

## Sentinel Automatic Trigger System (SATS-MINI) with VTOL Support – User and Programming Guide

*(as of V1.2.0 software, V2.1 hardware)*

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This document outlines how to use the SATS-MINI. This includes using the Shooty Chute Windows UI program to setup and program the SATS-MINI features. This guide also covers typical applications and setup for the SATS-MINI. Refer to the Product Guide for detailed technical information of the SATS-MINI. Also refer to the online help page [SATS-MINI Quick Start Guide and Resources](#) for more information and the software downloads.

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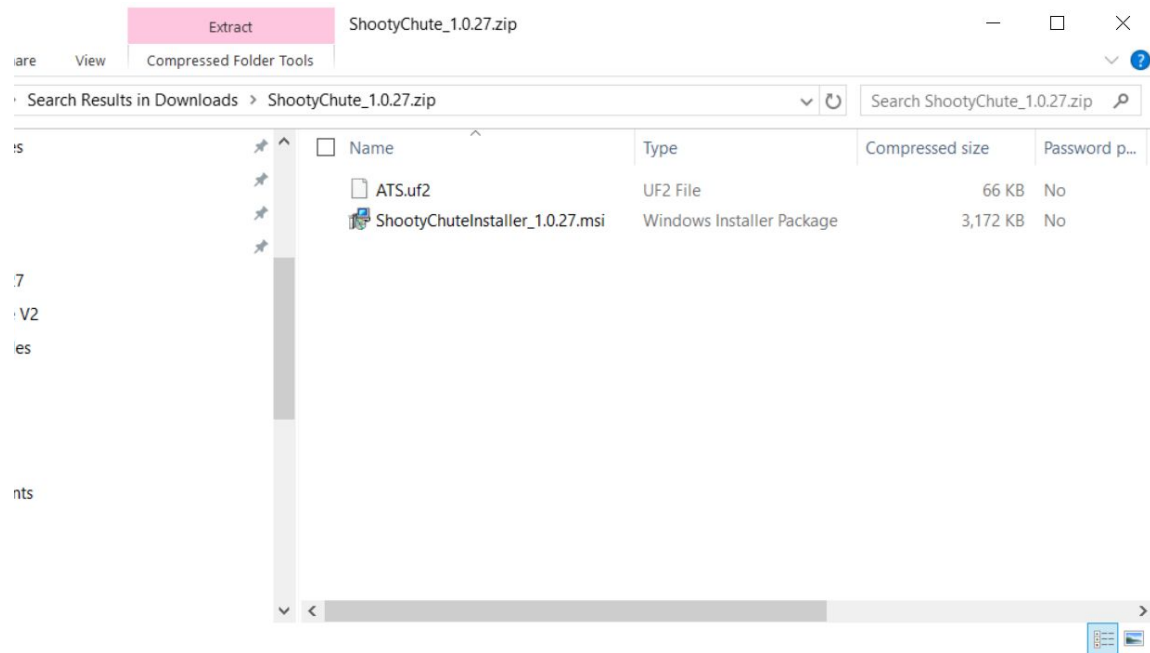
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# ShootyChute Software Installation

## Windows UI Installation

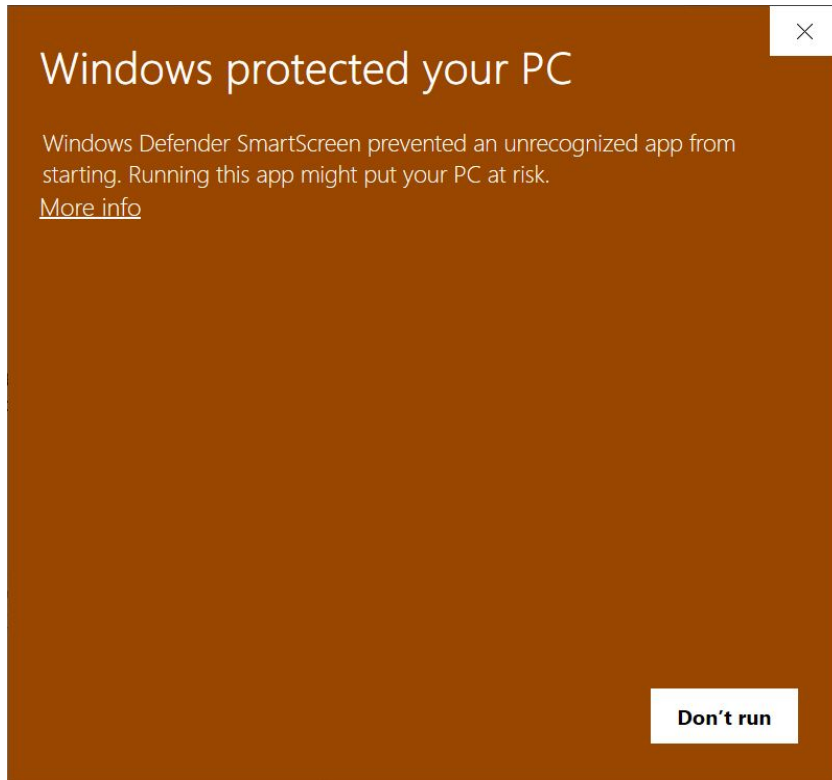
Download the installation bundle navigate to the [SATS-MINI Quick Start Page](#) on our website. Download the .zip file to your local hard drive. All releases have both the Windows UI and the firmware update file named ATS.uf2. We recommend always upgrading both the Windows UI and installing new firmware to maintain compatibility with new features. Below shows screenshots of the installation download.

