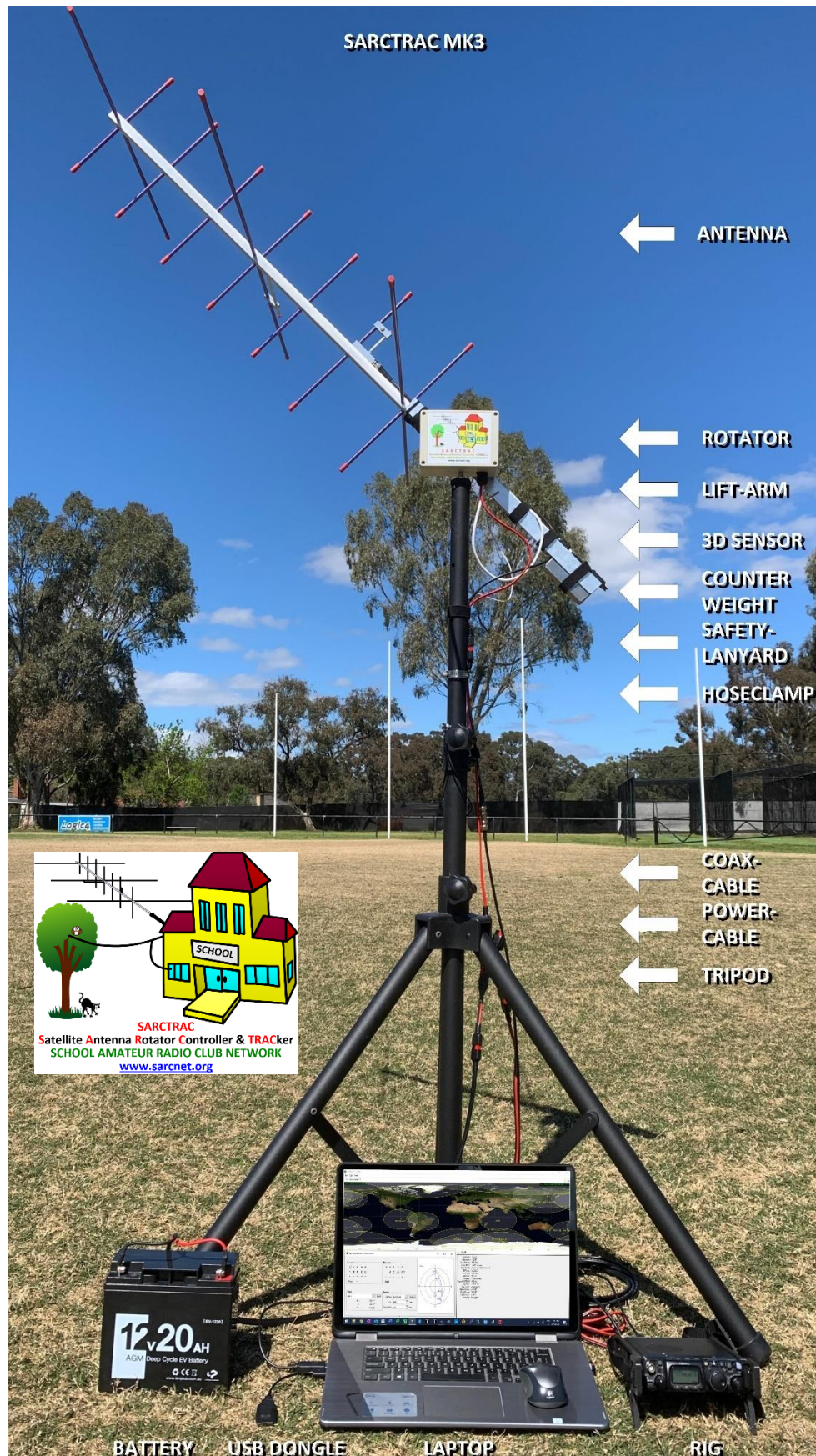


# SARCTRAC Mk3 User Manual



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## Introduction

SARCTRAC is a portable, integrated, satellite tracking system, which is now available as a fully assembled, tested and calibrated product. It provides a wireless connection to the same Windows or Linux PC and satellite tracking software you use to control your Amateur Radio transceiver (rig). With a SARCTRAC system and your own equipment you can listen to orbiting space beacons, make two-way satellite contacts and use free, third-party software to download earth images and decode satellite telemetry. It's both fun and educational!

**New for 2020:** The Amateur Radio International Space Station (ARISS) team and NASA have installed a permanent radio repeater on board the ISS. So now you can use SARCTRAC and your own equipment to listen and talk to other Amateur Radio enthusiasts via the ISS!

## Background

SARCTRAC was developed so that students at our School Amateur Radio Clubs can have fun and learn about Low Earth Orbiting satellites during our lunchtime sessions.

SARCTRAC takes minutes to set up, in the playground, on a mountain summit, down at our local footy oval or even in the backyard. Use it with your favorite PC-based, satellite tracking and radio control application right away. To listen and talk to satellites we like to use our Yaesu FT-817 radio, but for some satellites you can just use a hand-held, VHF/UHF FM radio, or even a pair, so you can hear your own signal coming from the satellite. Our School Amateur Radio Club students think SARCTRAC is really fascinating to watch - and so do we. They try to imagine where the satellite is, by looking along the antenna boom and ask: "It's up there?"

The inspiration for SARCTRAC was to help little kids have fun in space: Well, at least to play with things in low earth orbit! You might be surprised just how many tiny cube-sats and regular polar-orbiting satellites there are. The first challenge is to know when are where the satellites will be. Then to point a hand-held antenna up at them for about 10 minutes while they pass overhead. You also have to constantly adjust your radio transmitter and receiver frequencies to compensate for something called Doppler shift. It turned out that our young radio enthusiasts found all that quite challenging, which detracted from the fun of getting to know our new friends in space. It was hard for us, too, just getting everything to work at different schools: So we set about to design a fully automated system.

To make friends with a satellite you first have to know when and where it will be; point a small, directional antenna at it and use an Amateur Radio transceiver to listen or talk through it. It is a bit like fishing in the sky and just as challenging. It is really exciting when the kids hear their first satellite and then realise where it is. They always ask. "Can we talk to it?" We say. "Of course, you can." But the reality is that satellites move so fast that their position and radio frequency is constantly changing. Tracking a satellite by hand, while trying to tune an Amateur Radio transceiver for a typical 10-



minute overhead pass, is a real chore for kids. Setting up an automatic tracking system, with a commercial antenna rotator is both tricky and expensive. So, we designed SARCTRAC to be quick and easy for the kids to set up, and now, it does all the work for them. SARCTRAC helps kids spend more time listening to signals from space, receiving data or pictures and even communicating with others via satellites. School kids in space? We say "No problems"!

## History

We first introduced our free, Arduino-based, "Mini Satellite-Antenna Rotator" in 2015. It was a great success, with over 900 radio enthusiasts from around the world building one. Unfortunately, sourcing the correct components, compiling and uploading the software and calibrating the sensor was too much for many who attempted building it. Let alone the pitfalls of setting up and using third-party, satellite-tracking software. And, as much as we love helping our readers out, we realised that we were spending more time supporting them than developing new projects for the kids.

We partly solved that problem by designing an integrated satellite tracking system that just works: SARCTRAC Mk1 took us over 15 months to develop and was the second generation of our 3D-Sensor based antenna rotator. It was half the size of the original unit with many new features. SARCTRAC Mk1 was offered as a DIY kit with all the parts and software required. Unfortunately, it only supported one type of radio: The Yaesu FT-817 and was only suitable for the experienced builder. So, we were still confronted with a large support effort.

In 2020, due to the COVID-19 pandemic, we experienced parts shortages, freight delays and months of home isolation. So we spent another 5 months re-designing and developing SARCTRAC Mk2, with many more new features. We offered the first 40 units as a fully assembled, tested and calibrated product. This approach provided us with a wealth of experience in the production process. In the end we decided this was the only way to ensure quality components, production processes, reduced support effort and, ultimately, reader satisfaction. We expect to continue our small-scale production effort of fully assembled, tested and calibrated SARCTRAC Mk2 products next year, even though our primary goal is introducing STEM to school kids using Amateur Radio.

In 2021, we produced SARCTRAC Mk3. We totally revised the project addressing many user, hardware, software, integration, production and support issues: Most readers just wanted the cheapest-possible, AZ-EL rotator to steer their hand-held satellite antennas and to use with their own PC-based, satellite tracking and radio control applications. Quite a few had problems configuring SARCTRAC to connect to their home WiFi network. They wanted a dedicated, wireless solution that did not require the use of a WiFi router. Some had problems when the cables got wound up. They needed a fool-proof safety cut-off device. SARCTRAC Mk2, with a built-in Raspberry Pi 3B+ tracker and web-server, required a lot of power, a large heatsink and was noisy on the VHF/UHF satellite bands. So we went back to basics and designed a cheap,

low-power, low-noise, rotator, with a dedicated wireless link, that would work with popular, many free, PC-based, satellite-tracking applications.

## Acronyms and Abbreviations

This manual uses the acronyms and abbreviations shown in Table 1.

***Table 1 - Acronyms and Abbreviations***

<b>Term</b>	<b>Meaning</b>
<Key>	A key on the PC keyboard
3D	Three-Dimensional
A	Ampere
AC	Alternating Current
AZ	Azimuth
CAT	Computer Aided Technology
DC	Direct Current
EC	European Commission
EL	Elevation
EMC	Electro Magnetic Compatibility
EMI	Electro Magnetic Interference
EMR	Electro Magnetic Radiation
FCC	Federal Communication Commission
PC	Personal Computer
RF	Radio Frequency
RPM	Revolutions Per Minute
RX	Receive
SARCTRAC	Satellite Antenna Rotator Controller and TRACker
SELV	Separated Extra Low Voltage
SSID	Service Set IDentifier
TX	Transmit
USB	Universal Serial Bus
V	Volt
WiFi	Wireless Network
<b>CAUTION:</b>	This box provides advice to avoid injuries
<b>WARNING:</b>	This box provides advice to avoid damage
<b>IMPORTANT:</b>	This box provides advice for correct operation

## Features

- Automatically rotates a satellite antenna under the control of a PC-based, satellite tracking application.
- Light-weight and quick setup on a sturdy tripod - Best suited for portable operation.
- Uses a 3D sensor mounted on the antenna-boom - Does not require any on-site orientation or calibration.
- Built-in, high-torque DC motors - Steers a hand-held, dual-band, satellite antenna via a counterbalanced lift-arm.
- Can be remotely controlled by popular, (mostly) free, Satellite Tracking applications on a Windows or Linux PC, Laptop, Raspberry Pi etc.
- Includes a dedicated WiFi USB dongle - Wireless remote control up to 30m/100ft away.
- Built in WiFi Access Point - No WiFi router or hotspot required.
- Emulates AMSAT EasyCommII rotator protocol – Steers antenna and provides antenna position feedback
- Tested with PstRotator™, Gpredict™, SatPC32™ and Orbitron™. Others TBA.
- Built-in serial terminal utility for manual user control, debug, monitoring, calibration, configuration and simulation.
- Built in microcontroller - Low noise, fast start up and no shutdown procedure required.
- Low power - Runs off 12 VDC, 125 mA, 1.5 W. Can be battery-powered. Includes reverse polarity protection.
- Low Radio Frequency Interference - Barely audible noise on VHF/UHF.
- High Electro Magnetic Compatibility - Tested with 50Wrms continuous RF power on VHF/UHF.
- Factory calibration - Improved pointing accuracy and repeatability.
- New PID motor controller - Smoother antenna positioning and better stability.
- Provides an intelligent anti-windup algorithm - Automatically unwinds the cables between passes.
- Provides safe operation under continuous motor-stall condition.
- Provides a quick-disconnect DC power connector and lanyard - Foolproof anti-windup safety device.

