QUICKCLOSE Version 3.1

ASTRO program

The ASTRO program is designed to enable a surveyor to determine true bearings (azimuths) and map grid bearings to a reference object (RO) by observations of either the sun or a specific star. The two azimuth determination methods used in the ASTRO program are by ex-meridian altitudes and hour-angles.

To run the ASTRO program press the **|ASTRO|** menu key from GEOD module COMP menu (from the Quickclose main menu, press |->| |GEOD| |COMP| |ASTRO|.

16.001 General considerations and precautions in the choice of observed body

In general, determination of azimuth from star observations provides greater accuracy than using the sun. Also, provided sufficient care is taken with time-keeping, the hour-angle method is generally more accurate and simpler than the altitude method.

The best stars to use are circumpolar stars such as α ***Ursae Minoris*** (Polaris) in the Northern Hemisphere and σ ***Octantis***, in the Southern Hemisphere, for precise azimuth determination. The further away from the celestial pole one goes, the faster the apparent motion of heavenly bodies, and therefore a greater possibility of reduced accuracy. It is better to observe stars close to elongation (when the apparent motion is vertical). Elongation occurs when the star appears to the left or right of the celestial pole. Nevertheless, if sufficient care is taken with observations and a lower accuracy of azimuth determination is acceptable, then in practice any identified star can be chosen. Stars with an altitude of less than 15° should be avoided if the altitude method is used, due to unreliability of the refraction correction computed at low altitudes. In tropical regions where the celestial pole is at a low altitude it is recommended not to use close circumpolar stars for this reason.

Familiarisation with the different constellations is a definite advantage, alternatively a star atlas or a software package such as ***Skymap*** should be used to assist with star identification.

16.002 Timing accuracy required for observations

Hour angle observations require very accurate time observations. For astronomical bodies close to the celestial equator (such as the sun) **an error of 1 second in time will result in an error of 15 seconds in azimuth**. If a star is observed close to a celestial pole (a circumpolar star) timing is less critical, particular if the star is observed at elongation (when the apparent motion of the star is vertical). Ex-meridian altitude observations do not require an exact time, however the observed time should be accurate to within 30 seconds if possible.

The DUT correction is a minor correction that should be applied to the time signal received from a radio signal / telephone time. This can be included into the overall clock correction. The DUT correction is usually very small, but for high accuracy azimuths, should be determined.

16.003 Accuracy required for entered position

As a general rule, 1 second (about 30 metres) of error in latitude and longitude will result in an error of about 1 second in azimuth.

The approximate position of the observation can be scaled off a topographic map. Position determined from a hand-held GPS is usually sufficient also. In all cases, ensure that the map projection is the same as that configured in the ASTRO program.

16.004 Time of observing

Observations of astro bodies below 15° altitude (Zenith angle > 75°) are not advised due to the unpredictability of atmospheric corrections (refraction), especially for altitude observations. Depending upon the instrument used, observation of bodies above 35° altitude (Zenith angle < 55°) are difficult unless a diagonal eye-piece is fitted.

16.005 Overview of observational procedure

A set of observations in ASTRO typically comprises;

Face left (or right) to the RO
Face left (or right) to the astro body
Face right (or left) to the astro body
Face right (or left) to the RO

The greater the number of sets of observations recorded, the more reliable the azimuth determination will be.

Observing the sun

WARNING! A Solar filter must be placed over one of the lenses of the observing instrument if the sun is observed directly, otherwise <u>serious eye damage</u> will result. Total stations that incorporate EDM into the optics will be damaged if laid directly onto the sun and a filter must be placed over the objective lens.

Hour angle method;

As the centre of the sun is practically impossible to be observed accurately (unless a Roelof's prism is fitted) the limb (or edge) of the sun must be observed. ASTRO does not compute the semi-diameter of the sun, therefore either the trailling (or leading) limb must be tracked on one face, and the opposite limb must be tracked on the other. When observations are meaned (the program does this) the centre of the sun is deduced, but only if the time between opposite face readings to the sun are kept to a minimum (3 minutes or less), otherwise curvature errors become too excessive.

Altitude method;

This method requires tracking two limbs (a quadrant) of the sun simultaneously (unless a Roelof's prism is fitted) and requires reasonable instrument skill. ASTRO does not compute the semi-diameter of the sun, therefore opposite quadrants of the sun must be tracked on alternate faces. For example, if the lower right quadrant is observed on the first face, then the upper left quadrant must be observed on the other (or vice-versa). When observations are meaned (the program does this) the centre of the sun is deduced, but only if the time between opposite face readings to the sun are kept to a minimum (3 minutes or less), otherwise curvature errors become excessive.

Timing between two faces

The reduction algorithm means two faces to an observed body. This alleviates the need to calculate semi-diameter etc.. Three minutes is the maximum time recommended between observations in two faces to the astro body before the error due to curvature becomes excessive.

Don't rely on a single set of observations. The ASTRO programs will not detect gross blunders in data entry. Garbage in - garbage out ! At least two different methods should be used to verify the accuracy of the azimuth determination.

