WHITE ELEPHANT GMBH

SkyTrack

Reference Manual

Urs Maurer

Version:	Modified:	
1.0	5-Oct-17	Original Issue
1.1	21-Dec-17	LX 200 protocol support
1.2	25-Oct-18	New SkyTracker hardware
1.3	8-Jan-19	Support different steps/rev per axis

Table of Contents

1 Introduction

SkyTrack is a PC program that is able to control the movement of a telescope to find and follow stars, planets, deep sky objects, small solar system bodies (SSSB) such as comets or near earth objects such as satellites.

The program supports telescopes that have simple stepper motors (without decoders) with either Equatorial or Azimuthal mountings.

The telescope can be controlled using the program's graphical user interface (GUI), a numeric keypad or via Stellarium. In the latter case the program sends feedback to Stellarium so that it can keep its display up to date. The use of Stellarium is not a requirement.

Other features that are often missing from contemporary products include:

- Favorites: a list of frequently observed objects.
- Horizon: For fixed telescopes and those at their "home" location, the actual horizon can be defined. The actual horizon differs from the true horizon when buildings obscure the true horizon. This feature allows the program to improve the accuracy of its filtering of visible objects.
- Only list objects that can currently be seen or, in the case of NEOs, are soon to be seen.
- Catalogs: Objects can be named according to a variety of catalogs. The same astronomical object is called different things according to the catalog used.
- On Earth Objects: For demonstration purposes, when the weather is overcast, it is sometimes useful to be able to position the telescope onto a nearby terrestrial object (e.g. a road sign). In this case the rotation of the earth must be ignored.
- Park position: For fixed telescopes or those at their "home" location, it is useful to park the telescope to a known position before powering off. This saves the need to realign the telescope next time it is used.
- Normal and Expert modes: Useful to prevent shared or public telescopes from being accidently misconfigured.

2 Getting Started

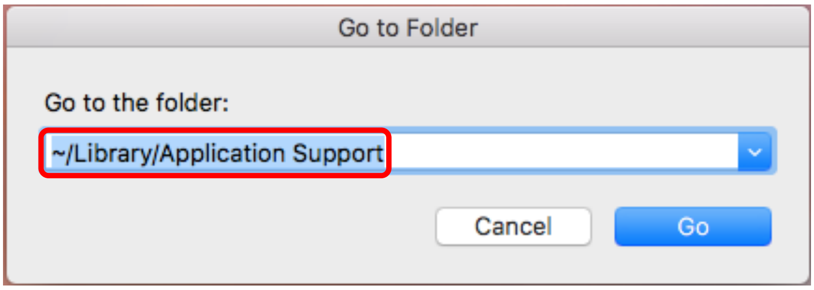
The easiest way to get SkyTrack running is to follow the instructions of the SkyTrack User Manual.

3 Configure SkyTrack

3.1 Locate the configuration data directory

3.1.1 OSX

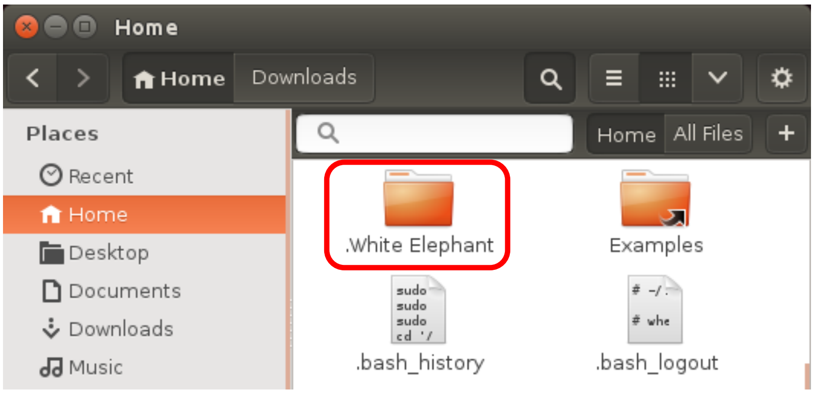
First open the application data directory by starting the **Finder's Go to Folder…** and then entering: **~/Library/Application Support**



Then browse to the SkyTrack data subdirectory: **White Elephant/SkyTrack**

3.1.2 Linux

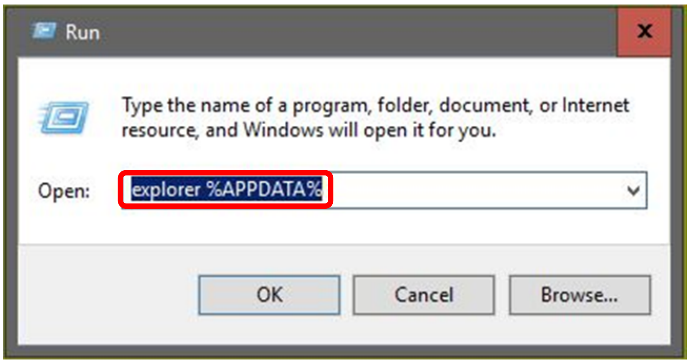
First open **Home** and make the hidden directories visible by entering: **Ctrl-h**



Then browse to the SkyTrack data subdirectory: **.White Elephant** and then **SkyTrack**

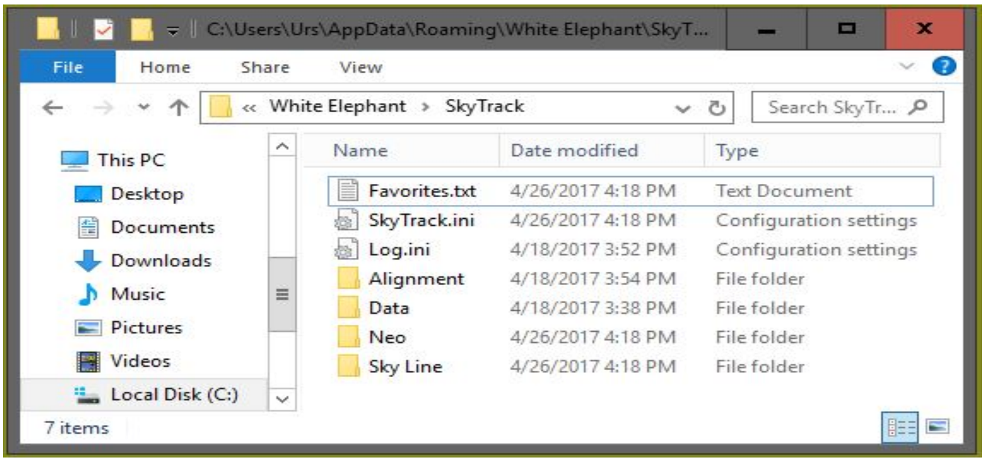
3.1.3 Windows 10

First open the application data directory by executing: **explorer *%APPDATA%***



Then browse to the SkyTrack data subdirectory: **White Elephant\SkyTrack**

3.2 Contents of SkyTrack data directory



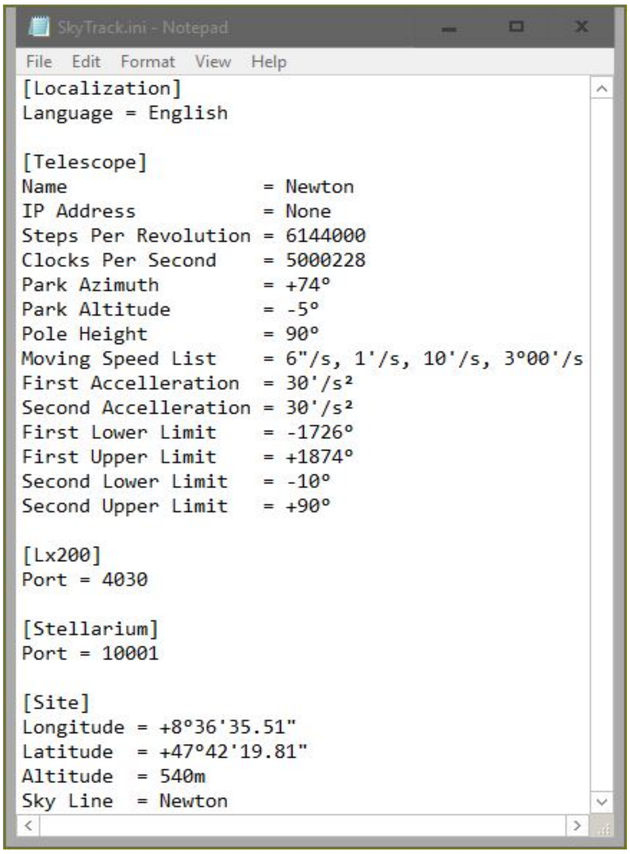
This directory contains the following configuration data:

- SkyTrack.ini -> program configuration data
- Favorites.txt -> list of the favorite sky objects
- Log.ini -> configuration of program logging
- Sky Line -> sky line definition data
- Alignment -> alignment correction data
- Neo -> near earth object information
- Data -> binary program data
- SSSB -> small solar system body information

3.2.1 Program configuration data (SkyTrack.ini)

The file SkyTrack.ini contains information on how to control the telescope. It is automatically generated when SkyTrack is first started. If Stellarium is already installed and configured, its configuration is taken to initialize the language and site information.

