# ASTRON USER NOTES (Ver 2.00 Beta 14Oct 2018)

Click on any item to navigate to it.

[ASTRON USER NOTES (Ver 2.00 Beta 14Oct 2018) 1](#_Toc527228246)

[1. INTRODUCTION. 2](#_Toc527228247)

[2. CAUTION. 2](#_Toc527228248)

[3. ASTRON VERSIONS. 2](#_Toc527228249)

[3A. Feedback on Version 2.00 which is under Beta test. 3](#_Toc527228250)

[4. GENERAL NOTES: Legend, layout & page navigation keys. 4](#_Toc527228251)

[5. GENERAL CALCULATION NOTES 5](#_Toc527228252)

[6. HOME PAGE. Part 1 – Almanac Section. 6](#_Toc527228253)

[7. HOME PAGE. Part 2 – Apparent Position Section. 8](#_Toc527228254)

[8. HOME PAGE. Part 3 – Sextant Altitude Corrections Section. 9](#_Toc527228255)

[9. HOME PAGE. Part 4 – Additional information now displayed. 11](#_Toc527228256)

[10. HOME PAGE. UNIDENTIFED BODY UTILITY. 12](#_Toc527228257)

[11. POSITION FROM LOCAL MERIDIAN PASSAGE OF ANY BODY. 13](#_Toc527228258)

[12A. (V2.00) SIGHT LOG AND SIGHT PLOTTER. 15](#_Toc527228259)

[12B. (V1.15) ADVANCE LINE OF POSITION. 17](#_Toc527228260)

[13. SIGHT PLANNER and SKY CHART. 18](#_Toc527228261)

[14. SETTINGS 20](#_Toc527228262)

[15. ARTIFICIAL HORIZON SIGHTS. 21](#_Toc527228263)

[16. BACK (“OVER THE TOP”) SIGHTS. 22](#_Toc527228264)

[17. INDIRECT OR NON-STANDARD USES 23](#_Toc527228265)

[18. LUNAR DISTANCES 26](#_Toc527228266)

[APPENDIX 1. 31](#_Toc527228267)

[ASTRON Version 2.0 BROWSER COMPATIBILITY. 31](#_Toc527228268)

[ASTRON Version 2.0 INSTALLATION. 31](#_Toc527228269)

[APPENDIX 2. 32](#_Toc527228270)

[ASTRON Version 1.15 COMPATIBILITY. 32](#_Toc527228271)

[ASTRON Version 1.15 INSTALLATION 32](#_Toc527228272)

[APPENDIX 3. NOTES ON TIME INPUT and TIME ZONES 33](#_Toc527228273)

[APPENDIX 4. RECENT REVISION HISTORY. 34](#_Toc527228274)

[APPENDIX 5. ACKNOWLEDGEMENTS. 35](#_Toc527228275)

[APPENDIX 6. MODIFYING ASTRON. 36](#_Toc527228276)

[1. Modifying either version. 36](#_Toc527228277)

[2. Modifying Version 2.0 36](#_Toc527228278)

[3. Modifying Version 1.5 36](#_Toc527228279)

[APPENDIX 7. ACCURACY AND TESTS. 37](#_Toc527228280)

[APPENDIX 8. Astron V2.00 Beta Testing 47](#_Toc527228281)

## 1. INTRODUCTION.

**These notes are written in English. Please use** <https://translate.google.com/> **to translate your saved copy into your own language.**

Astron (ἄστρον – Greek for Star) is a program for sextant users. Its primary objective is to combine almanac calculations, apparent body position calculations and sextant altitude corrections into an easy to use single page sight reduction utility. It was the predominance of Greek characters in the many formulae used that inspired the name Astron.

* As an almanac, Astron will, for an entered date and time, calculate the GHA, Dec, HP & SD of a body selected from a list of the 57 navigational stars, Polaris, Sun, Moon, Mercury, Venus, Mars, Jupiter and Saturn. Although intended for practical use in the present era, dates between 1905AD and 2999AD may be entered.
* If an assumed position is also entered, Astron will also calculate the Azimuth and Altitude of the selected body.
* If a sextant altitude is also entered, together with instrument correction, height of eye, temperature, pressure and observed limb, Astron will also calculate the Azimuth and Intercept from the assumed position.

The home page also displays the times of rise, meridian passage and set of the selected body and the ‘twilight windows’ for planet and star observations with a marine sextant. (If the body is unidentified, a sidebar utility can identify it given its approximate azimuth and altitude.) Supplementary features (Sight Plotter, Sight Planner, Lunars calculator and Mer Passage Latitude calculator) are included on separate pages.

To easily navigate this document, click on any item on the index page to go to that item. References within the document also have links to that reference. To return to the index page, press Ctrl + Home keys. (Alas many keyboards no longer have a Home key. The author uses a Logitech Bluetooth keyboard: Ctrl + FN + Left Arrow keys works on that!)

## 2. CAUTION.

Astron has been produced by enthusiastic amateurs. Whilst every effort has been taken to eliminate errors and inaccuracies, including cross checking with commercial software, almanacs and other printed publications, some errors and inaccuracies undoubtedly exist. Astron should never be used as a source of navigational information. It should never be installed on any ship’s equipment as such action could invalidate the vessel’s certification.

## 3. ASTRON VERSIONS.

These user notes refer to Version 1.15 and Version 2. Where differences occur, the normal font refers to Version 2 and differences in Version 1 are shown like this. Astron Version 2 is a new release and is only at Beta test stage. We would love to receive feedback. Please see para 3A below for details.

Astron Version 1 is the original spreadsheet version running under Microsoft Excel. Various additions and improvements have been added over time and the latest version is Astron V1.15. It is effectively frozen and will only be updated if any bugs are reported. See [Appendix 2](#_ASTRON_Version_1.15) for compatibility and installation notes.

Astron Version 2 has the same look and feel as Version 1.15. It is written as a web page and should run (after resolution of any problems revealed by Beta testing) on any modern computer with recent versions of most browsers. Please read [Appendix 1](#_APPENDIX_1.) , “Compatibility and installation notes”, especially regarding choice of browser if you wish to use the software when offline.

It is intended to continue developing Astron Version 2 as the language used (JavaScript) gives much more flexibility than Excel as evidenced by the improvements in Meridian Passage, Lunar modules, Sight Log/Plotter and Sight Planner/Sky Chart. Version 2 is primarily a rewrite of V1.15 in JavaScript and we wish to allow several months ‘settlement’ before proceeding with the following planned additions:.

1. Add lunar body/times predictor to Planner page.
2. Improve Home Page and other displays for better screen fit.
3. Add (substantial) code to enable offline use with Safari and Microsoft browsers.
4. Add user selectable alternative method for lunars. (Three sight method).
5. Enable LOP’s from Lunar Distances to be used with Sight Plotter and Sight Log.

## 3A. Feedback on Version 2.00 which is under Beta test.

We would love to receive feedback on Astron V2.00 or these user notes. Version 2 is a rewrite in a different language and may take a short while to mature. This is especially so as browser’s behaviors differ and even the same browser may behave differently on different platforms.

We don’t like those boring online forms: please just send a chatty email to [1billritchie@gmail.com](mailto:1billritchie@gmail.com) stating your problem, comment, brickbats or bouquets.

Please add the following where relevant.

1. Screenshot(s) showing screen(s) with subject input and output.

2. Device details. EG Apple iPad 9.7" (2017) 128GB

3. Device operating system. EG iOS 10.0.

4. Browser details. EG Chrome for iPad V69.0.3497.105

5. Whether browsing online or browsing saved offline file.

Most importantly, we would like to hear about anything wrong, so we can correct it quickly. However, your suggestions for improvements are also welcome.

Thank you in advance for your feedback.

## 4. GENERAL NOTES: Legend, layout & page navigation keys.

**1. LEGEND**. Ensure that ALL main input fields are correct before using result. Fields coloured  are intermediate calculations for information only, whilst results are coloured . Additional supplementary utilities, such as unidentified body, have their text in a subdued grey, optional input fields shown as  and results shown as . The legend for items whose units or range can be altered, either directly or on the Settings page, are shown in **blue**. The legend for items that refer you to another page is in the same colour as the appropriate tab below the main table.

**2. PAGES.** The HOME PAGE is the main working page. If you are elsewhere, click the Home Page tab located at the top of any page. (V1.15 bottom of page) The home page carries out both the almanac processes of calculating the geographic position of the body at the instant of observation and the subsequent sight reduction. Values inserted on the home page are also used elsewhere to avoid duplicating entries.

The following supplementary pages are selected from the tabs located at the bottom left of the home page. (V1.15 any page, except for Advance LOP which is reached by scrolling down from the home page). All supplementary pages (V1.15 except Manual Almanac) are ‘children’ of the ‘parent’ HOME PAGE, using (in context) the time, body, assumed position, etc, selected on the Home Page.

SIGHT LOG AND SIGHT PLOTTER. (V1.15 Advance LOP.) See [Section 12](#_12._ADVANCE_LINE).

PLANNER and SKY CHART. See [Section 13](#_13._PLANNER.). (V1.15 no Sky Chart)

SETTINGS. See [Section 14](#_14._SETTINGS).

STAR INFO. This page lists star data for the entered date sorted in various orders. (V1.15 for 1.1.2000 only)

MER PASSAGE. See [Section 11](#_11._LATITUDE_FROM).

LUNARS. See [Section 18](#_18._LUNAR_DISTANCES).

MANUAL ALMANAC. V1.15 only. This is a supplementary working page in V1.15 only. It is intended for those who prefer to use a printed almanac and just want Astron to calculate the apparent position and perform the sight reduction, or to locate an unlisted body from published data.

Note: In fact Astron 2.00 has only one ‘page’: the above ‘pages’ are really ‘sections’ and are all in a vertical sequence with large gaps between them. This method ensures much faster operation than having separate HTML pages. Always move between ‘pages’ using the navigation tabs on each ‘page’.

**3. NAVIGATION WITHIN HOME PAGE.** To perform a sight reduction, ALL the main input fields (in this colour) should be completed. Navigate between them with the mouse, touchpad/screen, TAB or ENTER keys. If an input is out of range, an appropriate alert will pop up, the last valid value will be restored and ‘focus’ will remain on that field. (If you input a blank field, Astron assumes that you have entered ‘0’ which may or may not be a valid input.) The ESC key responds similarly to the TAB key if the entry is unchanged, otherwise it restores the last valid value and maintains ‘focus’. Navigation to Settings fields, Identify Body fields and the Menu fields on the last line can only be done with mouse or touchpad / screen. This is deliberate so that TAB/ENTER successively takes you through all the input fields for a sight reduction but ignores all other fields.

On Android tablets when the on-screen (virtual) keyboard is in use, the TAB/ENTER keys are replaced by a ‘NEXT’ key which, alas, ignores the above logic and tabs through every input field in the order it thinks best including those on other pages! We suggest only using touchpad/stylus to navigate with Android tablets with on-screen keyboards.

With Microsoft Edge and Internet Explorer (which only work in online mode) the ‘focussed’ entry field has an ‘X’ beside it which clears the existing entry. There is no need to use this – on all browsers Astron clears the field automatically when you first enter a letter or number. If you just wish to change part of the entry, such as 2018 to 2019, just backspace out the 8 and enter 9.

**4. CALCULATION.** Astron recalculates all dependent fields whenever any field is changed. There is no ‘calculate’ button, but you do need to ‘exit’ the last entered field to initiate the final calculation. Do not use any result until you are sure that you have correctly entered all input fields; intermediate results may appear incongruous! The last valid entered data and settings will be recalled upon next use, provided you have not changed to a different browser. (V1.15 Press “Save” or set your spreadsheet program’s auto save to “ON” to save data and settings.)

**5. VIEW CODE.** If you wish to view or indeed tinker with Astron’s formulae, see Appendix 6, MODIFYING ASTRON, near the end of these notes. (V1.15 only: Some rows and columns and several other pages are hidden for clarity. These are all for intermediate calculation processes only.)

6. **WHY SO MUCH INFORMATION?** This software is intentionally ‘verbose’. It could have been written with just the input fields and an output display of only azimuth and intercept. However, the author hopes that the intermediate data displayed assists understanding the various stages of the process and helps avoid errors. Some intermediate results are also useful when using the software for indirect or unintended purposes.

**7. SETTINGS.** Astron has various user configurable settings. On the release version home page, time input is set to Ship’s Time mode, Time Zones are used rather than Zone Differences and units for height, temperature and pressure are set to metres, °C and hPa. If you receive Astron from another person, these settings may have been changed. Other settings are initially set to the default settings as described in [Section 14](#_14._SETTINGS) . These notes, to avoid repetition, assume that the default settings are used.

8. The following symbols are used to abbreviate some on-screen legend.

Sun **☉**, Moon **☾**, Any star **☆**, Mercury ☿, Venus **♀**, Mars **♂**, First Point of Aries ♈.

9. Astron V2.0 is a large program and may load or run slowly on older machines. No significant running delays are noticeable on our two-year-old Microsoft Surface Pro 3 (Windows 10 – Intel I5 – 8Gb RAM).

## 5. GENERAL CALCULATION NOTES

**Numbers:** All calculations are carried out using 15 significant figures. Outputs are normally rounded to whole numbers or to 1 decimal place. Inputs to integer cells (cells without decimals) are truncated before use. (EG: 2018.9 year is truncated to 2018.) If you enter a value into a decimal cell with more decimal places than displayed, the entered value is used but the display is rounded to the set number of places.

**Cell Rounding*:***V1.15 only. If the calculation result is (say) 12° 59.96', when rounded to 1 decimal place will display 12° 60.0'. This should be interpreted as 13° 00.0'.

**Division by zero:** Exceedingly rare cases may occur (caused by trigonometry operations on chance interim values of exactly 0 or 90 degrees) which give a “NaN” error. (V1.15: #NUM! or #DIV0! Error.) If this occurs, please work around it by changing (say) the entered time by 1 second. This is a theoretical bug as it must be exactly 0 or 90 to 15 significant figures – the author has never seen this occur.

## 6. HOME PAGE. Part 1 – Almanac Section.

**Display:**

The Home Page has a yellow border. The intention is that such border should automatically fill your screen or window horizontally and that zoom (gestures or Ctrl + Mouse Wheel) should then adjust the vertical scale to your liking. However, browser individuality and screen resolution may not always achieve this. (V1.15 has the Advance LOP utility (with blue border) below the main display. The intention is that only the top display with cream border is normally visible.)

**Using Tablets and Smart Phones:**

If you are using a tablet without an external keyboard, the on-screen keyboard may overlap the normal display. You may have to reduce the size of the display or use ‘portrait’ orientation to stop this happening. With smart phones, the same applies and, although results are correct, the need for excessive scrolling makes smart phone use impractical.

