

FUNCTIONS OF THE PROGRAMS

One of the three choices of the **HELP** which can be called when starting a program provides a synthetic description of the function of the related program.

To easy an overall view of the matters dealt with in the book, the texts of all the 27 operative programs are summarized in this section.

- SEXTANT DATA REDUCTION -

From sextant altitude of a celestial body to true altitude
and vice versa. Atmospheric refraction and dip

This double program enables the calculation of the "true" altitude of a celestial body from the "sextant" altitude and vice versa.

The program corrects the sextant altitude, taking the atmospheric refraction and the height of eye of the observer above the sea level (dip) into account.

Enter:

- sextant index correction
- height of the observer's eye above the sea level (dip)
- semi-diameter (*) of the Sun or the Moon
- horizontal parallax of the Sun or the Moon.

The reverse procedure, from "true" to "observed" altitude, applies only to stars and planets.

The semi-diameter of Sun and Moon, as well as the Moon parallax for the relevant day and time can be directly obtained with the program ALTITUDE AND AZIMUTH of the set CELESTIAL BODIES POSITION or read in the daily page of the NAUTICAL ALMANAC.

(*) Enter the semi-diameter value with positive (+) or negative (-) sign, according to whether the lower or the upper limb of the disk has been observed.

- SEXTANT h - t INTERPOLATION -

True altitude of a celestial body obtained from a series
of h - t readings within a chosen deviation

Enter the series of pairs altitude h and time t read with the sextant and the chronometer, as well as the sextant index and the chronometer correction. The program asks for a value of deviation of the altitude, shows what readings are within the range of validity and in the right side section of the form displays a graph of the $h - t$ readings along an interpolation straight line.

Then choose a time to which the altitude has to be referred to (*) and, after having entered the sextant corrections (as in the program SEXTANT DATA REDUCTION), the program provides the "sextant" and the "true" altitudes at the chosen time t .

Furthermore, the values of the "sextant" and the "true" altitudes for other times (*) can be obtained.

(*) The choice of the time is arbitrary, but, in order to obtain reliable results, the time should be chosen inside the sequence of the reading times, or only slightly outside (approximately no more than ten minutes outside).

- THE TRUE LINE OF POSITION -

Points of a true line of position: longitude and azimuth
for given latitude

If the altitude h of a celestial body at a time t is known, an instantaneous position circle can be drawn on the Earth's sphere.

The centre of the circle lies in the "geographical position" of the celestial body and its radius is the "zenith distance" ($90^\circ - h$).

Without any Calculation Table, such as HO or similar, the program immediately provides the coordinates (latitude and longitude) of a series of points of an arc, that is a part of the position circle, drawn on the Earth's sphere.

By repetitively entering a series of latitudes, the program provides the corresponding longitudes (and azimuths) of points lying on the circle of position; a position line can consequently be plotted on a nautical chart.

The program warns if the entered latitude is external to the position circle.

The program can deal with any type of celestial body: Sun, Moon, planets, stars.

First enter the date, the time and the type of the observed body.

Then the program offers a choice between two options:

- enter the sequence of sextant and chronometer readings (from two to seven pairs of readings are possible) and choose a time (*). The program automatically deduces from the sequence of the read altitudes whether the body is rising or setting and consequently whether the point is westward or eastward the longitude of the geographical position of the body.
- directly enter the "true" altitude h of the observed celestial body at a time t

In the former case, corresponding to the actual situation when sailing, the program provides a value of longitude for each entered value of latitude; the azimuth in each point is also provided.

In the latter case, the program provides two values of longitude for each value of latitude; consequently, two points of the circle of position of the celestial body in the two rising and setting phases are obtained.

(*) The choice of the time is arbitrary, but, in order to obtain reliable results, the time should be chosen inside the sequence of the reading times, or only slightly outside (approximately no more than ten minutes outside).