1 - After downloading you can click on the .zip file to view the contents:

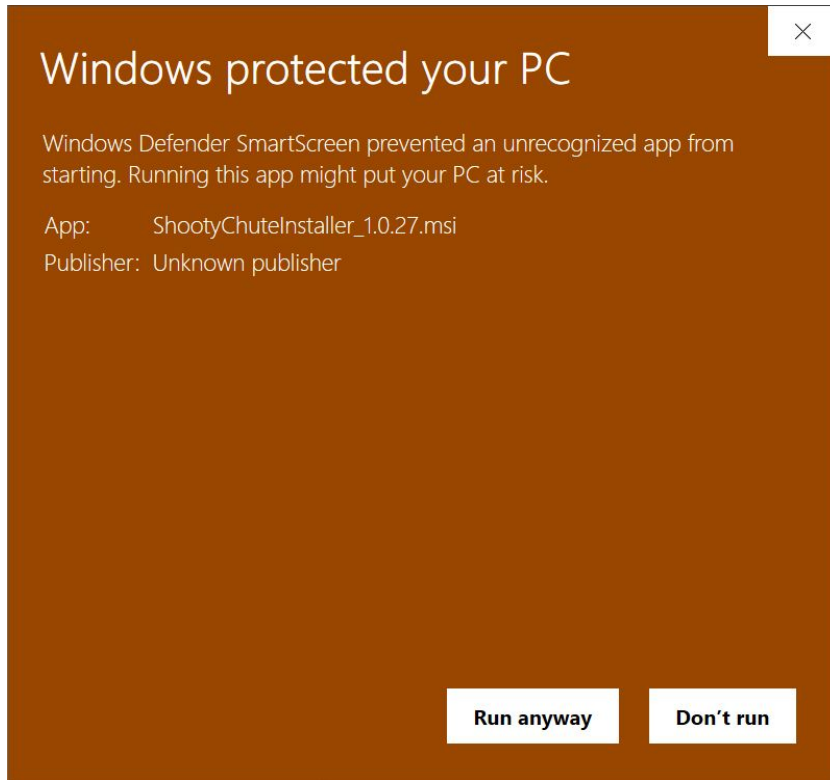


To install the Windows UI click on ShootyChuteInstaller\_xxx.msi to install.

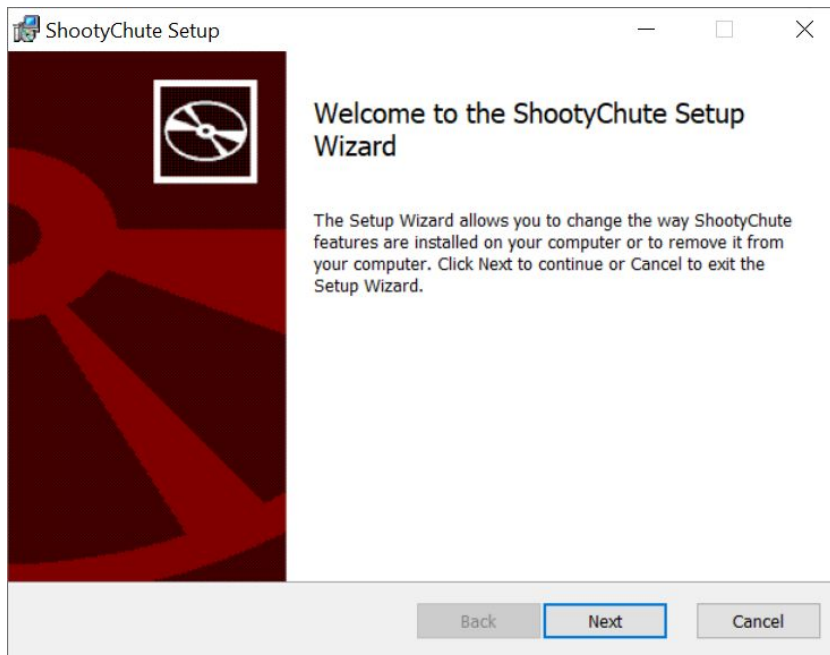
2 - After clicking you may see a screen like this. Click on More Info.



3 - You will then see this. Click on Run Anyway.



4 - Then go through the wizard to install the program. You can install a desktop icon.

