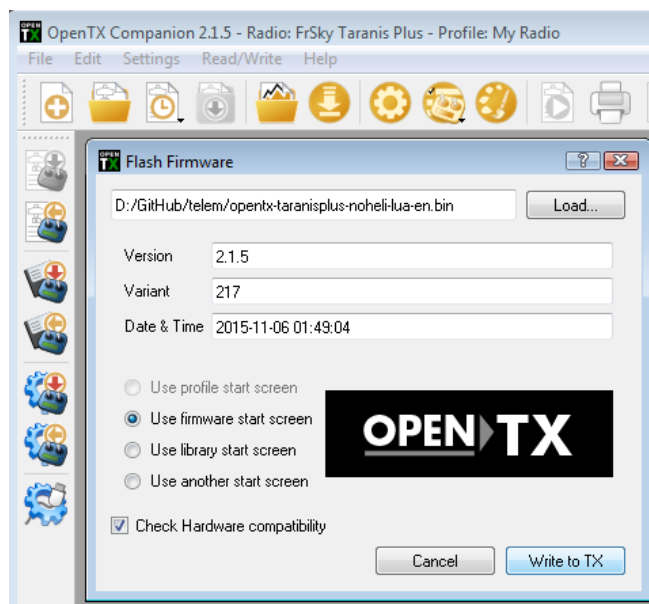
6. Enter bootloader mode on the Taranis by sliding both horizontal trims, each under the main sticks, towards the center and then turning the Taranis on. The top of the Taranis LCD screen should now display “Taranis Bootloader.”



7. 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.

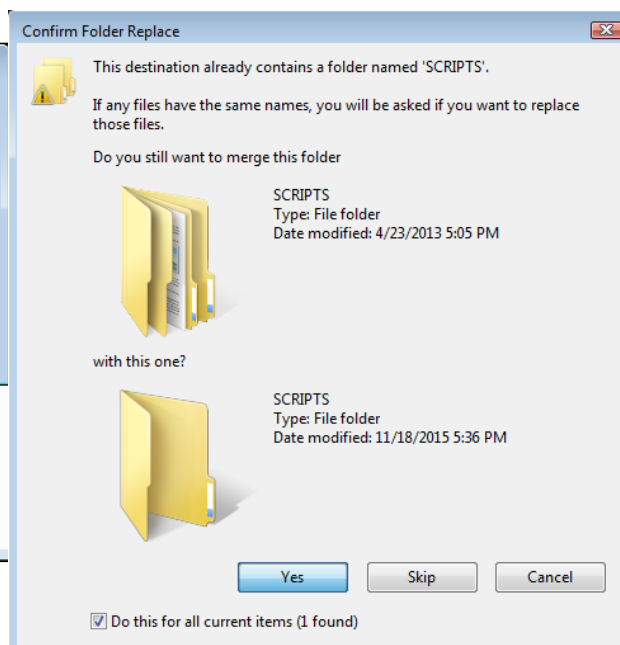
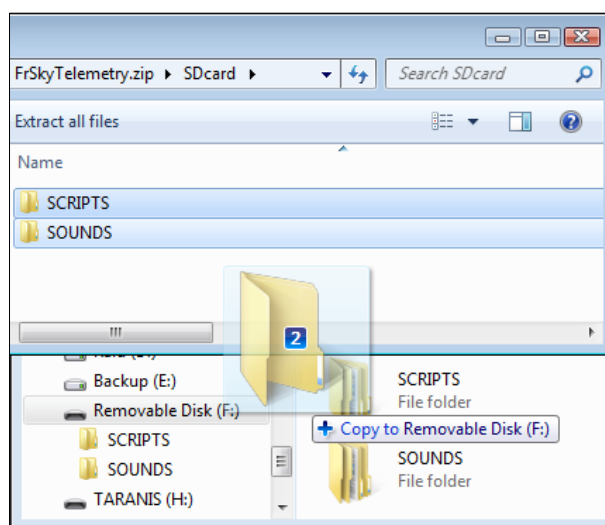


8. Locate/load the firmware (.bin) which was downloaded earlier, then click on the “Write to TX” button. A popup window should display a progress bar which will eventually reach 100%. If flashing is successful, “Flashing done” will appear. Click on the “Close” button to close the popup window.



➤ 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 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 not overwrite (delete) the folders already on the SD card.