## Links

- [SARCTRAC Mk3 Project](#) - All about SARCTRAC Mk3
- [SARCTRAC Mk3 Product](#) - How to buy SARCTRAC.
- [SARCTRAC Mk3 Production](#) - See how SARCTRAC is made
- [SARCNET YouTube Channel](#) - See videos of SARCTRAC working

## Safety

SARCTRAC is only to be used under adult supervision. It must never be operated unattended. Stand away from the antenna while operating. Immediately disconnect the power to avoid any damage or injury.

Please read the following very carefully. We accept no responsibility or liability for the following:

- SARCTRAC is a portable, power-operated, robotic machine with autonomous behaviour.
- SARCTRAC may move the attached antenna, without warning, in any direction.
- Restricted access and constant supervision are required to prevent injury or damage.
- Installation of appropriate safety guards, signage and a cut-off switch are recommended.
- Immediately disconnect the power to avoid any possible injury or damage.
- Not suitable for unattended operation - Movement may cause injury, cable or antenna damage.
- Not suitable for fixed or permanent outdoor installation - Unit is light-duty.
- Beware of moving parts - Unit may move without warning. Do not stand near operating unit.
- Beware of eye hazards - Moving satellite antennas are prickly. Eye protection is recommended.
- Beware of pinch hazards - Keep fingers away from moving parts.
- Beware of electromagnetic radiation hazards - Do not use with high power (> 10W) transmitters.
- Beware of electrocution hazards - Do not use near power lines.
- Beware of lightning hazards - Do not use in thunderstorms, or in rainy or windy conditions.
- Unit must be fitted and tested with the safety lanyard and quick-disconnect cables provided.
- Read the on-line user manual at <https://www.sarcnet.org/sarctrac.html> before operation.



## Safety Testing

We have conducted the following safety testing of the completed product:

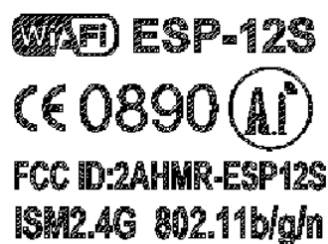
- Motor stall: The motors do not overheat or draw excessive current under continuous, full-power, stalled conditions.
- Antenna impact: The Arrow™ Antenna elements were not damaged under full-power impact with stationary objects or under continuous, restraint conditions.
- Human impact: The human operator was not damaged under full-power impact with the antenna. Note: Eye damage could occur even when the antenna is motionless.
- Cable windup: The motors provide 50kg.cm of static torque and can easily strip cables which have wrapped around the motor shafts. Stripped power cables could create short-circuits. To prevent this, a lanyard, which is connected between the lift-arm and a quick-disconnect DC power connector, operates to disconnect the power if the unit rotates more than about two turns. The user manual provides a step-by-step procedure to correctly install and test this safety feature.

## Specifications

- Enclosure Size: 145x105x65 mm (5.7x4.1x2.2 inch). Operating Temperature: 0-40 Celsius.
- Ingress protection: Enclosure: IP65. 3D sensor: IP68. USB dongle: IP68.
- Anti-Windup safety mechanism: Quick-disconnect power cables with lanyard.
- Sensor cable: 1 m. Power cable: 1 m. USB cable: 150 mm. USB cable type: USB2.0, type A.
- Operating voltage: 12-15 VDC. Current: 125 mA (typical). With reverse polarity protection.
- WiFi mode: 802.11b/g/n. WiFi band: ISM2.4GHz. WiFi range: 30 m (100 ft) typical.
- Sensor type: Absolute position sensing 3D Magnetometer/Accelerometer.
- Control type: Real-time position feedback system with PID motor controller.
- Rotation range: Azimuth +/-360 degrees. Elevation +/-360 degrees.
- Rotation speed: 0.5 RPM (3 degrees per second) azimuth and elevation.
- Rotation torque: 50 kg.cm static, 25 kg.cm dynamic.
- Rotation accuracy: < +/- 5 Degrees (depends on local magnetic environment)
- Rotation mode: Shortest-path with configurable anti-windup algorithm.
- Start-up time: 10 seconds. No shutdown time required.
- Rotator emulation - Serial protocol: AMSAT EasyCommII with position feedback - 9600/N/8/1.

## Regulatory Compliance

- SARCTRAC is essentially a pair of microcontroller modules which have been granted [FCC approval](#) and [CE approval](#). The regulatory compliance marks are shown in Figure 1.
- SARCTRAC has a technical folder, which indicates it comprises the microcontroller modules, together with additional sensors, drivers and motors, which due to their nature and operating conditions would not affect this base EMI/EMC qualification. In fact, the reduction of EMI to nearby receivers and EMC with nearby transmitters, to levels well below international standards, was a key design requirement of this product.
- SARCTRAC has been assembled with lead-free components and solder and complies with Restriction of Hazardous Substances (RoHS) requirements.
- SARCTRAC operates on 12VDC @ 125mA and complies with Separated Extra Low Voltage (SELV) device requirements.
- SARCTRAC introduces additional safety risks, which have been fully identified above. Some operational safety testing has been carried out to qualify the safety risks as minor. The additional safety risks have been reduced, by design, to as low as is reasonably practicable.



*Figure 1 – Regulatory Compliance Mark*

## Limitations

- Only suitable for rotating a single, 2kg, Yagi antenna mounted on a counterbalanced lift-arm.
- Motors are light-duty: Forcing them, dropping or bumping the tripod may strip the metal gears.
- Any magnet brought near the 3D sensor may magnetize it, invalidating the factory calibration.
- Unit will oscillate unless solidly mounted on a rigid stand such as a heavy-duty (speaker) tripod.
- Unit will oscillate unless the 3D sensor is rigidly mounted on the counterbalance Lift-Arm.
- Unit will not track correctly if the 3D sensor is located near any magnetic materials
- Unit will not track correctly if operated within 30 degrees latitude of the North or South poles.
- Unit will not track correctly if operated with high-power transmitters (> 50W).

## Disclaimer

This is partly a DIY construction project for the experience builder. We are not responsible for your time, costs, tools, availability or substitution of parts. We are not responsible for your lack of adherence to stated instructions, limitations, cautions, warnings and safety directions. We will replace or refund the price of equipment in the event of a proven manufacturing defect. This is the total limit of our liability.

## SARCTRAC Setup

Before SARCTRAC can be used it needs to be set up properly. Please follow these steps, in order, to get SARCTRAC ready for operation.

### Inventory Check

SARCTRAC comes in a box with the following components. Please check that there are no shortages, or any damage.

1. SARCTRAC Rotator with the following attachments:
  - a. SARCTRAC 3D sensor.
  - b. SARCTRAC quick disconnect power cable with safety lanyard.
2. SARCTRAC USB dongle.
3. SARCTRAC accessories bag:
  - a. 1 - 2.5 mm hex key.
  - b. 2 – 6 mm shaft hubs with 2 - M3x4 mm stainless-steel cap screws.
  - c. 1 - 6g x 9.5 mm pan-head stainless-steel self-tapping screws.
  - d. 4 - M3 x 12 mm countersunk stainless-steel screws.
  - e. 8 - M3 x 10 mm pan-head stainless-steel screws, washers & hex nuts.
  - f. AZ and EL hubs, each with 2 - M3 x 4 mm Socket Head cap screws.
4. 1 - 27-51 mm stainless-steel hose clamp

**WARNING:** The SARCTRAC 3D sensor is a sensitive magnetometer/accelerometer. Any magnet (e.g. a magnetic-tipped screwdriver) brought within 100 mm (4 inches) of the sensor may permanently magnetize it, invalidating the factory calibration.

### Additional Items

To set up SARCTRAC in accordance with this manual you will need the following additional items:

1. DC power supply (or batteries) capable of supplying 12 VDC at 250 mA.
2. Satellite antenna: Hand-held, dual-band (ArrowII or equivalent)
3. Tripod: Heavy duty speaker tripod (Jaycar CW2860 or Altronics C0524 etc).
4. Tripod Mount: 1 - 25 mm (1 inch) threaded poly pipe plug or cap to suit tripod.
5. 3 - stainless steel self-tapping screws, etc. to secure the tripod mount.
6. Lift-Arm and Counterbalance:
  - a. 1 - aluminium angle stock: 500x30x30x3 mm (20x1¼x1¼x1/8 inch)
  - b. 1 - aluminium diecast box: 101x51x25 mm (4x2x1 inch), Altronics H0451, Hammond 1590G or similar.

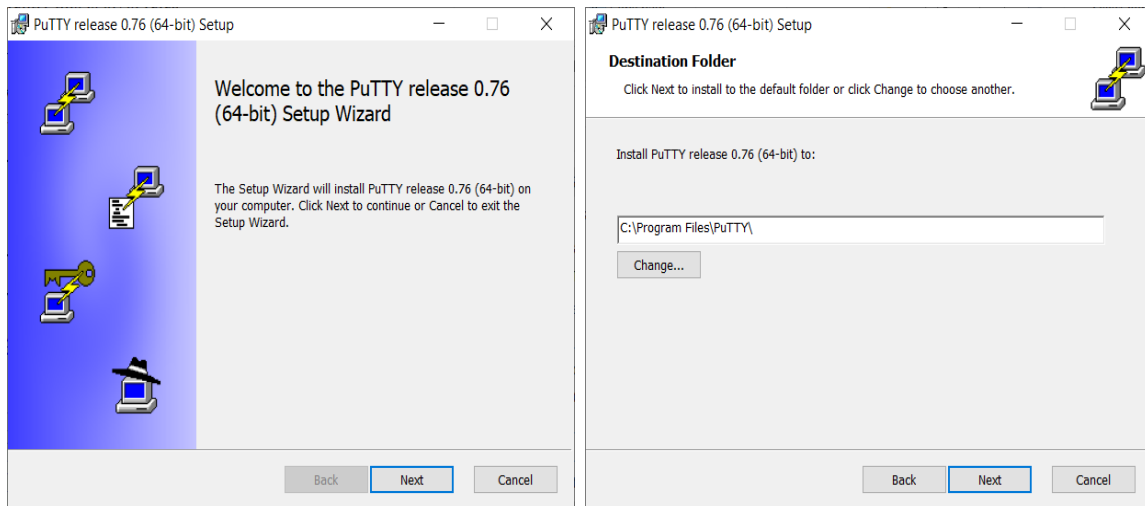
- c. 750 g (1.7 lb) lead shot (or old solder or pieces) to fill the diecast box.
  - d. 6 - Velcro Strips, 150 mm (6 inch) x 25 mm (1 inch), double-sided
  - e. 2 - Cable Ties, 150 mm (6 inch)
7. Tools:
- a. Hacksaw or cut-off saw to cut the aluminium angle stock.
  - b. Small flat file to smooth the aluminium angle stock.
  - c. Hand-held drill with 3 mm (1/8 inch) Drill bit.
  - d. Blow-torch or epoxy-resin to melt or secure the lead shot.
  - e. Kitchen scales to weigh the lead shot.
  - f. Small Phillips and flat screwdrivers.