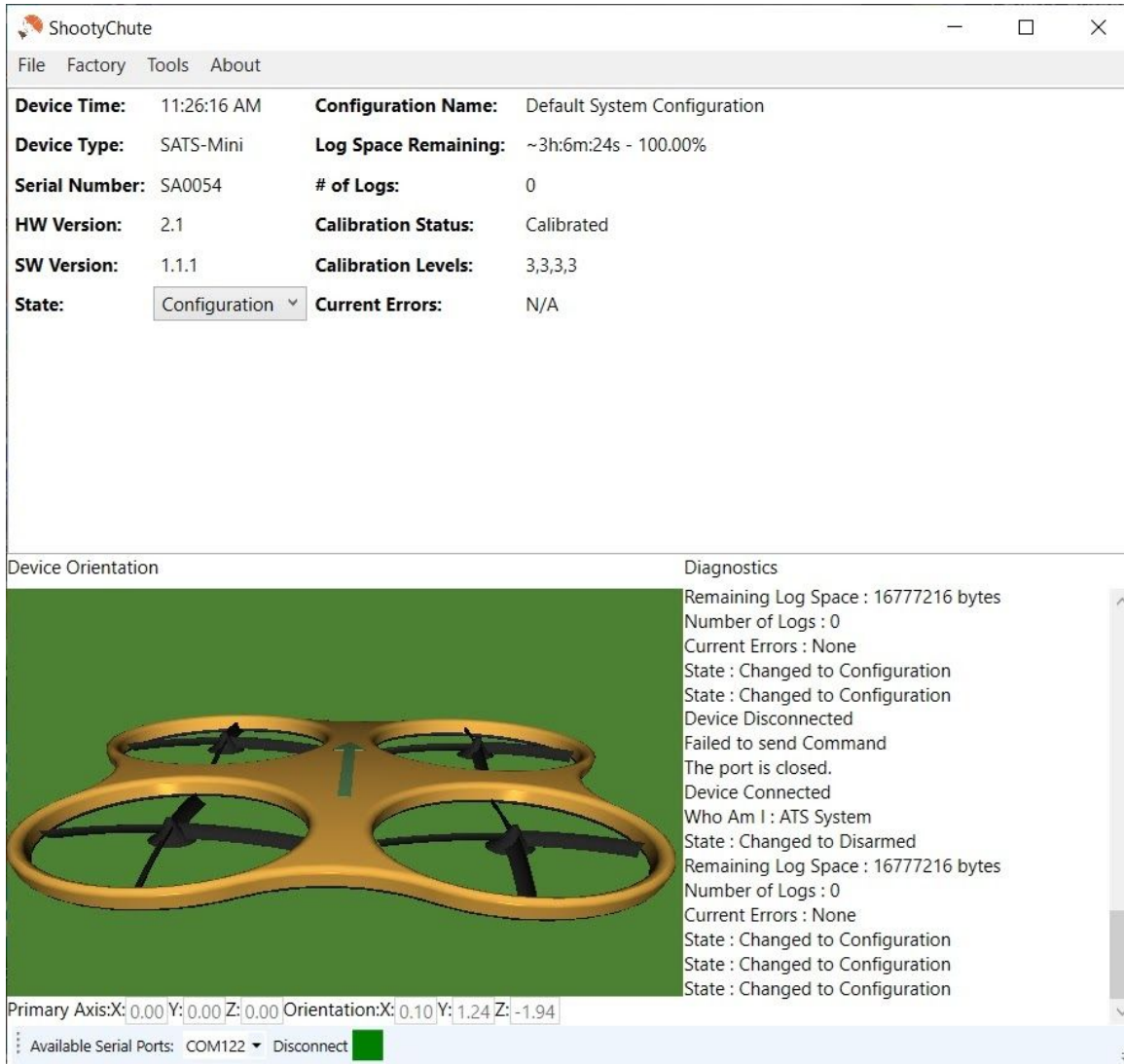


5 - To run the program click on the icon and click Yes to run.

**TIP: Plug in the SATS-MINI USB port first into your PC in order to allocate a port.**

## Connecting the SATS

Select the COM port for the SATS-MINI. If you have several ports listed you may need to try several ports to connect. After starting the ShootyChute app and connecting to the SATS MINI you will have a screen like this.



## Dashboard Information

Moving the SATS-MINI around will cause the virtual drone to track the movement of the SATS-MINI. The screen is divided into several sections:

- Top - This is a dashboard showing various metrics and statuses of the SATS-MINI.
- Bottom Left - This shows the virtual drones and orientation that the SATS-MINI sees.
- Bottom Right - These are diagnostic messages from communications between the SATS-MINI and the ShootyChute UI.