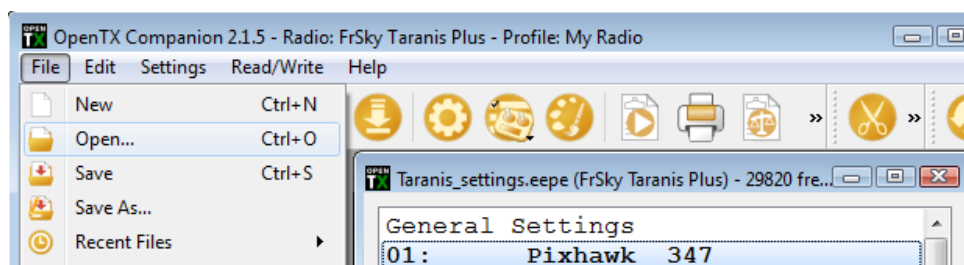
➤ Configure Taranis to discover sensors and execute scripts

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.

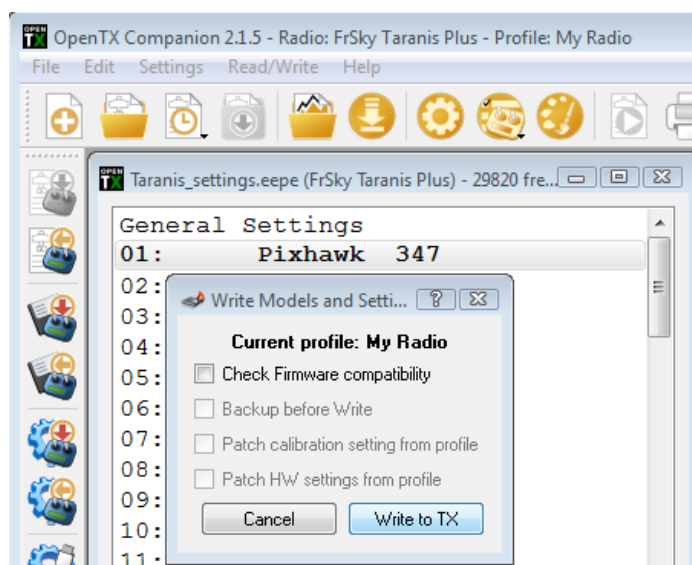
Option A. If you are willing to start with a new Taranis configuration (simple):

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 the 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.

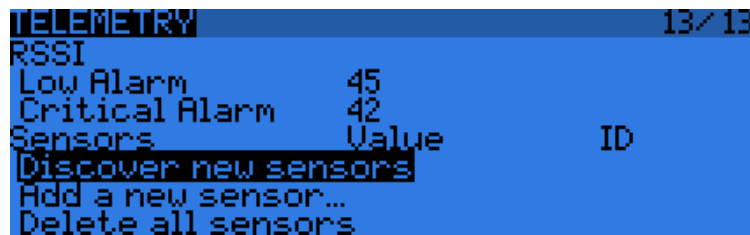




4. You may need to bind your Smart Port receiver to your Taranis again since the Taranis settings have been overwritten. Other settings may differ from your previous configuration, so you are advised to check all settings before any flight!

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

1. The Pixhawk emulates FrSky sensors and OpenTX 2.1.x requires the sensors connected to the FrSky receiver to be discovered. To discover the emulated sensors, unplug the USB cable, turn off the Taranis, then turn it back on normally (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.”



3. Power on the Pixhawk and make sure the FrSky receiver is powered. Wait approximately 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 the following sensors as discovered, in addition to one named “RSSI” and one named “GPS”:



If you intend to 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
LowVx10 35
CritVx10 34
SoundON? 1
RepeatT 10
```

From this screen, several parameters can also be configured:

- 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.
6. 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!

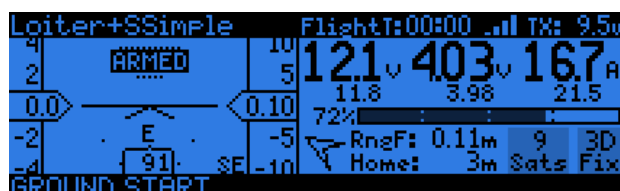


3. Display description and usage

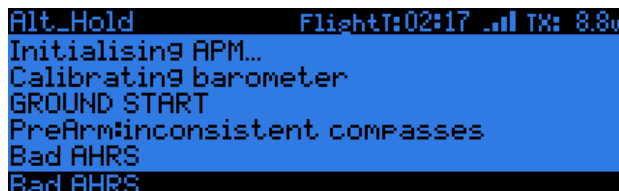
Turn on the Taranis. From the main page, long press on the PAGE button. If the Taranis is configured properly, the LCD display should show this screen:



Press MENU to continue. There are two display screens provided in the user interface. Press MENU to cycle between the Flight screen and the MAVLink screen.



Flight screen



MAVLink screen

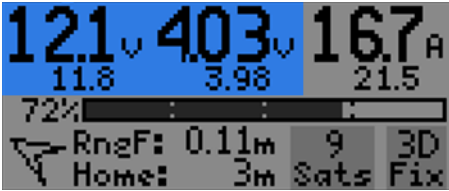
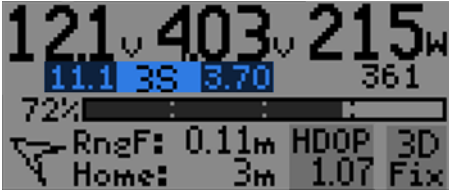



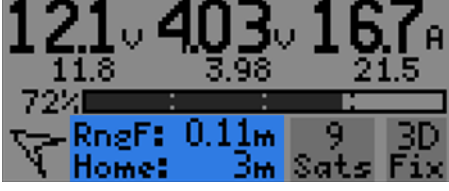

Flight screen

The first screen contains the following flight and safety information from the Pixhawk:

Top bar	
Flight mode + simple/super simple mode.	Loiter+SSimple FlightT:00:00 TX: 9.5v
Flight timer showing actual flight time based on landing detector.	Loiter+SSimple FlightT:00:00 TX: 9.5v
Radio link quality between Taranis and receiver (link starts to become unreliable at 2 or less bars).	Loiter+SSimple FlightT:00:00 TX: 9.5v
Taranis battery voltage.	Loiter+SSimple FlightT:00:00 TX: 9.5v

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



Right panel		
Battery pack voltage from power module (left) and the lowest LiPo cell voltage (right). Cell voltage from FLVSS LiPo sensor (if present), otherwise calculated based on the battery pack voltage.		By default, the lowest recorded voltage is represented below in smaller font.
		If ENT is pressed, the nominal voltage levels are displayed instead, along with the number of cells in the battery pack.
Current or power draw from power module. Press ENT to toggle between current and power.		The highest recorded current/power draw is represented below in smaller font.
Battery bar with percentage remaining (retrieved from ArduCopter). Blinks if below 25%.		Pixhawk must be configured for the power module and the battery capacity (in mAh) used: copter.ardupilot.com/wiki/com-mon-3dr-power-module/
Vehicle orientation relative to home position (e.g., arrow pointing straight down means Copter facing home)		Home position is determined by the Pixhawk based on a valid GPS signal.
Rangefinder distance and distance from home		Rangefinder distance will be reported only if a rangefinder is connected and configured.
Left: Number of satellites or HDOP. Press ENT to toggle between the two.		Right: GPS fix status (no GPS, no fix, 2D, or 3D).



Message bar	
Latest MAVLink message (of type statustext, sys_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 PAGE button from the first screen. On the main panel of this screen, the last five MAVLink messages are shown, in the order in which they were received:

This allows the user to see the 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 (standard OpenTX feature)

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 such as:



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. 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,
- “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.