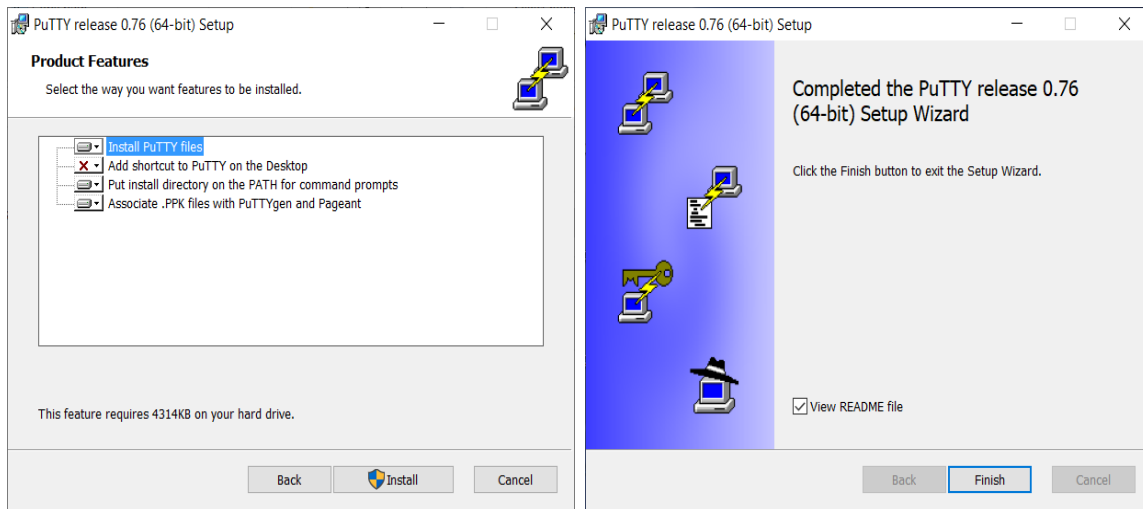
## Software Installation

First: If you plug the USB Dongle into your computer and it is not recognized, you will need to download a USB driver. A suitable driver for Windows, Linux or Max can be downloaded from here: [http://www.wch-ic.com/downloads/CH341SER\\_ZIP.html](http://www.wch-ic.com/downloads/CH341SER_ZIP.html).

Second: Install a free serial terminal application used to configure and control SARCTAC:

1. On Windows:
  - a. Open a browser and download PuTTY for Windows, 64bit, 32bit, x86 or ARM processors from here:  
<https://www.chiark.greenend.org.uk/~sgtatham/putty/latest.html>
  - b. Run the installer. If asked "Do you want PuTTY to make changes to your device": Select "Yes".





**Figure 2 - PuTTY Installation**

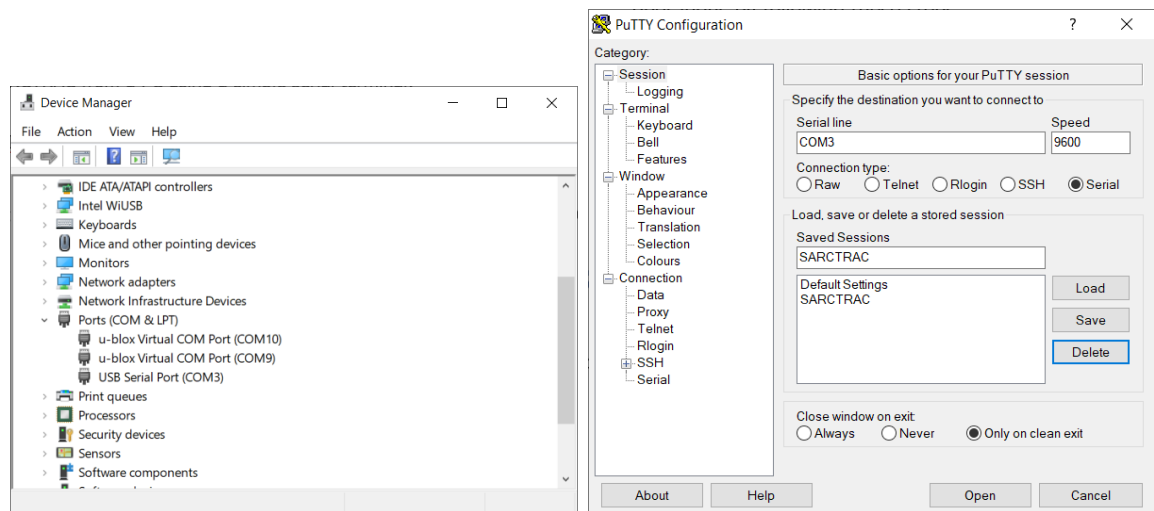
2. On Linux, open a terminal window and type:
  - a. `sudo apt-get update`
  - b. `sudo apt-get -y upgrade`
  - c. `sudo apt-get -y install putty`

## User Login

Log in to SARCTRAC from a PC using the serial terminal application installed above:

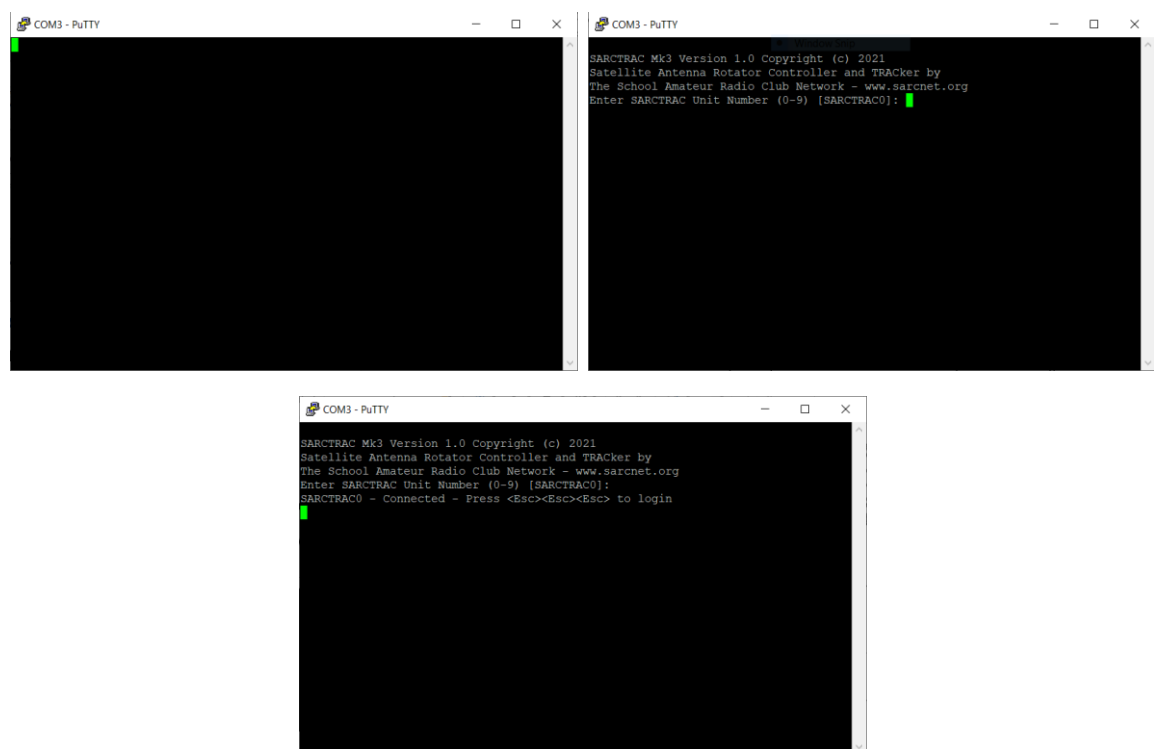
1. Turn the power supply on.
2. Check/adjust the power supply output for 12 VDC.
3. Turn the power supply off.
4. Place the rotator with the label-side down, on the test bench, in front of you, such that the cables are facing towards you.
5. Connect the quick disconnect connector. They will snap together.
6. Connect the power supply to the rotator: Positive to the red wire and negative to the red wire with the black stripe. Note: SARCTRAC has reverse-polarity protection.
7. On Windows: Start Device Manager; or
8. On Linux: Open a terminal window and type "`dmesg`"
9. Plug the USB dongle into a free USB port on your PC.
10. On Windows: Note the COM port number of the new device now appearing in Device Manager, e.g. COM3; or
11. On Linux: Open a terminal window and type "`dmesg`" again. Note the new attached device, e.g. `ttyUSB0`.
12. Start PuTTY.
13. Select Connection type: Serial
14. Change the Serial line to the COM Port/USB device for the SARCTRAC dongle.
15. Change the Speed to 9600.
16. Save the settings: Type "SARCTRAC" in Saved Sessions and press Save.





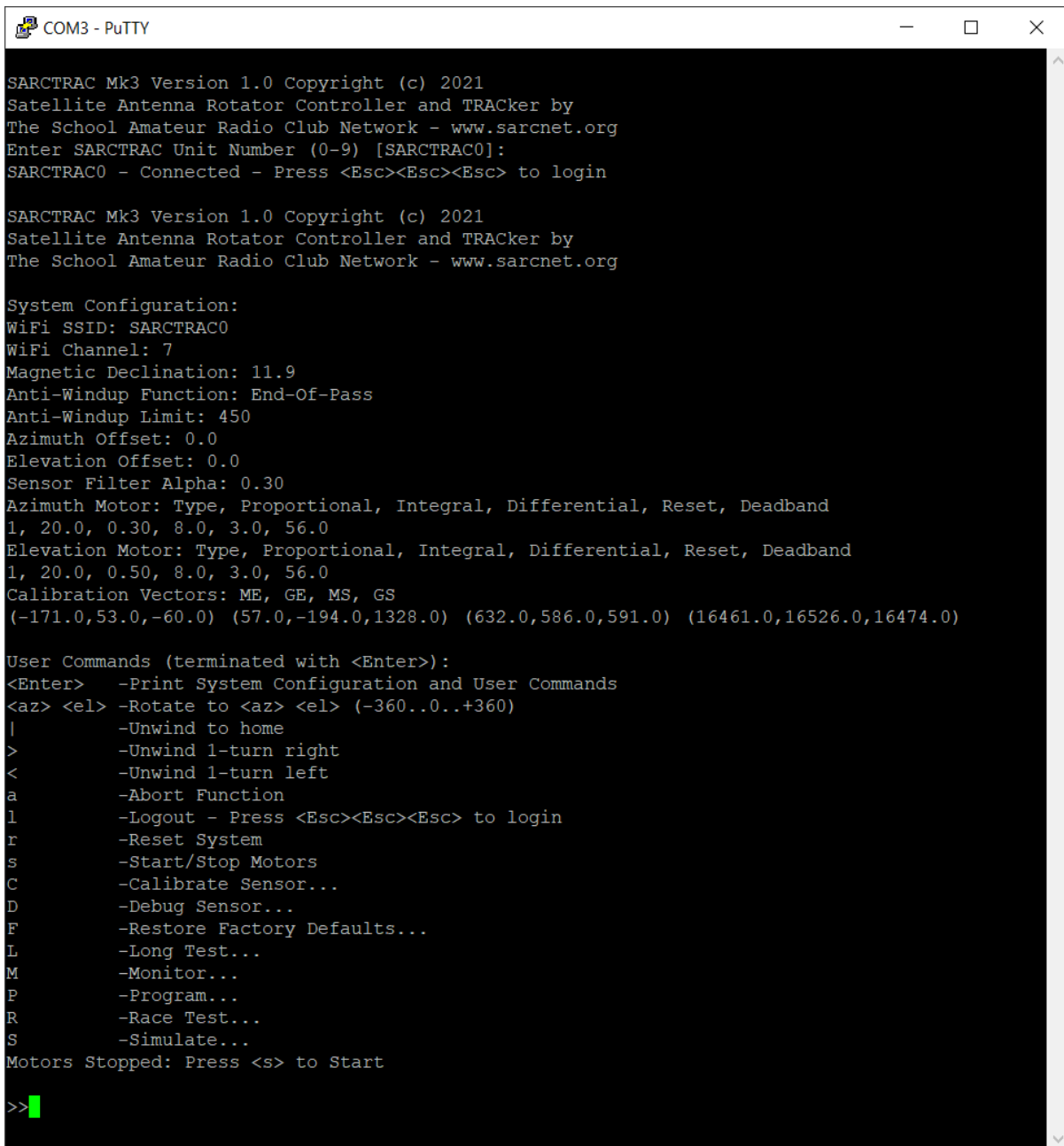
**Figure 3 – Device Manager and PuTTY Configuration**

17. Select SARCTRAC and press Open. You should see a black PuTTY terminal window. See Figure 4.
18. Press <Esc> three times to log in to the USB Dongle.
19. The USB dongle will show that it is set up to connect to "SARCTRAC0", that means SARCTRAC unit 0. Note that you can enter a different SARCTRAC unit number, here, if you have previously changed the unit number of the rotator.
20. Turn the Power Supply on.
21. The USB dongle will connect to the rotator via a dedicated WiFi link. The display will show the SSID of the rotator, the connection status and prompt you to log into the rotator.