**Enter Date and Time**:

You can enter date and time in either GMT Watch Time or Ship’s Watch Time. Simply click on the header “Ship’s Time” and pick “GMT”, or vice versa. The header and other items will change accordingly. Which mode you use is entirely your choice. However, to avoid explaining both methods repetitively, except where specifically stated, date/time input in Ship’s Watch Time is assumed and described in these notes.

So, enter your ship’s watch date and time of observation. Invalid dates (say 2001 Feb 29) are rejected with an error message. Should this occur, you may need to change the day to 28 or less (thereby entering a valid date) before you can change the month or year. (V1.15: Astron gives error message but calculates assuming (say 1st March) was intended.)

Then enter your Watch Correction. If your watch is (say) 15 seconds slow, enter +15. (-15 if fast.) Values between -60 and +60 seconds are permitted. Do not confuse with the term Watch Error which is of opposite sign. Note that entering a Watch Correction does not change the time display that you have entered on the input line, but the corrected time is displayed (in both GMT and Ship’s Time) on the right of the screen. Of course, if you always adjust mentally (or have one of those super-watches), just enter zero.

**Enter Time Zones / Zone Descriptions / Daylight Saving:**

Astron can be configured to work using either Time Zones or Zone Descriptions by clicking on the header as with Time entry mode. Time Zones are positive East of Greenwich, whilst Zone Descriptions are negative East of Greenwich. Time zones between -12 and +14 may be entered. (ZDs between -14 and + 12). Please set the method you prefer. These notes describe the Time Zone method only to avoid repetition.

A section on the upper right of the Home Page asks you to enter the Time Zone offset that you are using (+E/-W) and a Daylight-Saving hour if applicable. Astron displays both GMT and Ship’s Time adjacently to the time zone entry fields, with a green background for the one which is the current date/time entry mode. Note that Time Zones and Daylight Saving not only affect the hour, they can also affect the day, the month and possibly even the year. The prime purpose of displaying both times, including day of the week, is to allow you to cross check that the intended time has been entered. Time Zones are positive East of Greenwich. Partial hours are permitted as decimals, so for India (5h 30m ahead of GMT) enter +5.5.

**Select Body****:**

Click on the displayed body name and the arrow that appears on the right of that cell and use the pick list to select the required body. Sun, Moon and planets are first on the list, then stars in alphabetical order. Stars whose names are in UPPER CASE are all first magnitude (<=1.5). (You can also fast track by typing the first few letters of the body name.)

You have now entered all the required information to use Astron as a basic almanac. Astron shows the GHA and Declination of the body at the selected time. It also shows the body’s Horizontal Parallax and Semi Diameter in the Sextant Altitude Corrections section.

The cell beside the body name varies depending on the body as follows: -

SUN: Astron displays the value of the equation of time at the user entered instant. If the sign is +ve, this indicates that the ‘true’ Sun is ahead of the ‘mean’ Sun and thus the Sun’s meridian passage will be that time interval before 12:00 local mean time. Vice versa for a -ve sign.

MOON: The Moon’s phase is displayed, indicated as a percentage of full Moon illumination. A “+ve” sign indicates that the Moon is waxing, a “-ve” sign indicates waning.

OTHER BODIES: Astron displays the apparent magnitude of the body. If the body is Saturn, the magnitude includes the light from the rings, with the component from the planet alone in brackets. e.g. “0.7 (1.1)”

**Mercury:** Although not normally listed in navigation almanacs, Mercury is included in Astron as its apparent magnitude exceeds even that of Sirius for a few days once or twice on each 116-day apparent orbit.

**Polaris:** With Astron, treat as any other star and plot LOP (very nearly E/W) using displayed azimuth and intercept. GHA may be up to 0.5' in error (due meridian convergence near the pole exaggerating very small angular inaccuracies), but declination, azimuth, altitude and intercept calculation accuracy is within 0.2'/0.2nm unless Ass Lat is North of 87°N. (See 17.3 for Astron’s interpretation of a traditional Polaris latitude sight.)

## 7. HOME PAGE. Part 2 – Apparent Position Section.

**Enter assumed latitude and longitude.**

Unlike when using sight reduction tables, there is no requirement to use specific values to facilitate table look up methods. Choosing the whole degree values nearest to your DR position usually simplifies plotting the subsequent line of position. (However, if you are using Astron to cross check a tabular sight reduction, or vice versa, then you will need to input the same assumed latitude and longitude that you were obliged to use for table look up.)

Input of exactly 180° longitude and 90° latitude is prohibited. If required, use 179° 59.9’, etc.

Having now also entered your assumed position, Astron displays the apparent position (Azimuth and Altitude) of the selected body at the selected time. Do not use the additional features described in Home Page Part 4 yet as some values are dependent on HoE, Temperature, Pressure and Limb to be entered in Part 3.

## **8**. **HOME PAGE. Part 3 – Sextant Altitude Corrections Section.**

**Sextant Reading (Hs):** The value must be less than 140°. Values over 90° are to cater for sextants using an artificial horizon and for back “over the top” sights. For real horizon sights, entering angles close to 90° is not allowed for plotting accuracy and limb ambiguity reasons. (See [Section 15](#_15._ARTIFICIAL_HORIZON) for artificial horizon sights and [Section 16](OVER#_16._BACK_() for back “over the top” sights.)

**Index Correction (IC):** When zeroing your sextant on a distant object, an “off the arc” calibration reading is deemed a positive index correction. (H1 = Hs + IC). Do not confuse with often used Index Error (IE) which is of opposite sign. (Beware of a not infrequent error when reading ‘off the arc’ values – an off arc reading of 0.2’ (IC = +0.2’) will show on the main scale between 0° and -1°, but on the vernier as 0.8’.)

**Units for HoE, Temperature and Pressure.** You can change these (between metres / feet, Celsius / Fahrenheit and hectopascals / inches of mercury) by clicking on the associated header fields. *(*V1.15: The Home Page settings carry across to the Manual Almanac page.*)* Changing units automatically changes the entered value accordingly. (V1.15 not so!)

**Height of Eye (HoE):** Enter the accurate height of the observer’s eye above sea level. A platform midway fore and aft reduces HoE variations due to pitching. A low and on-centreline platform reduces HoE variations due to rolling. A lower platform reduces refraction anomalies for low altitude sights (and can sometimes give a horizon with a distant fog bank.) In big seas or swells, it is normal to take sights when on the crests – do not add half the wave height to your HoE as the horizon is similarly affected.

**Temperature and Pressure Corrections for refraction.** Enter the ambient air temperature and pressure. Beware of results when Hs is less than 5° due to natural anomalies from the computed normal corrections for the input temperature and pressure. Exactly on the visible horizon, some authors record measuring anomalies of up to 20', equivalent to up to 20 nm error in position line. However most of these reports were measured from platforms of significant elevation, such as cliff tops and even mountain observatories, often over intermediate terrain and usually with a distant sea horizon. Most of the reported natural anomaly is usually attributable to temperature variation of the air mass below the level of the observer. Computer and tabular methods usually treat that part of the refraction (below the sensible horizon) as part of the HoE correction and do not include any provision for non-standard below sensible horizon atmospheric effects. For an observer on the deck of a small vessel well away from the influence of land or ice, these anomalies are usually far smaller.

**Correction for parallax:** In addition to the usual corrections for parallax, Astron also includes a further correction to allow for the oblateness of the earth. (Reducing earth radius as latitude increases.) For the Moon, this further correction is 0' at the equator, decreasing to -0.2' at the poles and is negligible for other bodies. Astron shows the values of both the Horizontal Parallax (if the body were on the horizon) and the Parallax Correction actually applied to the body’s present altitude. (V1.15 shows only the parallax correction).

**Limb:** The Home Page calculates semi diameter for Sun, Moon and planets. For Sun and Moon, select the appropriate limb*. (*V1.15: Enter U, L, or C in upper or lower case.) For stars, semi diameter is zero, so select any value. For planets, normally select centre and observe centre of planet. However, Venus’ aspect (like the Moon) is seldom vertical and the apparent centre is seldom the true centre. (The Nautical Almanac listed positions for Venus are pre-adjusted for the apparent centre – with Astron, if you select “L” or “U” for any planet and can observe accordingly, it will correct for semi diameter.)

**Correction for semi diameter:** The displayed SD correction, for a Moon sight only, includes a further correction for augmentation. (Increased apparent Moon semi-diameter when overhead because you are an earth’s radius closer to it.) This is 0' on the horizon increasing to +0.26' at the zenith.

**Calculated Azimuth and Intercept.**

Now that the above sextant corrections have been entered, Astron calculates the azimuth and intercept of the line of position (LoP) from your assumed position. If these were 173º and 10.3nm Away, assuming an accurate sight, the observer was somewhere on a line drawn in direction 083º/263º through a point displaced 353º / 10.3nm from the assumed position. Provided the intercept is less than 200nm, pressing the adjacent “Add Sight” button will show your LoP on the Sight Plotter.

The above almanac and sight reduction process is the main purpose of Astron. All the following utilities are supplementary to this main purpose.

## **9**. **HOME PAGE. Part 4 – Additional information now displayed.**

When all previous inputs are complete, the following additional information becomes valid.

**Observation Windows:**

Astron displays the ship’s times of the AM and PM Observation Windows for the assumed position. (V1.15: not displayed if the Sun is the selected body).Star and planet sights can normally only be taken with a marine sextant during an observation window before sunrise and after sunset when the light levels are such that both body and horizon are visible. Of course, the time zone and daylight-saving fields must have been correctly entered. The default window is based on the time when the centre of the Sun is between 3° and 9° below the celestial horizon. However, you may prefer different values and, if so, you can change these using the “Settings” page as explained in [Section 14](#_14._SETTINGS). In high latitudes, there may be no window as the Sun may remain too low or too high all that day. If so, “None” is displayed. These times are for the ship’s time day. If the ship’s time differs from exact local time for the Assumed Longitude (it usually will!), in high latitudes a displayed time could be on the Previous or Next Ship’s Time Day. Such occurrences are suffixed with a “P” or “N”. (V1.15: such occurrences display “None”). Observation window times do not infer that the selected body will be visible. Calculation accuracy is believed to be within 1 minute for latitudes below 60° but times are only a guide in higher latitudes.

**Rise, Mer Passage and Set Times.**

The ship’s times of rise, upper meridian passage and set of any selected body (V1.15: works for stars only) at the Assumed Position are displayed in the lower right corner. These are calculated using the height of eye, temperature, pressure and limb that you have set in Sextant Altitude Corrections, not the upper limb / sea level / standard conditions that are used in almanacs. Calculation accuracy is believed to be within 5 seconds, except for near circumpolar situations. However, naked eye observation of rising and setting will be quite different from these times, partly due to refraction anomalies but mainly due to atmospheric extinction. See 17.1A for more detail on atmospheric extinction, a subject under practical study by the author whenever opportunities arise. Displayed times are when these three events occur on the selected (ship’s time) date, so, for an evening star rise, say 2200, the displayed set time would be for when it previously set on the morning of that (ship’s time) day, not for the set the following morning. Occasionally an event can occur twice on a given day, just after and just before midnight, in which case, the later event time is shown below the earlier one. If the body does not rise or set that day, NONE is displayed. (If using GMT input mode, note that the times will be for the present day in ship’s time, which may be different from the entered GMT day.) Times are still listed in daylight and the time of upper meridian passage is always displayed, even if the body is below the horizon. Upper Meridian Passage times are when the body transits the local upper meridian (LHA=000.00), not the times of maximum altitude (culmination) which can be different due to observer motion and/or the body’s declination not being constant. (The time of lower meridian passage for any star will be 11h 58m 02s earlier and later.)

This module of Astron can help refute the myth that the Moon cannot rise twice in the same day because her meridian passage times are around 50 minutes later each day. Try entering the following settings: Any GMT or ship’s time, 2025 June 19th, Time Zone 0, Daylight Saving 0, Moon, N65 00.0 E000 00.0. The reason is that (on this date) her declination is becoming more Northerly at a rate of over 6 degrees per day. (See also 11.5 re Moon Meridian Passage)

**General Note on Observation Window and Rise, Mer Passage and Set Times.**

The twilight observation window and times of sunrise, upper meridian passage and sunset are always given in Ship’s Time. If you want to see these times in GMT, temporarily set the time zone and daylight-saving fields to zero. If you do this, the times will be for the events during the GMT day, not during the ship’s time day.

At the risk of confusing the issue, you can set Ship’s Time to any world time. So, if you live in California and set your date to 1st January 2018, Time Zone to -8 but set your Assumed Position to 0N 105E (near Singapore), Astron will state that sunrise time is 15:00:07. That is the Californian time on 1st Jan Californian date when the sun (upper limb) is rising in Singapore. But Singapore is 15 hours ahead of California, so the Singapore time of that same event is 06:00:07 on 2nd January Singapore time. (You would need to change the input date to 31 Dec 2017 to find that the Californian date/time when the Sun is rising in Singapore on 1st Jan Singapore date is 31 Dec 14:59:39)

**Geocentric Lunar Distance:** This is also displayed. See section 18, Lunars.

## **10**. **HOME PAGE.** UNIDENTIFED BODY UTILITY.

This facility will hopefully help identify the body that gave you a brief sight opportunity in a cloud gap.

We assume that date, time and Assumed Lat/Long have been entered. Then enter the approximate observed altitude and TRUE bearing of the unidentified body in the fields near the right edge of the screen. Astron will display the nearest body to that apparent position.

Note that only the listed bodies can be identified. (Sun, Moon, Mercury, Venus, Mars, Jupiter, Saturn, the 57 navigational stars and Polaris). Other bright stars, such as Castor or Becrux, will not be found. Like the main display, the logic continues to work for bodies below the horizon and ignores invisibility in daylight. You may prefer to use the Sight Planner and Sky Chart page which gives tabular and graphical azimuth, altitude and magnitude information on all well positioned listed bodies for the selected date, time and assumed position. Some sight reduction programs automatically select the body from the Assumed Position, time and sextant reading – we choose not to do this as it restricts Astron’s flexibility.

**Arc distance between bodies.**

(Users of Astron V1.14 should upgrade to V1.15 (or V2.0) as V1.14 contains a bug in this utility.)

Below the unidentified body display, the arc distance between the selected body and the previously ‘unidentified’ body is displayed. This may be useful in resolving an apparent conflict and it can also be used for sextant practice or checking. For example, if you wanted to find the arc distance between Canopus and Sirius, first select Sirius and enter the displayed Computed Azimuth (Zn) and Computed altitude (Hc) in the unidentified body fields. Then (without changing time or assumed position) select Canopus and the arc distance between them will be displayed.

As this can be used for sextant checking, a few further details are pertinent.