The content of the configuration file is split into the sections Localization, Telescope, Stellarium and Site.



```
[Localization]
Language = English

[Telescope]
Name                  = Newton
IP Address            = None
Steps Per Revolution = 6144000
Clocks Per Second     = 5000228
Park Azimuth          = +74°
Park Altitude         = -5°
Pole Height           = 90°
Moving Speed List     = 6"/s, 1'/s, 10'/s, 3°00'/s
First Accelleration   = 30'/s²
Second Accelleration = 30'/s²
First Lower Limit     = -1726°
First Upper Limit     = +1874°
Second Lower Limit    = -10°
Second Upper Limit    = +90°

[Lx200]
Port = 4030

[Stellarium]
Port = 10001

[Site]
Longitude = +8°36'35.51"
Latitude  = +47°42'19.81"
Altitude  = 540m
Sky Line  = Newton
```

The Localization section contains:

- **Language** = <*language*>
  The language is English, French, German, Greek, Italian or Spanish.

The Telescope section contains the following properties:

- **Name** = <*name*>
  The Telescope's <*name*> to be shown in the SkyTrack windows title bar. If the name is **Setup** then the SkyTrack program runs in expert mode. (See chapter 4)

- **IP Address** = <*address or name*>
  If the name is "SkyTracker" for Windows (or "SkyTracker.local" for Linux and OSX) then SkyTracker hardware must be connected via Ethernet. If the name is "None" then the telescope is simulated.

- **Steps Per Revolution** = <*number*>
  Defines the number of micro steps used to turn a telescope axis by 360°.
  The SkyTracker hardware stepper controller uses 16 micro steps per step.

  If the gearing is different per axis the two values must be individually defined.
  First Steps Per Revolution = <*number*>
  Second Steps Per Revolution = <*number*>

- **Clocks Per Second** = <number>
  Defines the time resolution of the actual hardware. For the SkyTracker hardware a value of 5,000,000 is used.

- **Park Azimuth** = <angle>
  Park Altitude = <angle>
  Park azimuth and altitude define the telescopes park position.

- **Pole Height** = <angle>
  For an azimuth mount the pole height should be set to **90°**. For an equatorial mount <angle> should be replaced by the word **Latitude**.

- **Moving Speed List** = <speed>, <speed>, <speed>, <speed> …
  An ascending list of speeds is used to manually control the telescope via the arrow keys. The **+** and **–** keys change from one value to the next or previous. The last value of the list is the maximum speed for all movements except when adjusting (movements whilst tracking an object).

- **First Acceleration** = <acceleration>
  Defines the maximum acceleration for the azimuth or right ascension axis.

- **Second Acceleration** = < acceleration >
  Defines the maximum acceleration for the altitude or declination axis.

- **First Lower Limit** = <angle>
  First Upper Limit = <angle>
  Second Lower Limit = <angle>
  Second Upper Limit = <angle>
  Define the Positioning limits for two axes. An upper and lower limit of **0°** means no limit. The equatorial mount's second upper limit with a value over **90°** specifies the declination value after a meridian flip.

  Examples:

  - Equatorial Mount

    First Lower Limit = -360°
    First Upper Limit = +360°
    Second Lower Limit = -30°
    Second Upper Limit = +210°

  - Azimuthal Mount

    First Lower Limit = -1726°
    First Upper Limit = +1874°
    Second Lower Limit = -10°
    Second Upper Limit = +90°

The Lx200 section contains:

- ***Port*** *= <number>*
  Defines the port number for the Lx200 protocol server. This enables a smart phone or tablet computer to control the telescope.

  Examples:

  SkySafari 5 Pro (Telescope Setup: Scope Type – Meade LX-200 Classic)

The Stellarium section contains:

- ***Port*** *= <number>*
  Defines the port number used by the Stellarium telescope control.

The Site section contains:

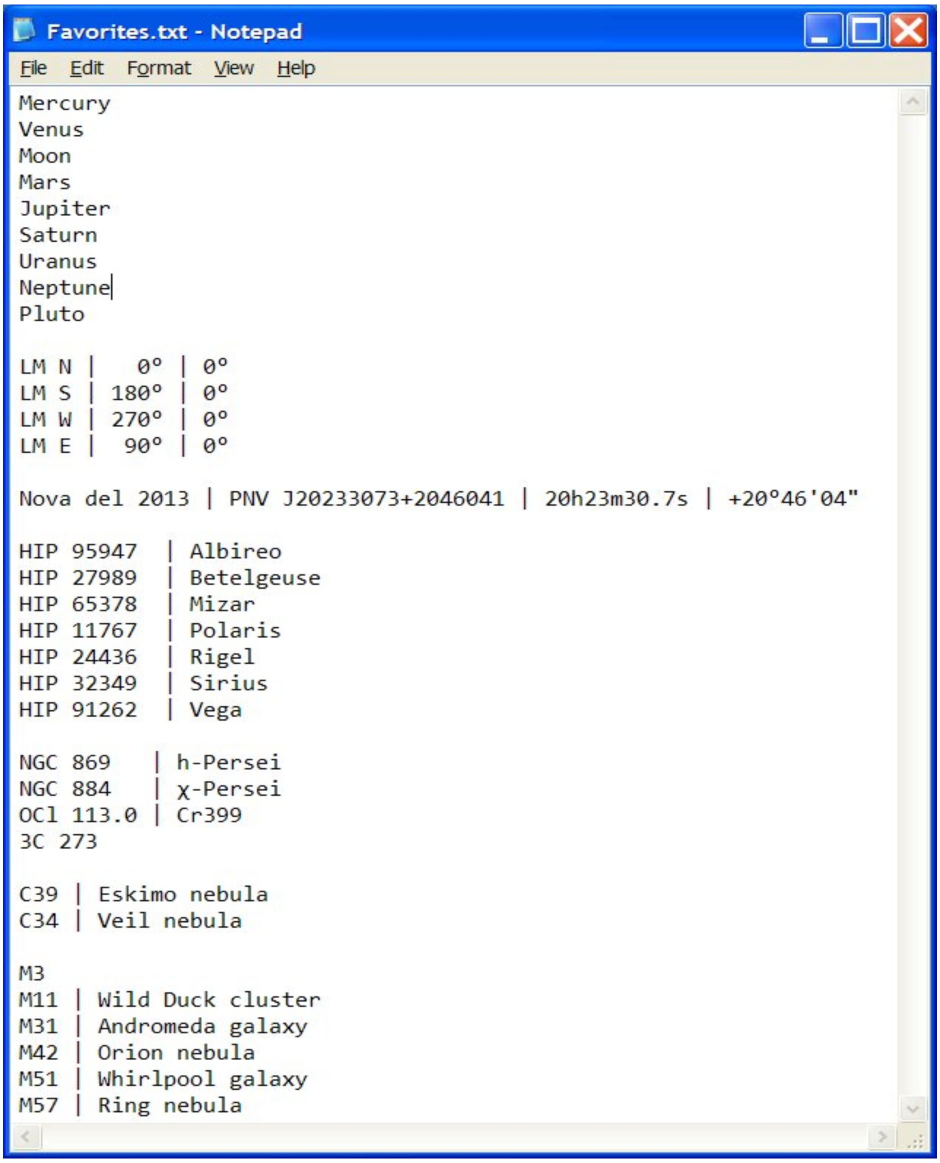
- **Longitude** = <angle>
  Latitude = <angle>
  Altitude = <angle>
  Telescope location information.

- **Sky Line** = <name>
  Defines the name of the sky line database file (see chapter: Set Sky Line)

3.2.2 Favorites list of Sky Objects (Favorites.txt)

The file Favorites.txt is automatically generated when SkyTrack is first started. In this file, one object per line of text can be defined. Empty lines are allowed.

For example:




```
Mercury
Venus
Moon
Mars
Jupiter
Saturn
Uranus
Neptune
Pluto

LM N |   0° | 0°
LM S | 180° | 0°
LM W | 270° | 0°
LM E |  90° | 0°

Nova del 2013 | PNV J20233073+2046041 | 20h23m30.7s | +20°46'04"

HIP 95947  | Albireo
HIP 27989  | Betelgeuse
HIP 65378  | Mizar
HIP 11767  | Polaris
HIP 24436  | Rigel
HIP 32349  | Sirius
HIP 91262  | Vega

NGC 869   | h-Persei
NGC 884   | χ-Persei
OCl 113.0 | Cr399
3C 273

C39 | Eskimo nebula
C34 | Veil nebula

M3
M11 | Wild Duck cluster
M31 | Andromeda galaxy
M42 | Orion nebula
M51 | Whirlpool galaxy
M57 | Ring nebula
```

3.2.3 Solar Objects

For solar objects, any of the following names, in any of the supported languages, are allowed:

- **Sun**
  Warning: if no solar filter is in use, the sun **must not** be added to the list.
- **Moon**
- **Mercury**
- **Venus**
- **Mars**
- **Jupiter**
- **Saturn**
- **Neptune**
- **Pluto**

3.2.4 Small Solar System Bodies (SSSB)

A file with the extension **.sssb,** placed in the folder where the file Favorites.txt is located, defines an SSSB. The name can then be added to the favorites list.