**Figure 4 – PuTTY Terminal Window**

22. Press <Esc> three times, this time to log in to the rotator.
23. This display will show the rotator's system configuration, a list of user commands and the motor status. See: Figure 5.



```
COM3 - PuTTY

SARCTRAC Mk3 Version 1.0 Copyright (c) 2021
Satellite Antenna Rotator Controller and TRACker by
The School Amateur Radio Club Network - www.sarcnet.org
Enter SARCTRAC Unit Number (0-9) [SARCTRAC0]:
SARCTRAC0 - Connected - Press <Esc><Esc><Esc> to login

SARCTRAC Mk3 Version 1.0 Copyright (c) 2021
Satellite Antenna Rotator Controller and TRACker by
The School Amateur Radio Club Network - www.sarcnet.org

System Configuration:
WiFi SSID: SARCTRAC0
WiFi Channel: 7
Magnetic Declination: 11.9
Anti-Windup Function: End-Of-Pass
Anti-Windup Limit: 450
Azimuth Offset: 0.0
Elevation Offset: 0.0
Sensor Filter Alpha: 0.30
Azimuth Motor: Type, Proportional, Integral, Differential, Reset, Deadband
1, 20.0, 0.30, 8.0, 3.0, 56.0
Elevation Motor: Type, Proportional, Integral, Differential, Reset, Deadband
1, 20.0, 0.50, 8.0, 3.0, 56.0
Calibration Vectors: ME, GE, MS, GS
(-171.0,53.0,-60.0) (57.0,-194.0,1328.0) (632.0,586.0,591.0) (16461.0,16526.0,16474.0)

User Commands (terminated with <Enter>):
<Enter> -Print System Configuration and User Commands
<az> <el> -Rotate to <az> <el> (-360..0..+360)
| -Unwind to home
> -Unwind 1-turn right
< -Unwind 1-turn left
a -Abort Function
l -Logout - Press <Esc><Esc><Esc> to login
r -Reset System
s -Start/Stop Motors
C -Calibrate Sensor...
D -Debug Sensor...
F -Restore Factory Defaults...
L -Long Test...
M -Monitor...
P -Program...
R -Race Test...
S -Simulate...

Motors Stopped: Press <s> to Start

>>
```

**Figure 5 - SARCTRAC Login Screen**

## Bench Test

Having logged into the rotator, a quick bench test will check that everything is working and help you get acquainted with the system.

1. Note the location of the AZ and EL shafts: The AZ shaft is next to the cable-gland on the rotator. The EL shaft is on the larger side, facing upwards.
2. Hold the sensor in your hand, flat side down, with the cable pointing away from you, facing approximately North and horizontal.
3. Press <s><Enter> to start the motors – They will start to turn very slowly.
4. Point the sensor West: The AZ shaft should turn CW.
5. Point the sensor East: The AZ shaft should turn CCW.
6. Point the sensor Down: The EL shaft should turn CW.
7. Point the sensor Up: The EL shaft should turn CCW.
8. Point the sensor up or down until the flat side of the EL shaft is facing towards you. Note: This will make attaching the lift-arm in a later step much easier.
9. Press <s><Enter> to stop the Motors.
10. Turn the power supply off.
11. Disconnect the power supply from the rotator.

The Bench Test is now complete.

## Tripod Mount

Make a tripod mount for the Rotator:

1. Note: SARCTRAC has to be mounted rigidly on a stand or tripod. SARCTRAC uses a closed-loop feedback control system. If not rigidly mounted it will oscillate wildly.
2. Prepare an extra heavy-duty speaker tripod. Remove the speaker bracket and the existing shaft plug, if fitted.
3. Prepare your own tripod mount to suit your tripod. Note: This will vary depending on the brand of tripod you have and the pipe accessories available at hardware outlets in your country. The tripod mount must permit the AZ hub to be secured, with the four screws provided, to the top of the vertical tripod shaft.
4. A 25 mm (1 inch) threaded poly pipe plug worked for us.
5. First, check that the pipe plug or cap is a tight fit.
6. Secure the AZ hub to the top of the tripod mount using the four screws, flat washers and nuts provided. Hint: Place the AZ hub inside the tripod mount to accurately mark/drill the four mounting holes.
7. Secure the tripod mount to the top of the tripod shaft with 3 self-tapping stainless-steel screws. The tripod mount must be rigid.
8. Mount the rotator's AZ motor shaft on to the AZ hub at the top of the tripod mount. Note: Always leave a 3 mm gap between the AZ hub and the rotator enclosure to prevent the hub screws touching the motor-mounting screws. See Figure 6.



*Figure 6 - Tripod Mount*

### **Lift-Arm**

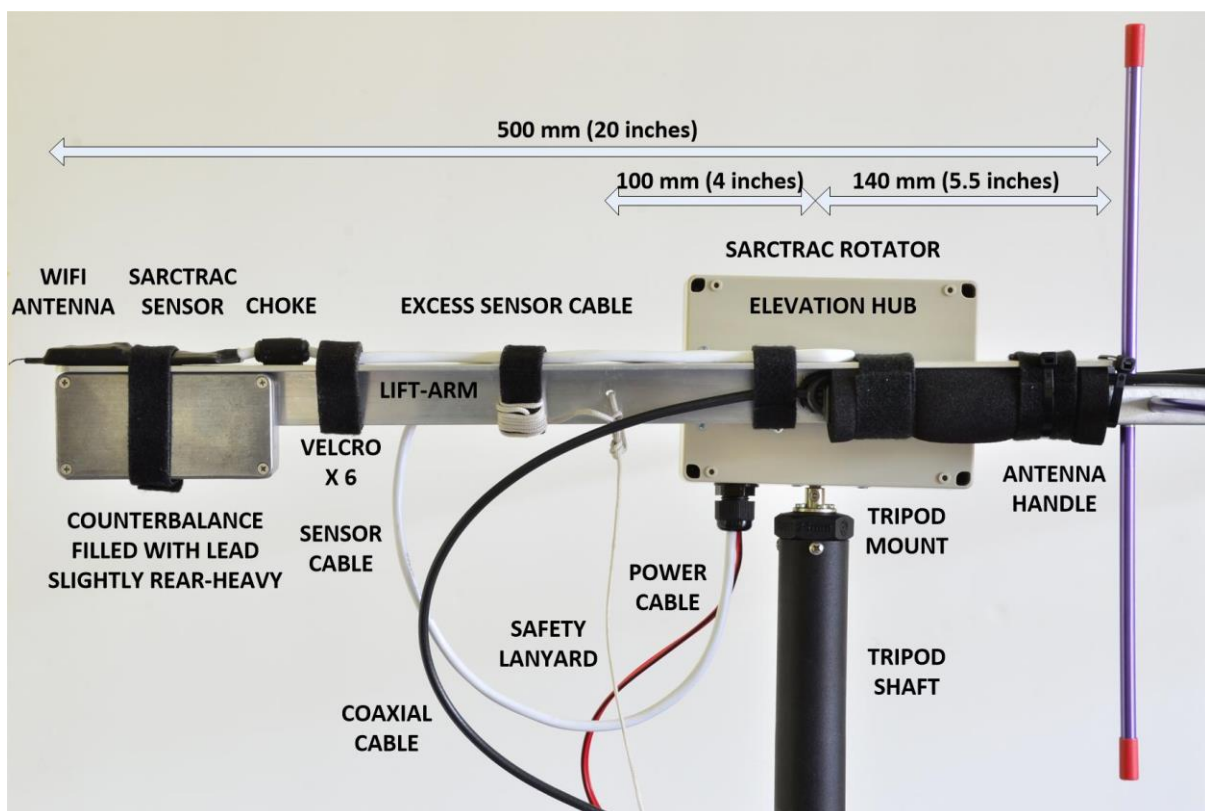
Make a counterbalanced lift-arm suitable for your antenna:

1. Cut the aluminium angle stock to size using a hacksaw or cut-off saw.
2. Round the sharp edges of the aluminium angle stock with a flat file.
3. Make a counterweight from a diecast aluminium box, filled with lead shot:
  - a. Remove the cover and discard the ferro-magnetic steel screws.
  - b. Fill the box with lead shot to a total weight of 750 g (1.7 lb) - suitable for the Arrow antenna. The exact weight may need to be adjusted, later, to balance the antenna and cables.
  - c. Melt the lead shot in a well-ventilated, fire-proof area (e.g. outside on a house brick) with just sufficient heat from a blow-torch and allow it to cool. Or use epoxy resin to secure the lead shot instead.
  - d. Replace the cover.
  - e. Replace the steel screws in the counterweight with the 4 non-magnetic, countersunk, stainless-steel screws provided. Note: The lift-arm assembly must be totally free of all magnetic material, such as mild steel.
4. Drill a 3 mm (1/8 inch) hole through the lift-arm and only 3 mm (1/8 inch) into the diecast box.
5. Secure the counterweight to one end of the lift-arm with the self-tapping metal screw provided.
6. Secure the antenna handle to the lift-arm using 2 Velcro strips. The flat sides of the lift-arm should be on top of the antenna handle and to the left of the antenna handle, while looking along the antenna boresight. The wide Antenna elements should be horizontal so that they clear the tripod. Note: Velcro is used

for quick release of the antenna if hand-held operation is later required. For a more rigid installation you can use cable-ties (or hose-clamps).

7. Mark the balance point of the counterbalanced lift-arm/antenna assembly: Balance it on a round tube (marker pen) near the corner of a flat table.
8. Secure EL hub to the outside of the left side of the lift-arm, close, but in front of the balance point by 12 mm (1/2 inch), using the 4 screws, flat washers and nuts provided. Note: A slight rear-heavy balance offset will help reduce backlash. Ours was mounted 140 mm (5½ inches) from the antenna end of the lift-arm.
9. Secure the counterbalanced lift-arm/antenna assembly to the EL motor shaft tightening the hub screws with the 2.5 mm hex key. The assembly should be nearly horizontal. Note: Always leave a 3 mm gap between the EZ hub and the Rotator enclosure to prevent the hub screws touching the motor-mounting screws. See Figure 7.
10. Carefully raise the centre-shaft of the tripod to ensure that the lift-arm, in any position, cannot touch the tripod pin, tripod clamp or tripod legs.
11. Use the tripod pin and tripod clamp to lock the shaft into position.