1. Provided both bodies are above the celestial horizon, the apparent arc is calculated. This is the arc as would be measured with an accurate sextant and includes the effects of refraction and parallax. The entered temperature and pressure are used for the refraction calculations. (Abnormal refraction can cause errors with low altitude bodies.)
2. If either body is below the celestial horizon, the geocentric arc is calculated. This is the arc as would be measured by an observer at the centre of the earth. (Aberration is still included – see 5/ below.)
3. The calculated arc is always between body centres. This is to avoid complicating this simple utility with near/far limb entries. The result is only given to the nearest degree if ether body is the Sun or the Moon. For the same reason the result is given to the nearest minute if either body is a planet. Accuracy between stars (above 20° elevation) is believed to be better than 0.05’ and the result is given to 2 decimal places.
4. See Note 2 at the end of [Section 18](#_18._LUNAR_DISTANCES) (lunars) which enables accurate display of such arc distance between the Moon’s limbs and other bodies.
5. The calculation includes the effect of annual aberration, the seasonal apparent displacement of a body due to the earth’s motion (relative to the body) as it orbits the Sun. This can cause the apparent position of each body to differ from its mean apparent position by up to 0.34’ in both SHA and Declination depending upon time of year. The effect is greatest when the arc distance is itself large. (The smaller correction due to the rotational velocity of the earth is less that 1.5% of the above and is ignored.) The following table (calculated with zero refraction) shows the arc distances on the 1st of each month in 2018 between Fomalhaut and Antares. In this example, the maximum difference of 0.85’ occurs between April and October.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
| 82°  51.60’ | 82°  51.37’ | 82°  51.20’ | 82°  51.10’ | 82°  51.12’ | 82°  51.25’ | 82°  51.44’ | 82°  51.66’ | 82°  51.85’ | 82°  51.95’ | 82°  51.94’ | 82°  51.82’ |

1. The conclusion from the above is that, if you seek maximum accuracy for whatever reason, choose bodies with altitudes above (say) 20° and always enter the correct date, time, location, temperature and pressure. Some say that interstellar angles only change very slowly with time due to stellar proper motion, but this is not so due to refraction and aberration. For interest, proper motion in this example affects the arc distances for each month ten years hence by only 0.04’ whilst the inter-month differences due to aberration remain as the above table. (Over the same 10-year period, precession (and nutation) cause a much larger change (in SHA) of the order of 8’ but, as the positions of both bodies are affected equally, precession and nutation have no effect on inter-stellar arc distances.)

## 11. POSITION FROM LOCAL MERIDIAN PASSAGE OF ANY BODY.

Traditionally a separate method is used to calculate the latitude of a body from an observation at its maximum or minimum altitude. If the exact time of such event is known, longitude can also be calculated. Astron’s implementation of this works as follows –

**Pop-up prompt.** Whenever the entered data results in a local hour angle near to 360°, Astron thinks that you may be trying to resolve an upper meridian passage sight. It therefore shows a ‘pop-up’ entitled “Upper Meridian Passage Sight?” and, below it, “See separate 'Mer Passage' page.” Similar prompts are shown if the LHA is near 180° for a lower meridian passage sight. If you are not making a meridian passage sight, just ignore this pop-up.

**Meridian Passage Sight Utility.** You need to press the tab entitled “Mer. Passage” (bottom of screen) to see this utility. It covers both upper and lower meridian passage sights. This text assumes that an upper meridian passage (body at maximum altitude) has been triggered by the Local Hour Angle being near to 360. See further down the page for a (much less frequently used) lower meridian passage sight.

1. Uncorrected Upper Meridian Passage. (Body at maximum altitude.)

The top set of values (light green) display the time, observer’s latitude and longitude assuming that: -

* The observer was stationary.
* The body’s declination was not changing. (Always the case with stars, but seldom with nearer bodies.)
* The entered sextant altitude (Hs) was the measured maximum altitude of the body and
* The entered date/time was the exact time of maximum altitude.

Latitude calculation. Proviso. An Upper Meridian Passage sight can have two solutions at equal distances North and South of the declination (latitude) of the body. Astron resolves this ambiguity by stating that the assumed latitude MUST be in the correct sense. By this, we mean that if you were facing South to take the sight, then you were North of the body and the assumed latitude MUST be North of the declination of the body, and vice versa. With this important proviso, the accuracy of the assumed latitude has no other effect as the latitude is calculated using the declination at the entered time of maximum altitude and the maximum sextant altitude itself.

Longitude calculation. The accuracy of the assumed longitude need only be within 10 degrees of your actual position (to trigger the pop-up display) but the accuracy of the time of maximum altitude is critical to this calculation of longitude. However, such observation time is unlikely to be accurate as the exact time of maximum altitude is difficult to observe. Such time is often more accurately determined by the median time of (usually several) pairs of equal altitude observations or by mathematical or graphical best fit methods. Using such a method will improve longitude accuracy but cannot work with Polaris and is unlikely to give a good result with the high declination stars Kochab, Atria and Miaplacidus. Observer motion also has a much larger effect on high declination bodies. At sea, twilight duration restricts opportunities to use such methods for bodies other than the Sun, the Moon and perhaps Venus.

2. Corrected Upper Meridian Passage.

If the observer is moving and/or if the declination of the body is changing (usual with Moon, Sun and planets), then the time and altitude of maximum observed altitude (“upper culmination”) will be different from the time and altitude of the body as it crosses the observer’s local meridian (“transit”). Once you have entered your vessel’s COG and SOG (V1.15: and the Body Declination Rate) the second set of values in this utility (dark green) shows the time and observer position when the body transited the observer’s upper meridian. (LHA = 000° 00.0’)

Note 1: This is the observer’s position at the stated time of transit, not at the time of the observation.

Note 2: Changes to COG and SOG update the same values in the Advance Line of Position utility. (V1.15: not so).

The Body Declination Rate is calculated automatically by Astron V2.00.

(For V1.15: To find the Body Declination Rate, proceed as follows.

1. Tab to the Home Page, advance the time by exactly one hour and write down the new declination. (If a star, ignore this - go straight to stage 5. Star declination rates are always zero.)

2. Reset Astron back one hour to the time of culmination and ensure other fields are unchanged.

3. Now note Astron’s value for the declination of the body at the time of culmination. The difference is the Body Declination Rate in minutes of arc. The sign is positive when the stage 1 (1 hour later) declination is more Northerly and negative if the stage 1 declination is more Southerly.

4. Tab back to the Mer. Passage page.

5. Enter your vessel’s COG, SOG and the above noted value for Body Declination Rate.)

3. Lower meridian passage. (Body at minimum altitude.)

A lower meridian passage is detected by Astron when the local hour angle is near to 180°. The same display is used, but the associated legend changes accordingly. Enter the home page display with the minimum observed altitude and the time of lower culmination. Then read ‘minimum’ and ‘lower’ for ‘maximum’ and ‘upper’ in 2. above. The proviso on assumed latitude accuracy does not apply for a lower meridian passage sight. You can enter any latitude you like as a body can only be circumpolar in one hemisphere.

V1.15: Previous versions did not calculate Lower Meridian Passage sights if the assumed latitude was on the polar side of the body. This restriction is removed in V1.15.

4. Note. We have received a report that the time of upper meridian passage calculated by this utility differs from the time shown in the lower right of the Home Page. This is not a bug!

* The Home Page calculates the time of meridian passage for the body when observed from exactly the assumed position on the (ship’s time) date. Entered time and sextant altitude have no effect on this.
* This utility calculates the position from the entered time of observed culmination and entered maximum sextant altitude, before and after corrections for observer motion and body declination change. Assumed position has no effect on this provided the proviso in 1. above is observed.
* If you set the assumed position to the corrected position in this utility, both times will agree.

5. Moon. Because the Moon’s orbit is more nearly aligned with the ecliptic rather than the equator, her declination can change surprisingly rapidly, resulting in large corrections. Try entering the following settings: Time Zone 0, 2025 June 19th, 06:00:00 GMT (or ship’s time), Moon, N40 00.0 E000 00.0. Hs 52° 00.0’, IC 0, HoE 0, T 10C, P 1010 hPa, SOG 0. The declination rate is over 16’ per hour compared with the Sun’s maximum of just over 1’ per hour. The difference between observed culmination and transit is 3m 35s resulting in a longitude correction of 52.1’ (39.9nm). This is a near extreme example at the time of a major lunar standstill.

## 12A. (V2.00) SIGHT LOG AND SIGHT PLOTTER.

Sight Log and Plotter is only available in Version 2. For V1.15, see 12B, Advance Line of Position.

This page can be accessed by using either the SIGHT LOG or the ADD SIGHT tab below the Home Page display. The ADD SIGHT tab is only displayed when the current calculation results in an intercept value of less than 200nm. The Sight Log page consists of four parts.

**Part 1. Advance LoP’s to fix time.**

The upper table allows you to designate (and subsequently change) the time of a fix and your (constant) SOG and COG between the earliest sight time and the fix time. Any sights that you add to the sight log will be ‘advanced’ to this time. Fix times earlier than the sight time (retired LOP’s) are not supported. This is to allow for sights over midnight - Astron assumes that an ‘earlier’ entered fix time is on the following day. The entries in this table (time, SOG, COG) are saved when you exit Astron.

**Part 2. Sight Log.**

The second table displays each sight that you add from the Home Page in the order you enter them, which is not necessarily in time order. Sights can be deleted individually or together. Sights are shown in a rainbow of colours that correspond with the Sight Plotter colours, which repeat if you have more than six sights. The logged sights are not saved when you exit Astron.

**Part 3. Astron Sight Plotter.**

When you add a sight to the sight log, a chart is drawn showing that line of position, together with all other LoP’s in the Sight Log, all advanced to the time of the fix. The centre of the chart is the advanced latitude and longitude of the last added LoP. The scale of the chart (which we express as chart width in nautical miles) is such that all LoP’s will be shown (with a maximum of 600nm). Hovering your mouse over this chart will display the coordinates of the mouse position. Please regard this ‘Astron’ chart as the primary chart because the Google Map (see below) only works when you are online.

You can **change the chart centre** by a single mouse click at the desired new centre. You can **change the chart width** by preset amounts using the width selector. Changed values will remain until you change them again, add a new sight or exit Astron. Once you have clicked on this chart, you can also use the “P” key (“P for PLUS”) to increase the chart width or “M” key (“M for MINUS”) to decrease it. (We wanted to use + and – keys, active throughout the page, but have not yet succeeded in finding a way that works with all popular browsers.)

**PART 4. Google Sight Plotter.**

If you are online, a similar chart using Google Maps is also displayed below the Astron Sight Plotter. The chart centre is the same, but the scale (and hence coverage) is only approximately the same and the projection is different. You can zoom and move the Google map with mouse or the usual pinch gestures – these do not affect the Astron Sight Plotter. (However, changing the Astron scale or centre resets the Google Map accordingly.)

Notes.

1. Times are displayed in the time input mode (GMT or Ship’s Time) that is selected on the Home page. If, having added a sight to the Sight Log, you then change the Time Input Mode, Time Zone or Daylight Saving Time before adding a further sight, the Sight Log will adjust the displayed times of all sights to what they would have been if they had been taken with the changed time settings.

2. The Astron chart projection is azimuthal equidistant, orientated to True North and using the currently chosen chart centre as reference datum. We use this projection so that great circles passing through the chart centre are straight lines. For maximum accuracy, recentre the chart on your fix position. (Google Map projection is spherical Mercator.)

3. When advancing Assumed Positions, Astron assumes you are sailing a rhumb line if your Assumed Latitude is below 60°. In higher latitudes, Astron assumes that you are sailing a great circle with the entered COG being the COG at the time of the sight.

4. The azimuth/intercept offset of the LoP from the advanced Assumed Position is calculated as a great circle. This is mathematically correct, though traditional plotting methods usually assume a rhumb line.

5. LoP’s are in fact circles centered on the (advanced) geographical position of the body. This can be seen at larger chart width settings or with high altitude sights. Traditional plotting methods usually assume the LoP is a ‘straight’ line with restrictions on high altitude sights.

6. Large chart widths show more of the equal altitude circles for each body. These vary from geometric circles in accordance with the chart projections.

7. If you change the values of COG or SOG, they will also change in the Meridian Passage utility.

## 12B. (V1.15) ADVANCE LINE OF POSITION.

This utility has been replaced in V2.00 by the Sight Log and Sight Plotter described in 12A. The following text only applies to Astron Version 1.15.

This utility, accessed using the tab entitled “Advance LOP” (bottom of screen) will hopefully assist in plotting a fix from multiple observations whilst under way. It only works if you choose a fix time that is equal to, or later than, the time of the last of the observations. Your COG and SOG must be constant throughout the period.

* For each entered observation in turn, enter (or check) the chosen fix time, course over ground (COG) and speed over ground (SOG). Astron will display the distance that the line of position (LOP) from this observation needs to be advanced (in the direction of the COG) to advance the LOP to the fix time. Many navigators prefer to work this way, plotting both the LOP at the observation time and the advanced LOP at the fix time.
* Some, however, prefer to advance the assumed position(s) and plot only the advanced LOP’s. So, for those who do this, Astron also calculates the advanced assumed latitude and longitude from which you should plot the calculated azimuth and intercept, assuming course and speed were held. (The azimuth and intercept values for the current sight are repeated here for convenience.) If you prefer the former method, just note the COG and the distance to advance and ignore the rest. Note that, if you have used the same assumed position for sights taken at different times, the advanced assumed positions will not be the same.
* You will need to record (or plot) the outputs for each observation before using Astron for the next observation.
* Fix times earlier than the sight time (retired LOP’s) are not supported. This is to allow for sights over midnight - Astron assumes that an ‘earlier’ entered fix time is on the following day. (You can cheat by temporarily reversing the times and entering the reciprocal of the COG, or by entering your earlier time as the same time interval later and again entering the reciprocal of the COG!)
* Astron uses time after watch correction for these calculations.
* Effectively, this is just a rhumb line DR calculator and it can be used for other short distance calculation purposes.
* Changes to COG and SOG do not update the same values in the Meridian Passage utility.

## 13. SIGHT PLANNER and SKY CHART.

Sky Chart is only available in Version 2.

This page is accessed using the Planner tab located at the bottom of the Home page (V1.15: any page). It will hopefully help you choose suitable bodies for a multiple body fix. It can also be used as a star (and planet) recognition aid. Bodies that will be invisible in daylight are not excluded.

* The PLANNER and SKY CHART are linked to the ­time and assumed position set on the Home Page. You can only change these by temporarily revisiting that page. Use the Home Page listing of the Ship’s Times of the AM and PM observation windows to help in choosing your planned observation time.
* The PLANNER lists the magnitudes, azimuths and altitudes of bodies at the chosen time as would be observed from the assumed position. Values are rounded to the nearest whole degree. The list is in order of AZIMUTH (i.e. true bearing) clockwise from North.
* The SKY CHART displays the positions of all above horizon bodies. The size of the ‘dot’ is in an (arbitrary) relationship to the body magnitude. It always starts in ‘Plan View’ (black on white background) but ‘Sky View’ (white on black background) can be selected. Sky View reverses the direction of East and West so that directions would be correct if the screen were over your head. (However, if you actually hold your device overhead with auto-rotate enabled, anything could happen!) If the name of a solar system body overlaps a star name, use the PLANNER table to resolve this.