- CIRCLE OF AZIMUTHS -

Choice of the most suitable celestial bodies to obtain a fix

This program enables the choice of the most suitable celestial bodies to obtain a reliable fix or a "selected" true line of position.

Enter the name of the place or its coordinates, date and time, as well as the course of the vessel.

The program shows in the left side of the form the list of all celestial bodies (Sun, Moon, planets, stars) having great brightness ($\text{magn} < 2$) and altitudes higher than 10° , together with the values of their altitude, azimuth and magnitude.

An azimuths circle is displayed in the right side of the form, with a line (red colour) showing the course of the vessel.

Every time the mouse is clicked on a body listed in the left side, an azimuth line appears in the azimuths circle, with its prolongation to $\text{az} \pm 180^\circ$. The line can be removed by clicking again on the name of the body. The value of the azimuth difference between the pair of the nearest azimuth lines is also displayed. In order to obtain reliable results, all azimuth differences should be not less than 15° . This being the case, the colour shifts from white to red.

- VESSEL POSITION (FIX) -

Vessel position from two to seven sights. Running fix.

Without assuming a Dead Reckoning point, as necessary in the standard procedure, this program, based on new spherical trigonometry equations, immediately provides the vessel position (fix) as the point, or the points, where the position circles drawn on the Earth's sphere cross one another.

No Calculation Tables, such as HO Tables or similar, and no graphical construction are required.

The program works with any type of celestial body: Sun, Moon, planets, stars and any number of sights from two to seven.

If only two sights are taken, the program provides the coordinates of two fixes, since two position circles always cross in two points. The two cross points are generally thousands of miles apart.

If three or more sights are taken, the program provides a single fix, since all position circles should cross, less or more exactly, in one point only, depending on the accuracy of the sextant and time readings.

Owing to the unavoidable inaccuracy of the sextant readings, instead of a single cross point, a series of very close cross points is obtained. Then the fix is assumed as the average point of all the cross points.

To avoid that the navigator takes as valid a fix obtained from too inaccurate data, the program automatically performs a series of controls. In the negative case, the program locks, a warning notice of "ERROR" appears and a list of possible causes is suggested.

Once obtained a fix, a procedure of verification is recommended.

The program allows the running fix procedure to be carried out, by entering the course and distance of every previous sight referred to the last sight.

Enter the date, the type of the observed celestial body and the time chosen for each sight. The program offers two options:

- enter the sequences of the $h - t$ sextant and chronometer readings (from two to seven readings are possible) of each observed body and choose a time to which any sight is to be referred to(*). This is the normal procedure when sailing
- directly enter the "true" altitude and the time of each sight.

Lastly, the program can provide course, distance and travelling time to a destination point. If two sights are taken, that is two fixes obtained, the program asks to which fix is to be referred to.

(*) The choice of the time is arbitrary, but, in order to obtain reliable results, the time should be chosen inside the sequence of the reading times, or only slightly outside (approximately no more than 10 minutes outside).

- EPHEMERIDES OF THE ARIES POINT -

Data of the Aries point for any longitude, date and time.

Direct / reverse procedure

In the direct procedure the program provides the Local Sidereal Time and the Local Aries Hour Angle for a date, time and longitude.

In the reverse procedure the program provides the UT and ST times when the Local Sidereal Time or the Local Aries Hour Angle takes a value.

Other Local Sidereal Times or Local Aries Hour Angles can further be entered for the same longitude and date.

- CELESTIAL BODIES POSITION - 1.st PROGRAM

ALTITUDE AND AZIMUTH FOR A PLACE, DATE AND UT TIME

Option: Three points to directly draw the INTERCEPT on a nautical chart

This program provides the altitude and the azimuth of a celestial body for a place, date and UT time.

The data are provided even if the celestial body is below the horizon (negative value of the altitude).

For the Sun and the 63 stored stars, directly enter their name.

For the Moon and the planets see INTRODUCTION (Ephemerides procedure).

Other times can further be entered for the same place and date.