**WARNING:** Although the motors use metal gears, they can easily be stripped by the leverage of the long antenna and lift-arm. Never mount an unbalanced antenna or lift-arm on the EL motor shaft. Never manually force the antenna up, down or sideways. Never drop or tip over the tripod. Never suddenly release the shaft of the tripod.



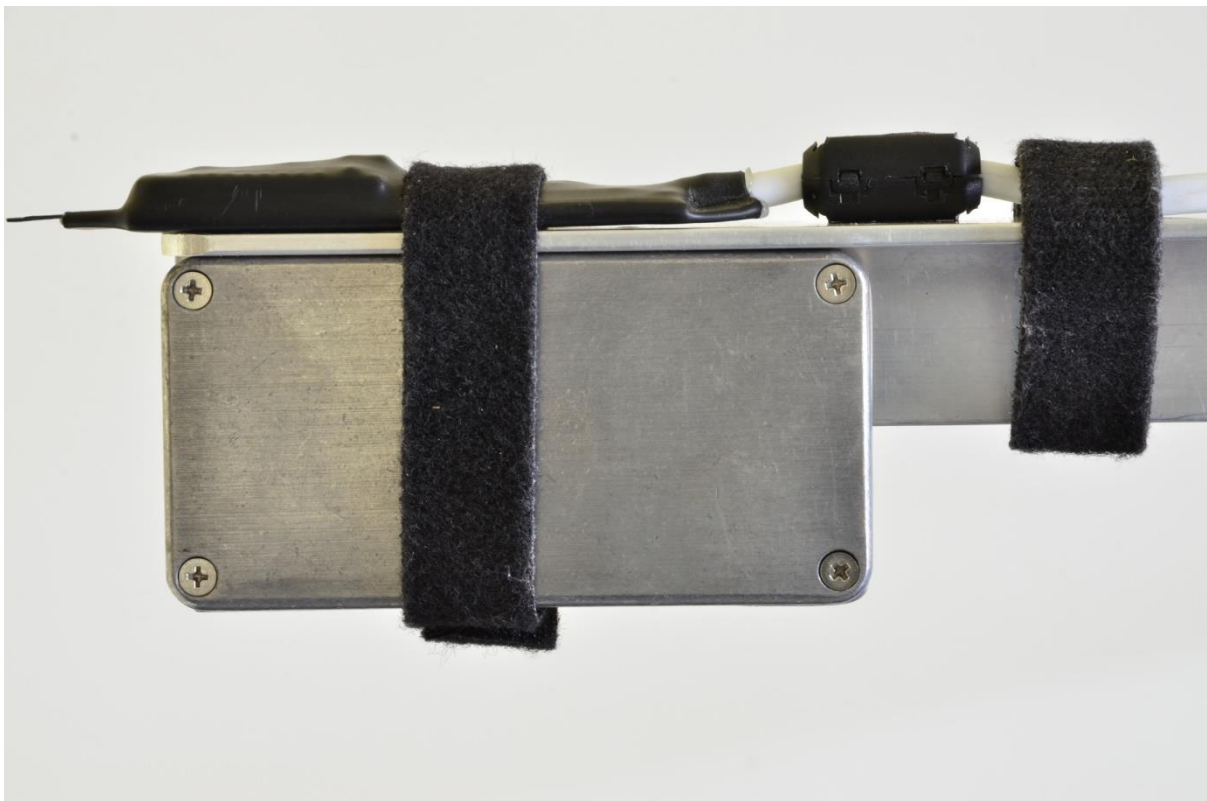
**Figure 7 - Lift-Arm**



## Sensor Mount

Mount the SARCTRAC sensor on the lift-arm:

1. Place the flat side of the sensor against the top, flat surface of the lift-arm with tip facing away from the rotator. Place the tip, with the antenna wire, protruding over the edge of the lift-arm above the counterweight. See Figure 8.
2. Secure the sensor with Velcro right around the counterweight. Remember not to force the motor shafts.
3. Route the sensor cable along the top of the lift-arm, around the front of the antenna handle and back along the bottom of the lift-arm as shown in Figure 7. This helps keep the sensor cable shielded from excess RF energy.
4. Secure the sensor cable with Velcro around the lift-arm.



**Figure 8 - Sensor Mount**

## Operational Check

Ensure that the antenna is mounted securely on the lift-arm; the lift-arm is securely mounted on the rotator and the rotator is securely mounted on the tripod.

**CAUTION:** Satellite antennas are PRICKLY BEASTS. SARCTRAC may move the antenna with little warning or in an unexpected direction. The antenna may be damaged or bystanders may be injured. NEVER operate SARCTRAC without constant adult supervision. NEVER stand next to the antenna when SARCTRAC is operating. Be prepared to IMMEDIATELY disconnect the power if the antenna moves in an unexpected direction, before it hurts someone or damages something.

1. Turn the Power Supply off.
2. Connect the power supply to the SARCTRAC rotator.
3. Unlock the tripod clamp and point the antenna facing roughly North.
4. Lock the tripod clamp.
5. Turn the power supply on.
6. Log into SARCTRAC.
7. Press the <s><Enter> to start the motors.

**Caution:** Stand clear of the antenna and lift-arm assembly as it will start to move.

8. SARCTRAC will steer the antenna to North and horizontal. This is known as the home position.
9. Turn the power supply off.

### **Safety Lanyard and Quick Disconnect Power Cable**

1. Unlock the tripod shaft.
2. Secure the lower side of the quick-disconnect power cable to the tripod shaft about 300 mm (1 ft) from the base of the rotator, directly below the rotator cable-gland, using a cable-clamp or a split-pin.
  - a. If you are using a cable-clamp, wrap some PVC tape around the tripod shaft to protect the paint and some PVC tape around the power cable to protect the insulation.
  - b. If you are using a split-pin, the nearest tripod hole will do. Use a cable-tie to attach the quick-disconnect power cable to the split-pin and silicon tubing to secure the split-pin.
  - c. Leave a loop, sufficient to allow the power cable to wrap twice around the tripod shaft.
3. In the same way, secure the coaxial cable to the cable-clamp or split-pin, directly below the rotator cable-gland, using a cable-tie. Leave a loop sufficient to allow the coaxial cable to wrap twice around the tripod shaft.
4. Thread the lanyard through the lanyard hole in the lift-arm, but do not secure it. Leave a loop sufficient to allow the lanyard to wrap 1½ turns around the tripod shaft.
5. Connect the quick-disconnect power cables together.
6. Face the antenna approximately north.
7. Turn the power supply on.
8. Login to the rotator using PuTTY (press <Esc><Esc><Esc> to log in)
9. Check the System Configuration for Anti-Windup Function: Off, or press <P><Enter> to change it to that mode.
10. Press the <s><Enter> to start the motors.

**Caution:** Stand clear of the antenna and lift-arm assembly as it will start to move.

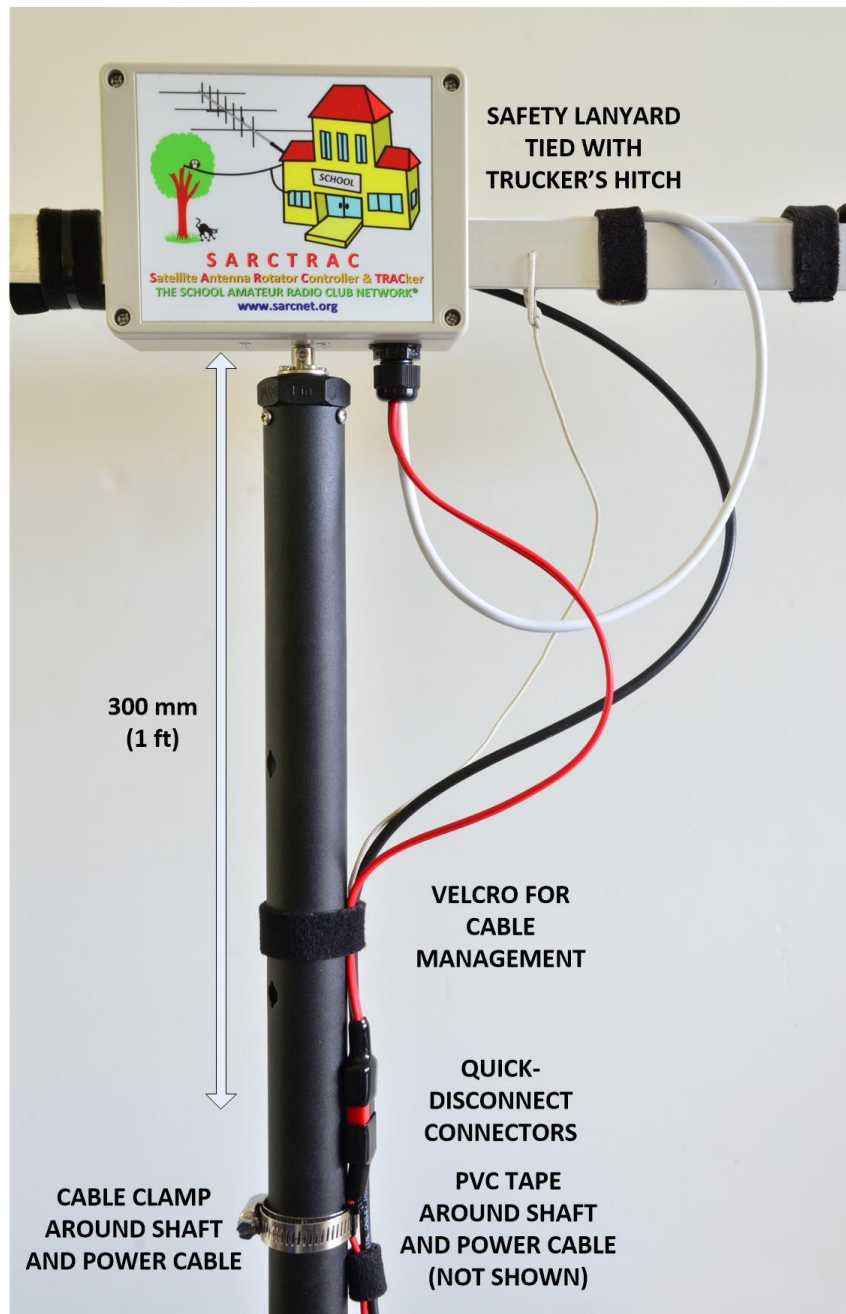
11. Slowly turn the tripod shaft to the right, while the rotator continuously tries to reposition the antenna back to North. Keep turning until the tripod vertical shaft

has been turned exactly 1½ turns. The quick-disconnect power cable connector will be opposite the cable-gland on the rotator.

12. Secure the lanyard to the lift-arm by pulling through any slack, gently pushing down on the rear of the lift-arm to remove more slack, then tying a knot in the lanyard at the lift-arm on the opposite side of the entry point. Note: If you are good at knots, a “truckers hitch” can be used to pull down the lift-arm into position.
13. Slowly turn the tripod vertical shaft to the left return it to the home position with the antenna pointing north and the quick-disconnect power cable connector directly below the cable-gland on the rotator.
14. Lock the tripod shaft. This is the starting position. The rotator should always be started in this position.
15. Now, if the rotator turns more than 1½ turns from the starting position in either direction, or if it points about 45 degrees downwards in either direction, the safety lanyard and the quick-disconnect connectors will activate to stop the rotator moving any further and possibly damaging the cables.
16. Please check that this safety device works in both directions from the starting position:
  - a. Press <<><Enter> twice to make the rotator attempt to turn two turns to the left. The safety lanyard should activate after 1½ turns.
  - b. Restore the rotator to the starting position (see the next step).
  - c. Press <>><Enter> twice to make the rotator attempt to turn two turns to the right. The safety lanyard should activate after 1½ turns.
17. When the quick disconnect connectors snaps open, you can restore rotator operations by following these steps:
  - a. Unlock the tripod clamp.
  - b. Gently press down on the lift-arm to provide some slack.
  - c. Reconnect the quick disconnect connectors by hand.
  - d. Press <Esc><Esc><Esc> to login to the rotator using PuTTY
  - e. Press <s><Enter> to start the motors.