V1.15 does not include SKY CHART, but it does include several further features no longer included in Version 2 as we have received opinions that the whole page is unnecessarily complicated. For completeness, these additional features are described on the next page.

*V1.15 only. Additional features of SIGHT PLANNER.*

* Bodies with a poor observational altitude (but maybe still useable) are shown in pale grey.
* *Only bodies within the range of Min Altitude and Max Altitude are displayed. These two values (suggested 20° and 70°) can be changed on this page.*
* Columns with more detailed values of Azimuth and Altitude are repeated if you scroll right on the Planner page.
* The columns headed “2”, “3” & “4” are for two, three and four body fixes respectively. Within these columns, bodies with good altitudes and good angular separations from the reference body are shown with their azimuth difference (+ve clockwise) from the reference body displayed. For a good two body fix, choose bodies with azimuth differences of +/- 90 degrees. For a three body fix, use +/- 60/120 degree differences and for a four body fix use +/- 45/90/135 degree differences. Remember not to choose bodies that are 180 degrees apart, i.e. near 135 & -45, etc.
* If the Sun is above the horizon, a yellow warning is given. Only the Sun, perhaps the Moon and possibly Venus could be visible! The Sun is deliberately included in the list of bodies to cater for possible Sun/Moon/Venus daylight sights. The altitude of the Sun is shown in the explanatory text.
* The NORMAL METHOD OF USE is to start on the Home Page and select your expected latitude, longitude and a time within the observation window. Then view the Planner page, use the information to choose a bright reference body with a good altitude, revisit the Home Page to select that body and then return and make your choices of other bodies. A red warning is given if you have selected a reference body that is below the horizon and an amber warning if it has a poor observational altitude.
* If the suggested bodies are too few, obscured or just not bright enough, try a different reference body.
* A separate area allows you to adjust certain settings to your own preference. These affect the display of the indicators of daylight, below horizon bodies, good body altitude and good angular separation. Any changed settings will be remembered only if you save before you exit Astron.
* Some other factors that may influence your choice are body magnitudes (1st magnitude stars are in CAPITALS), cloud and horizon conditions, proximity of the Moon, bodies obscured by sails, stars that you are sure you can recognise and the need to observe faint bodies first as soon as the horizon is visible before sunrise. Of course, overriding navigation criteria may dictate a totally different choice.
* By way of example, first set the following values on the Home Page. (Ship’s Time entry mode). Date: 2016 January 2nd.Ship’s Time: 04:45:00 Time Zone: +11.5 Daylight Saving: 0 Body: VENUS Lat: **S**29° 00.0’. Long: **E**168° 00.0’. Note that the proposed time falls within AM observation window. Then move to the Planner and observe that:
* The two body column suggests three alternatives, of which you would probably choose Jupiter (-87 degree intersect to your chosen reference body Venus.)
* The three body column suggests either the Moon or Arcturus (both about -60 degrees to Venus) and one of the (+60 degrees) RIGIL KENT, HADAR or ACRUX. (Not CANOPUS as it is opposite Arcturus/Moon). Five other stars also fall within the suggested range.
* The four body column suggests Jupiter (near -90), ARCTURUS (near -45) and RIGIL KENT or HADAR (near +45), Three other stars also fall within the suggested range.

You may like to try selecting a different reference body, (say Canopus or the Moon) and noting the changes in the suggested combinations. Also try temporarily changing the value of (say) the four body range parameter (from 10 to 5) to see how the number of possibilities reduces.

## 14. SETTINGS

Some settings, such as Time Entry Mode, are changed on the Home Page. Others are on the page “Settings” accessed from a tab below the main display on the Home Page. Changing a setting will alter the legend to relevant input fields accordingly. Any changes you make will be preserved provided you continue using the same browser. (V1.15: You need to press “Save”).

**The following settings are changeable on the Home Page.**

These are all in blue with a down arrow (▼) on the right hand side. EG : Date / Time in Ship’s Time ▼

Time Entry Mode. (GMT or Ship’s Time)

Zone Mode. (Time Zones or Zone Descriptions)

Height of Eye Units. (Metres or Feet)

Temperature Units, (Celsius or Fahrenheit)

Pressure Units, (hectopascals or Inches of Mercury)

If any of the last three units are changed, the corresponding entered value is changed automatically. (V1.15: not changed.). However, if you change Time Entry or Zone modes, you must also manually change the entered time and/or zone time.

**The following settings are changeable from the Settings page.**

In context, these are also shown in blue, but without any arrow.

**Show Right Ascension.**

The default setting is FALSE. This feature is provided for telescope users with Right Ascension equatorial mounts. If set to TRUE, the Right Ascension of the body will be displayed instead of its SHA. Note that this is the Right Ascension of the body at the exact input time. It will differ from a star catalogue value (often at J2000.0) as Astron has corrected the RA for proper motion, precession, nutation and aberration since the catalogue datum. (If you set Astron time to 2000 Jan 01 11:58:56 GMT the values should agree.)

**Artificial Horizon.**

The default setting is FALSE. If you are reducing a sight taken with an artificial horizon, first set this to TRUE. See [Section 15](#_15._ARTIFICIAL_HORIZON), Artificial Horizon sights.

**Adjust Twilight Observation Window times.**

As explained in [Section 9](#_9._HOME_PAGE.), (Additional information now displayed), the times shown here are the times when the Sun centre is between two selected angles of depression below the celestial horizon. These default angles are -3° and -9°. You can change these values (within stated limits) to suit your personal observation methods by changing the values of TOO LIGHT SUN DEPRESSION and/or TOO DARK SUN DEPRESSION. (The curious may ask why the DARK setting can be as low as -20°. This is for telescope users who like to know the time when certain very low light levels will be achieved.)

## 15. ARTIFICIAL HORIZON SIGHTS.

To use Astron for sights taken using an artificial horizon, you first need to set ARTIFICIAL HORIZON to TRUE. This is explained in [Section 14](#_14._SETTINGS_1) above. Having done so, note a warning “CAUTION: ARTIFICIAL HORIZON MODE” appears. The following example shows how Astron treats such a sight.

* Sextant reading 123° 45.6’. Index Correction +0.4. HoE 4.0m.
* Enter 123° 45.6’ in the Hs fields.
* Enter 0.4’ in the Index Correction field. Display is 123° 46.0’. All normal so far!
* Enter any value you like in HoE field! Display reads 61° 53.0’ regardless as HoE has no effect with an artificial horizon. The information value below the HoE field is exactly half the index corrected result.
* Enter Temperature & Pressure as normal.
* Take care determining which limb is observed. If the bottom of double reflected image touches the top of the image seen in the liquid (or horizontal mirror), this is a LOWER limb sight. Even greater care is necessary if you are using an inverting telescope! If in doubt, overlap both images and select Centre limb.
* Ensure other input fields are all entered correctly and plot azimuth and intercept as normal.

## 16. BACK (“OVER THE TOP”) SIGHTS.

Sometimes, when the horizon below the body is obscured or indistinct, a back sight can be taken. (The author’s Henry Hughes’ sextant only reads up to 130°, a few read over 135°.) If you insert a value for Hs greater than 90 degrees, (provided ARTIFICIAL HORIZON is not set to TRUE), Astron assumes that this is a back sight. The following example shows how Astron treats such a sight.

* Sextant reading 123° 45.6’. Index Correction +0.4. HoE 4.0m. Lower limb as observed in sextant.
* Enter 123° 45.6’ in the Hs fields. Note a warning “CAUTION: BACK SIGHT MODE” appears.
* Enter 0.4’ in the Index Correction field. Display is 123° 46.0’. All normal so far!
* Enter 4.0m in HoE field. Display reads 56° 17.5’. Note now that the altitude from the opposite horizon is displayed below this field. It has been corrected for dip, but by addition rather than the usual subtraction. (A sketch would show you why the dip must be reversed.) (180° - 123° 46.0’ plus 0° 03.5’ dip = 56° 17.5’)
* Enter Temperature & Pressure as normal.
* For a Sun, Moon or planet sight, reverse the limb. If you observed the lower limb to be on the horizon, this looks like a lower limb sight, but you must enter it as an upper limb sight, because you are now measuring it from the opposite horizon. If in doubt, take and rework an additional approximate cross check sight using the centre of the body and enter “C” in the limb field – if the resulting intercept differs by about 30 miles (Sun/Moon) you have chosen the wrong limb!
* Ensure other input fields are all entered correctly and plot azimuth and intercept as normal.

Use of back sight to reveal systematic error.

Comparing a back sight with a normal sight of the same body can reveal a systematic error. Such an error could be caused by incorrect index correction, anomalous dip, consistent incorrect technique or an instrument fault or maladjustment. Because of the sextant altitude corrections, you cannot just compare a normal sight altitude with the supplementary altitude of a back sight. With Astron, we suggest this method:

Take a normal sight, back sight and normal sight of the body in that sequence, recording the altitudes and times. Interpolate the normal sights to the time of the back sight. Then use Astron to compare the observed altitudes (Ho) of the back sight and the interpolated normal sight. This example uses the Moon to also show the limb effect.

Set-up: 2017 June 25. 16:12:34 Ship’s Time. Time Zone -2. DS=0.

Body = Moon. Assumed Lat 40N. Assumed Long 30W. IC=0, HoE 3m, T 10, P 1010.

Normal sight Hs 48° 57.2’. Lower Limb. Ho = 49° 49.6’.

Back sight Hs 130° 32.1’. Upper Limb. Ho = 49° 52.6’.

There is a 3.0’ difference, so you have a 1.5’ systematic error. As the back sight Ho was larger, increase your normal sight Hs by 1.5’. (Decrease if back sight Ho was smaller.) If you had previously taken other sights for a fix that you wish to correct for such systematic error, (in this example) also increase their recorded Sextant Altitudes (Hs) by 1.5’ and then rework all sights. If the resulting cocked hat is not small and entirely within the original, then you have other errors.

Some sources suggest achieving the above by plotting the LOP for a normal sight closely followed by the LOP for the back sight and then plotting a LOP midway between the two (very nearly) parallel lines. Then transfer any other LOPs by half the distance between the parallels. However, the rules of thumb governing which way to transfer the other LOPs (table below) can be confusing. It is tempting to always transfer a LOP towards the centre of the cocked hat, but that is not necessarily the case if other errors exist.

|  |  |  |
| --- | --- | --- |
|  | Intercept “Towards” | Intercept “Away” |
| Back sight Ho smaller | Move LOP towards AP | Move LOP away from AP |
| Back sight Ho larger | Move LOP away from AP | Move LOP towards AP |
| The above directions to move LOP are the initial directions. If a correction towards the AP is larger than the initial intercept value, this will cross the AP and move away on the other side. | | |

## 17. INDIRECT OR NON-STANDARD USES

These are indirect ways of using Astron for purposes other than its design objective of sight reduction. Some of them can be accomplished more easily with other dedicated software but are listed here just in case you do not have such software handy. Please familiarise yourself with the normal (preceding) uses of Astron before experimenting with these indirect uses or, indeed, any other uses that you invent yourself.

(Where ‘adjust’ is mentioned, please see 17.5, NOTES TO INDIRECT USES, at the end of this section).

**17.1A. Calculate time of rise or set of any body at any location.**

This information is already displayed for any body on the Home Page Version 2.0 and for stars only in V1.15.

So this method is only required with V1.15 and, even then, only for Moon, planets and more accurate Sun information.

Proceed as follows.

Enter Year, Month, Day, approximate Ship’s Time, chosen body, Location Lat & Long, Hs=\*\*\*, IC = 0, Act HoE, Temp, Press & (usually) Upper Limb. Watch correction should be zero and Time zone and daylight-saving time must also be correctly entered.

\*\*\*You can anticipate the extinction altitude from the table below and enter that in the Hs field instead of a zero value to get the approximate time when the body should become (or cease to be) visible. (The magnitude of the selected body is shown in cell D11.)

Then ‘adjust’ Hour, Minute and eventually Second to give an intercept value of 0.0nm. This is Ship’s Time of the event. GMT time (and date) is also given.

Note 1: Do not adjust to give a Hc of 0.0 – it must be the intercept of 0.0 to allow for refraction, etc.

Note 2. Inability to converge to an intercept of 0.0 indicates that the body does not rise (or set) that day.

If azimuth <180°, this is body rising time. Otherwise, it is setting time.

Calculation accuracy is believed to be within 5 seconds, except for near circumpolar situations. However, naked eye observation of rising and setting may be quite different from these times, partly due to refraction anomalies but mainly due to atmospheric extinction. The following table gives the author’s preliminary work on average altitudes above the visible horizon of bodies of various magnitudes at which they reach the naked eye visibility limit in good visibility conditions at sea at mid nautical twilight (sun depression 9°) looking towards the horizon opposite to the sun. Use of typical marine 7x40 binoculars (with clean lenses) following a setting body to extinction (before dawn) gives a benefit of the order of three magnitudes and improves horizon visibility.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Magnitude | -4.5 | -4 | -2.9 | -1.5 | -0.7 | 0 | 1 | 2 | 2.9 |
|  | Venus  (near max) |  | Jupiter / Mars  (max) | Sirius | Canopus | Vega | Antares / Spica | Hamal | Acamar |
| Extinction Altitude | 0° 00’ | 0° 06’ | 0° 18’ | 0° 42’ | 1° 00’ | 1° 18’ | 1° 48’ | 2° 33’ | 3° 30’ |

**17.1B. Calculate time of upper meridian passage of any body.**

This information is already displayed for all bodies on the Home Page in Version 2.0 and for stars only in V1.15.

In V1.15 times for Sun, Moon and Planets can be deduced in a manner similar to 17.1A, but ‘adjust’ time to give a Local Hour Angle of 000° 00.0’. In the case of the Sun, the value shown in the Equation of Time field may help save a few steps. (Lower meridian passage is similar, but ‘adjust’ to give a LHA of 180°.) These times are the true ‘transit’ times – observed ‘culmination’ times could be different due to observer motion and body declination change.

**17.1C. Calculate time when any body is at a specific true altitude.**

Also like 17.1A, but adjust time to give the desired value in the Computed Altitude (Hc) field. Negative values are also displayed, so accurate times of (centre limb) sun depression during twilight can be ascertained.

**17.2. Compass check. (Traditionally naked eye bearing at sunrise or sunset)**

Record pelorus bearing of event.

Input body, exact ship’s time of naked eye body rise/set, Act Lat & Long, Hs=0, IC=0, Act HoE, Act Temp, Act Press and Limb. Time zone and daylight saving time must also be correctly entered. The resulting intercept value should be near to zero. See text on atmospheric extinction in 17.1A. True rise/set is normally only observable with Sun, Moon or Venus.