For those using the procedure of the INTERCEPT, the program offers a great simplification: it provides the coordinates of three points to directly draw the intercept straight line on a nautical chart.

To start the procedure, press with the mouse on the INTERCEPT command button at the lower right hand corner of the form.

Enter the coordinates of the Dead Reckoning point and the "true" altitude of the observed body. The program provides the coordinates of three points P0 P1 P2 to draw the intercept straight line on a nautical chart and, as an additional information, the distance of the INTERCEPT from the Dead Reckoning point.

- CELESTIAL BODIES POSITION - 2.nd PROGRAM

TIMES AND AZIMUTHS AT AN ALTITUDE FOR A PLACE AND DATE

This program provides the times and relevant azimuths when a celestial body takes an altitude in a place and date. A celestial body takes an altitude twice in its diurnal arc: in the rising and the setting phase, at two azimuths symmetrical to the azimuth at the meridian passage (0° or 180°).

No time possible, if the chosen altitude is greater than the altitude at the meridian passage

Only one time possible, if the chosen altitude is exactly equal to the altitude at the meridian passage.

The program points out that the body is circumpolar, this being the case.

For the Sun and the 63 stored stars, enter their name.

For the Moon and the planets see INTRODUCTION.

Other altitudes can further be entered for the same place and date.

- CELESTIAL BODIES POSITION - 3.rd PROGRAM

TIME(S) AND ALTITUDE(S) AT AN AZIMUTH FOR A PLACE AND DATE

This program provides the time, or the times, and the altitude when a celestial body takes an azimuth in a place and date.

According to the latitude, the celestial coordinates of the body and the time, different situations can occur:

- no time possible
- only one time possible
- two times possible

The program points out that the body is circumpolar, this being the case.

Other azimuths can further be entered for the same date and place.

- CELESTIAL BODIES POSITION - 4.th PROGRAM

RISING, MERIDIAN PASSAGE, SETTING

This program provides the UT and ST times and the azimuths of rising, meridian passage and setting of a celestial body, as well as the altitude at the meridian passage in a place and date.

According to the type of the celestial body, the times of rising and setting refer to an altitude:

-0°50' for the Sun ("true" altitude of the centre of the disk)

-0°34' for stars, planets and non stellar objects

for the Moon the semi-diameter and parallax values have to be entered, which can be found in the daily page of the NAUTICAL ALMANAC or are directly provided by the FIRST POSITION PROGRAM.

The program points out that the body is circumpolar, this being the case, and provides the times and altitudes at the two meridian passages. The passages can occur at the same azimuth (0° 0° or 180° 180°), or at the opposite azimuths (0° and 180°).

- CELESTIAL BODIES POSITION - 5.th PROGRAM

TWILIGHTS

This program provides the rising and setting UT and ST times of the Sun ($h = -0°50'$) and the UT and ST times of the dawn and evening civil ($h = -6°$), nautical ($h = -12°$) and astronomical ($h = -18°$) twilights, as well as the duration of every twilight for a place and date.

- CELESTIAL BODIES POSITIONS - 6.th PROGRAM

REVERSE - TERRESTRIAL COORDINATES

This program provides the coordinates (lat long) of one or two points on the Earth, where a celestial body is seen at a time in a position (h, az) of the sky.

The program is the reverse of the program ALTITUDE AND AZIMUTH (exchange h az - lat long)

Three situations can occur:

- no terrestrial point exists, where the celestial body is seen in that position (h, az) of the sky

- the body is seen in that position (h, az) of the sky from one terrestrial point

- the body is seen at the same time in that position (h, az) of the sky from two terrestrial points. The two terrestrial points are usually very distant apart.

If the point is less than 100 km distant from a place stored in the PLACES DATA BASE, the program indicates the place and the distance in km.