Examples:
C2015-V2(Johnson)

3.2.5 Objects from Catalogs

The following syntax defines an object:

<object_id>
or
<object_id> ¦ <name>

For Caldwell and Messier objects the name is appended to the object id. For the other objects the name replaces the object id.

Examples:
HIP 32349 ¦ Sirius (**Sirius** in favorite list)
M57 ¦ Ring Nebula (**M57 Ring Nebula** in favorite list)

Objects can be defined from any of the following integrated catalogs.

- Caldwell
- HIP
- HR
- Messier
- NEO
- NGC
- OCl
- Quasars

3.2.6 Sky Objects

The following syntax defines a sky object:
<name> ¦ <description> ¦ <right ascension> ¦ <declination>

Example:
Nova Del 2013 ¦ PNV J20233073+2046041 ¦ 2h23m30.7s ¦+20°46’04”

3.2.7 On Earth Objects

The id “LM” (Land Marks) starts the definition for stationary objects.

LM <name> ¦ <azimuth> ¦ <altitude>

Examples:
LM Road Sign ¦ 259°43’ ¦ 2°38’
LM West ¦ 270° ¦ 0°

3.3 Small Solar System Bodies

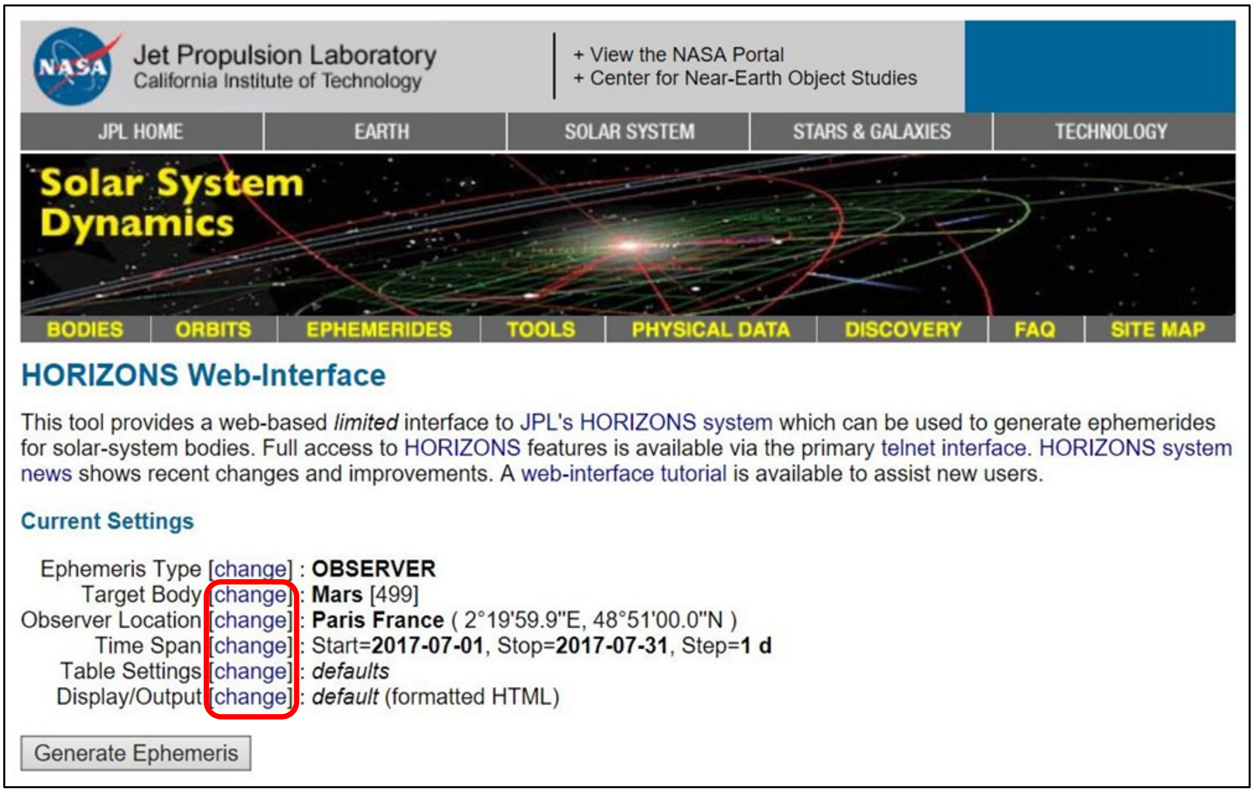
A small solar system body (SSSB) is an object in the solar system that is neither a planet, nor a dwarf planet, nor a satellite. For example: comets are small solar system bodies.

To track an SSSB, a table of its future positions - so called ephemerides – has to be downloaded.

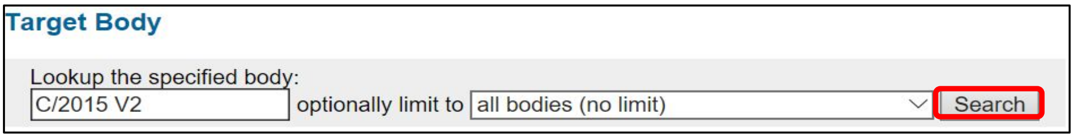
3.3.1 Download Ephemerides

The following Web-Interface allows the downloading of ephemerides:

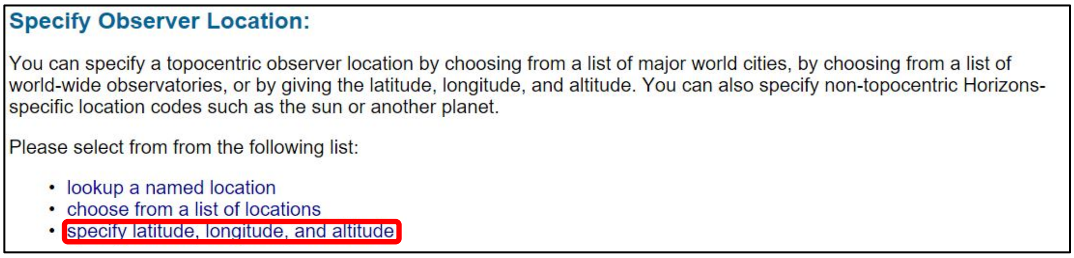
https://ssd.jpl.nasa.gov/horizons.cgi

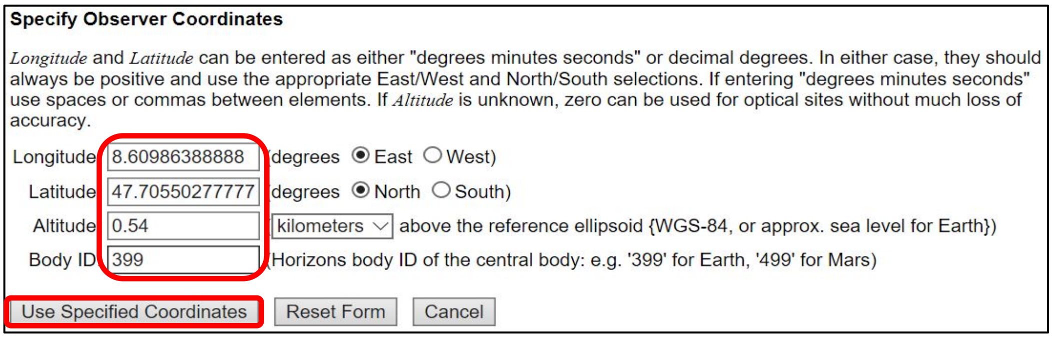


3.3.1.1 Change Target Body

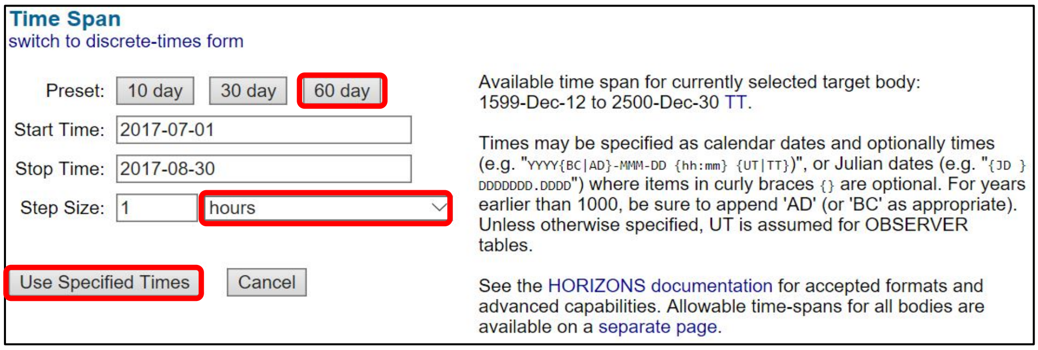


3.3.1.2 Change Observer Location

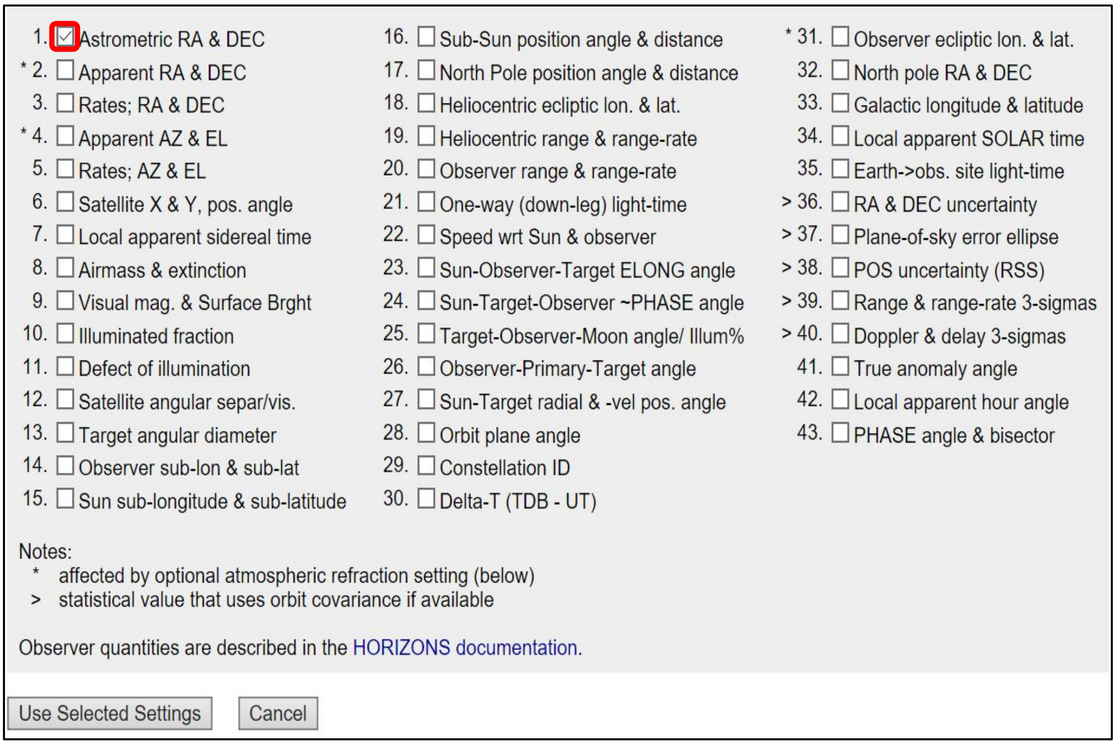


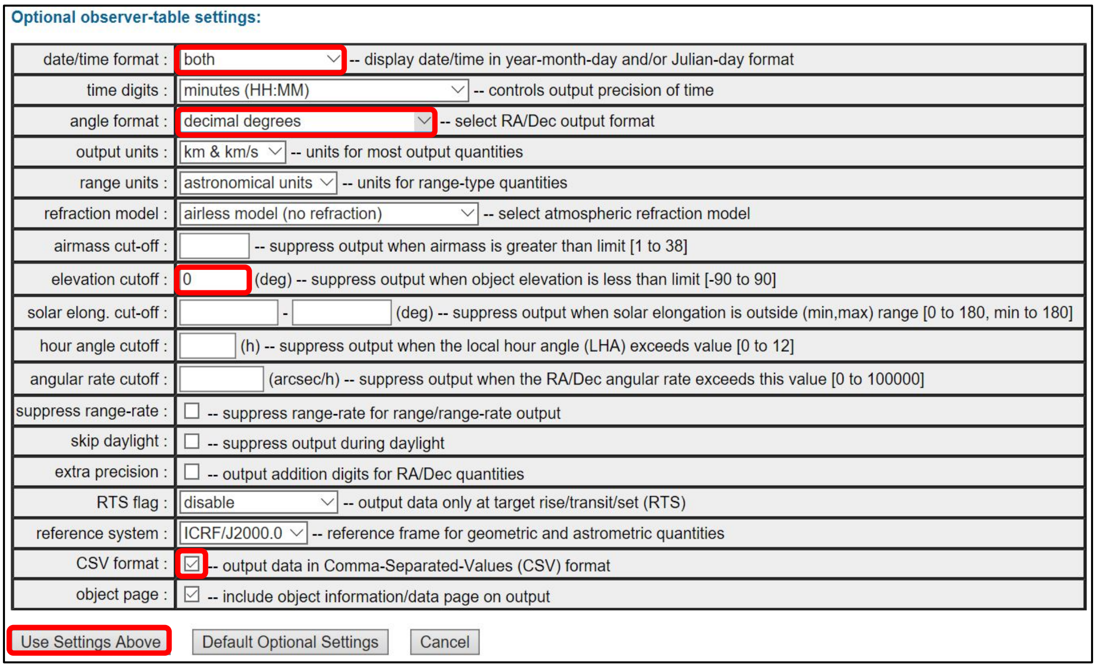


3.3.1.3 *Change Time Span*

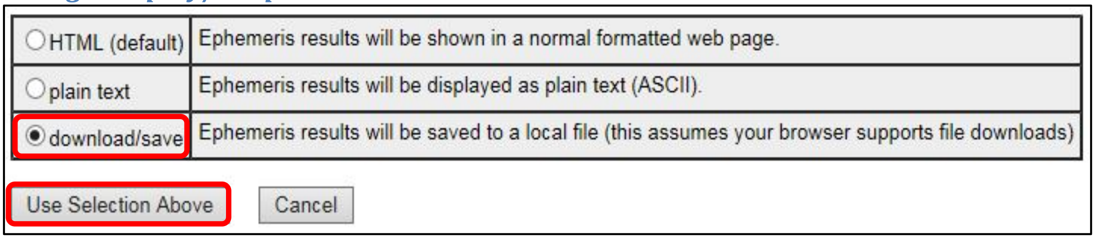


3.3.1.4 *Change Table Settings*

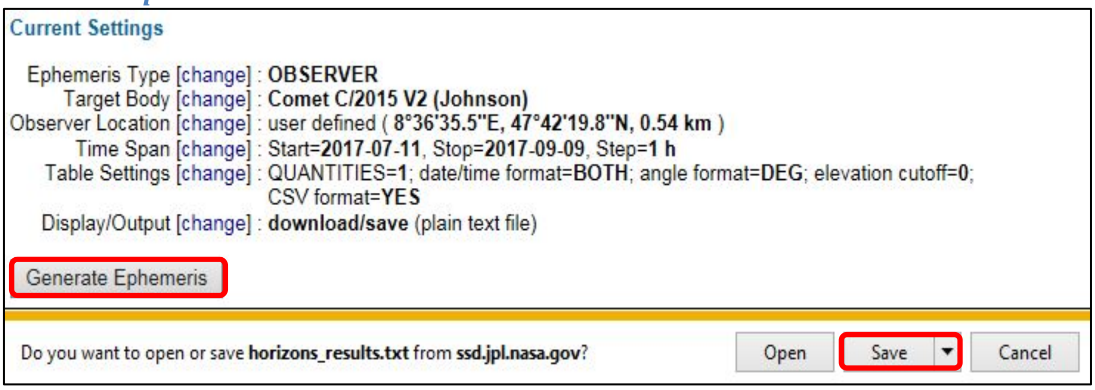




3.3.1.5 Change Display/Output



3.3.1.6 Generate Ephemerides

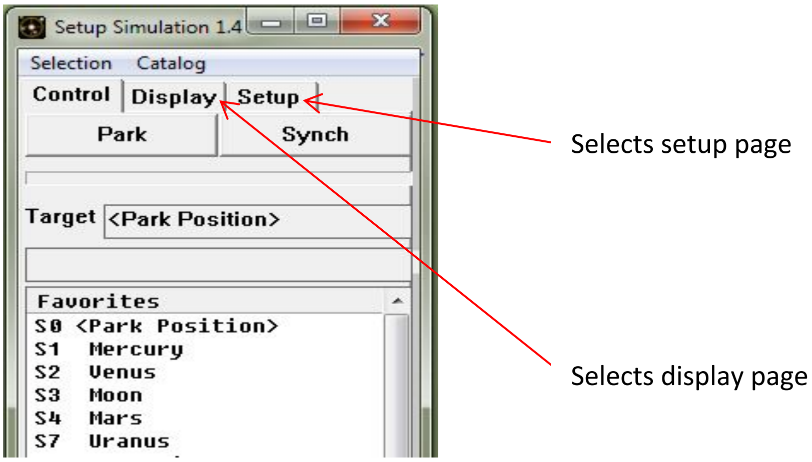


The new file **horizons_result.txt** can now be renamed to **C2015-V2(Johnson).sssb** and then placed in the same folder where the file **Favorites.txt** is located. Then the name **C2015-V2(Johnson)** can be added to the favorites list.

