

Error Model

This model is in the form of an Excel spread sheet, and is designed to calculate and display telescope pointing errors that are caused by orthogonal errors in the RA to DEC axis (fork arm height) and the LOS to DEC axis (Tube offset to one side)

The input variables are as follows:

%Centre Alt/Az+= The Altitude at which the telescope is synchronised on a star.

%Start Alt+= The lower range for the calculated graph.

%End Alt+= The upper range for the calculated graph.

%Tube Axis+= The angular offset of the LOS from the DEC axis in Arc Seconds.

%Dec Axis+ = The tilt of the DEC axis to the RA axis from orthogonal in Arc Sec.

If the %Tube Axis+variable has a positive value it relates to an offset of the telescope LOS in a clockwise direction when looking from above the telescope. If the %Dec Axis+variable has a positive value it relates to the left hand fork arm, when viewed from the eye piece end of the telescope, being longer than the right hand fork arm.

Typical values for a well aligned telescope (Meade LX200GPS 8+) with a 0.002+ error for mechanical assembly, will give the following values:

%Tube Axis+= ± 50 Arc Sec.

%Dec Axis+ = ± 34 Arc Sec.

To see how the errors in mechanical alignment affect the LOS of the telescope separately and in combination do the following.

For an Alt/Az mounted telescope set,

%Centre Alt/Az+= 60. %Start Alt+= 0. %End Alt+= 89.

%Tube Axis+= 50. %Dec Axis+ = 0.

Then set

%Tube Axis+= 0. %Dec Axis+ = 34.

With a combined error when,

%Tube Axis+= 50. %Dec Axis+ = 34.

and

%Tube Axis+= 50. %Dec Axis+ = -34.

or

%Tube Axis+= -50. %Dec Axis+ = 34.

For a Polar mounted telescope, do the same as for an Alt/Az mounted telescope except set the %Start Alt+ to reflect the Latitude at which the telescope is located.

%Start Alt+= Latitude - 90 degrees (for Northern Hemisphere)

The graphs produced show a plot of the change in pointing accuracy as a telescope is slewed in Alt from an alignment Alt = %Centre Alt/Az+

Whilst for completeness the curve for Δ Alt+ is plotted, it will be noted that its value is minimal.

How does one use this model to align a scope then?

To find out where and how large mechanical errors are on a particular telescope do the following.

Firstly setup and align the telescope conventionally as would be done for a normal viewing session.

Next slew the telescope to a suitable reference star, preferably at about 60 degrees above the horizon, then sync the scope to that star.

With the scope synced to a known reference star, the task is to find the pointing errors that are found at two further targets. Select one star at around 72 degrees, and another at around 30 degrees (or as close to the horizon as possible) The Az of the target stars is not too important, but it is best if they are in a similar location to the reference star. This lowers the impact of any telescope levelling errors.

Having selected the target stars, slew the telescope to each star in turn. See where the telescope thinks it is pointing when you are correctly viewing the star.

Record the values displayed by the telescopes display and then look up the actual coordinates of the star to find the pointing error.

During these measurements it is recommended that a good reticule eye piece (9mm) or camera is used to obtain precise measurements

With the measurement results obtained the task is to find the values of %Tube Axis+ and %Dec Axis+ that produce them. This is done by curve fitting.

Set the model variables as follows;

%Centre Alt/Az+= The Altitude at which the telescope is synchronised on a star.

%Start Alt+= The lower target star Alt .

%End Alt+= The upper target star Alt.

Now adjust the values of %Tube Axis+ and %Dec Axis+ to get the best fit.

HINT.

If the Target stars are at θ_1 and θ_2 degrees of Alt with the Reference star is at θ_0 degrees Alt and the value for Δ Dec Axis is set to 0 the Δ Az errors for the target stars will be equal and opposite, with the θ_2 degree target being the Δ Tube Axis value.

The task is now to progressively adjust the values of Δ Tube Axis and Δ Dec Axis alternately to get the best fit. This can be helped if further star measurements are made to get additional points.

Don't forget the effect of the sign of the values and the way that the errors combine to give complex curve shapes and axis intercepts. The use of the Microsoft Excel Solve function can greatly speed up this iterative solution to a curve fit.

It is normal to expect that the value of Δ Tube Axis will be larger than Δ Dec Axis since the Tube normally has the largest error in alignment and is the most difficult to set.

Conclusion.

When the mechanical error constants have been determined they can be used to indicate where and how much adjustment is needed to improve the telescope pointing across the sky, or they can be used to predict tracking errors in a particular sector of the sky.

The tracking errors are particularly useful to predict deviations while tracking fast moving objects, (satellites, asteroids etc.) Also it is possible to predict star drift (in Alt/Az mode) during long photographic exposure. In such a case during the exposure of multiple frames over a long period the Alt motion of a target will cause a predictable drift in Az with time, that is dependant on the position of the target in the sky with relation to the Horizon and Meridian of the telescope.

Enjoy!

Any questions or comments, please direct to the author,
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