## Upgrading the SATS-MINI Firmware

Firmware updates for the SATS-MINI are formatted as a self installing UF2 file format. The firmware file ATS.uf2 is in the release zip file download. In order to install:

1. Before upgrading the SATS-MINI save your configuration to your hard drive. After the update you can restore your settings to the SATS-MINI.
2. Power up the SATS-MINI and connect the USB cable. You should hear the beep that the USB port is recognized.
3. Before you start make sure the SATS-MINI is in the Idle state, the green light should be flashing which is Idle.
4. To load the firmware use a paper clip or other small tool and press the reset button twice within 1 second or less. There is an access hole in the SATS-MINI case to reach the Reset button (RST). This will put the SATS-MINI into the Bootloader mode and a drive letter will show up in your Windows File Explorer that says FEATHERBOOT. The status LED will also pulse red.
5. Open up the zip download folder. Drag the ATS.uf2 file into the FEATHERBOOT folder and you should see the red light flicker and the SATS-MINI will restart.
6. After the update you may have a purple flashing mode like indicating a configuration error. In all cases you should do a Factory Reset to configure the EEPROM and Flash memory to use the new firmware.
7. After Factory Reset the green idle light will start to flash and the SATS-MINI will be in Idle.
8. If you have a saved configuration you can load that up.

## Configuring the SATS-MINI using Shooty Chute Windows app

### Tools - Device Setup - General Settings

This is covered in the Quick Start guide.

### Tools - Device Setup - Channel Settings

After connecting to the SATS-MINI to configure the device click on Tools - Device Setup. This will open up a screen where you can configure all the features of the SATS-MINI.

The screenshot shows the 'Device Setup' window with the 'General' tab selected. The 'General Settings' section includes a configuration name field set to 'Default System Configuration', primary axis coordinates (X: 0.00, Y: 0.00, Z: 0.00) with 'Acquire' and 'Reset' buttons, a safety altitude of 0 meters with a checked 'Latch Armed' option, a supply power auto-shutdown timer set to 30 seconds, a log frequency of 20 Hz, and checkboxes for 'Terse Logging Mode', 'Auto-Erase Log', and 'Power On in Safety Mode'. The 'Channel Settings' section is divided into four channels:

- Channel 1 (5V Out):** Name: Trigger; Channel Type: Output Trigger; Channel Mode: PWM; Hold (deg): 45; Trigger (deg): 135; Always On: checked; Trigger Delay (ms): 0.
- Channel 2 (5V Out):** Name: Mode Select; Channel Type: Input Flight Mode Select; Channel Mode: PWM; Trigger (µs): 2000; Tolerance (%): 20; Trigger Flight Mode: Fixed Wing.
- Channel 3 (5V In):** Name: V2 Trigger; Channel Type: Output Trigger; Channel Mode: PWM; Hold (deg): 45; Trigger (deg): 135; Always On: checked; Trigger Delay (ms): 0.
- Channel 4 (5V In):** Name: NANO Ext Trig; Channel Type: Input Trigger; Channel Mode: PWM; Trigger (µs): 2000; Tolerance (%): 20.

At the bottom of the window are buttons for 'Save to File', 'Load from File', and 'Send to Device'.

## Tools - Device Setup - General Setting Details

The general settings allow you to configure high level functionality of the SATS-MINI. These are:

- Configuration Name - Enter for example your Drone name and other information that describe the setup.
- Primary (UP) Axis - This lets you capture the current SATS position and define this as UP. Mount the SATS-MINI on your drone and with the drone level, and pointing to magnetic north press Acquire to capture the IMU orientation that defines the drone up (Z) axis.
- Safety Altitude (m) - Enter the altitude where below this the SATS is in Safety, and above the SATS-MINI will go to armed. Entering 0 disables this feature. Units are meters.
- Supply Power Auto-Shutdown - Is enabled this causes the SATS-MINI to automatically turn off after a delay of XXX seconds after power removal. Use this to automatically allow the SATS-MINI to turn on, and also turn off bases on the external 5V power supply. (Software V1.0.29 and above)
- Flight logging options - Log Frequency, Terse Logging, Auto-Erase Log. These are prescribed below.



- Log Frequency - The Flight Log (black box recorder) can record at different rates as of V1.1.1 at 5hz, 10hz or 20 hz. Pre version 1.1.1 only 10 hz is available. The default log frequency is 10 entries per second. At 10 hz the flash memory can hold over 6 hours of flight time (when in safety or armed). Setting to 5 hs will approximately double the time available. 20 hz will be approximately half the time. In all cases the ShootyChutes dashboard will indicate the log space available, and how many flight logs are currently recorded. (Version 1.0.30 and later)
  - Terse Logging - If selected the detailed Flight logging is suppressed to save log space. However if triggered the previous 100 log events are written to Flash, then the trigger details. This allows many more flights to be made before the log fills up.
  - Auto-Erase - If enabled when the log memory is full the ISATS-MINI will automatically erase the log on upon power up.
- Power On in Safety Mode - Use this to cause the SATS-MINI to always power up in Safety / Armed mode. This makes sure the SATS-MINI is always ready to protect your drone even if the SATS-MINI is disarmed after use. We recommend this feature if enabled is used along with Altitude based safety. (V1.0.30 and later)

### **Tools - Device Setup - Channel Settings Details**

The SATS-MINI supports many virtual channel features. These include:

- Output Trigger - Output activated to eject the parachute or for Flight Termination
- Input Trigger - Input for an external trigger signal to eject the parachute
- Input Safety Override - Input used to assert the Safety state
- Output System Status - Output that signals when the SATS-MINI are in a specified operation state.
- Input Flight Mode Selector - Allows an external input to cause the SATS-MINI to select either of two completely independent sets trigger conditions. This is useful for VTOL aircraft where there are two distinct modes of flight being vertical take off (multi-copter) or forward flight (fixed wing).