Compare Astron’s Azimuth with recorded bearing, allowing for variation and deviation (unless a gyro compass).

This procedure is also valid for any visible body at any low altitude, not just at set/rise. In this case, record Ship’s Time and pelorus bearing and measure the (low) altitude with your sextant, entering Ship’s Time, measured Hs, IC, HoE, temperature, pressure and limb.

After a naked eye sight, remember to reset IC to your usual value.

**17.3. Latitude by Polaris.**

Observe the time and altitude of Polaris. Enter Date, Ships Time, Time Zone, Body Polaris, Ass Lat & Long, Sextant reading (Hs), IC, HoE, Temp & Press. Then, ‘adjust’ your entered Assumed Latitude to give an intercept of zero. This is your latitude. The above assumes a reasonably accurate time and assumed longitude. Errors of 6 minutes in time or 1.5 degrees of longitude can each result in latitude errors of up to 1 mile. (The same applies, of course, to time or assumed longitude errors when using the Nautical Almanac Polaris tables.)

**17.4. Exact time of full or new Moon.**

Select “Moon”. Enter approximate date.

‘Adjust’ day, hour, minute and eventually second whilst watching the waxing/waning +/- indicator. When this changes from + to – with a tiny time increment, this is the time of full Moon. (From – to + is new Moon.) (Using the +/- is more accurate than using the change in phase from 99% to 100%)

**17.5. NOTES TO ABOVE INDIRECT USES.**

Some of the uses refer to ‘adjusting’ an entry. This is best done by ‘guessing and halving’ as the following example (in Ship’s Time entry mode) shows. Entries and changes on each iteration are shown in RED. The example is to find the Ship’s Time of the rise of Mercury on 2nd January 2016 (Ship’s Time date) at a position 6 miles North West of Norfolk Island. (S29° 00.0’ E168° 00.0’.) Time Zone is +11h 30m with no daylight saving. (This example was written for V1.15 which does not calculate planet rise/set times. V2.00 does calculate rise/set times for all bodies but this is still valid as an example of ‘adjusting’.) The answer is 06:51:20. (19:21:20 GMT the previous day.) Alas, after all your efforts, this was after sunrise and the rise of Mercury would not have been visible! It looks complicated, but once you have done it a couple of times and get the hang of it, you can usually get the result in less than 15 seconds.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **INITIAL SETTINGS** | | Time Zone **11.5** | | Daylight Saving **0** | | | SHIP’S TIME ENTRY MODE | |
| BODY | ASS LAT | ASS LONG | Hs | IC | HoE | T | P | Limb |
| MERCURY | S 29 00.0 | E 168 00.0 | **0.0** | 0 | 5.5m | 28C | 1025 hPa | C |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **YEAR** | **MONTH** | **DAY** | **HOUR** | **MIN** | **SEC** | **AZIMUTH** | **INTERCEPT** | **COMMENT** |
| 2016 | 1 | 2 | 12 | 0 | 0 | 076.1 | 3957.9 A | Initial guess. Long way off. Subtract 6 hours. |
|  |  |  | 06 |  |  | 121.1 | 596.8 T | Now 600 off. Try another hour earlier. |
|  |  |  | 05 |  |  | 130.6 | 1235.8 T | Wrong way! Try 07:00 |
|  |  |  | 07 |  |  | 113.2 | 104.1 A | A little too far. Try 15 mins earlier. |
|  |  |  | 06 | 45 |  | 115.1 | 75.5 T | Not enough. Try 7 mins later. |
|  |  |  |  | 52 |  | 114.2 | 8.0 A | Getting closer. Just a little too far. Try 51 mins. |
|  |  |  |  | 51 |  | 114.3 | 4.0 T | 51 mins not enough, 52 too many. Try 30 seconds. |
|  |  |  |  |  | 30 | 114.3 | 2.0 A | Too much. Halve it. Try 15 secs. |
|  |  |  |  |  | 15 | 114.3 | 1.0 T | Too little. Halve the difference. Try 22 secs. |
|  |  |  |  |  | 22 | 114.3 | 0.4 A | Too much. Try 19 secs. |
|  |  |  |  |  | 19 | 114.3 | 0.2 T | Nearly there. Add 1 sec. |
|  |  |  |  |  | 20 | 114.3 | 0.0 | QED. |
| **2016** | **1** | **2** | **06** | **51** | **20** |  |  | **Answer in Ship’s Time.** |
| 2016 | 1 | 1 | 19 | 21 | 20 |  |  | Answer in GMT |

PS. “Why Norfolk Island?” The author was a jetlagged passenger on an aircraft near Norfolk Island before dawn on that local date. I did not see any lights of Norfolk Island, but there was a lovely view of Venus in the East. This inspired me to use Astron to see when Mercury would rise. This example also demonstrates the use of a time zone that is not a whole hour offset from GMT. Also, you may like to read “Alone over the Tasman Sea” by Sir Francis Chichester. An extraordinary example of solo navigation to find this tiny and remote island in 1931 in a Gipsy Moth biplane fitted with floats, using only a marine sextant and with no fuel to go anywhere else and no autopilot. He practiced taking Sun sights whilst pedalling a bicycle along a coast road.

## 18. LUNAR DISTANCES

The Lunar Distances module notes for V1.15 have been removed and the below text now only refers to Version 2 of Astron. The need for manual iteration (an Excel restriction) made that module quite complex and was one reason for the switch to Version 2. The actual module is still present in V1.15 and can be used with the on-screen instructions.

**18.1. Home Page: Geocentric Lunar Distance and Lunar Opportunity pop-up.**

Old Almanacs used to show the geocentric lunar distance (the angle between the centres of the two bodies as would be measured by an observer at the centre of the Earth) between the moon and a few suitable bodies at 3-hour intervals, leaving the user to interpolation to the desired instant. Astron, however, shows the geocentric lunar distance from the selected body for the entered date and time. Below this, a “Lunar Opportunity” hint is displayed only when the Moon and the selected body are in such positions that a good quality lunar may be possible, assuming the entered time and location are reasonably correct. You can visit the Lunar Sight page at any time and, if the ‘pop-up’ was not present, it will tell you the reason(s) why.

**18.2. Find Longitude and GMT from Lunar Distance (Lunars)**

Lunars are a traditional method of finding GMT (and hence longitude) from the observed lunar distance (sextant measured angle after index correction) between the Moon’s illuminated limb and another body near to the plane of the moon’s path. It was used extensively in the 17th and 18th centuries before the invention of accurate chronometers. (Book and TV Series “Longitude” – the story of John Harrison.) The calculations were complex and many vessels are thought to have foundered due to calculation or method rather than observation errors.

The basic principle is that the Moon moves Eastward relative to the background of stars at a predictable rate. Effectively, the stars near the Moon’s path are the time markings of a clock in the sky and the Moon is the hand of the clock. By measuring the angle between the Moon and a known star (plus a simultaneous altitude measurement of that star) the GMT and longitude of that observation can be calculated. The Moon’s sidereal orbit takes 27.3 days, which is only about one Moon diameter (30 minutes of arc) per hour. If you can measure the lunar distance to an accuracy of 0.5 minutes of arc you can deduce the time to an accuracy of one minute and hence longitude to within 15’. The Sun or a planet can be used instead of a suitable star as Astron compensates for their individual apparent motion against the fixed background of stars. The accuracy of the Moon/body distance measurement is paramount – drawing a graph of several sights and using best fit values is common practice. In the hands of expert navigators, lunars provided surprising accuracy. Lieutenant James Cook, on his first great voyage in 1770, charted the longitude of what he called “Cape North”, the most North-Eastern point in New Zealand, as W186° 53’. To us that is E173° 07’, only 4 miles from Google Earth’s calculations. His longitude for the most Southerly point of New Zealand (“Cape South” on Stewart Island) was even more accurate.

Astron’s implementation attempts to integrate lunars with its normal sight reduction function, thereby hopefully avoiding duplication of entries. This section is accessed from the “Lunars” tab at the bottom of the screen. When you first see this page, you will probably be confronted by a series of warnings or cautions. Have faith! Astron remembers the value of the last entered “Measured Lunar Arc” (and most other previous inputs) and all of these will vanish when you have entered valid data.

**SIMPLE EXAMPLE.** Let’s start with a simple example, showing the method with some explanations. You are stranded on an island with the unlikely combination of a friend, cloudless skies, two sextants, a computer with Astron (but no internal clock), a solar panel charger and an old tin clock that seems to work ok when wound up.

INITIAL PREPARATION.

Set Astron in GMT input mode (see 16.1) and set Watch Correction to 0. (Astron works Lunars quite happily in Ship’s Time, but because your longitude is unknown, GMT mode is suggested.)

Enter Astron with your guess of GMT date (**2017 Dec 25),** latitude (**S10° 00.0’**) and longitude (**E105° 00.0’**). Choose the nearest multiple of 15 for your assumed longitude. Then you know that you are (in this case) 7 hours ahead of GMT and as it is about 10 o’clock local time, so enter 03:00:00 into Astron. (Entering +7 in the time zone field (or -7 if set to ZD) and 0 daylight saving will then give meaningful (and useful) local twilight and rise/set times.)

STAGE 1. Find your latitude.

You choose to determine your latitude using the Sun’s upper meridian passage method (Section 11).

You measure the Sun’s lower limb maximum altitude (76° 56.8’) as your friend simultaneously resets your tin clock to 05:00:00. (12:00 minus 7 hours.) Don’t bother with allowing for the equation of time – such detail will come out in the wash.

Select the Sun as body, enter **05:00:00** as GMT and the observed Sun’s maximum altitude of **76° 56.8**’, together with the sextant altitude correction data of IC=0, HoE=**2.4m**, T=**25C,** P=**1010 hPa** and limb=**Lower**. You will see a pop-up on the right of the page inviting you to visit the Meridian Passage page. After setting your SOG to **0**, this page shows your latitude (**S10° 33.3’**) which you enter in the Assumed Latitude fields. (The displayed longitude is meaningless as the time is just a guess, so leave Assumed Longitude as E105° 00.0’.)

PREPARATION FOR STAGES 2 and 3.

Soon you notice the Moon in the East, too low for an accurate sight as the recommended minimum altitude is 20°. Time to prepare for the next stage. You will need to take two sights simultaneously, so you are fortunate to have a friend and two sextants. (There are, of course, ways with a single observer and sextant, but we are trying to simplify things!) One sight will be the Sun’s altitude, the other the angle between the Moon’s illuminated limb and the Sun’s nearer limb to the Moon. The Moon’s illuminated limb is (always) the one nearer the Sun. As the Moon gains altitude, you do a few practice simultaneous sights and after a late lunch of clams and coconut milk you finally settle for the following values. Tin Clock Time 08:05:06, Sun (lower limb) Altitude 40° 49.6’, Sun (near limbs) Lunar Distance 77° 36.1’.

STAGE 2. Enter the Sun’s altitude.

Set GMT to **08:05:06**. Check entered latitude remains S10° 33.3’, longitude as E105° 00.0’. Set the Sextant Altitude (Hs) fields to the Sun’s lower limb altitude of **40° 49.6’**.

(Background information: As you have guessed both time and longitude, probably both are incorrect. If you now assume, for a moment, that your guess of GMT was correct, you could obtain a line of position from your Sun altitude measurement. Where this intersects your latitude would be your longitude. However, if your time guess had been (say) exactly one hour earlier, this same altitude would have given your longitude as 15 degrees further East. There is a relationship between longitude and time and Astron will calculate (but not display) a longitude to give a compatible relationship between the entered altitude, latitude and time. We call this synchronisation. You could say that (at this stage) “both time and longitude are now equally wrong!”

STAGE 3. Enter the Lunar Sight.

Use the tab to switch to the “Lunars” page and enter **77° 36.1’** in the Measured Lunar Arc fields and select Near in both limb fields. Observe the display of index correction, temperature and pressure. This is to remind you these entered values on the Home Page are also used for the ‘Lunar’ calculation. Astron (invisibly) calculates the theoretical lunar distance that you would observe at the entered time and location and compares this with the entered Observed LD. (OLD = Measured Lunar Arc + Index Correction). It then revises the time and longitude iteratively until the calculated arc equals your OLD. It then displays (dark green cells) the calculated time when you took the Lunar Sight and the corresponding longitude.

So, at the instant of the ‘simultaneous’ lunar and altitude sights, Astron calculated that the GMT was 08:16:06 and your position was S10° 33.3’ E105° 41.0’. Your tin clock read 08:05:06, so it was exactly 11 minutes slow. Pasting S10° 33.3’ E105° 41.0’ into Google’s search box will show you where you were.

**DEVELOPMENT OF THE METHOD.** We shall now discuss real world variations to the simplified example.

Single observer. To obtain the altitude of the sun (or other body) simultaneously with the lunar sight, you can take altitude sights before and after the lunar sight, noting the tin clock times of both sights, then interpolate to the lunar sight time accordingly. (As you don’t have pencil or paper, do the sums with a stick in the sand!)

Latitude measurement. Measuring latitude by the upper meridian passage of the Sun is a good method and gives you a clue as to (local) time. The sun’s declination varies with time and, at an equinox, can be as much as 1’ per hour. However, this will only affect the result if your guess of GMT was substantially in error. Latitude can also be measured (at sea only during twilight) by the upper or lower meridian passage of a planet or star. Polaris sights create a problem as the corrections depend upon time and longitude, both of which are unknown. An error of 15° longitude with correct time (or 1-hour time error with correct longitude) can give a Polaris sight latitude error of up to 10.3’. The solution for a Polaris latitude (or bad GMT initial guess) is to rework everything starting with your newly found position and time.

Ship’s run. The above example on an island eliminated the need to allow for ship’s run by advancing (or retiring) your latitude sight to the time of the Lunar Sight. However, this will normally be necessary. You can either plot it or use the SIGHT LOG (V1.15: ADVANCED LINE OF POSITION) utility (Section 14). Only enter the advanced latitude into Astron as you are going to change the longitude in stage 2 regardless.

Simultaneous altitude measurement (Stage 2). As mentioned above, the purpose of stage 2 is solely to synchronise your assumed longitude with your assumed time. To do this the body’s azimuth should be within 60° of due East or West. This is necessary to obtain a line of position that intersects your latitude at an adequate angle. Astron will complain with a “bad azimuth for longitude determination” message if this is not the case. (In the above example, you would have had to wait until well after local noon for this reason also.)

Choice of body for lunar distance measurement (Stage 3).

Traditionally, the old Almanacs displayed lunar distances for a few selected bodies that were close to the ecliptic, which is the average path of the Moon. However, the actual path can vary substantially from this, especially around ‘lunar standstills’, making bodies some way off the ecliptic also suitable at certain times. Astron compares the path of the Moon with the angle between the Moon and the selected body, using this as one factor in the Quality Index quoted below the sight result.