<b>Caution:</b> Stand clear of the antenna and lift-arm assembly as it will start to move.
--

- f. Slowly turn the tripod shaft in the direction required to allow the rotator to unwind the cables. Stop when the quick-disconnect power cable connector is directly below the cable-gland on the rotator and the cables are unwound.
  - g. Press <r><Enter> to reset the rotator starting azimuth to the rotator home (North).
18. Remember to press <P><Enter> to program the Anti-Windup Function to On or End-Of-Pass, as required.



***Figure 9 - Safety Lanyard and Quick Disconnect Power Cable***

## SARCTRAC Manual Operation

The SARCTRAC serial terminal utility can be used to manually operate, control, reset, program, debug, monitor, simulate and test satellite tracking operations.

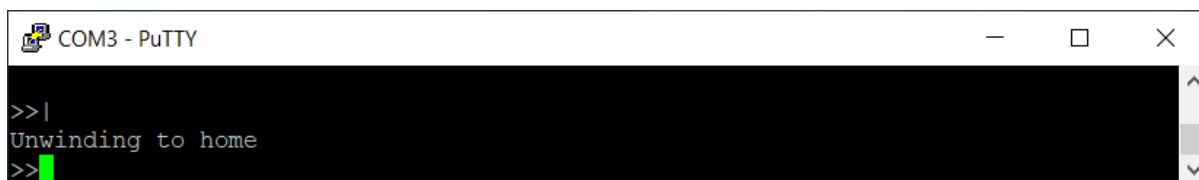
1. Log into the rotator <Esc><Esc><Esc> and proceed with the following steps to test out each command.
2. Press <s><Enter> to start and stop the motor operation. See Figure 10. Note 1: The following commands automatically start the motors if they were stopped: |, >, <, s, D, L, M, R, S. Note 2: The following commands automatically stop the motors if they were started: 1, s, C, F, P.



```
>>s
Motors Started
>>s
Motors Stopped
>>
```

**Figure 10 – Start/Stop command**

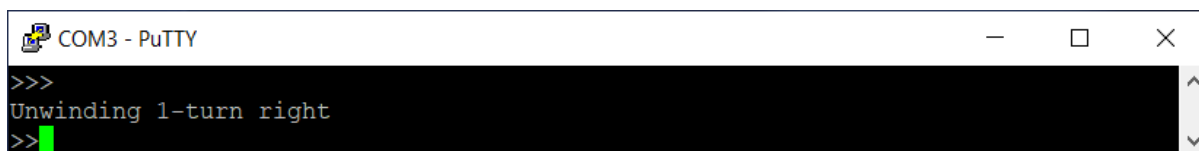
3. Press 30 45<Enter>. The rotator will move to 30 degrees azimuth and 45 degrees elevation.
4. Press 0 0<Enter>. The rotator will return to the home position.
5. Press -30 45. The rotator will move to -30 degrees azimuth and 45 degrees elevation.
6. Press <|><Enter>. The rotator will return to the home position.



```
>>|
Unwinding to home
>>
```

**Figure 11 – Unwind to home command**

7. Press <>><Enter>. The rotator will unwind one (1) turn to the right and reset the starting position to the home position. Note: Cancel this command with <<><Enter>.



```
>>>
Unwinding 1-turn right
>>
```

**Figure 12 – Unwind 1-turn right command**

8. Press <<><Enter>. The rotator will unwind one (1) turn to the left and reset the starting position to the home position. Note: Cancel this command with <>><Enter>.



```

COM3 - PuTTY
>><
Unwinding 1-turn left
>>

```

**Figure 13 – Unwind 1-turn left command**

9. Press <a><Enter> to abort the following functions: D, L, M, R, S. Note: If these functions are running, the command letter itself is not displayed because user character echo is switched off during these commands.

```

COM3 - PuTTY
>>a
Function aborted
>>

```

**Figure 14 – Abort command**

10. Press <1><Enter> to logout and stop the motors. Press <Esc><Esc><Esc> to log back in.

```

COM3 - PuTTY
>>1
Motors Stopped
Goodbye - Press <Esc><Esc><Esc> to login

```

**Figure 15 – Logout command**

11. Press <r><Enter> to reset the system and set the starting position to the current position.

```

COM3 - PuTTY
>>r
System Reset
Starting Azimuth = 0.7 Degrees
>>

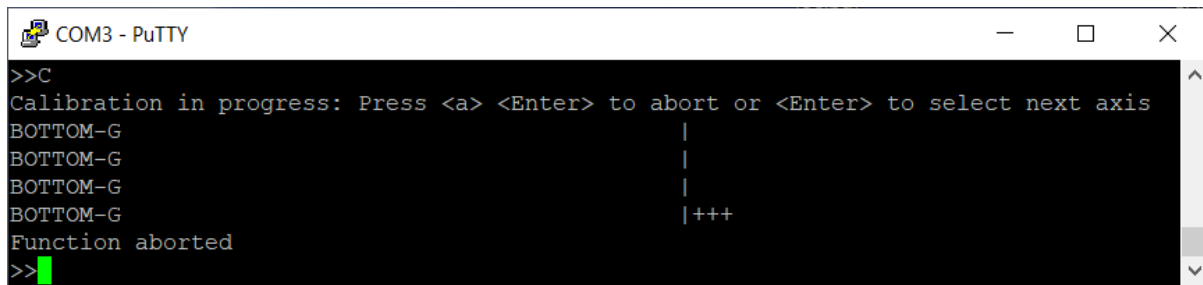
```

**Figure 16 – System reset command**

12. Press <C><Enter> to calibrate the sensor. Press <a><Enter> to abort. Do not use this command without further instructions from the factory. See:

Elevation Motor Deadband – Zero motor drive = N/255x12V. Increase for quicker motor start up. Decrease for less dither.	0-255	56
---	-------	----

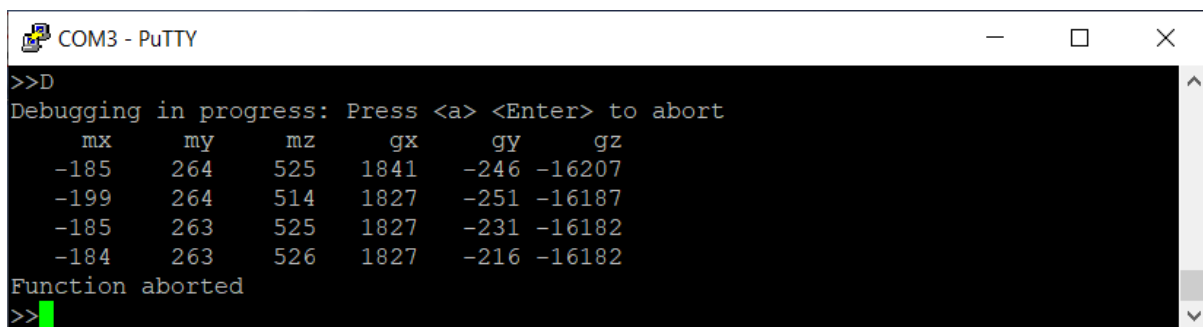
13. SARCTRAC Sensor Calibration.



```
COM3 - PuTTY
>>C
Calibration in progress: Press <a> <Enter> to abort or <Enter> to select next axis
BOTTOM-G
BOTTOM-G
BOTTOM-G
BOTTOM-G
Function aborted
>>
```

**Figure 17 – Calibration command**

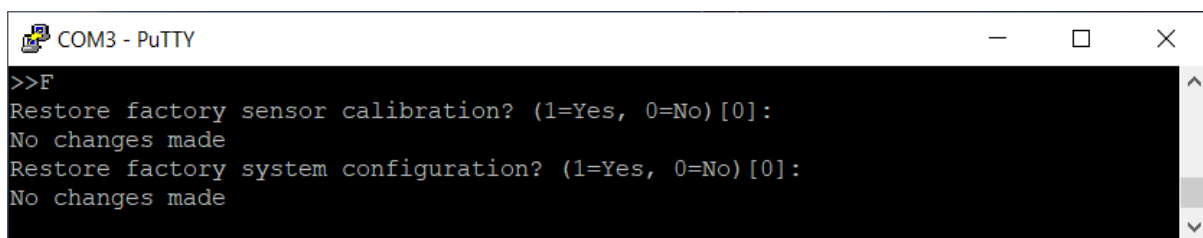
14. Press <D><Enter> to see the raw 3D Sensor data.
- Magnetometer x, y and z axis
  - Accelerometer x, y and z axis
  - Type a<Enter> to abort this display.



```
COM3 - PuTTY
>>D
Debugging in progress: Press <a> <Enter> to abort
  mx    my    mz    gx    gy    gz
-185   264   525  1841  -246 -16207
-199   264   514  1827  -251 -16187
-185   263   525  1827  -231 -16182
-184   263   526  1827  -216 -16182
Function aborted
>>
```

**Figure 18 - Debug command**

15. Press <F><Enter> to restore the factory default sensor calibration and system configuration. When asked, press <1><Enter> to restore the data or <0><Enter>, or just <Enter>, to skip it and make no changes.



```
COM3 - PuTTY
>>F
Restore factory sensor calibration? (1=Yes, 0=No)[0]:
No changes made
Restore factory system configuration? (1=Yes, 0=No)[0]:
No changes made
```

**Figure 19 – Restore factory sensor calibration and system configuration**

16. Press <L><Enter> to start a long test sequence which takes 25 minutes to complete. This test turns the rotator to various cardinal positions (in order to demonstrate motor control, calibration, anti-windup and home functions. The error results of this test are not indicative of the calibration accuracy of the system rather they can be used to adjust the PID motor controller settings.

```

>>L
Long Test in progress (19 tests, 24.5 minutes): Press <a> <Enter> to abort
Azimuth Test
Test 1. Error = 0.1 degrees. Going to: 0 0
Test 2. Error = 0.7 degrees. Going to: 90 0
Test 3. Error = 0.5 degrees. Going to: 180 0
Test 4. Error = 0.5 degrees. Going to: 270 0
Test 5. Error = 0.5 degrees. Going to: 360 0
Anti-Windup test
Test 6. Error = 0.4 degrees. Going to: 480 0
Unwinding to home
Test 7. Error = 0.6 degrees. Going to: 0 0
Test 8. Error = 0.2 degrees. Going to: -90 0
Test 9. Error = 0.9 degrees. Going to: -180 0
Test 10. Error = 1.1 degrees. Going to: -270 0
Test 11. Error = 0.6 degrees. Going to: -360 0
Anti-Windup test
Test 12. Error = 0.3 degrees. Going to: -480 0
Test 13. Error = 0.2 degrees. Going to: 0 0
Unwinding to home
Elevation Test
Test 14. Error = 0.5 degrees. Going to: 0 90
Test 15. Error = 0.5 degrees. Going to: 120 90
Test 16. Error = 0.2 degrees. Going to: 240 90
Test 17. Error = 0.3 degrees. Going to: 360 90
Test 18. Error = 1.0 degrees. Going to: 0 0
Unwinding to home
Test 19. Error = 1.0 degrees. Going to: 0 0
Average error = 0.5 degrees
Test complete
>>

```

**Figure 20 – Long test command**

Press <M><Enter> to see a display of the system operation including:

- d. The AZ and EL angles – Where the antenna is actually pointing.
- e. The AZ and EL set points – Where the antenna has been set to move to.
- f. The AZ Windup angle – Accumulated degrees from the starting position.
- g. The Windup flag – Anti-Windup has been activated = 1, otherwise 0
- h. The AZ and EL error angles – The error between actual and set angles.
- i. The Received Signal Strength Indicator - In dBm: 0 (strong) -100 (weak)
- j. Type a<Enter> to abort this display.