All inputs and outputs support PWM signal type. Also supported are DC level types.

### **Inputs and outputs during startup**

All IO pins will float during device startup (tri-state). If during this time you want to make sure a pin is held high or low use an external 1K resistor to pull high or low. Once the SATS-MINI is active outputs will be immediately driven depending on configuration.

Input's one active have passive 10K pullups and unless driven low will otherwise float high.

## Channel Configuration for Default Configuration

**Channel Settings**

Channel 1 (5V Out)		Channel 2 (5V Out)	
Name:	Trigger	Name:	Trigger Delayed
Channel Type:	Output Trigger	Channel Type:	Output Trigger
Channel Mode:	PWM	Channel Mode:	PWM
Hold (deg):	45	Hold (deg):	45
Trigger (deg):	135	Trigger (deg):	135
Always On:	<input checked="" type="checkbox"/>	Always On:	<input checked="" type="checkbox"/>
Trigger Delay (ms):	0	Trigger Delay (ms):	500

Channel 3 (5V In)		Channel 4 (5V In)	
Name:	Sky V3 Trigger	Name:	NANO Ext Trig
Channel Type:	Output Trigger	Channel Type:	Input Trigger
Channel Mode:	PWM	Channel Mode:	PWM
Hold (deg):	45	Trigger (us):	2000
Trigger (deg):	135	Tolerance (%):	20
Always On:	<input checked="" type="checkbox"/>	Acquire	
Trigger Delay (ms):	0		

Save to File Load from File Send to Device

The image above shows the channel configuration that will work for most applications.

Channel 1 - Trigger out, PWM, 45 to 135 degrees servo position, PWM always on, 0 ms delay

Channel 2- Trigger out, Level, High, 500 ms channel delay

Channel 3 - Trigger out, PWM, 45 to 135 degrees servo position, PWM always on, 0 ms delay, Channel can accept 5V power in. This is ideal for the Skycat V3 trigger which supplied 5V power to the SATS-MINI. and also accepts the parachute trigger in.

Channel 4 - Input Trigger, Detect PWM pulse at 2000us +- 20%. This is ideal for the Nano TBS receiver used for the rescue radio.

For Trigger PWM output the Always On option, when checked, causes the PWM pulse to always be present at all times so a mechanical servo is always driven. Clearing this will cause the servo PWM to only be present when the servo needs to move. Not checking Always On can possibly save power. Electronic servo switches, like those used on the the Skycat V2 or V3 trigger, must have a continuous pulse in order to operate properly. In this case Always On must be checked.

In all cases for PWM outputs the servo position can be set using the sliders. For Trigger PWM outs the position is listed as servo arm degrees with the default being 45 degrees (1000us) and 135 degrees(2000us). These can be manually set as well by typing the degrees into the box.

For PWM inputs these wait for a pulse width where the pulse high time matches the Trigger (us) value and within the tolerance. The default is 2000us (2 ms) with a tolerance of +- 20%. Use the Acquire button to sample the current PWM pulse and save it to the uS box. Be sure the tolerance is set to 10% or more.

### Input Safety Override, Output Status

The screenshot below shows the SATS channels programmed for four variants of Input Safety, and Output System Status.

The screenshot displays the 'Channel Settings' interface for four channels, arranged in a 2x2 grid. Channel 1 (5V Out) is named 'In Safety PWM', has an 'Input Safety Override' type, 'PWM' mode, and is armed with a 2000us pulse and 20% tolerance. Channel 2 (5V Out) is named 'In Safety Level', has an 'Input Safety Override' type, 'Level' mode, and is armed at a 'High' level. Channel 3 (5V In) is named 'Out Sys Stat PWM', has an 'Output System Status' type, 'PWM' mode, and is triggered by a 2000us pulse with a 45us hold. Channel 4 (5V In) is named 'Out Sys Stat Lev', has an 'Output System Status' type, 'Level' mode, and is triggered at a 'High' level. All channels have a 'Trigger State' of 'Disarmed'. A vertical scrollbar is visible on the right side of the interface.