- SOLAR SYSTEM -

Orbital positions of the planets around the Sun at a date.
Heliocentric longitudes. Elongations from the Sun, visibility.
Dates of entrance of the planets in the zodiacal constellations.
Moving the planets

This program offers three options:

- Image of the true elliptical orbits of the five main planets: Venus, Earth, Mars, Jupiter and Saturn with the Sun in a focus of each orbit.

- The positions of the five main planets at a date are displayed on five concentric circles, with the Sun in the centre.
The direction towards the Aries point and the scale of the heliocentric longitudes are displayed on an outer circle.
By clicking with the mouse on each planet, the two elongation lines of the planet and the Sun from the Earth are displayed, together with a series of data: the elongation angle of the planet from the Sun, the interval of visibility during the 24 hours and the zodiacal constellation.
Furthermore, the motion of each planet along its orbit from an initial to a final date can be started by clicking on the command button START/STOP MOTION. By clicking again on the button, the motion is stopped.
All data, including the ones of the minor planets Mercury, Uranus and Neptune, not displayed on the main figure, are listed in the LOG BOOK.
Other dates can further be entered.

- Zodiacal Dates
The program provides for a solar year or for a chosen interval between two dates (maximum one year):
 - the entrance dates of the Sun and the seven planets in the successive zodiacal constellations
 - the days of permanence in every constellation.

- ALMANAC -

Diagrams of the rising, meridian passage and setting time lines
of a celestial body in a place during an interval of days up to a year

This program provides the time lines of different colours displaying the rising (blue), meridian passage (red) and setting (yellow) times of a celestial body in a place within an interval of days, from three days up to a year.

The standard times are plotted on the vertical axis and the dates on the horizontal axis. The 00h ST or the 12h ST can be set at the centre of the vertical axis.

If the body is circumpolar, two time lines are displayed for the upper and lower meridian passage.

By clicking with the mouse on whatever point of the lines, or on the two arrow buttons, a date can be selected, for which the program provides the times and the azimuths of rising, meridian passage and setting, as well as the time duration above the horizon and the time duration of night visibility in the chosen place.

The time lines of rising and setting of the Sun can be superimposed. The two upper and lower areas of the figure, referring to daylight time, are blanketed.

- PLANETS -

A unique diagram of the time lines of rising or meridian passage or setting of the
five (seven) planets together in a place during an interval of days up to a year

This program provides the time lines of different colours displaying the rising, or the meridian passage, or the setting of the five planets (it is also possible to add Uranus and Neptune) in a place within a range of days, from three days up to a year.

The standard times, from 00h to 24h, are plotted on the vertical axis and the dates on the horizontal axis.

By clicking the mouse on whatever point of the time lines, or on the two arrow buttons, the times for a chosen day are displayed.

In the case of the option meridian passage, two choices are allowed for the Sun: to plot the time line of the meridian passage only or the time lines of the rising and setting time as well.

With the first option and for any point of longitude $n . 15^\circ$ the same diagram is obtained as the ones reported in the NAUTICAL and the ASTRONOMICAL ALMANACS of the year.

When the rising and setting times of the Sun are included, the program also provides the night visibility of the rising, or the meridian passage, or the setting of the planets during one of the three periods of the night: evening, full night, dawn or during the day light.

- DIURNAL ARCS -

Trace of the diurnal arc of a celestial body in the sky.

Position every half-hour.

Availability of a celestial body at the dawn or evening twilight

This program provides the trace of the diurnal arc of a celestial body in the sky, position every half hour from its rising to its setting for a place and date.

The program applies to any type of celestial body: Sun, Moon, planets, stars, non stellar objects. Direct procedure for Moon and planets: enter the name of the body.

The successive positions of the celestial body are indicated with small circles. The altitudes are plotted on the vertical axis and the azimuths on the horizontal axis, with the azimuth 0° or 180° in the centre, according to whether the declination of the celestial body is greater or smaller than the latitude of the place.

The first integer UT and ST hour or half hour after rising and before setting are displayed at the bases of the arc. The age of the Moon (in days from 0 to 28/29/30) is also displayed.