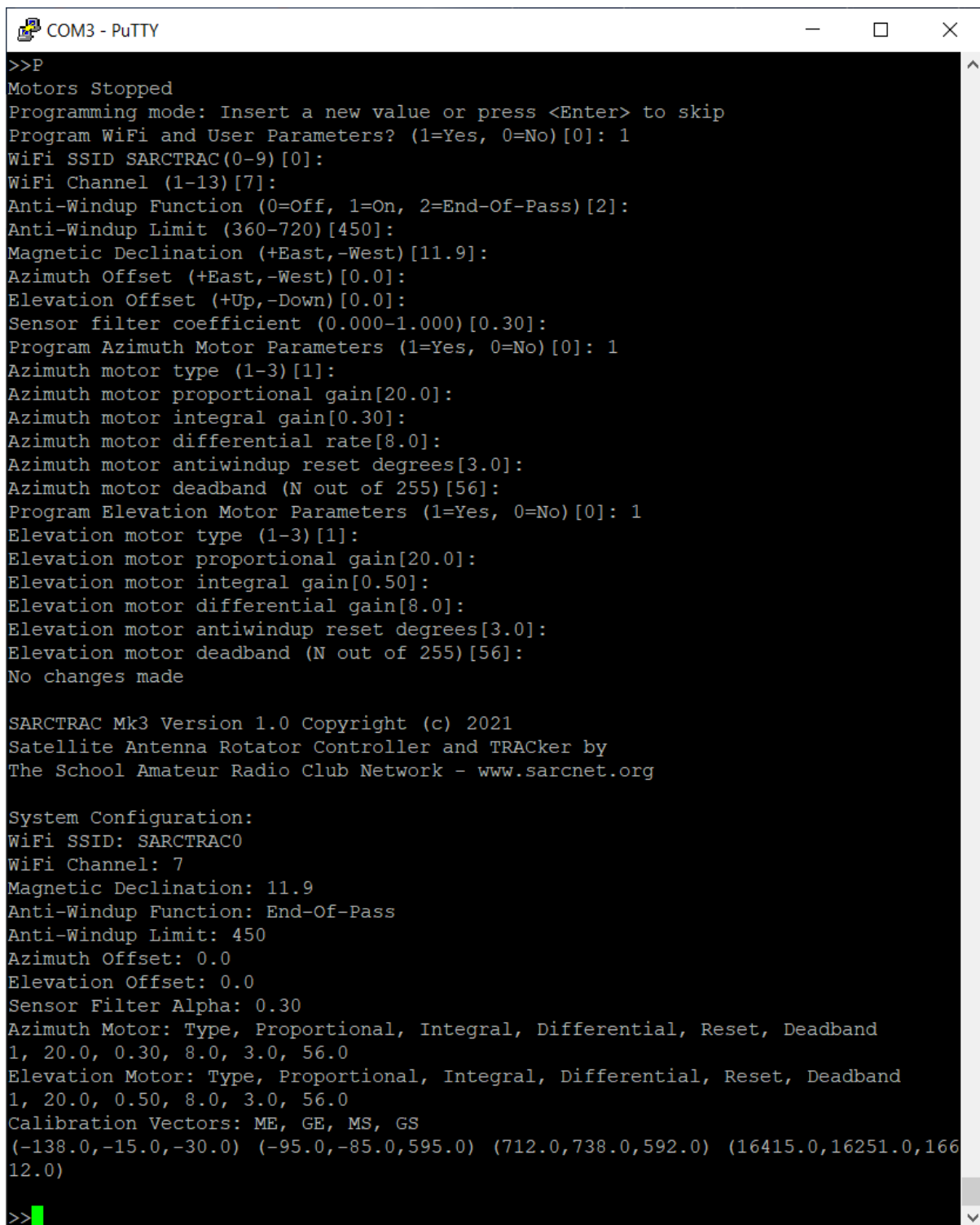
```

>>M
Monitoring in progress: Press <a> <Enter> to abort
  az    el  azSet  elSet  azWind  Windup  azErr  elErr  RSSI
  0.0   0.1    0     0     0       0     0.0   0.1   -30
 -0.1   0.1    0     0    -0       0    -0.1   0.1   -30
 -0.4   0.1    0     0    -0       0    -0.4   0.1   -29
  2.1   0.1    0     0     2       0     2.1   0.1   -28
Function aborted
>>

```

**Figure 21 – Monitor command**

17. Press <P><Enter> to program the device.



```
>>>P
Motors Stopped
Programming mode: Insert a new value or press <Enter> to skip
Program WiFi and User Parameters? (1=Yes, 0=No)[0]: 1
WiFi SSID SARCTRAC(0-9)[0]:
WiFi Channel (1-13)[7]:
Anti-Windup Function (0=Off, 1=On, 2=End-Of-Pass)[2]:
Anti-Windup Limit (360-720)[450]:
Magnetic Declination (+East,-West)[11.9]:
Azimuth Offset (+East,-West)[0.0]:
Elevation Offset (+Up,-Down)[0.0]:
Sensor filter coefficient (0.000-1.000)[0.30]:
Program Azimuth Motor Parameters (1=Yes, 0=No)[0]: 1
Azimuth motor type (1-3)[1]:
Azimuth motor proportional gain[20.0]:
Azimuth motor integral gain[0.30]:
Azimuth motor differential rate[8.0]:
Azimuth motor antiwindup reset degrees[3.0]:
Azimuth motor deadband (N out of 255)[56]:
Program Elevation Motor Parameters (1=Yes, 0=No)[0]: 1
Elevation motor type (1-3)[1]:
Elevation motor proportional gain[20.0]:
Elevation motor integral gain[0.50]:
Elevation motor differential gain[8.0]:
Elevation motor antiwindup reset degrees[3.0]:
Elevation motor deadband (N out of 255)[56]:
No changes made

SARCTRAC Mk3 Version 1.0 Copyright (c) 2021
Satellite Antenna Rotator Controller and TRACker by
The School Amateur Radio Club Network - www.sarcnet.org

System Configuration:
WiFi SSID: SARCTRAC0
WiFi Channel: 7
Magnetic Declination: 11.9
Anti-Windup Function: End-Of-Pass
Anti-Windup Limit: 450
Azimuth Offset: 0.0
Elevation Offset: 0.0
Sensor Filter Alpha: 0.30
Azimuth Motor: Type, Proportional, Integral, Differential, Reset, Deadband
1, 20.0, 0.30, 8.0, 3.0, 56.0
Elevation Motor: Type, Proportional, Integral, Differential, Reset, Deadband
1, 20.0, 0.50, 8.0, 3.0, 56.0
Calibration Vectors: ME, GE, MS, GS
(-138.0,-15.0,-30.0) (-95.0,-85.0,595.0) (712.0,738.0,592.0) (16415.0,16251.0,166
12.0)

>>
```

**Figure 22 – Program command**

18. Press <R><Enter> to start a race test sequence. This test turns the rotator to within 1 degree of 5 cardinal positions and then moves to the next. The elapsed time results of this test are not are not indicative of the calibration accuracy of the system, rather they can be used to determine if the calibration process has been completed properly or is grossly inaccurate.

```
COM3 - PuTTY
>>R
Motors Started
Race Test in progress: Press <a> <Enter> to abort
Starting from home
Test 1. Elapsed = 0.0 seconds. Going to: 0 90
Test 2. Elapsed = 37.9 seconds. Going to: 90 0
Test 3. Elapsed = 56.6 seconds. Going to: 180 0
Test 4. Elapsed = 38.6 seconds. Going to: 270 0
Test 5. Elapsed = 36.4 seconds. Going to: 360 0
Total elapsed = 169.5 seconds
Motors Stopped
Test Complete. Unwind to home? (1=Yes, 0=No)[0]: 1
Motors Started
Unwinding to home
>>
```

**Figure 23 – Race test command**

19. Press <S><Enter> to see a simulation of satellite tracking
  - a. The monitor data will be displayed.
  - b. The antenna will track at 1 degree per second via the following points:
  - c. (0, 0), (90, 90), (180, 0), (270, 90), (360, 0), then in reverse.
  - d. Type a<Enter> to abort this function.
  - e. Type 0 0<Enter> to return to the home position.

```
COM3 - PuTTY
>>S
Motors Started
Simulation in progress: Press <a> <Enter> to abort
  az    el  azSet  elSet  azWind  Windup  azErr  elErr  RSSI
-0.1   0.2    1     1    -0      0   -1.2  -0.9  -28
 0.6   0.5    2     2     1     0   -1.5  -1.6  -28
 1.1   0.7    3     3     1     0   -2.0  -2.4  -28
 0.2   1.3    4     4     0     0   -3.9  -2.8  -29
Function aborted
>>
```

**Figure 24 – Simulation command**



## SARCTRAC Automatic Operation

SARCTRAC can be used in conjunction with a number of popular satellite tracking applications to automatically track satellites. These applications may also control your rig frequency to compensate for Doppler shift.

The following sections provide brief information for setting some popular satellite tracking applications. Only the important configuration information is shown.

To set up SARCTRAC with any tracking application you will first need to know:

- The COM Port Number of the SARCTRAC Dongle: e.g. COM3 on Windows or /dev/ttyACM0 on Linux
- Baud Rate: Must be 9600bps
- Rotator Protocol: EasyCommII. However, for different applications, this translates into: "Rotator model 202", "SARCNET", "EASYCOMM-I" or "SAEBRTTrackBox", so you might have to do some research to find the configuration setting corresponding to this protocol.

### Gpredict™

You must first install HAMLIB.

**On Windows:** Open a terminal window and execute the following commands:

```
cd \Program Files (x86)\<Your HAMLIB folder>\bin\  
rotctld -m 202 -r COM3 -s 9600 -T 127.0.0.1 -t 4533 -vvv
```

**On Linux:** Open a terminal window and execute the following commands:

```
rotctld -m 202 -r /dev/ttyACM0 -s 9600 -T 127.0.0.1 -t 4533 -vvv
```

#### Start Gpredict:

Select Edit Preferences | Interfaces | Rotators

Select Add New

Name: SARCTRAC

Host: 127.0.0.1

Port: 4533

Az type 0° → 180° → 360°

Select Antenna Control

Select Settings

Device: SARCTRAC

Cycle: 1000msec

Tolerance: 0.01

### PstRotator™

Select Communication | RS232 / TCP Server

Select Communication | EL / AZ + EL COM Port | COM 3

Select Setup | EL / AZ + EL Controller Select SARCNET

### Orbitron™

Select WispDDE Driver

Start the WispDDE Client

Open the WispDDE Client

Select Settings | Interface Type: EASYCOMM-I

Select Settings | Baud Rate: 9600

### **SATPC32™**

Select Setup | Rotor Setup | Rotor interface/controller | SAEBRTTrackBox

Select Setup | Rotor Setup | Settings

LPT: 3

Delay: 30

Turning point: S

Select Setup | Rotor Setup | Optional Settings

Update antenna positions: in time intervals

Time interval (sec.): 1

## SARCTRAC Application Notes

The following application notes are included here for those interested in getting the most out of their satellite ground station.