Total dependence on the hour-angle observations is unwise, unless the reliability of the time source is guaranteed. Murphy's law is unfortunately a determining factor.

16.006 Notes on the reduction algorithm and ephemeris program

The following corrections are applied automatically in the algorithm;

Earth curvature, atmospheric refraction and parallax.

Dislevelment of the trunnion axis

This is one of the few errors not cancelled by meaning observations in two faces, and becomes more critical if observations are made at higher altitudes (zenith angles closer to zero). The following formula should be used to apply this correction.

(L-R)/((n*v)/TAN(ZD))

where;

L-R	=	Horizontal difference between readings in two faces
n	=	number of end readings on the plate bubble
v	=	angular value of one plate bubble division

Note: The plate bubble will move if directly exposed to the sun, so should be covered if need be.

Accuracy of the solar ephemeris and computation of R.

The solar ephemeris is derived from a simplification of the algorithm outlined by Jean Meeus in ***Astronomical Algorithms***. The simplification model is an adaptation of the model used by G.G.Bennett as outlined in the ***Australian Surveyor, August 1980***. The in-built ephemeris agrees with Jean Meeus to within 1 second for all dates and times up to 2010.

16.01 To compute azimuth & grid bearing by sun or star observations

Press **|ASTRO|**

Select either the SUN or a STAR as the astro body observed.

If a star is observed, at the prompt, type in the Right Ascension (RA) and Declination (Dec) of the star and press ENTER (note RA is in HH.MMSSS format and Dec is in DD.MMSSS format).

Select either the Altitude or Hour-Angle method.

At the Enter time zone prompt, edit the time zone (hours ahead of Greenwich Mean Time (GMT)) of the observations and press ENTER. The time zone should be adjusted for daylight saving, if necessary (usually by adding an hour to the standard time zone).

Edit the combined clock and DUT correction (in seconds), and press ENTER.

At the prompt:

Enter Date of
obs. in DD.MMYYYY
format

Type in the local date when the observations were taken. For example
31st December 2005 would be entered as 31.122005

Entering position

If the GEOD Coordinate format (refer to section 13.53 of the user manual) is configured for latitude / longitude or Cartesian;

At the prompt;

POSITION
(ϕ is - in S&W Hem.)

:ϕ : Type in the latitude of the observation in DD.MMSSS format (or decimal degrees) . Latitudes in the Southern Hemisphere will be negative. Press the | ▼ | key.

:λ : Type in the longitude in DD.MMSSS format (or decimal degrees). Latitudes in the Western Hemisphere will be negative. Press [ENTER]

If position configuration is for Grid Coordinates

At the prompt

POSITION

:Zone : Type in the Grid Zone (1 if there is only one zone) and press | ▼ |

:E : Type in the Easting and press | ▼ |

:N : Type in the Northing and press [ENTER]

If the altitude method is chosen, at the prompt;

ATMOSPHERIC DATA

:Temp. : Type in the temperature in degrees Celsius. Press the | ▼ | key.

:Press. : Type in the barometric pressure in the mbar or hPa specified in the configuration and press [ENTER].

If atmospheric measurements haven't be taken, enter realistic estimates, otherwise the refraction correction will be in error. Standard atmospheric pressures are usually between 980 and1030 hPa.

For each set of observations;

At the prompt

REFERENCE OBJECT
Face 1 <) ?

Type in the Horizontal angle observed to the Reference Object to which the azimuth / grid bearing is to be computed. Press [ENTER]

At the prompt for Time 1;

Enter the clock time for the first observation to the astro body. In the case of the sun this will be the time of co-incidence of the vertical cross-hairs tangential to the leading (or trailing) limb (edge) of the sun (or both vertical and horizontal for altitude observations) simultaneously, or if a Roellefs prism is used the centre of the sun.

In the case of a star. The time at which the star crossed the central cross-hair (or vertical cross-hair for HA obs).

At the prompt;

ASTRO BODY
Face 1

:Hor. <): type in the observed horizontal angle to the sun at the time of observation. Press the | ▼ | key (for altitude obs, or press ENTER for HA obs).

(and for altitude observations)
:Zen. <): type in the observed zenith angle to the sun. Press [ENTER]

The above prompts are repeated for observations on the other face. Ensure that the opposite limb(s) is tracked on the second face.

At the prompt

REFERENCE OBJECT
Face 2 <) ?

Type in the Horizontal angle on the second face observed back to the Reference Object to which the azimuth / grid bearing is to be computed. Press [ENTER]

The computation is displayed as follows

Datum / Map Grid used Grid Zone
Central Meridian of Grid Zone

To the Reference Object;
Azimuth (True Bearing)
Grid Bearing (with convergence already added)

Note the azimuth/bearing in the field book

If repeated sets of observations are to be made, note the azimuth / grid bearing in a field-book and press **|CONT|** to repeat the process for another set of observations.

Repeated computations should be meaned separately, and if necessary blunders can be ignored.

To exit the program press **|EXIT|**

To repeat a set of observations press |CONT|