### Channel 1 and Channel 2 - Safety Override

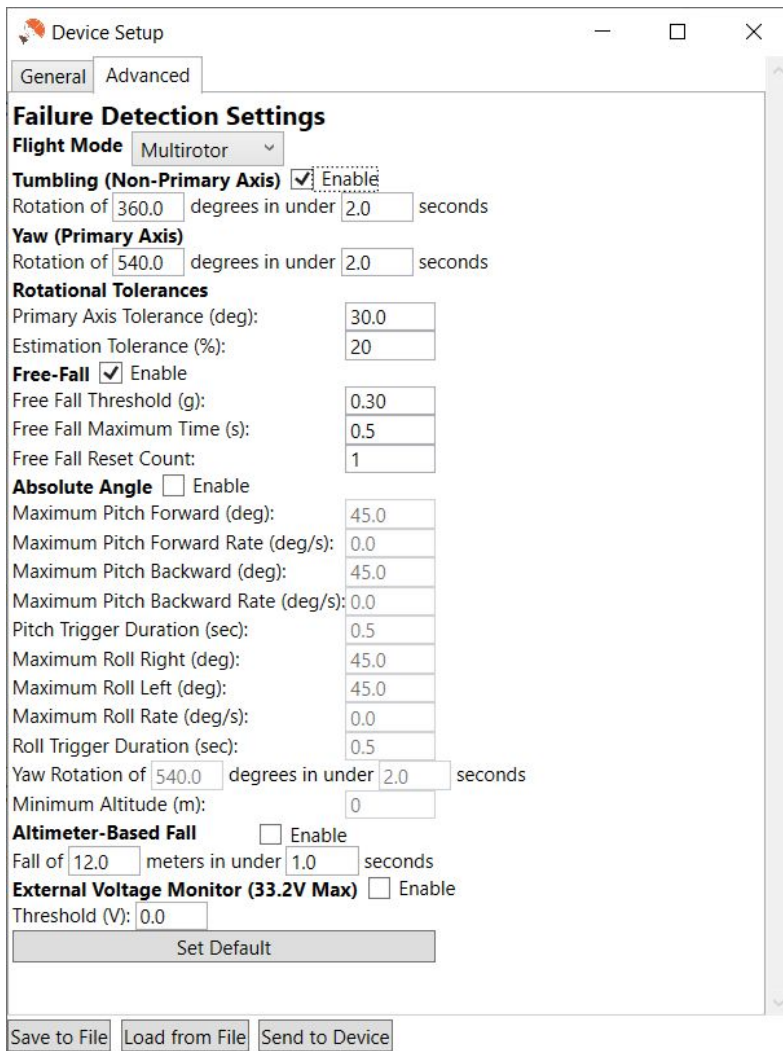
This allows an external device like the Pixhawk Autopilot auxiliary channel to manually assert a safety override of the SATS-MINI. If configured the default is to stay in safety unless the armed uS or level, depending on configuration, are met. For example Channel 1 is set to look for a 2000us wide PWM pulse. The SATS-MINI will stay in the Safety as long as the PWM input pulse does not match 2000us (+- tolerance). Once the PWM pulse matches then the SATS-MINI goes into the armed state. If Latch Armed is set the SATS-MINI will stay armed once entered. Otherwise the SATS-MINI can toggle between Armed and SAFETY depending on the PWM pulse. Same basic operation applies for Level detection.

### Channel 3 and Channel 4 -Output System Status

This programs the channel outputs to signal when the SATS-MINI is in a given operational status. Both PWM and Level output types are supported. Use this for example to signal the Autopilot is the parachute system in the Armed state or Safety state.

### Tools - Advanced Settings

Click on the Advanced Tab to configure the SATS-MINI parachute trigger conditions.



## Flight Mode

As of V1.2.0 the SATS-MINI supports multiple flight modes, these are labeled Multirotor and Fixed Wing. Used together the SATS-MINI can be used with VTOL aircraft.

## Miltirotor Specific Detection Features

Typically miltirotor would use the trigger features Tumbling (Non-Primary Axis) and Yaw (Primary Axis) detection with Rotational Tolerance to control how the Z axis rotation is measured.

### Tumbling (Non-Primary Axis) failure settings

These settings control the trigger of the SATS-MINI due to rotation around the X or Y axis. The default is 360 degrees rotation in 2 seconds or less.

### Yaw (Primary Axis) Settings

These settings control the trigger of the SATS-MINI due to rotation around the Yaw (Z) axis. The default is 540 degrees rotation in 2 seconds or less. This allows the panning rotation of the drone to have a larger margin before the SATS triggers.

## **Rotation Tolerance**

The Primary Axis Tolerance (deg) sets the allowable deviation of the Yaw (Z) axis from perfect vertical. As long as the Yaw is within this deviation then the Yaw axis settings will govern the detection of rotation. If the Yaw axis is past the allowable tolerance then the SATS-MINI will fuse all three X / Y / Z axis to determine rotation and also use the Tumbling settings for detection.

The Estimation Tolerance (%) is used by some internal code in case of high speed rotation to guard against sampling aliasing. The SATS-MINI samples at 40 times per second and because of the high sampling rate this setting may be removed in a future version.

## **Fixed Wing Specific Flight Mode - Absolute Angle**

This detection allows a virtual “flight envelope” to be specified while in Fixed Wing mode. Settings include maximum pitch forward and back. Also roll both left and right.

Maximum angular rate specified in degrees per second can also be specified for both pitch forward, and backwards. Also for roll rate for both left or right.

For all detection types a time component can be specified that allows averaging of the measurements. Having a short time, like 0.1 seconds, means the trigger happens very quickly when exceeding the maximum for a short time. Having a long time slows the detection down and makes the SATS-MINI more forgiving when moving quickly in and out of the maximum range.