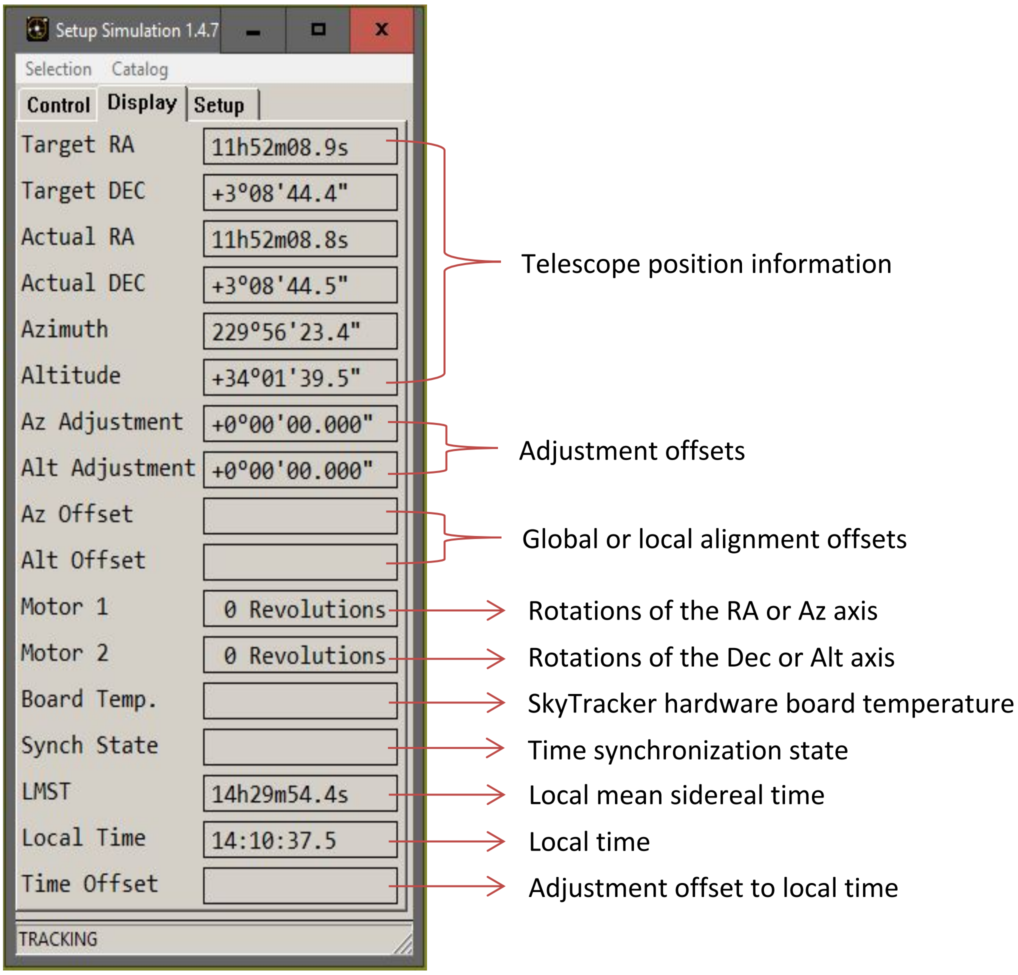
4 Telescope Setup

To enable a telescope setup the mode has to be changed from normal to expert. This can be achieved by changing the name in the file SkyTrack.ini to Setup.

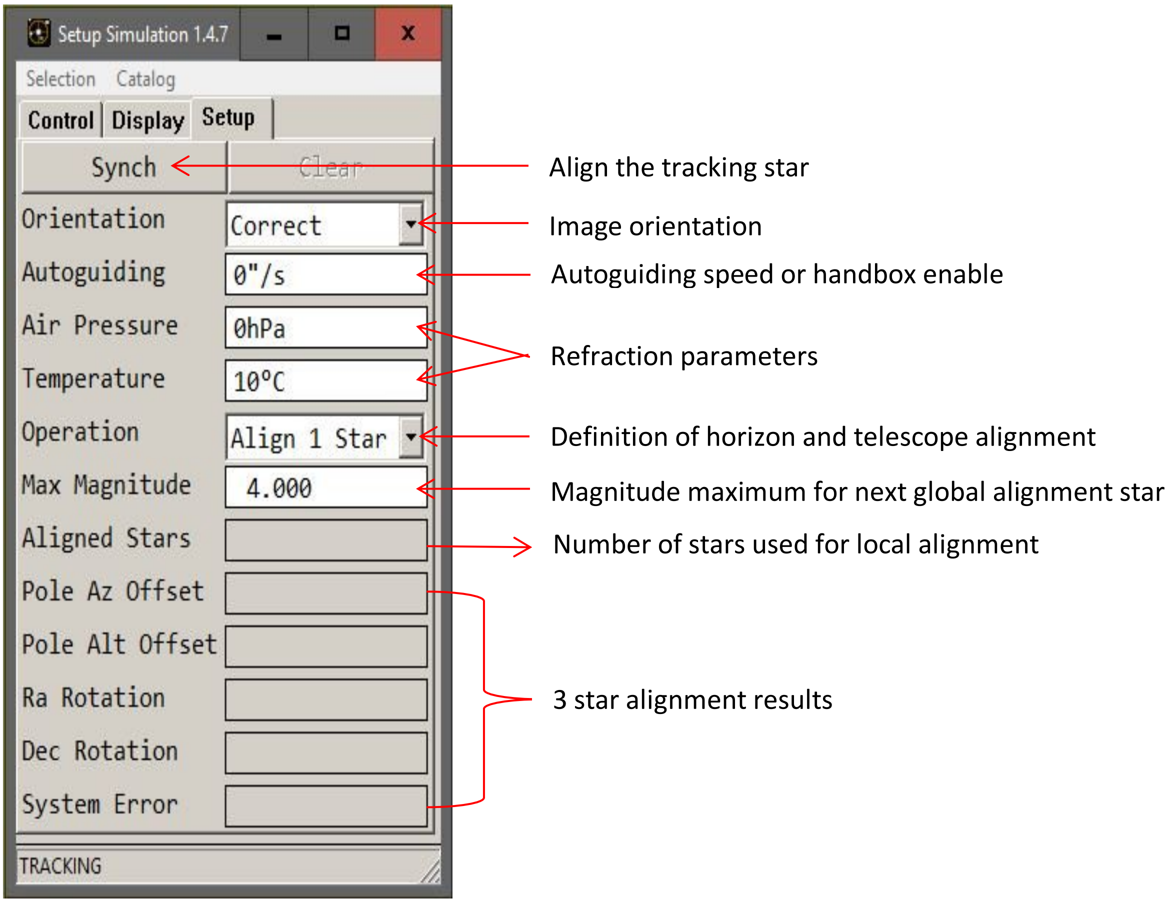
After the next start of SkyTrack the following should be visible:



4.1 Display Page



4.2 Setup Page



4.2.1 Image Orientation

Whilst tracking, the meaning of the arrow keys to adjust a sky object can be changed.
The pull-down menu allows the selection of one of the following image orientations:

- **Correct**
- **Upside Down** Up - Down keys swapped.
- **Backwards** Left - Right keys swapped.
- **Rotated** Up - Down and Left - Right keys swapped.

4.2.2 Autoguiding Speed

The speed for autoguiding is defined in arc seconds per second. A typical value would be **8"/s**.
A value of **0"/s** allows the use of a handbox instead of an autoguiding camera.

4.2.3 Refraction Parameters

Two parameters are used to correct the refraction.

- Air Pressure in hecto Pascal
- Temperature in degrees Celsius

A value of zero for the air pressure switches off the refraction corrections.

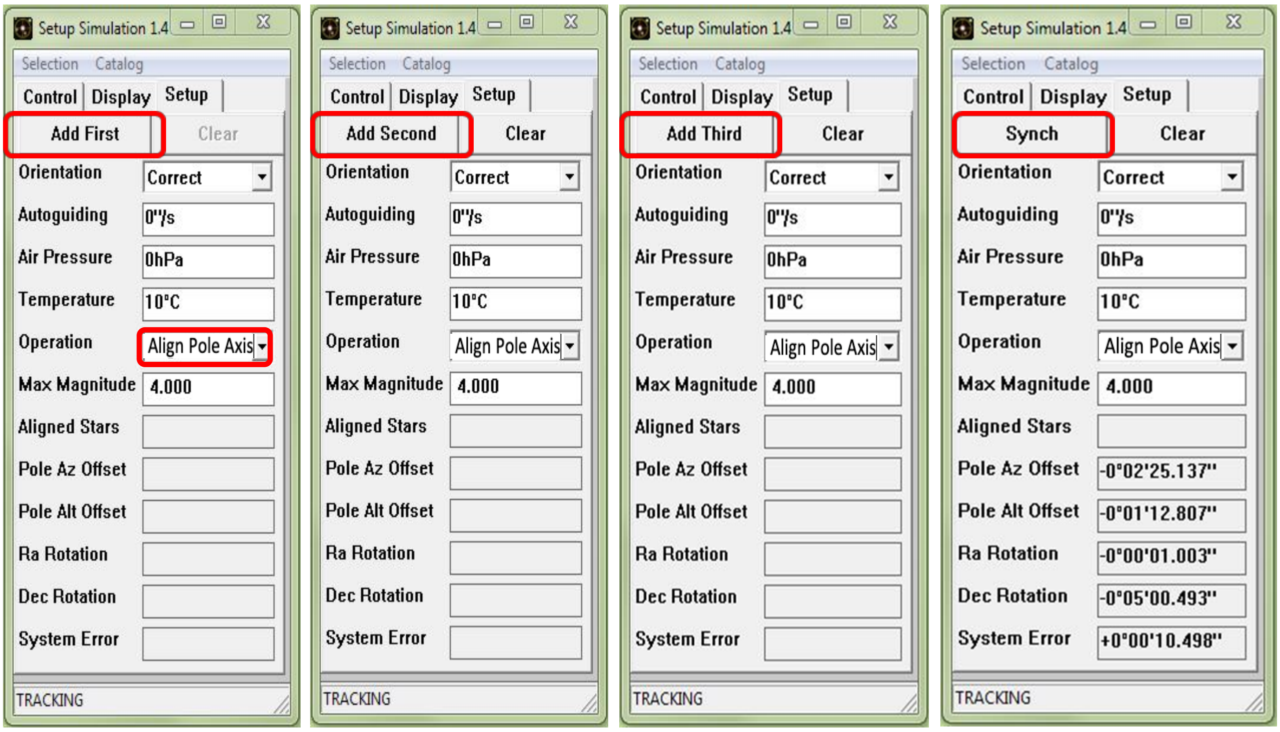
4.2.4 Setup Operation

One of the following operations can be selected (see corresponding chapter for more information).