Normally, the appearance of the lunar distance pop-up indicates that the chosen body may be suitable for a lunar. For the Lunar Sight, suitable Sun/Moon positions only occur on about 9 days each lunar month. At other times, you must use a star or planet which, at sea, normally restricts your observation times to twilights. Astron’s Planner page may help with your choice. A Lunar Sight can be taken all night, but the need for a simultaneous altitude sight of the ‘other’ body usually negates this. Some skilled observers can tell when an apparent moonlit horizon is genuine – if you are confident of this, use it.

Selection of limbs. The illuminated limb of the Moon is always the one nearer the Sun, but it is not necessarily the one nearer the body you are using! For a Sun/Moon sight, it is usual to use both near limbs (N/N) but Astron permits you to use the (more difficult to observe) Sun’s far one (F/N). Stars have a zero semi-diameter correction so select either F or N. For planet/Moon sights, planets may have a discernible disc or crescent, especially if you are using the telescope eyepiece, so all four combinations are possible. (Jupiter can have a semi diameter up to 0.3’ – up to a 9-mile error in longitude if the centre of the planet is used instead of the correct limb.) Take great care identifying which limbs you are using. When very near to full Moon, it is difficult to determine visually which is the illuminated edge. In this case, momentarily make the “Moon” the selected body. If the phase is suffixed by a “+”, it is waxing and the illuminated edge is the Western edge. A “-“ indicates the Eastern edge. (If the solar Lunar Distance is greater than 175°, the error of using the ‘wrong’ edge will be less than 0.1’.) Saturn should be used with care when the ring is visible as the semi-diameter calculated is that of the planet alone. (If the two values quoted in the magnitude field for Saturn differ by more than about 0.2, be cautious.) Note that Astron does not verify that the limb(s) you have selected are the illuminated ones. (A future revision may do so!)

Limitations. The method requires that you know your approximate location and time. It is not a universal tool to find your location, date and time following your release from a long captivity by pirates! Depending on circumstance, permissible ‘errors’ in your guess of time or longitude vary greatly. Astron will give one or more warnings if the combination of entries is such that a valid time and longitude cannot be reasonably accurately calculated. It also gives cautions if a valid calculation reveals a large difference between calculated and input time, longitude or sextant altitude. (Typically, >= 1 hour / 15°). Various items of supplementary information are also given – these should help resolve any reason for rejection.

Final stage. Having achieved a “SUCCESS” result, we suggest that you press the button entitled “Set Home Page date / time and longitude to this lunar result.” There should be no significant change in the result, but some of the supplementary information may change as the assumed position and time have changed. If you have a result with one or more CAUTIONS and you are happy with them, resetting using this button should, again, not materially affect the result but should clear the cautions.

Warnings and Cautions.

When the entered data is unsuitable for a Lunar Sight, the Home Page ‘pop-up’ will not appear and the Lunar Sight page will display various warnings and cautions. There is a list of such warnings and cautions at the end of this section which, hopefully, gives information that explains the reasons. Please note that ‘entered data’ includes the entered arc distance on the lunars page. This will have been remembered from the last sight and may be very different from the present value.

Notes on calculation methods.

* The Astron (two-sight) method requires an accurate body/Moon arc sight and a simultaneous accurate altitude sight of the body. Because the latitude has already been ascertained, probably by using Astron’s Meridian Passage utility, this is sufficient to deduce GMT and longitude. Accuracy falls off rapidly when the ‘other’ body has an amplitude (azimuth from 090/270) exceeding 45°.
* Traditional lunar calculation methods (three-sight) require an accurate lunar arc measurement and approximate altitudes of the body and Moon. Such methods have a lesser amplitude restriction but only yield GMT. Separate conventional observation(s) using your corrected watch time are subsequently necessary to deduce longitude.
* We chose the two-sight method as it yields time and longitude with less to do at the peak time. Dedicated lunar programs usually use the three sight method. If the author finds himself with lots of spare time, he may add the three sight method and give you, dear user, the choice of methods.
* Traditionally the observed lunar distance was ‘cleared’ to a geocentric lunar distance before interpolation with the almanac’s listed (three hourly) geocentric lunar distances. In Astron, the reverse method is used – the geocentric distance for the assumed time is calculated and ‘un-cleared’ to give a theoretical observed lunar distance. Rather than interpolating between two chosen values, Astron then iteratively adjusts time and longitude until the (re)calculated theoretical lunar distance equals your OLD.

Practicing lunars. If you wish to try your lunar skills from your backyard without a horizon, you can cheat by entering the correct time of Lunar Sight, your GPS position, index correction, temperature, pressure, HoE and limb. Then ‘adjust’ (see 17.6) the body’s Hs value so that Ho is exactly the same as Hc (or intercept = 0 which is the same thing). Then enter your measured lunar arc on the lunars page. The differences in time and longitude between the entered (light green) and revised (dark green) values indicate the accuracy of your Lunar Sight. (In fact, any value for HoE and Limb will do as the ‘adjustment’ takes care of that – but IC, pressure and temperature are important.) As you know your longitude, you can use local time (Ship’s Time mode) if you so prefer.

**LUNAR WARNINGS, CAUTIONS and DISPLAYED INFORMATION.**

This part details the warnings, cautions and information messages that are given in various circumstances on the Home or Lunar Sight pages.

1. **Home Page display of Geocentric Lunar Distance.**

Astron shows the geocentric lunar distance at the entered date and time. This is between the centres of the bodies and, as the geocentric observer is at the centre of the earth, it does not vary with assumed position.

2. **Home Page “Lunar Opportunity” pop-up.** This is only displayed when the Quality Index (see 5. below) is above 60. This is an arbitrary value and this (and other stated values below) may be altered in future issues following feedback. If the ‘pop-up’ is displayed, a valid lunar result with a “SUCCESS” label should normally be achievable with the entered Home Page values once you have entered a valid Measured Lunar Arc on the Lunar Sight page. (However, sights ‘between twilights’ are not excluded but will rarely be possible.)

3. WARNINGS. These are displayed on the Lunar Sight page in the following circumstances when a sight is invalid. Home Page pop-up is not displayed. Result fields are blank.

* Quality Index below 40.
* Diverging or erratic iteration. This only occurs if the combination of entered date, time, assumed position, object Hs and lunar arc is unrealistic.
* The selected body is the Moon herself.
* The calculated lunar arc differs from the entered arc by more than 30°.
* The Moon is below the horizon.
* The selected body is below the horizon.
* The entered lunar arc is greater than 135°.
* The entered Hs differs from Hc by more than 15°.
* The entered latitude exceeds 80° N/S.

4. CAUTIONS. These are displayed on the Lunar Sight page when a sight is of mediocre quality or observation is unlikely. Home Page pop-up is not displayed. Result fields are populated.

* If the Quality Index is between 60 and 40.
* If the calculated time differs from the assumed time by more than 60 minutes.
* If the calculated longitude differs from the assumed longitude by more than 15°.
* Star and planet (except Venus) sights. When the Sun’s altitude exceeds -3°.
* Sun sight. If the lunar arc is less than 12°.

Sometimes you will see a valid result with two cautions before you have entered your measured arc. This is usually because the (remembered) arc value happens to be more or less correct for one or two days before or after the current day.

5. QUALITY INDEX. (QI) The perfect value is 100. This occurs when the Moon is moving exactly towards or away from the selected body. The QI is calculated (on a Cosine cubed basis) as the (acute) angle between the Moon’s motion and the direction of the selected body. Example values are 95 if 10°, 83 if 20°, 65 if 30°, 45 if 40°. This is quoted as the “**alignment**” QI.

* This is cumulatively reduced by several other factors to give an “**overall**” QI, which determines the WARNINGS and CAUTIONS displays above.
* QI is reduced if Moon or body below 20° altitude. It can be applied for both bodies! (Example: QI reduced to 25% of its prior value at 10° altitude).
* QI reduces rapidly as the selected body’s amplitude (azimuth from 090/270) exceeds 45°.
* QI is reduced to 0 in all the WARNING situations above.
* QI is ensured below 60 in all the CAUTION situations above.

6. SUPPLEMENTARY INFORMATION. Regardless of the sight’s success or failure, the following information is given.

* The alignment and overall Quality Index values.
* The apparent direction in which the Moon is moving against the star background at the time of her upper meridian passage. (090° means Eastwards parallel to the horizon.)
* The apparent direction of the selected body from the Moon at her meridian passage.
* The relative (acute) motion angle between the above.
* Whether the lunar arc is increasing or decreasing.
* The azimuth (Zn) and altitude (Hc) of both the Moon and the selected body.
* Reasons for any significant reductions from ‘basic’ QI. This often duplicates information already given in a warning or caution.
* The computed Observed Lunar Distance. This is displayed to help you detect errors in your measured lunar arc entry. It is the arc you would measure (after index correction) between the entered limbs if you were exactly at the assumed position at the entered time under the entered temperature and pressure. However, be aware that entering this value will not give a position/time identical to your entered time and assumed position unless you also adjust the Hs of the ‘other’ body so that Ho = Hc (or intercept = 0), thereby synchronising longitude and time.

7. OTHER RELATED INFORMATION AVAILABLE ON HOME PAGE.

* Times of rise, meridian passage and set for the selected body.
* AM and PM observation window times.
* The phase of the Moon and her azimuth (Zn), altitude (Hc) and times of rise, meridian passage and set. (Temporarily select Moon as body).

## APPENDIX 1.

### ASTRON Version 2.0 BROWSER COMPATIBILITY.

Online Mode.

Astron V2.0 is written in HTML and JavaScript and is opened in your browser as a normal web page. We have tested it using the below listed recent versions of Chrome, Firefox, Opera, Internet Explorer, Microsoft Edge and Safari. Astron may not respond correctly with older versions of these browsers.

Offline Mode.

So that it will work at sea, or elsewhere without an internet connection, we have tried to give Astron 2.00 the ability to also run as a locally stored web page. By locally stored, we mean saved as a .html file in a location of your choice on your hard disk and opened from that location. However, this needs features that, at present, are only implemented on Chrome, Firefox and Opera browsers running on Apple and Windows 10 desktops / laptops and on Windows 10 tablets. (If you need your iPad or Android tablet to work at sea, use Astron V1.15.) This table summarises the situation.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Browser/  Platform | **Chrome**  **(V49).** | **Firefox**  **(V60).** | **Opera**  **(V53)** | **MS Edge**  **(V17).** | **MS Internet Explorer V11** | **Safari**  **(V11.1)** |
| **Windows 10 PC** | Online and offline | Online and offline | Online and offline | Online only | Online only | Not available |
| **Apple Mac**  OS X 10.10 | Online and offline | Online and offline | Online and offline | Online only | Not available | Online only |
| **iPad** | Online only | Online only | Online only | Online only | Not available | Online only |
| **Android tablet** | Online only | Online only | Online only | Online only | Not available | Online only |
| **Windows 10 tablet.** | Online and offline | Online and offline | Online and offline | Online only | Online only | Not available |

Both Modes.

If you switch browser between uses, the recalled initial values will be those last used by that browser on that device.

### ASTRON Version 2.0 INSTALLATION.

Online Mode. The latest version of Astron 2 can be run from this link:- [https://vigilanceofbrixham.co.uk/Astron/Astron.html](https://vigilanceofbrixham.co.uk/Astron.html) .

Offline Mode.

If your browser and device are ok in the table above, having loaded Astron in online mode as above, a right mouse click should reveal a ‘Save As’ option. Then select ‘Webpage, html only’ and browse to enter your desired hard disk location. To then run as an internally stored webpage, just click on that stored file’s name/icon. (Do not save to a ‘cloud’ folder, such as Google Drive or Dropbox, as these may occasionally ‘hang’ whilst trying to synchronise far from land.)

User Notes. This document can be downloaded from :-

[https://vigilanceofbrixham.co.uk/Astron/Astron%20User%20Notes.docx](https://vigilanceofbrixham.co.uk/Astron/AstronUserNotes.docx)

Updates. Significant updates will be notified by way of a ‘post’ on <fer3.com> and be uploaded to <https://vigilanceofbrixham.co.uk/Astron/Astron.html> so that link will always hold the latest version and updates will be seamless to online users. Minor updates will be uploaded without notification. Offline users will need to ‘Save As’ as described earlier. Your last used settings and input values will be preserved, provided you do not switch browser.

Feedback. Astron V2.00 is a Beta test version and feedback is requested. Please see [section 3A](#_3A._Feedback_on) of this document for details.

## APPENDIX 2.

### ASTRON Version 1.15 COMPATIBILITY.

Astron V1.15 requires Microsoft Excel (or similar) to run it. The author chose Excel rather than a versatile compiled programming language such as C++ (his favourite) as Excel is now available on many platforms. Additionally, because macros are never used, Astron cannot create any risk to the user of downloading malicious code (and should never give rise to any warnings of such possible risk.)

**For Windows PC users**. Astron was developed using Excel 2016 and has been tested on Windows 8/10 desktops, laptops and Microsoft Surface / Surface Pro 3 tablets, including on 2 Atlantic crossings. All tests used fully licenced Excel versions from 2007 upwards. Some formatting features display incorrectly with Excel 2007 and Excel 2010 or later is recommended.

**For Google Sheets users** on any platform. Alas Astron 1.15 is incompatible with Google Sheets.

**For Apple Mac users.** Astron has been successfully tested on a modern Apple Mac running Excel for Mac V14.7.1.

**For iPad users.** Astron has been tested (and very successfully compared with tabular results) on an Atlantic crossing using an iPad running Microsoft Excel Mobile for iPad. (Free as at Sept 2016)

**For Android tablet users.** Astron has been modified (V1.10) and tested to run under Microsoft Excel Mobile for Android. (Free as above). We have also had a report of Astron running on Android using Polaris Office, but it opened as “protected sheets” and required unprotection before any inputs could be made.

**For Windows tablet users.** Microsoft state that, provided the tablet screen diagonal is 10.1 inches or less, Astron should run using (similarly free) Excel Mobile for Windows, but has not been so tested yet. On screens larger than 10.1 inches, Microsoft state that many user features are inhibited and therefore this version of Excel is not suitable to run Astron. Maybe they want you to buy the full version! However, the author tried using Excel Mobile for Windows on his Microsoft Surface Pro 3 (with 12” diagonal screen) and it worked just fine, not only on the tablet itself but also on an external screen or projector. Perhaps the simultaneous presence of a licensed version of the (full) Excel 2016 on that machine caused this to happen.

**For smart phone users.** The above three Mobile versions of Excel will run Astron “in a fashion” on their respective platforms, but the small screen size requires excessive scrolling and is thus not recommended for practical use. Those who persist with the scrolling will find that the results are correct! Because of the size of Astron, we also suggest that you save it to your SD card to save time and charges.

**For newcomers to Astron.** If you have not yet used Astron, don’t have Excel on your device and just want to get the look and feel of it, try Microsoft Excel OnLine. This is found and accessed through your internet browser and works with many platforms. Astron runs, but some forced cell format, colour and size changes impair the design and ease of use. Also, of course, an online version is of no use if you are at sea! (You need to press the “Edit on Line” button to start.)