```
CUSTOM SCRIPT LUA1
Script      telem
Name
Inputs
LowUx10     35
CritUx10    34
SoundON?    1
RepeatT     10
```

“telem” script configuration screen



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.

This is an agreement between you and Craft and Theory LLC with offices located at 2517 Sayles Pl. SE, Unit 11, Washington, D.C. 20020. By accepting delivery of the product, or by downloading, copying, installing, or using all or any portion of the software, or any updates to the software, you accept and are bound to all the terms of this agreement.

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.

Craft and Theory warrants that the software will perform substantially as described in its documentation for ninety (90) days from the date of initial receipt of the software by the original licensee. Licensee acknowledges that (i) the software may not satisfy all of licensee's requirements and (ii) the use of the software may not be uninterrupted or error-free.

In the case of a breach of warranty during the warranty period, the software will be replaced, or the license fee paid for the software (if any) will be refunded, at the discretion of Craft and Theory. The foregoing limited warranty does not apply to any software that is not published by Craft and Theory, including third-party software that programmatically interoperates with the software.



CRAFT AND THEORY MAKES NO WARRANTIES WHATSOEVER FOR SERVICE, SOFTWARE, MAINTENANCE OR SUPPORT FOR NON-CRAFT AND THEORY BRANDED PRODUCTS. SUCH PRODUCTS, SERVICE, SOFTWARE, MAINTENANCE OR SUPPORT ARE PROVIDED BY CRAFT AND THEORY "AS IS" AND ANY THIRD-PARTY WARRANTIES, PRODUCTS, SERVICE, SOFTWARE, MAINTENANCE OR SUPPORT ARE PROVIDED BY THE ORIGINAL MANUFACTURER OR SUPPLIER, NOT BY CRAFT AND THEORY.

THE LIMITED WARRANTY ABOVE IS THE ONLY WARRANTY OFFERED BY CRAFT AND THEORY. TO THE MAXIMUM EXTENT PERMITTED BY APPLICABLE LAW, CRAFT AND THEORY PROVIDES THE PRODUCT AND THE SOFTWARE "AS IS" AND WITH ALL FAULTS, AND HEREBY DISCLAIM ALL INDEMNITIES, WARRANTIES, CONDITIONS, REPRESENTATIONS AND TERMS, EITHER EXPRESS, IMPLIED, WHETHER BY STATUE, COMMON LAW, CUSTOM, USAGE OR OTHERWISE, INCLUDING, BUT NOT LIMITED TO, WARRANTIES OF TITLE AND NON-INFRINGEMENT, ANY IMPLIED WARRANTIES, DUTIES OR CONDITIONS OF MERCHANTABILITY, OF FITNESS FOR A PARTICULAR PURPOSE.

EXCEPT FOR THE EXCLUSIVE REMEDY OFFERED BY CRAFT AND THEORY ABOVE AND ANY REMEDIES THAT CANNOT BE EXCLUDED OR LIMITED UNDER LAW, CRAFT AND THEORY WILL NOT BE LIABLE TO YOU FOR ANY LOSS, DAMAGES, CLAIMS, OR COSTS WHATSOEVER INCLUDING ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES, ANY LOST PROFITS OR LOST SAVINGS, ANY DAMAGES RESULTING FROM BUSINESS INTERRUPTION, PERSONAL INJURY, DEATH, FAILURE TO MEET ANY DUTY OF CARE, STRICT PRODUCT LIABILITY OR OTHERWISE, OR CLAIMS BY A THIRD PARTY, EVEN IF CRAFT AND THEORY HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

THE EXTENT OF CRAFT AND THEORY'S LIABILITY UNDER THIS WARRANTY IS LIMITED TO THE REPAIR, REPLACEMENT, OR REFUND, AS PROVIDED ABOVE. IN NO EVENT SHALL CRAFT AND THEORY'S LIABILITY EXCEED THE PURCHASE PRICE OR LICENSE FEE PAID BY THE PURCHASER OF THE PRODUCT OR LICENSEE OF THE SOFTWARE.

THE FOREGOING WARRANTY, LIMITATIONS, AND EXCLUSIONS APPLY TO THE EXTENT PERMITTED BY APPLICABLE LAW IN YOUR JURISDICTION. YOU MAY HAVE RIGHTS THAT CANNOT BE WAIVED UNDER CONSUMER PROTECTION AND OTHER LAWS.

If any part of this agreement is found void and unenforceable, it will not affect the validity of the balance of this agreement, which will remain valid and enforceable according to its terms. This agreement may only be modified by Craft and Theory. This is the entire agreement between you and Craft and Theory relating to the product and the software and it supersedes any related prior representations, discussions, undertakings, communications, or advertising.

The software is subject to the separate software license agreement accompanying or made available to you in connection with the software. If any portion of the software contains or consists of open-source content, you may use that content under the terms and conditions



under which that content is distributed. You agree that you will be bound by any and all such license agreements. Title to software remains with the applicable licensor(s). In no event will Craft and Theory be liable to you for damages, including any general, special, incidental or consequential damages arising out of the use or inability to use the software.

5. Software License Agreement

This is a license granted by Craft and Theory to use the software. The structure, organization, databases, and source code of the software are the valuable trade secrets and confidential information of Craft and Theory. Except as expressly stated, this agreement does not grant you any intellectual property rights in the software. The software and any authorized copies that you make remain the intellectual property of Craft and Theory. Craft and Theory retains all intellectual property rights to the software and grants you a non-exclusive and non-transferable right to install and use the software on your compatible device in accordance with the terms listed below:

- (a) You are prohibited from installing the software on more than one compatible device concurrently;
- (b) You may make one backup copy of the software (i.e., for re-installation purposes only);
- (c) You may make a one-time transfer of your rights in the software to a purchaser of the device upon which the software is installed;
- (d) You are prohibited from renting, leasing, selling, sublicensing, assigning, lending the software to others;
- (e) You are prohibited from publishing, transferring, copying, or authorizing to be copied any portion of the software onto another computer or device;
- (f) You are prohibited from modifying, porting, adapting, translating, reverse engineering, decompiling or disassembling the software, or otherwise attempting to discover the source code of the software;
- (g) You are prohibited from using this software in any manner other than as permitted by this agreement. You are prohibited from using the software in a manner inconsistent with its design or documentation.