- **Align 1 Star** to Synch to the tracking object (clears the adjustment offsets).
- **Align Pole Axis** to adjust the pole axis (only for equatorial mounts).
- **Align Global** alignment using many stars to generate a global correction matrix.
- **Align Local** local alignment (if autoguiding is not possible).
- **Set Sky Line** to define the actual horizon.

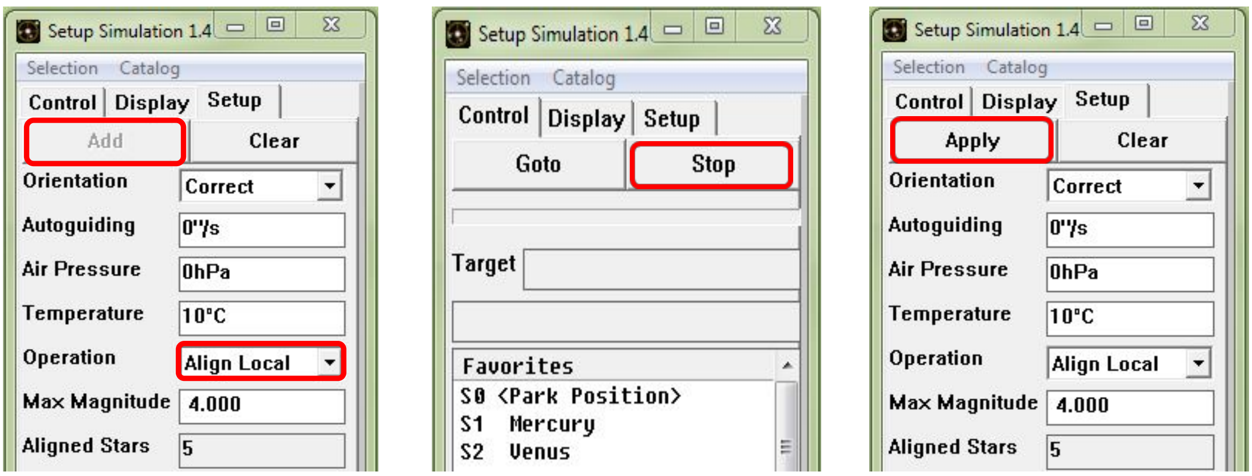
4.3 Pole Axis Alignment

To align the pole axis of an equatorial mount three stars have to be aligned. The stars should not be close to the pole or zenith and the altitude should be greater than 30 degrees. After aligning the third star, the telescope is positioned so that mechanically aligning it back to the third star the pole axis will be aligned. The Synch button allows synchronizing the RA and Dec axis. The System Error depends on the quality of the telescope and how precise the aligning was done. If the error is too big the Clear button can be used to allow a new alignment procedure



4.4 Local Alignment

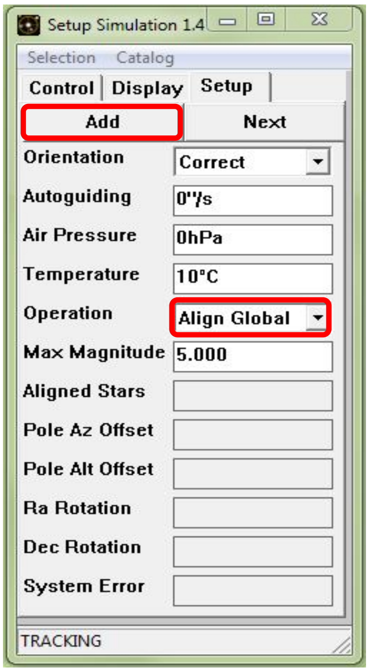
If autoguiding is not possible, local alignment can be used to position the telescope more precisely in a local area. At least five stars have to be aligned. After the telescope is stopped the Apply button completes the operation.

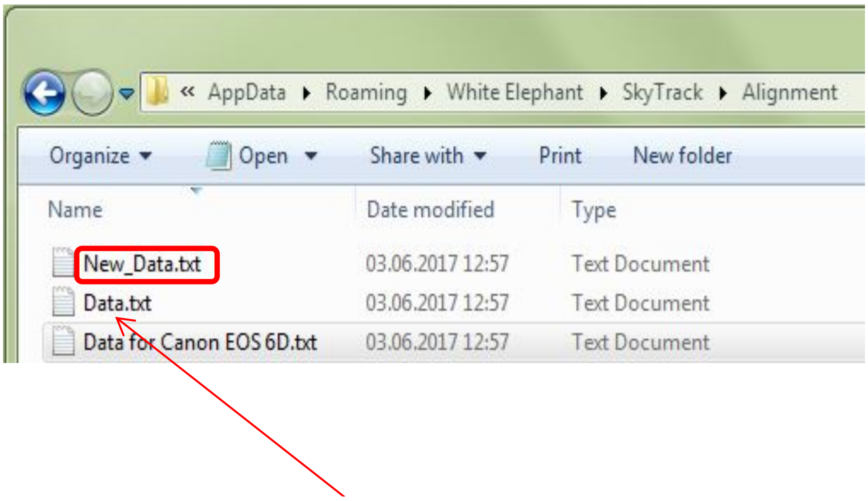


4.5 Global Alignment

The global alignment operation allows the alignment of typically around 50 stars to build a global correction matrix. The alignment information is added to a file called **New_Data.txt** in the alignment folder in the SkyTrack application data area. To keep the file it can be renamed.

After the Align Global operation is selected the next tracked star enables the adding of alignment data. The next star is positioned automatically according to the first star's altitude and the chosen maximum magnitude. If there are no more stars to add in the current altitude band, the operation can be restarted to add data at a different altitude. The Next button allows going to the next star without adding the data of the actual star.

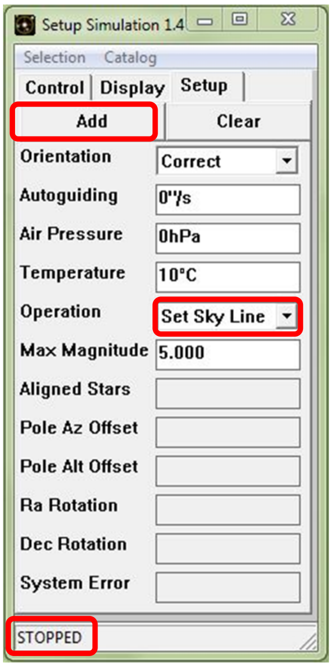




To use the Information for a global correction matrix the file has to be renamed to **Data.txt** and SkyTrack has to be restarted.

4.6 Set Sky Line

To define the actual horizon the telescope has to be directed to landmarks at the horizon and then by pushing the add button added to the database. The database is located in the sky line folder of the SkyTrack application data area.



The name is taken from the SkyTrack.ini file

5 Hardware

5.1 Stepper Controller

The SkyTracker controller is connected via Ethernet to a PC running the SkyTrack program. A handbox or an autoguider can be connected to the guider input.