The colour of the trace and the points changes according to day or night times: red / blue.

The program allows the navigator to know whether a celestial body is available for sextant observation during the dawn or evening twilight.

By clicking with the mouse on any small circle of the arc or on one of the two small boxes with arrows, the data of time, altitude and azimuth are listed in a box.

It is also displayed whether the body is circumpolar or always below the horizon.

The altitude and azimuth at every half-hour in the 24 hours are listed in the LOG BOOK, with the indication of night visibility or body below the horizon.

- IMAGE OF THE SKY -

Rectangular or semi-circular image. h and az values of every celestial body. Ecliptic and equator lines.
Addition of other celestial bodies. Choice of various types of images of the sky. Function STEP

This program provides the image of the sky, extended to the whole circle of the horizon or to a part of it for a place, date and time.

The azimuths of the celestial bodies are plotted on the horizontal axis: 180° or 0° in the centre, according to whether the place is in the northern or in the southern hemisphere. The altitudes of the bodies are plotted on a vertical axis or on a semi-circumference.

Various options of VIEW can be chosen:

- rectangular or semi-circumference image
- only stars of magnitude less than 2 (view of a night sky with poor visibility)
- a free choice of stars among the ones stored in the STARS DATA BASE
- only stars of the first level, i.e. the 63 stars stored in the STARS DATA BASE
- stars of first and second level
- stars of all three levels (1207 stars)
- the same stars with the constellation lines
- 24 non stellar objects
- the lines of the equator and the ecliptic, with the zodiacal subdivisions
- the names of the stars, constellations and non stellar objects

The Sun, the Moon, the four main planets (Venus, Mars, Jupiter and Saturn) and the Polaris, if present, are always shown, independently of the chosen option.

The chosen option can be saved as default.

Furthermore, the position of any other celestial object (up to eight) can be added, by entering its celestial coordinates R.A./SHA and Dec.

The name, altitude and azimuth of each body shown in the image of the sky can be displayed in a box in the upper part of the image by clicking with the mouse on the body; the same applies for the zodiacal constellations along the ecliptic line.

With the rectangular image, any of the twelve sectors of the image (four sectors of azimuth and three of altitude) can be obtained with the function ZOOM, by clicking the right mouse button.

With the semi-circumference image, the image of the whole sky (i.e. extended to the whole azimuth circle $0^\circ - 360^\circ$) or of a limited range of azimuth 180° or 90° can be displayed.

Successive images of the sky (at following or previous times) can be obtained using the function STEP and the keys F1 and F2. Any time interval from 1 to 1440 minutes (24 hours) can be chosen.

The LOG BOOK provides the list of all bodies above the horizon, with their values of altitude and azimuth, independently of the selected type of VIEW. Owing to the considerable length of the list (more than some hundreds of stars), a part only of the list can be printed, if wanted.

- MOTION OF THE CONSTELLATIONS -

Motion of one or a group of constellations in the sky.
Successive positions of the stars every half-hour in the 24 hours

This program provides the sequence of images of a group of constellations every half-hour from their rising to their setting seen in a place and date.

A choice of 31 sets of constellations is available, including all the main 48 constellations. Each set has a main star. The rectangular configuration is adopted. Altitudes are plotted on the vertical axis, azimuths on the horizontal axis, with the azimuth 180° or 0° in the centre, according to whether the declination of the main star is greater or smaller than the latitude of the place.

The sequence of images is activated by pressing on one of the two command buttons with arrow.

The program provides information about the group of constellations and the main star: circumpolar, rising and setting, always below the horizon, as well as, optionally, the altitudes and azimuths of all stars.

- IDENTIFICATION OF STARS AND CONSTELLATIONS -

around an estimated point of the sky

A star or a group of stars and their constellations around an estimated point of the sky can be identified.

Enter the altitude and azimuth of an estimated point of the sky for a place, date and time. The program provides the celestial equatorial coordinates (SHA/R.A. and Dec) of a hypothetical star located in the estimated point of the sky.