Like the Miltirotor Yaw trigger Absolute Angle and has this trigger source to guard against fast rotation that might be a sign of a top-stall, or flat spin.

For all angular trigger setting the value to 0 will disable it.

**NOTE:** There is no hard rule which detection type must be used for either flight mode. For example some flyers may want to use Absolute Angle for both Multirotor and Fixed Wing.

## **Common Detection Types for all Flight Modes**

The remaining detection types are available in both flight modes. Settings in one flight mode are independent of the other so these can be closely tailored to the specific application.

### **Free Fall Settings**

This setting guards against power failure where the drone falls from the sky. Default settings are acceleration under 0.3 g detected for 0.5 seconds duration. This should be good for most Multirotor applications. This is equivalent to about 6 ft of falling. The Free Fall Reset count tells the SATS-MINI how many samples are allowed where the g force may exceed the threshold to then reset the time. This guards against possible false vibration from being able to hold off free fall detection. For Fixed Wing use Free Fall may be trickier to use.

### **Altimeter-Based Fall**

This allows the detection of failures where the drone is coming down fast, but not in free fall, or flipping out of control. This can happen if you have low power where altitude can not be sustained and the drone is not completely out of control. We call this a “slow motion crash”. (Version 1.1.1 or later).

## **External Voltage Monitor**

Your main power for your drone can be connected to the expansion port pin 8. The SATS-MINI can monitor up to 33.2V max. If enabled when the external voltage falls below the threshold set then the SATS-MINI will trigger the parachute. This feature addresses one of the ASTM F3322-18 requirements for external power monitoring. (1.1.1 or later software).

## **Saving and Loading Setups**

At the bottom of the Device Setup screen are buttons that can save and load configuration, as well as to send the configuration to the SATS-MINI.

Save to File and Load to File - Use these to save or load your SATS-MINI configurations to your hard drive. This is also good to use before upgrading your SATS-MINI software in case there are configuration changes.

## **Send to Device**

Edit made to the SATS-MINI settings are not immediately sent to the device. Once you have made all your changes then use the Send to Device button to upload to the SATS-MINI. After the upload the device will auto-restart with the new settings active..

## **Other Tools**

### **Send Default Configuration**

This sends current release default configuration to the SATS-MINI overwriting the current configuration. The SATS-MINI will auto-restart after uploading.

### **Dump Log**

Use this to download the flight log to your hard drive. The file is saved in .csv format suitable for viewing in Excel or Google Sheets.

### **Erase Log**

After downloading you can erase the log file. Unless erased logs from each flight will be appended to the previous log. The SATS-MINI flash memory can record a bit more than 6 hours of detailed flight information.

### **Reset to Factory Defaults**

Use this to reset the configuration EEPROM and Flash memory to the default factory settings. After some software upgrades this may be needed to reset the configuration. The UI will let you know after upgrade if you must do a Factory Reset. This can take about 5 minutes to complete.

## **SATS-MINI Installation**

The SATS-MINI can be installed in any secure location on the drone where it can be accessible. Also when using the Multirotor trigger only the SATS-MINI can be installed in any orientation. If you have 5V available from your Autopilot then that can be connected to Channel 3 or Channel 4 to provide external power to the device. This will also charge the liPo battery. After installing be sure to calibrate the device, outlined below.

## SATS-MINI Orientation Calibration

In order to optimize the SATS-MINI detection algorithm for Multirotor only applications you need to tell the system which way is up. The calibration procedure allows you to mount the SATS-MINI on your drone in any imaginable orientation and it will work the same. Follow these steps:

1. Mount the SATS-MINI on your drone. Any orientation is Ok.
2. Turn on the SATS-MINI, The IMU is calibrated at the factory so it can quickly orient magnetic north. But we do recommend moving your drone 90 degrees in all three axis to make sure the IMU is locked. You may see a jump in the virtual drone position indicating the IMU is locked.
3. This next step is optional and is not required for proper SATS-MINI operation. In order to have the SATS-MINI exactly track your drone movement so the Shooty Chute virtual drone matches the physical drone movement you will want to orient your drone to face magnetic North. If you have a cell phone compass, or a tool like GPS Essentials it can tell you which way to point your drone.
4. Next put your drone in a level position (optionally facing magnetic north) so calibration can capture the physical SATS-MINI orientation. In the UI go to Tools - Device Setup. Click Acquire in order to capture the raw IMU orientation. You will see angle values populate the X / Y / Z fields. Clicking acquire again should result in consistent values.
5. Upload that to the SATS-MINI and restart the SATS-MINI.
6. Reconnect the UI and the SATS-MINI and the UI drone should appear level and the drone arrow will face away from you. You may need to rotate your drone 90 degrees around the Z axis to get the IMU to lock. If you did step #3 your movement of the drone tilting will be exactly matched by the UI Drone. Also it's key that the IMU is internally calibrated (step 2). If the virtual drone does not seem to be in the proper orientation then the IMU manometers may not have been completely settled when you acquired the position. Repeat the calibration process if needed. In any case the Z axis will be very close to optimal for the detection algorithm to work properly after calibration in any case

## Testing and Verification

After setting up your SATS-MINI be sure to test and verify all operations. Use the ShootyChute UI for some of these tests.