### Electro Magnetic Interference

Electro Magnetic Interference (EMI), also known as Radio Frequency Interference (RFI), can be a significant problem when listening for weak, VHF/UHF signals, emanating from tiny, tumbling satellites in orbit. A directional antenna automatically pointed at the satellite is a definite advantage, but it is not the whole solution to the problem. Careful setup, design and correct use of system components can make a big difference to your satellite communications experience.

All non-linear or digital electrical devices create EMI. On the VHF/UHF bands, as used for satellite communications, EMI can originate from:

- The SARCTRAC Rotator or Sensor.
- The PC controlling the rotator.
- The DC power supplies used for the rotator, computer and radio.
- Other electronic devices in your house or neighbourhood.
- Cables, which radiate EMI, can act as antennas.

The first step in minimising EMI is determining the source. We start by using our radio and antenna to identify the EMI culprits using the following process:

1. Connect the Yagi antenna (while mounted on the tripod) to the radio.
2. Switch the radio to SSB and adjust it to its most sensitive setting settings.
3. Tune over the VHF and UHF satellite bands: For example: 145.8-146.0MHz and 435-438MHz.
4. Note the frequencies of suspicious noise signals (hash, pulsing, clicking and buzzing) and carriers (tones and birdies) and their signal strength according to the radio's S-Meter.
5. Unlock the tripod, turn the antenna around by hand to peak up the signal strength of the noise source and determine its horizontal direction. If the signal strength of the noise source changes, it must be external to the antenna/rotator assembly.
6. If the noise source appears to be inside the house, locate it by systematically tuning devices off and on.
7. Lock the tripod in the home position. Turn on SARCTRAC, log into the serial terminal utility (<Esc><Esc><Esc>) and use it to point the antenna vertically (0 90 <Enter>). This will minimise most terrestrial sources of EMI so you can concentrate on any noise from SARCTRAC.
8. Tune over the VHF and UHF satellite bands, again, looking for any noise or carriers that were not there when SARCTRAC was off. If in doubt, power off SARCTRAC to determine if it is the source.
9. For comparison, the results of our testing are as follows:

Sources of EMI by signal strength:

1. Neighbourhood signals (Strong hash and carriers) S8.
2. Laptop PC running application for rotator/radio control (Loud pulsing) S6.
3. Laptop and radio power supplies (wideband hash) S5.
4. CAT cable from PC to radio (audible hash, clicking, pulsing) S2.
5. SARCTRAC rotator/sensor (barely audible hash and birdies) S0.

Now that you know the sources of EMI, you can attempt to minimise it by monitoring the noise source and using the following steps:

1. Relocate the station to a quieter area.
2. Turn off the offending equipment.
3. Run the offending equipment off batteries.
4. Re-locate the offending equipment.
5. Re-route cables away from the antenna.
6. Try installing clip-on ferrite chokes on cables.

### Electro-Magnetic Compatibility

Electro-Magnetic Compatibility (EMC) is a measure of how a system responds to the presence of nearby Radio Frequency (RF) energy sources. SARCTRAC is mounted at the antenna and receives high levels of exposure to RF energy. Since there is no balun at the antenna, RF currents can flow down the outside of the coax and can be coupled into the sensor cable. Like any other computerized system, SARCTRAC has limits to amount of RF energy it can deal with. So, how much RF is too much? Here are the results of our testing:

**Table 2 – Electro Magnetic Compatibility Tests**

Power Mode Band	Result	Conditions
10W FM VHF/UHF	Pass	Feed via Arrow II 10W Duplexer.
50W FM VHF/UHF	Pass	Direct Feed. EMI choke on cable at sensor.
50W FM VHF/UHF	Fail	Direct Feed. No EMI chokes. Rotator disconnection while transmitting; or Antenna motion halted while transmitting; or Antenna motion locked requiring power cycle.
>50W FM VHF/UHF	Unknown	Recommend additional EMI chokes on coax at antenna feed points and on sensor cable.

**Conclusion:** The use of some EMI chokes on the sensor cable at the sensor, and/or the coax cables at the antenna feed points, is mandatory for operation above 10W. The number of EMI chokes required will depend on the feed-point balance, the SWR at the operating frequency and the separation between the sensor cable and the coax cable over all orientations of the antenna. The operation above 50W was not tested, so be careful. Also, always be mindful of human Electro-Magnetic Radiation (EMR) limits.

## Polarization Fading

Polarization fading occurs as the satellite tumbles through space and the dominant polarization of its signal changes with respect to that of the receiving antenna. Most of the Amateur satellite antennas and the hand-held, dual-band antenna used in this project are linearly polarized. So, it can be expected that the signal and antenna polarization will be mismatched at some point in each overhead pass of a satellite. For some reason this effect is more noticeable when the satellite is close to zenith, just when you expect to receive the strongest signals!

## Tracking Accuracy

SARCTRAC uses a 3D magnetometer and accelerometer in a closed-loop, feedback control system to point the antenna at the predicted azimuth and elevation of a satellite. The calibrated accuracy of the sensor better than say  $\pm 5$  degrees and, with a fast-moving target, say 1 degree per second, the control system will always be lagging a couple of degrees behind. This is more than sufficient accuracy to position a small Yagi antenna, with a 90-degree beamwidth, at a satellite, but it would not be suitable for say a parabolic dish antenna.

## PC-Based Satellite Tracking Applications

We are often asked which is the best PC-based satellite tracking application to use. The answer is, that it all depends on what you want to do and how you want to do it.

- First, SARCTRAC only emulates the AMSAT™ EasyCommII rotator protocol, which is efficient and, unlike some protocols, provides position feedback.
- Second, you will most likely need an application that will control your radio equipment as well.
- Third, everyone has a different computer and operating system.
- Finally, each PC-based satellite tracking application has many different features and displays. Some you may need, some you may not. Some you may like, some you may not. The only real way to find out is to download and test them.

Here is a checklist to help you choose a PC-based satellite tracking application:

- ☐ General
  - ☐ Is it compatible with your computer and operating system?
- ☐ Rotator Control
  - ☐ Is it compatible with AMSAT™ EasyCommII rotator control protocol?
  - ☐ Does it display both the set antenna position and the actual antenna position?
  - ☐ Does it provide automatic and manual rotator control?
  - ☐ Does it sequence satellites and satellite passes?
  - ☐ Does it automatically position the rotator for the next satellite pass?
  - ☐ Are the rotator position update rates configurable?
  - ☐ Can you select your favourite group of satellites to track?
  - ☐ Does it provide a prediction of future satellite passes?

- ☐ Does the prediction show Local/UTC, AOS AZ, LOS AZ, Max EL, Pass Duration?
- ☐ Does it show which satellites are currently visible?
- ☐ Does it show satellite positions and footprints on a map?
- ☐ Does it automatically update satellite TLE files from the Internet?
- ☐ Radio Control
  - ☐ Does it do automatic Doppler frequency correction?
  - ☐ Is it compatible with your radio and CAT cable?
  - ☐ Can new satellite frequencies and modes be added?
  - ☐ Can you tune the frequencies incrementally from the set frequencies?
  - ☐ Are radio frequency update rates configurable?

Based on our testing, the following PC-based satellite tracking application are at least compatible with SARCTRAC on the indicated operating system:

- PstRotator™ (Windows)
- Orbitron™ (Windows)
- Gpredict™ (Windows, Linux)
- SatPC32™ (Windows)



# SARCTRAC Maintenance

## SARCTRAC Configuration

The SARCTRAC system configuration is displayed every time <Enter> is pressed by itself, at the prompt (>>). It can be changed by pressing <P><Enter> and following the prompts. The system configuration information is shown in Table 3.

**Table 3 - System Configuration**

Parameter and Description	Range	Default Value
WiFi SSID – WiFi Service Set Identifier	SARCTRAC0-9	SARCTRAC0
WiFi Channel – The RF channel in the 2.4GHZ ISM Band. Change to avoid local channel congestion.	1-13	7
Anti-Windup Function – Repositions the rotator to with 180 degrees of the starting position.	Off, On, End-Of-Pass	End-Of-Pass
Anti-Windup Limit – Degrees. At which point the anti-windup function operates to unwind the cable.	360-720	450
Magnetic Declination – Degrees. Add this value to True bearings to get Magnetic bearings (+ for East, - for West). See: <a href="#">NCEI Online Calculator</a> .	+90 - -90	11.9
Azimuth Offset – Degrees (+ for East, - for West).	+90 - -90	0.0
Elevation Offset – Degrees (+ for Up, - for Down).	+90 - -90	0.0
Sensor Filter Alpha – Decrease to increase smoothing of the 3D Sensor data	0-1	0.30
Azimuth Motor Type - 1 = DC Motor via L298N Driver 2 = DC Motor via LMD18200T Driver 3 = AC via Aptinex Opto Triac Driver	1-3	1
Azimuth Motor Proportional Gain – Increase for faster convergence. Decrease for less overshoot.	0-50	20.0
Azimuth Motor Integral Gain – Increase for better convergence. Decrease for less dither.	0-20	0.30
Azimuth Motor Differential Rate – Increase for greater acceleration/deceleration. Decrease for less overshoot.	0-20	8.0
Azimuth Motor Reset – Reset integration beyond this angle. Increase for faster convergence. Decrease for less overshoot.	0-30	3.0

Azimuth Motor Deadband – Zero motor drive = N/255x12V. Increase for quicker motor start up. Decrease for less dither.	0-255	56
Elevation Motor Type - 1 = DC Motor via L298N Driver 2 = DC Motor via LMD18200T Driver 3 = AC via Aptinex Opto Triac Driver	1-3	1
Elevation Motor Proportional Gain – Increase for faster convergence. Decrease for less overshoot.	0-50	20.0
Elevation Motor Integral Gain – Increase for better convergence. Decrease for less dither.	0-20	0.50
Elevation Motor Differential Rate – Increase for greater acceleration/deceleration. Decrease for less overshoot.	0-20	8.0
Elevation Motor Reset – Reset integration beyond this angle. Increase for faster convergence. Decrease for less overshoot.	0-30	3.0
Elevation Motor Deadband – Zero motor drive = N/255x12V. Increase for quicker motor start up. Decrease for less dither.	0-255	56

### **SARCTRAC Sensor Calibration**

The SARCTRAC sensor comes carefully pre-calibrated at the factory using a non-magnetic, 3-axis, magnetometer/accelerometer calibration gimbal. The factory calibration is saved in the non-volatile memory in the unit and it can be restored by the user. The factory calibration should achieve +/- 5 degrees accuracy: More than enough for a hand-held Yagi antenna, which may have a 3dB beamwidth of +/- 45 degrees. However, the Earth's magnetic field is weak and it is subject to local magnetic anomalies, such as iron and steel. Calibration, in itself, cannot mitigate the effect of strong local magnetic anomalies. On a ship, you may have seen that the compass is mounted on a binnacle, which has two magnetic balls designed to null-out local magnetic anomalies. This approach is impractical for SARCTRAC, where the sensor is constantly moving. The best strategy is to remove the local magnetic anomalies or to relocate SARCTRAC to a magnetically quiet area. You can locate magnetic anomalies by moving a compass around the area and checking for any deviations. In the event that the SARCTRAC 3D Sensor needs to be recalibrated we would do it at the factory. While we can provide you with the calibration procedure and an on-line instructional video of how to do it yourself, but we really don't recommend you try it.