Then, when a radius (max. 30°) of a circle around the estimated point is chosen, the program lists the names of the stars and their constellations lying within the circle, as well as their position (h and az) and their angular distance from the estimated point. The search can be limited to the 63 stars of the STARS DATABASE or extended to more stars up to magnitude 3-4, the ones available in the program SKY IMAGE.

Planets are not included in the search.

The program works for latitudes within the band $75^\circ\text{N} - 75^\circ\text{S}$.

Other radii of the estimated circle can be entered.

- ROUTES - 1st PROGRAM

Great circle route between a start and a destination point at a speed.

Initial course, distance, vertex.

Plotting the route point by point

This program provides the initial course, the distance travelled at a speed and the time duration.

The program also provides the coordinates of the vertex (the point of the route of greatest positive or lowest negative latitude), as well as the distances from the vertex to the start and the destination points.

The vertex is not provided when it is external to the route, nor when the route:

- crosses the equator
- is along the equator (constant course 90° or 270°)
- is along a meridian (constant course 0° or 180°)

Moreover, the program can provide the data to plot point by point a great circle route : by entering an arbitrary series of longitudes internal to the route, the latitudes of the points along the route are provided.

- ROUTES - 2.nd PROGRAM

Destination point - Great circle route

Coordinates of the destination point along a great circle route, given the start point, the initial course and the distance. Instead of the distance, the speed and the time duration can be entered.

- ROUTES - 3.rd PROGRAM

Course and distance - Rhumb line route

Rhumb line route between a start and a destination point at a speed. The program provides the course (constant), the distance and the duration.

- ROUTES - 4.th PROGRAM

Destination point - Rhumb line route

Coordinates of the destination point along a rhumb line route, given the start point, the course (constant) and the distance travelled.

Instead of the distance, the speed and the time duration can be entered.

- LEGS -

Legs route.

Course, distance, duration in each leg along the WPs.

Accumulation.

Enter the coordinates of a start point, an arbitrary number of intermediate points (WPs) and the speed in each leg. The program provides course, distance and duration in each leg, as well as the progressive travelled distance and time.

- TACKS -

Route with tacks. Destination point and duration in every leg.

Accumulation

Enter the coordinates of a start and a destination point, the course and distance (or alternately the speed and duration) in each leg. The program provides the coordinates of the intermediate points (Dead Reckoning), the partial times, the accumulated travelled distance, as well as course, distance and duration of a direct route from each intermediate point to the destination point.

- GREAT DISTANCES -

Rhumb line legs along a great circle route. Accumulation.

This program allows to plot a route between a start and a destination point along a great circle route travelled with rhumb line legs of a pre-set constant length.

The program provides for each leg:

- the coordinates of the partial point
- the rhumb line course in the leg
- the accumulated distance travelled from the start.

Lastly, the program provides the total distance travelled and a percentage comparison among the great circle route distance, the total travelled distance and the rhumb line distance. The program does not work for routes along the equator or a meridian line (course 0° or 180°).

- MERCATOR CHART -

Plotting the grid of a Mercator chart.
Subdivisions of the increasing latitudes.

This program provides the data to draw the grid of a Mercator nautical chart on a graph paper sheet or a common squared sheet

Enter:

- the central latitude
- the step of the subdivisions on the axis of the latitude (minutes of a degree)
- the length of the axis of the latitude (mm)
- the scale of the axis of the longitude (mm/degree)

The program provides the progressive distances (mm) of the subdivisions on the axis of the latitude from the chosen central latitude.

The program is limited to the band of latitudes 75°N - 75°S.

- CALENDAR -

Number of days elapsed between a pair of dates. Day of the week

This program offers a choice between:

- the number of days, and optionally the time, elapsed between a pair of dates, with the indication of the day of the week
- the date of the day after or before a number of days elapsed from an initial date, with the indication of the day of the week.