### Multirotor drones

NOTE: The SATS-MINI is not designed for Aerobatic or racing drone applications. It is optimized for delivery, photography, or industrial drone applications.

1. Test for rotation detection - This may be easiest to do before the SATS-MINI is mounted to the drone. After arming with the red light flashing flip the device end over end and the SATS-MINI should trigger showing a blue flashing light. You can use a Servo to verify movement.
2. Test for Free Fall detection - After arming, toss the SATS-MINI into the air about 6 ft up being careful to minimize rotation allowing the accelerometer sensor to detect free fall. After about ½ second the SATS-MINI should trigger to a blue light.
3. Make sure the SATS-MINI IMU is calibrated. The ShootyChute UI top pane note the line Calibration Status says "Calibrated". All units are calibrated at the factory and should not need recalibration. If it does not indicate calibration or you see the Error indicator show that there is a IMU error contact Fruity Chutes for assistance.

4. With the drone level on the ground using the ShootyChute UI check that the virtual drone should also be level.
5. Rotating the drone will cause the virtual drone to rotate.
6. Test the parachute channel endpoints. You can toggle the SATS-MINI states using the mode pulldown. If you have an energetic parachute system like CO2 or Pyro be sure to disconnect these first. Use a servo to test for channel operation.
7. If you are using advanced features like altimeter safety or overrides be sure to verify these in a barro chamber (Jar with a tube you can suck on to cause a vacuum).
8. If you are using external trigger input be sure to test again for proper operation.
9. Dry run your setup - If you are concerned about possible false triggers due to sensitive setup parameters test fly the SATS-MINI on your drone first and make sure the device does not trigger accidentally. Fly the drone at the edges of the flight envelope to see if you can false trigger the SATS. If you do see a false trigger then download the flight log to see the conditions. You may need to adjust the trigger settings.
10. After testing, download the Log file and verify for expected operation.

### **Fixed Wing using Absolute Angle**

Testing is similar to Multicopter Drones except we are testing Absolute Angle detection features.

NOTE: The SATS-MINI is not designed for Fixed Wing aerobatic applications. It is optimized for delivery, photography, or industrial drone applications.

1. Test Pitch and Roll settings by rotating the SATS-MINI to the trigger angle or slightly beyond. Moving quickly well past the trigger angle will result in a faster trigger. Also using shorter times for averaging will also speed up the detection, but it will be less immune to larger rotation for short times. Be sure to ground test all angle parameters.
2. Test Angle rate of change. Rotating the SATS faster, even for a short time, will cause a large angular rate of change.
3. For Fixed Angle it's a very good idea to flight test using your FixedWing drone. Fly the drone up to the expected flight envelope you expect. Then analyze the log files to see if you have any false triggers that are not expected. If so adjust those parameters and fly again.

### **Tips for Flight Testing**

You can use your Multicopter or Fixed Wing drone and test flying to quickly understand what the flight envelope is. After flying the Log file will record all the rotations, accelerations, and angular rotation rates.

For Multicopters set the rotation angles to be very large and time short so it's very hard to false trigger. For Absolute Angle set the angle settings to 0 to disable these. Then go through some tests flying the drone how you would expect in actual use. Then download the log. In Excel you can measure the MAX and MIN limits for the columns to quickly understand what the limits are. To do this use in Excel the formula MAX(range), or MIN(range) on each of the columns to understand the limits. Then tune your SATS-MINI setting for these maximums and minimums plus extra margin so you have some safety margin against false deployment. Continue to test fly to gain confidence it will not false trigger.

Likewise it's important to fly the drones at extremes outside the envelope to make sure the SATS-MINI does catch these. These can also include forward stalls, tip stalls, or flat spins.



## **Best Practices**

1. Unless you're using an external 5V input power feed make sure you charge the SATS daily before flight. Charging can be done via USB cable to your computer. Charging takes about 90 minutes. The Yellow charge light will extinguish once charged.
2. Before flight make sure the SATS-MINI is sufficiently charged. The SATS-MINI LiPo is sufficient to operate the unit for up to 6 hours of operation (when not using the Nano receiver). When there is under one hour of battery life left the device will chirp twice per second. Do not fly if the SATS-MINI is chirping since the battery life may be short.
3. Check the parachute launcher and connection to the SATS-MINI before flight.
4. Before takeoff make sure the SATS-MINI is armed (or in safety if used).
5. After flight disarm the SATS-MINI and turn to save battery and log space.

## **What To Do After Parachute Deployment**

If the SATS-MINI triggers a parachute deployment be sure to disarm the SATS-MINI and download the log file. The log events will show what condition caused the parachute to eject. If you like please send the log to Fruity Chutes and we can do a post-deployment analysis to verify operation. Also helpful would be to indicate the drone type, weight, parachute system and so on. Also flight conditions.

If you have questions please Contact Us!