**For Open Office Users.** Alas, free Open Office Calc (V4.1.2) does not run Astron in .XLSX format. It does work with a worksheet exported in .XLS format, but then too many features depending upon cell colour and conditional formatting are lost to justify issuing a separate worksheet to run under Open Office.

**For Libre Office Users.** Astron runs adequately under free (suggested donation US$10) Libre Office Calc (V5.1.5.2). Some conditional formatting is missing but in general it is an adequate alternative if you don’t have a licenced copy of Microsoft Excel. (On first use of the settings page, it displays and interprets 0.0 as “FALSE” and any other number as “TRUE” – until you have entered “TRUE” or “FALSE” into all options) Also, upon your first saving of this, set the default to .ODS format, thus preserving the original .XLSX format file for future use with Excel.

**Microsoft Excel Viewer Users.** This is just a viewer, you can’t input values and it is not suitable.

ASTRON Version 1.15 INSTALLATION

Astron V1.15 can be downloaded from <https://vigilanceofbrixham.co.uk/Astron115.xlsx>

We suggest that you install Astron (Astron 115.xlsx) somewhere on your local drive, maybe on your desktop, but not in a folder that is synchronised with a ‘cloud’ service such as Dropbox, Google Drive or OneDrive. This is to avoid the possibility of the workbook not loading because it is trying to synchronise whilst your vessel is beyond Wi-Fi and cellular data range. Provided Excel (or equivalent) is configured as your default spreadsheet program, just clicking on the file name or icon should run Astron. We suggest that an early action should be to select Auto Save to ON – then next time it will start with your most recent settings and input values.

ASTRON V1.15 Updates.

Development of Astron1.15 has ceased and will only be updated should any bugs be found. Any revised files will be renamed Astron116, etc.

## APPENDIX 3. NOTES ON TIME INPUT and TIME ZONES

**A note on obtaining accurate time**. If you seek very high accuracy, be aware of setting your chronometer from time signals on digital radio, digital TV, GPS and the internet. A delay of around two seconds is common on digital radio/tv. There are also unverified internet reports of some analogue radio transmissions being reworked as ‘relays’ of the digital signal, thus questioning their accuracy too. Time displayed on a GPS may also be delayed even though the unit knows time within a few nanoseconds, especially soon after switch on but also if the time display driver subroutine has a low priority with a busy processor. Several websites have feedback mechanisms that measure and correct for internet time delays, claiming accuracies of hundredths of a second. However, your computer display has its own delays, especially when caches are used. The author has tested several such websites and found differences between them of up to 4 seconds with other applications running. Try for yourself running two or more in separate windows and another on your smartphone.

**Time zones** are +ve East of Greenwich, are set by international agreements and range from -12 to +14.

Many high seas sailors use **Zone Descriptions** which are -ve East of Greenwich and are defined as strictly dependent on longitude bands. (EG A ZD of +1 applies to the band between W007° 30’ and W022° 30’). Astron lets you choose your preferred method. Astron uses a looser definition of Zone Differences to allow for values of minus 13 and minus 14 (for Samoa and the Line Islands) and for decimal values (such as for India and the Marquesas Islands.) Your previous value will need to be updated if you change this setting, usually just by changing the sign.

**Choice of working in GMT or Ship’s Time.** Traditionally GMT has always been used for Astro Navigation. This is because Almanac data is (necessarily) in GMT. If you are using Astron to compare results with an Almanac (or Sight Reduction Tables), then GMT should be used. However, if you are using Astron alone, the choice is yours. If you have always used GMT, give Ship’s Time a try. (Outputs of times of body rise, mer passage, set and observation windows are, in any case, always given in Ship’s time.)

## APPENDIX 4. RECENT REVISION HISTORY.

2.00 Complete rewrite using Javascript / HTML.

Sight Log and Sight Plotter added to replace Advance LoP.

Rise, Mer. Passage and Set times now displayed for any selected body, not just stars.

Mer Passage utility now calculates body declination rate automatically.

Manual Almanac sheet discontinued.

Sight Planner utility simplified. Sky Chart added.

Home Page now shows Geocentric Lunar Distance to selected body.

Lunars utility now iterates automatically. Quality Index and other info added.

Button added to update input values to lunar result values.

1.15 Bug fixed in arc distance between two stars.

(A cell reference in refraction calculation accidentally changed after testing – sorry!)

Sun Upper Meridian Passage time displayed alongside Sun rise/set times.

Lunars utility now on separate page.

Mer. Passage utility now on separate page and includes lower meridian passage.

1.14 Body magnitudes column added to Planner page.

Table and comments on atmospheric extinction added to notes on rise/set times.

Utility added to show arc distance between stars.

Utility added to refine upper mer. passage sight for ship’s velocity and body declination change rate.

Stylus bug fixed. (Occasionally graphics mode was triggered when using stylus to select input cell.)

Units for HoE, Temperature and Pressure now changeable on Settings page.

1.13 Times of Rise, Meridian Passage and Set for selected star now displayed.

User can now use Zone Descriptions if preferred to Time Zones.

Watch Correction field now always visible.

‘Twilight’ observation window times now user adjustable.

1.12 Planner: Extra columns added for accuracy verification against US Naval Observatory data.

Lunar Distances calculator added. (Beta test only.)

Lunar distances now only pop-up in usable circumstances.

1.11 Lunar Distances pop-up added.

1.10 Planner presentation improved.

Now compatible with recent Android tablets running Excel Mobile for Android.

Optional entry of watch correction added.

1.09 Date range changed. Now 1905AD to 2999AD.

## APPENDIX 5. ACKNOWLEDGEMENTS.

Astron was developed from many of the spreadsheets published on [http://www.navigation-spreadsheets.com](http://www.navigation-spreadsheets.com/) with the permission of, and thanks to, the developer. Those spreadsheets provide the ‘drivers’ for many of the results shown on Astron and remain the source of solar, earth, lunar and planetary motion data. The stellar data source is now SIMBAD4 Revision 1.5. Utilities, including unidentified body finder, choice of time and zone entry modes, all body rise/set times, observation window times, Sight Log and Plotter, Planner and Sky Chart, back sight mode, artificial horizon mode and meridian passage are original coding. The classic reference book “Astronomical Algorithms” by Jan Meeus has been used to cross check many of the formulae used. NASA’s website <http://eclipse.gsfc.nasa.gov/SEhelp/deltatpoly2004.html> was used for Delta T predictions to 2999AD. The section on lunars was coded using the logic described in “Longitude by the Method of Lunar Distance” by Wendel Brunner, PhD, MD. <https://www.starpath.com/resources2/brunner-lunars.pdf> . The corrections for observer and body motion with meridian passage sights were coded using the formulae quoted by James D Wilson in Appendix 1 of <http://fer3.com/arc/imgx/v32n1-6.pdf>.

Astron V1.15 has been cross checked against the examples in the last two editions of The American Practical Navigator, against data from the US Naval Observatory and against other digital and tabular sources with results listed in Appendix 7, Accuracy and Tests.

Astron v2.00 has been checked at every stage of development against the (thus verified) values in V1.15 plus many further random checks against USNO data.

## APPENDIX 6. MODIFYING ASTRON.

### 1. Modifying either version.

Comments were written for the benefit of the author and any successor, not with an audience in mind! Please, don’t change the original, work on a renamed copy!

### 2. Modifying Version 2.0

Astron V2.0 is written in standard HTML (HTML5), CSS and JavaScript. It was developed using over 25 individual files, but these have all been combined into a single .HTML file approaching 2Mb in size to simplify distribution, installation, load speed and use. This file can be viewed and changed with any text editor. However, being so large, a powerful programmer’s editor is recommended. The most likely things you might wish to change should be possible by changing the values of certain global constants. For instance, if you wanted to change the available chart widths of the sight plotters, initially search for

“const CHART\_WIDTHS”. You should find “const CHART\_WIDTHS = [9600, 4800, 2400, 1200, 600, 300, 120, 60, 30, 12, 6, 3, 2, 1];” . Just revise the values here, observing formatting precisely. The next two lines “const GRID\_STEPS=” and const “GOOGLE\_ZOOMS =” must have the same number of values.

To change the format of output fields to show extra decimal places, search for “const EXTRA\_DIGITS”. The default value is 0 which displays the author’s intended outputs. Changing this to (say) 2 will add two extra decimal places to all decimal fields with a risk of loss of some cell formatting. The author uses this for testing and debugging – you should have no need!

### 3. Modifying Version 1.5

Many supplementary pages are hidden for clarity. These are all for intermediate processes only. Also, some rows and columns on the visible pages are also hidden. If you wish to view or indeed tinker with these, please read on. The following assumes that you are using a fully licenced version of Excel 2016. Earlier versions, mobile versions, on-line versions and alternatives may have different or reduced capabilities. (The only ‘temporary tinkering’ the author has himself done is to alter the number format of output fields to show a greater number of decimal places – usually for testing purposes.)

The first move is to make a copy of Astron, rename it and only tinker with that copy.

So, step 1 is {File/SaveAs/AstronCopy.xlsx}.

The whole workbook is protected. To unprotect the workbook: {Review/UnProtect Workbook}. No password is required.

To view a hidden sheet: {Home/Format/Hide & Unhide/Unhide sheet}. Then select the sheet you wish to view. Each sheet must be unhidden individually. (KuTools Excel Add-In includes an ‘unhide all’ facility.)

All sheets are individually protected. To allow any changes, or indeed to see the underlying formulae, you must unprotect that sheet: {Review/Unprotect Sheet}. Again, no password is required.

Some rows and/or columns on the visible sheets are also hidden for clarity – these also contain only intermediate working data. You can identify such a row or column by the missing letters or numbers in the headers. To reveal a hidden row, select the two adjacent cells in the header row (or column), right click and press unhide. (When unhidden, hidden rows/columns have a “H” in the left/top cell – so you know which to hide to return to the normal (hopefully uncluttered) display.)

If you do delve around, you will see how large Astron really is. (24 sheets, 19 of them hidden.) All code is standard Excel coding, deliberately avoiding macros. There is much use of Styles, Defined Names, Cell formatting, Conditional Formatting, Data Validation and Hiding of sheets, rows and columns containing only intermediate calculations. Good luck with it – and please, don’t change the original, work on a renamed copy!

## APPENDIX 7. ACCURACY AND TESTS.

Formatting and terminology are fairly ‘loose’ in this appendix as it is basically a record of the author’s testing.

**Introduction.** General body position calculation accuracy for the present era (and corrections for parallax and semi diameter) has nearly always been found to be within 0.2’ of the positions extracted from a nautical almanac. Similarly, sight reduction accuracy has nearly always been found to be within 0.2nm of the results when using sight reduction tables with the same inputs. (Accuracies for Polaris, low altitude sights, sunrise, sunset and am/pm observation windows are discussed in the preceding sections.) Details of some tests where Astron has been validated against other software and tabular methods are given below. This includes (7.5) a sample of calculated altitudes and azimuths of above horizon bodies at a quoted instant and location, compared with the US Naval Observatory data for the same instant and location. These are usually identical and the author has yet to find a disagreement greater than 0.1’. Indeed, the fact that more than 90% are identical infers, bearing in mind that both data sources are rounded to 0.1’, that both sources usually agree to within 0.02’. In general, observation inaccuracies (and meteorological anomaly effects for low altitude sights) are far greater than Astron’s calculation inaccuracies.

Many of the following are a record of accuracy checks carried out by the author during development of versions up to 1.15. Version 2.00 has been methodically rechecked using the same examples, with most of the results being identical and none showing more than 0.1’ difference. (Except lunars –see 7.6)

Several items refer to the American Practical Navigator by Nathaniel Bowditch (and successors). These refer to the examples in the 2002 edition. Astron V2.00 has also been checked against the (different) examples in the 2017 edition with similar results.

**7.1. Test Astron’s Almanac calculations against other references.**

X-Check GHA and Dec values for 1994.06.16. UT 08.15.23

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Astron Version 1.07** | | **Nathaniel Bowditch**  **American Practical Navigator** | |  | |
| Sun | 303° 42.1' | N23° 20.6' | 303 42.1 | N 23 20.5 |  |  |
|  |  |  | **Henning Umland** | |  | |
|  |  |  | **www.celnav.de** | | **StarPilot PC** | |
| Sun | 303° 42.1' | N23° 20.6' | 303° 42.1' | N23° 20.6' | 303° 42.1' | N23° 20.6' |
| Moon | 220° 27.7' | N00° 07.6' | 220° 27.7' | N00° 07.6' | 220° 27.6' | N00° 07.5' |
| Mercury | 289° 42.3' | N21° 15.7' | ~~~~~~~ | ~~~~~~ | 289° 42.6' | N21° 15.8' |
| Venus | 264° 18.5' | N21° 48.7' | 264° 18.5' | N21° 48.7' | 264° 18.3' | N21° 48.7' |
| Mars | 343° 10.7' | N16° 26.1' | 343° 10.7' | N16° 26.1' | 343° 10.3' | N16° 26.1' |
| Jupiter | 174° 56.1' | S12° 02.8' | 174° 56.1' | S12° 02.8' | 174° 55.8' | S12° 02.8' |
| Saturn | 043° 48.5' | S08° 31.8' | 043° 48.5' | S08° 31.85' | 043° 48.1' | S08° 31.8' |
| Acamar | 343° 42.7' | S40° 19.5' | 343° 42.6' | S40° 19.5' | 343° 42.5' | S40° 19.5' |
| Sirius | 286° 59.8' | S16° 42.6' | 286° 59.8' | S16° 42.6' | 286° 59.7' | S16° 42.6' |
| Polaris | 351° 52.6' | N89° 14.1' | 351° 52.6' | N89 14.1 | 351° 52.4' | N89° 14.1' |
| Aries | 028° 13.2' | ~~~~~~~~ | 028° 13.2' | ~~~~~~~~ | 028° 13.1' | ~~~~~~~ |

**7.2. Test Astron’s almanac and sight reduction.**

Compare with Bowditch P303 for a low altitude hot temp low pressure example.

X-Check values for 1994.06.16. UT 08.15.23 Lat 30N Long 44 42.1W

Sun Upper Limb.

Hs 03 20.2, IE 0 , HoE 5.5, T 31C, hPa 982.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Astron V1.01** | **Bowditch** | **Umland** | **StarPilot** |
| GHA | 303° 42.1’ | 303° 42.1’ | 303° 42.1’ | 303° 42.1' |
| Dec | N23° 20.6’ | N23° 20.5’ | N23° 20.55’ | N23° 20.6' |
| Hc | 02° 39.6’ | 02° 39.6’ | 02° 39.5’ |  |
| Zn | 064.5° | 064. 7° | 064.45° | 064.5° |
| Ho | 02° 48.2’ | 02° 48.1’ | 02° 48.2’ |  |
| Int | 8.6T | 8.5T | 8.6T | 8.7T |

**7.3. Check of Greenwich Apparent Sidereal Time calculations.**

Astronomical algorithms by Jan Meeus P84 line 10

Example in http://www2.arnes.si/~gljsentvid10/sidereal.htm above, about 4/5 way through.