5.1.1 Power and Ethernet Connections

Supplied Cables:

Ethernet

Power:
- Blue wire: positive
- Brown wire: negative
- Black wire: unused

5.1.2 Motor and Guider Connections

Supplied Cables:

Motors:
- White and Brown wires: Coil A
- Black and Blue wires: Coil B

Guider:
- Brown wire: ST4 Yellow
- Green wire: ST4 Blue
- Pink wire: ST4 Green
- Blue wire: ST4 Red
- Red wire: ST4 Black

Sync:
- Yellow wire: Pulse
- Red wire: GND

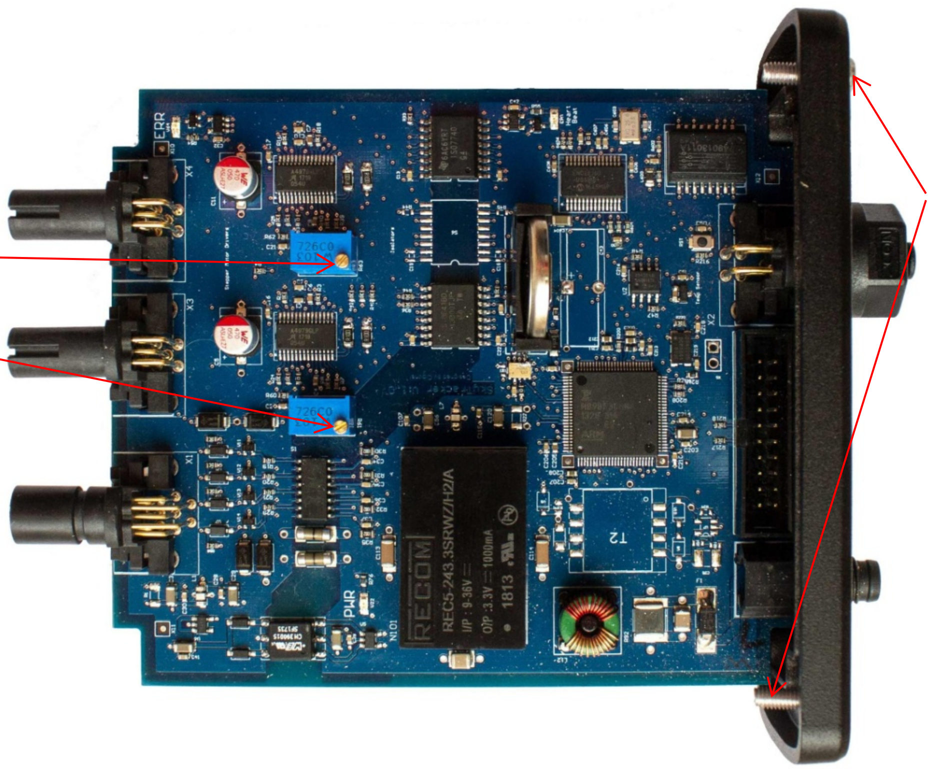
To change the direction of the motor rotation either the white and brown or the black and blue wires must be swapped. The ST4 wiring for the RJ12 connector is documented in chapter 5.2.2.

The sync pulse can be used to synchronize the internal clock to an external time reference - further details on request.

The white and grey wires are reserved for future development. These must be left disconnected.

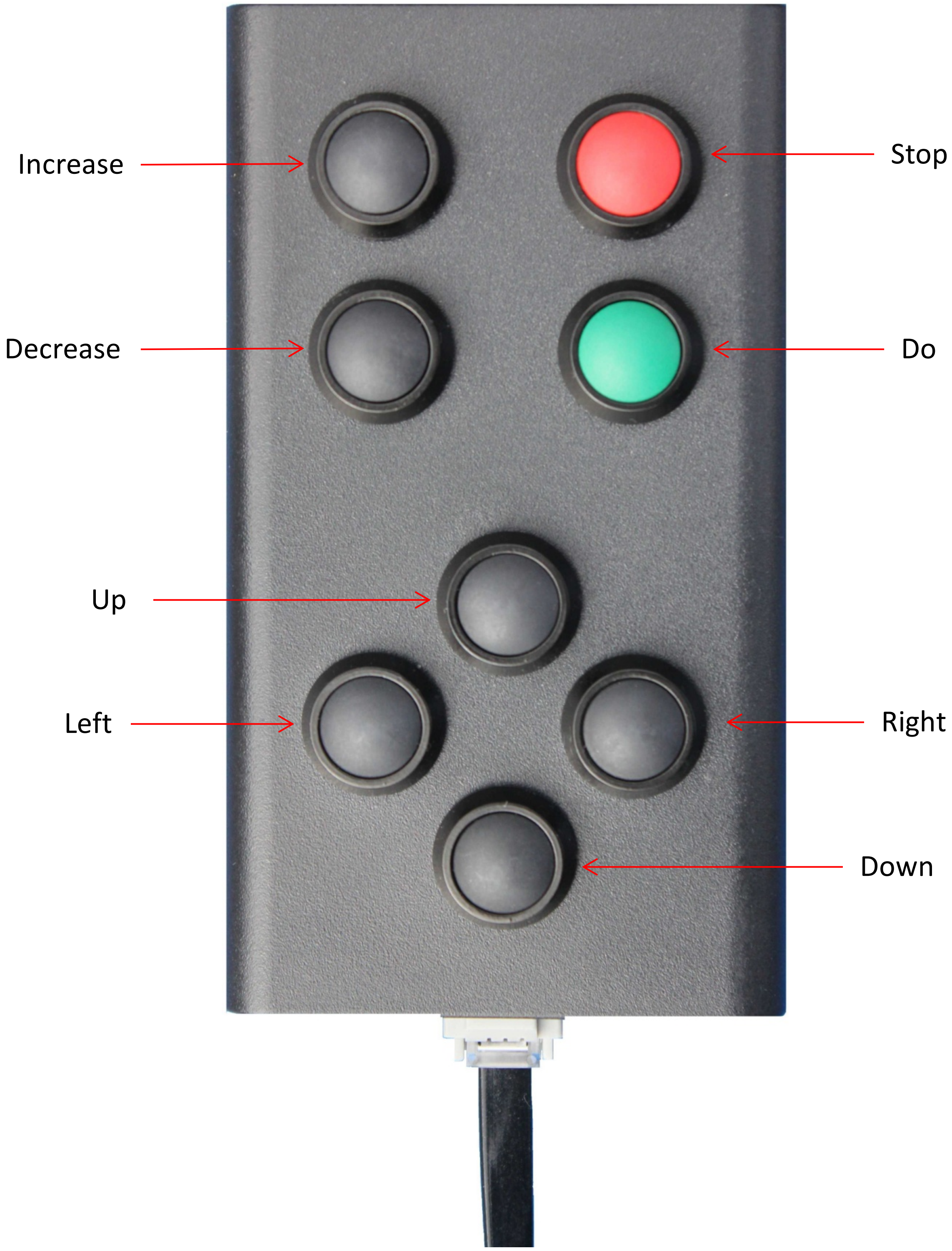
5.1.3 Stepper Controller Board

Two potentiometers on the controller board are used to adjust the current of the stepper motors.

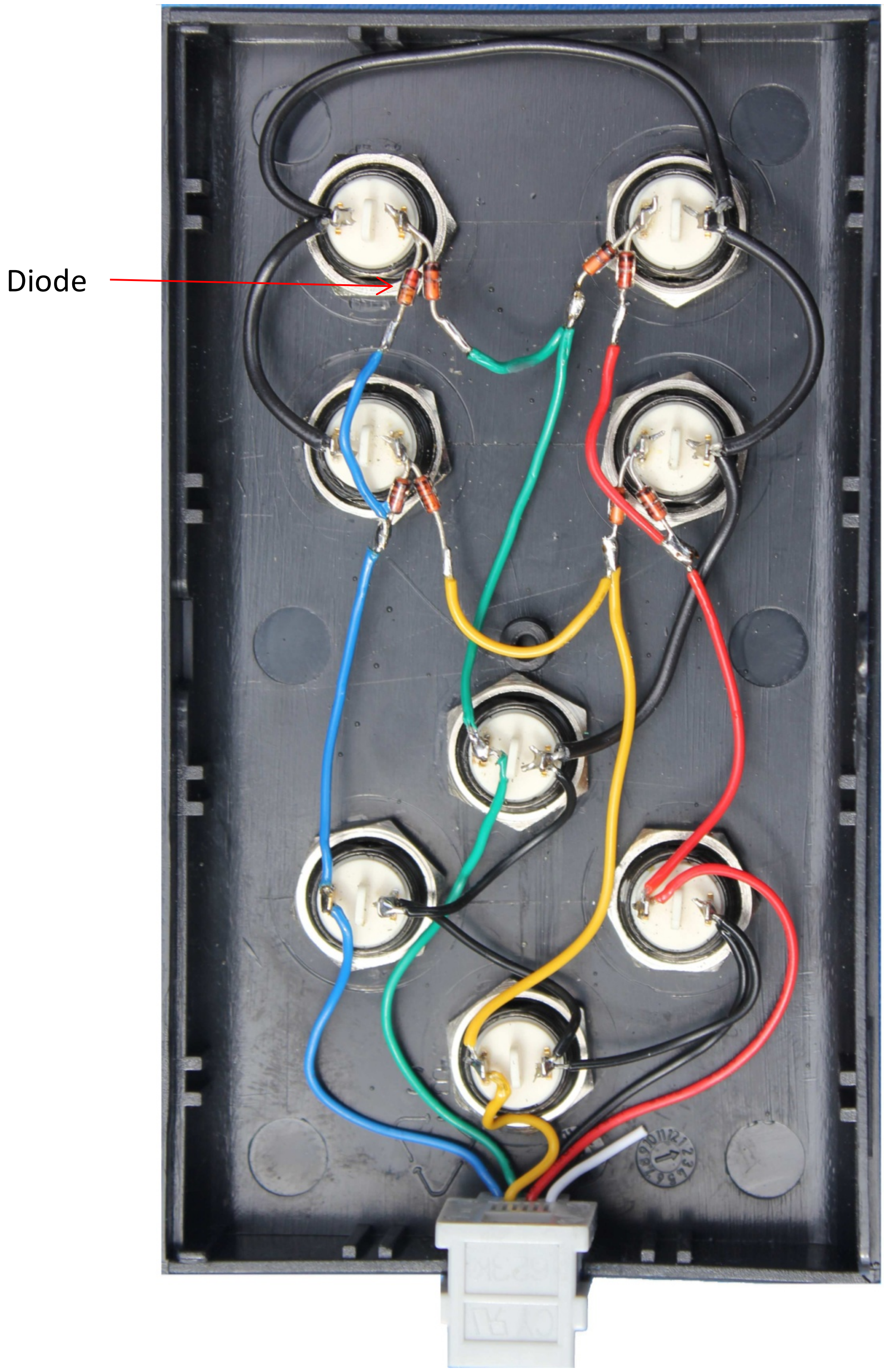


5.2 Handbox

The following pictures show a possible handbox implementation.

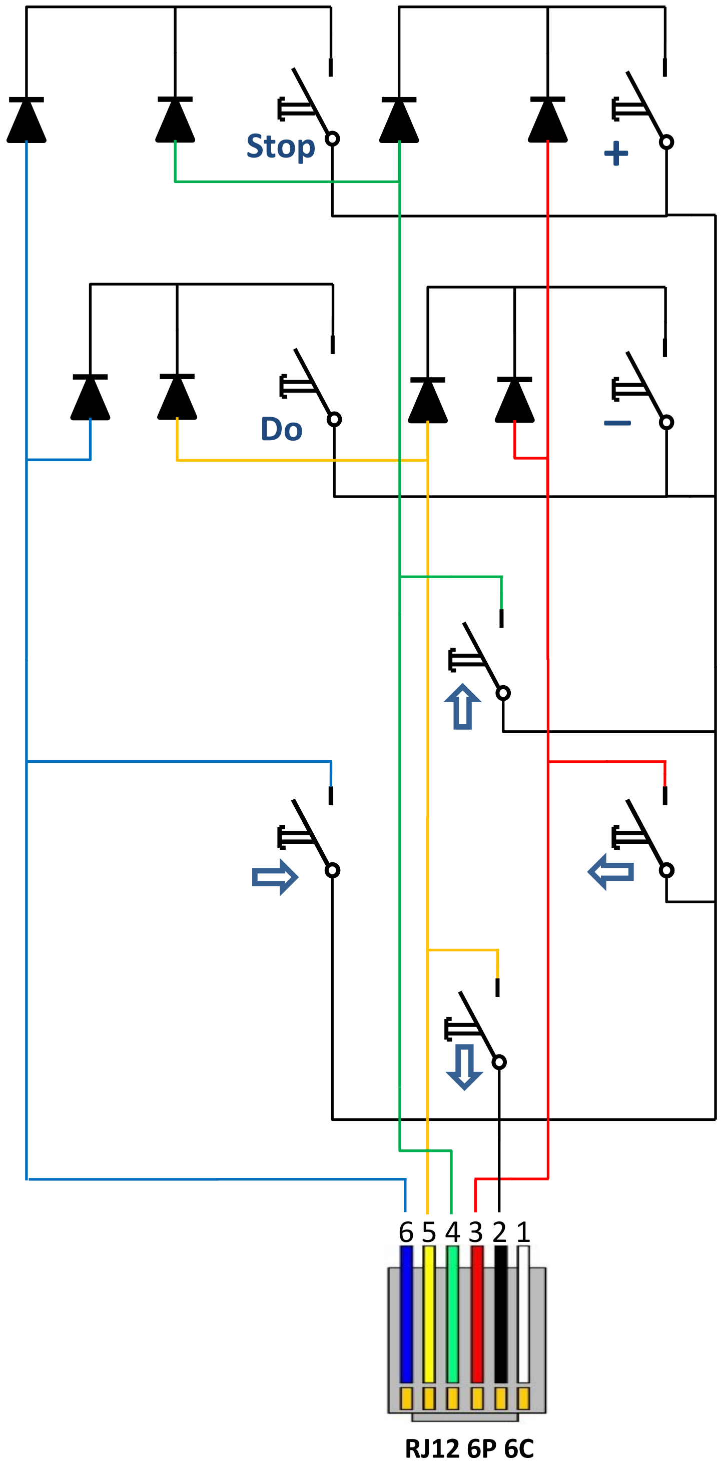


5.2.1 Handbox Inside



5.2.2 Handbox Schematics

The handbox is shown from the back (left and right is swapped).
For the diodes the type 1N4148 could be used.



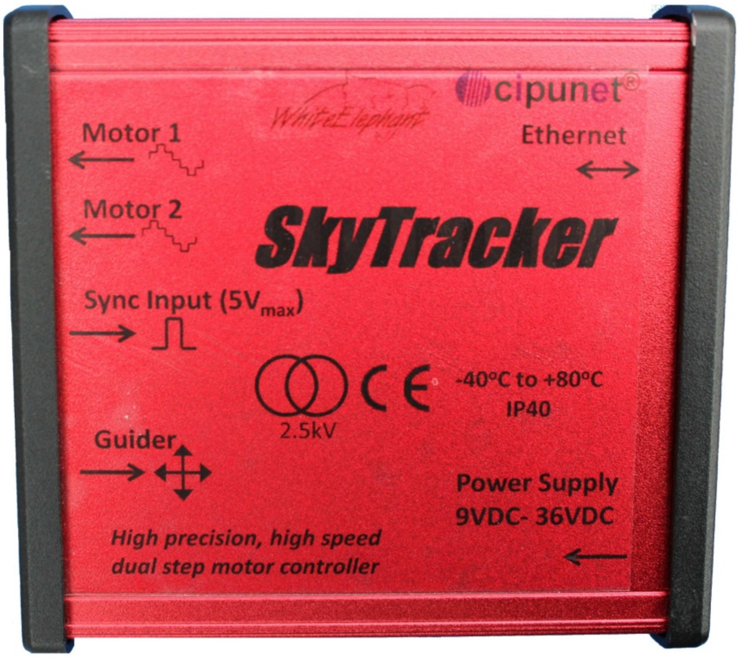
RJ12 wiring for autoguiding (ST4) with supplied Guider Cable:

1 – Not connected
2 – Red wire
3 – Blue wire
4 – Pink wire
5 – Brown wire
6 – Green wire

6 Legacy Hardware

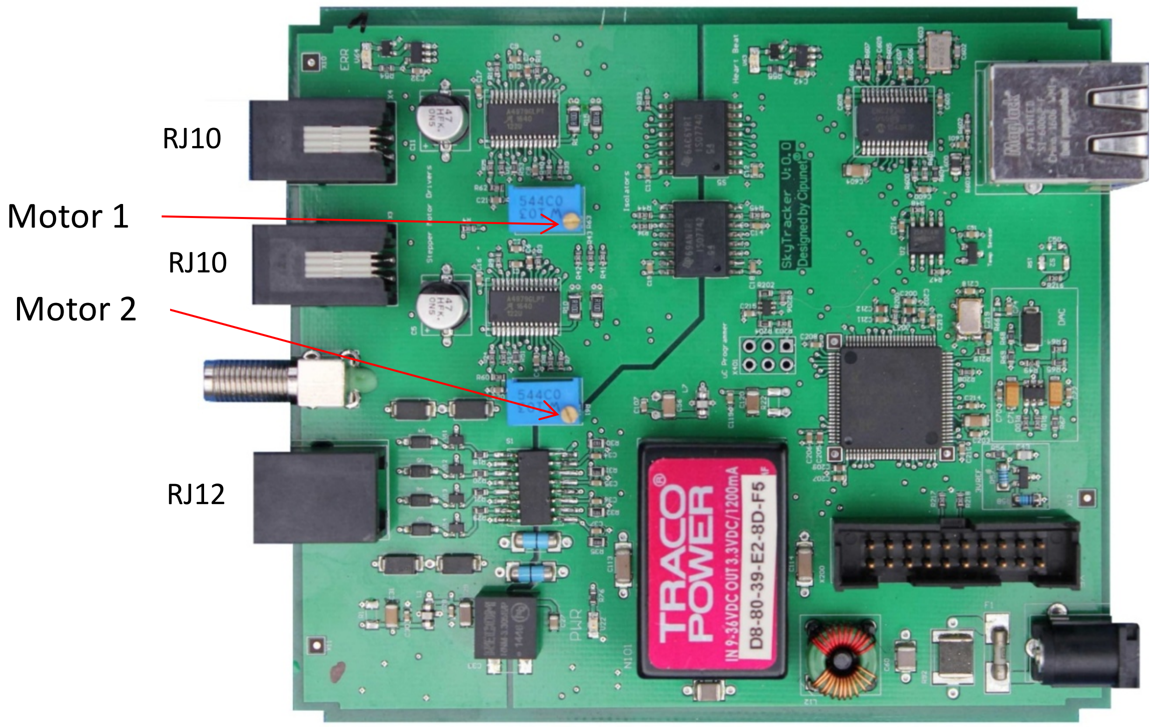
6.1 Stepper Controller

The SkyTracker controller is connected via Ethernet to a PC running the SkyTrack program. A handbox or an autoguider (ST4) can be connected to the guider input.



6.1.1 Stepper Controller Board

Two potentiometers on the controller board are used to adjust the current of the stepper motors.



The stepper motors coil A (B) have to be connected to pins 1 and 2 (3 and 4) of the RJ10 connectors. To change the direction of rotation either the connections 1 and 2 or else 3 and 4 must be swapped.