1994.06.16. UT 18.00.00

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Meeus** | **Astron** | **Umland** | **ICE (The Gospel)** |
|  | **Example** | **V1.01** |  |  |
| GAST degrees | 174.774570 | 174.774573 | 174.774583 | 174.774573 |
| Difference from ICE (Deg) | -0.000002 | 0.000000 | 0.000011 | 0.000000 |
| ditto (mins of arc) | -0.00012 | 0 | 0.00066 | 0 |

**7.4. Compare against tabular methods for Moon, Sun, a planet and a star.**

2016 Almanac from <https://www.thenauticalalmanac.com>

Sight Reduction Tables from <https://www.celestaire.com/pubs/category/2-pub-229.html>

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Body | Limb | Date | GMT | Hs | IC | Ass Lat | Ass Long | °C | hPa | HoE(m) |
| **Moon** | L | 2016:11:12 | 19:53:56 | 22 27.7 | 0.7 | N20° 00.0’ | W033° 30.6’ | 20 | 1034 | 6 |
| **Astron 1.07** | Azimuth | Intercept | **Tabular** | Azimuth | Intercept |  |  |  |  |  |
|  | 091.2° | 40.7T |  | 091.2° | 40.6T |  |  |  |  |  |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Body | Limb | Date | GMT | Hs | IC | Ass Lat | Ass Long | °C | hPa | HoE(m) |
| **Sun** | U | 2016:11:12 | 20:17:19 | 40 54.2 | 0.6 | S30° 00.0’ | E179° 43.9’ | 20 | 1010 | 2.4 |
| **Astron 1.07** | Azimuth | Intercept | **Tabular** | Azimuth | Intercept |  |  |  |  |  |
|  | 088.0° | 49.6A |  | 088.1° | 49.8A |  |  |  |  |  |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Body | Limb | Date | GMT | Hs | IC | Ass Lat | Ass Long | °C | hPa | HoE(m) |
| **Venus** | C | 2016:11:12 | 19:43:19 | 24 33.7 | 0.6 | N20° 00.0’ | W028° 22.6’ | 20 | 980 | 2.4 |
| **Astron 1.07** | Azimuth | Intercept | **Tabular** | Azimuth | Intercept |  |  |  |  |  |
|  | 228.2° | 23.0T |  | 228.2° | 23.2T |  |  |  |  |  |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Body | Limb | Date | GMT | Hs | IC | Ass Lat | Ass Long | °C | hPa | HoE(m) |
| **Acrux** | C | 2016:11:12 | 16:43:58 | 2 02.2 | 0.3 | N15° 00.0’ | W170° 21.0’ | 10 | 1010 | 2.4 |
| **Astron 1.07** | Azimuth | Intercept | **Tabular** | Azimuth | Intercept |  |  |  |  |  |
|  | 158.6° | 15.2T |  | 158.5° | 15.2T |  |  |  |  |  |

**7.5. General cross check for any place and time against US Naval Observatory data.**

Website <http://aa.usno.navy.mil/data/docs/celnavtable.php> displays computed altitudes and azimuths for all listed above horizon bodies for an entered latitude, longitude, date and time. A check using GMT/UT 2016 Jan 1 00:00:00 ALat S29° 00.0’ ALong E168° 00.0’ shows Astron (V1.10) giving identical results to the USNO data for all listed bodies and, as stated in the introduction, for the present era (and up to the USNO limit of 31 Dec 2035) we have yet to find a difference of more than 0.1’. The first 8 are reproduced below.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **~~~~~Azimuth~~~~~** | | | **~~Observed Altitude~~** | | |
| **Body** | **Astron** | **USNO** | **Diff.** | **Astron** | **USNO** | **Diff.** |
| Sun | 65.5 | 65.5 | 0 | 077° 05.5' | 077 05.5 | 0 |
| Venus | 286.1 | 286.1 | 0 | 062° 41.9' | 062 41.9 | 0 |
| Mars | 275.7 | 275.7 | 0 | 029° 53.8' | 029 53.8 | 0 |
| Saturn | 293.1 | 293.1 | 0 | 071° 23.4' | 071 23.4 | 0 |
| ACHERNAR | 150.3 | 150.3 | 0 | 011° 17.6' | 011 17.6 | 0 |
| ACRUX | 210.8 | 210.8 | 0 | 029° 32.1' | 029 32.1 | 0 |
| Al Na'ir | 128.8 | 128.8 | 0 | 037° 52.7' | 037 52.7 | 0 |
| Alphecca | 326.2 | 326.2 | 0 | 025° 22.3' | 025 22.3 | 0 |

(V1.15 only) If you wish to do your own testing you can use the more detailed values of Azimuth and Altitude that are repeated , if you scroll right on the Planner sheet. Using GMT mode, insert same date, time and assumed position into Astron and the above site and compare results. Only above horizon bodies are shown and these may be in daylight and not visible. USNO bodies are in alphabetical order - Astron in Zn order. So it is easier to compare from Astron to USNO rather than the other way around.

Astron’s altitude corrections can also be cross checked against the USNO altitude corrections and these similarly always seem to agree within 0.1’. If you wish to do this, set IC to 0, HoE to 0, Temp to 10°C, Press to 1010 hPa and limb to ‘L’ (Sun/Moon) else ‘C’. Then adjust Hs to make Ho the same value as Hc. Because of rounding of individual corrections, just compare Astron’s total correction (Ho-Hs) with the USNO’s ‘sum’ field.

**7.6 Lunars cross checks. (Using V2.0)**

7.6.1. Check against Frank Reed Lunars Calculator V4. (http://reednavigation.com/lunars/lunars\_v4.html)

(The Lunars Calculator V4 takes inputs of position, time and OLD and calculates the error of the sight. Astron corrects the assumed longitude and time for a given lunar distance and actual latitude. Some reverse logic is necessary to compare results.)

Data. 2017 Jan 5th. 08:19:42 UTC. Actual Position S41° 06.5 E175° 05.2. HoE 0m. IC = 0. Std T&P. Venus & Moon Lower limbs. Then ‘adjust’ Lunars Calculator OLD input to give a zero error. Such OLD is 36° 30.0' (Near). (NB HoE 0m used to allow additional cross check with USNO.)

First, check that the initial almanac data and altitude calculations all agree.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | GHA Venus | Dec Venus | GHA Moon | Dec Moon | Venus App Alt(Ho) | Moon App Alt(Ho) |
| Lunars Calculator V4 | 255° 28.9' | S11° 45.7' | 220° 32.8' | N00° 54.9' | 22° 17.9 (L) | 37° 00.0 (L) |
| Astron V1.13 | 255° 28.9' | S11° 45.7' | 220° 32.8' | N00° 54.9' | 22° 17.9 (L) | 37° 00.0 (L) |
| USNO | 255° 29.0' | S11° 45.7' | 220° 32.9' | N00° 54.9' | 22° 17.9 (C) | 37° 00.0 (L) |

Note: Input Sextant Altitude (Hs) for Venus is **22° 19.9,** which gives Ho of 22° 17.9 after altitude corrections.

The method used by Astron uses latitude obtained from a separate (usually meridian passage) observation adjusted for ship’s run, so for this test we will stick with S41° 06.5’. We don’t know GMT or longitude, so ‘guess’ Ass Long E179° 00.0’ and Ass Time 2017 Jan 5th 08:00:00. (Example chosen to also test iteration logic across 180E/W). Enter Observed LD of 36° 30.0' (Near/Near) in Astron Lunars page and use Astron to find if Longitude and Time agree with the Lunar Calculator’s initial position and time. Note, the method requires only one (simultaneous) altitude sight, so Moon altitude measurement unnecessary.

Enter: GMT Mode. Date: 2017 Jan 5th. Ass Time: 08:00:00. Watch Correction: 0. Time Zone: +12. Daylight Saving: 0.

Body Venus. Latitude: S41° 06.5’ Ass Long: E179° 00.0’

Sextant Altitude 22° 19.9’ HoE 0m. IC = 0. Std T&P. Limb=Centre

On Lunars Page …Enter LD 36° 30.0' (Near/Near).

Astron Results: **GMT 08:19:39** Longitude: **E175° 06.0’**

(V1.15 gives GMT 08:19:40, Longitude 175 05.6E.)

(A good test, that one, as the stage 2 synchronised longitude to give an intercept of 0.0 crosses the 180 meridian as 179 59.0W!)

Gross checks.

1. Change assumed date to Jan 3rd, 4th, 6th or 7th, with all other inputs unchanged. Astron results identical, with caution given. (Not always such a wide range of validity).

2. Date back to 5th. Change Ass Long to 160E, 165E, 170E, 179 59.9E, 179 59.9W, 175W, 170W, 168W with all other inputs unchanged. Astron results identical, with caution(s) given.

Using Lunars Calculator ‘backwards’ at lat S41° 06.5’ with a zero longitude error and LD of 36° 30.0’.

1. At the Astron time of 08:19:39 , longitude is E175° 08.9'. **2.9’E of Astron.**

2. At the Astron longitude of E175° 06.0', time is 08:19:42. **3 secs later than Astron.**

Note 1: **3 secs time and 2.7 minutes longitude** difference is not serious but will be pursued in due course. Changing the ‘Measured Arc’ by exactly 0.1’ in Astron (in this example) results in a change of time of 11 seconds and change of longitude of 2.8 minutes.

Note 2: 25 random time/body checks of Geocentric Lunar Distance made against <http://reednavigation.com/lunars/lunars_pre.asp> . 24 agreed exactly, 1 had 0.1’ difference. (Only 9 listed stars checked.)

7.6.2. Check against example in <https://www.starpath.com/resources2/brunner-lunars.pdf>

This example quotes a measured OLD of 51° 43.6’ N at GMT 23:24:00 on May 7th 2000 from Lat 47 40.5′ N, Lon 122° 23.9′ W discussed in Section 3. The Hs of the Sun is not given, so we use that actual position and time to find the Sun’s lower limb Hs with IC=0, Hs = 6 feet, T=10C, P = 1010hPa. This is 39° 15.4’.

However, let us imagine that we guessed the GMT as 23:38:00 (14 mins later) and our longitude as W126° 00.0′. (3° 36.1’ further West.)

So**, inputs** for this check are

**2000 May 7 23:38:00 N47 40.5 W126 00.0.** Sun **Lower** limb. **39° 15.4’**. (lunars page), OLD **N51° 43.6’ Near Near.**

Astron 1.15 gives a GMT of 23:24:04, **4 secs fast**, and longitude of W122° 24.8', **0.9’ farther west.**

Astron 2.00 gives a GMT of 23:24:03, **3 secs fast**, and longitude of **W122° 24.7’, 0.8’ farther West**.

As a further check, the Lunars Calculator (7.6.1) confirms that, at the stated sight time, the initial location and OLD to be correct within 0.3’ longitude and 0.1’ arc.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | ACT LONG  (of observer) | DEDUCED LONG | DIFFERENCE | ACT GMT  (of sight) | DEDUCED  GMT | DIFFERENCE |
| Brunner | W122° 23.9’ | 122° 28.9’ | 5.0’W | 23:24:00 | 23:24:08 | 8s fast |
| Astron 1.15 | W122° 23.9’ | 122° 24.8’ | 0.9’W | 23:24:00 | 23:24:04 | 4s fast |
| Astron 2.00 | W122° 23.9’ | 122° 24.7’ | 0.8’W | 23:24:00 | 23:24:03 | 3s fast |

Notes. Brunner Page 10 states Moon: HC = 63° 27 3′. Astron 63° 27.06’ USNO 63° 27.0’. Also states Sun parallax neglegible. Astron Sun HP 0.15’, parallax 0.11’.

7.6.3 Further checks with V2.00 with large input ‘errors’.

Using same sight as above.

(Datum now Actual Position **N47 40.5 W122° 23.9’**. **Actual GMT 23:24:00**).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Intentionally incorrect input | Calc. GMT | Diff from Actual GMT | Calc Long | Diff from Actual Long | Cautions given |
| Correct Long,  Time -1 hour. | 23:24:05 | +5s. | 122 25.2 | 1.3’W | Large difference time caution |
| Correct Long,  Time -1.5 hour. | 23:24:05 | +5s. | 122 25.2 | 1.3’W | Large difference time caution |
| Correct Long,  Time -2.0 hour. | Not calculated warning. | | | | |
| Correct Time,  Long + 15° | 23:24:05 | +5s. | 122 25.2 | 1.3’W | None |
| Correct Time,  Long + 23° | 23:24:05 | +5s. | 122 25.2 | 1.3’W | Large difference long caution |
| Correct Time,  Long + 30° | Not calculated warning. | | | | |
| GMT -1 Long 15E | 23:24:05 | +5s. | 122 25.2 | 1.3’W | Large difference time and long caution |
| GMT -1 Long 15W | Not calculated warning | | | | |
| GMT +1 Long 15W | 23:24:05 | +5s. | 122 25.3 | 1.4’W | Large difference time and long caution |
| GMT +1 Long 15E | Not calculated warning | | | | |

**7.7. Test of times of Star Rise, Meridian Passage and Set.**

These times are normally only listed in almanacs to the nearest minute. Astron has a believed (calculation) accuracy of 5 seconds, except for near circumpolar situations, so, just for interest in comparing observed times with theoretical ones, times are displayed to 1 second. We cannot find a separate source to make accurate comparisons. The USNO Celestial Navigation Data omits bodies with an Ho below +1°, so we have compared times when the star is just above 1°.

A: Ship’s Time Mode. 2016 Mar 03 Sirius 30N 179 59.9E TZ+12. DS +1 HoE 3m T 10C P 1010hPa.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SIRIUS after RISE15:45:33 (02:45:33 UTC) (Using HoE 0m) | | | | |
|  | Hc | Hs | Corr | Ho |
| USNO | 1 00.1 | 1 21.8 | 21.7 | 1 00.1 |
| Astron | 1 00.1 | 1 21.9 | 21.8 | 1 00.1 |

|  |  |  |
| --- | --- | --- |
| **SIRIUS on 03 Mar Ship's Time** | | |
| **Rise** | **Mer Passage** | **Set** |
| **15:37:33** | **20:59:46** | **02:25:55** |
|  |  |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SIRIUS before set. 02 17:33 (13:17:33 UTC D-1). (Using HoE 0m) | | | | |
|  | Hc | Hs | Corr | Ho |
| USNO | 1 04.4 | 1 25.7 | 21.3 | 1 04.4 |
| Astron | 1 04.4 | 1 25.7 | 21.3 | 1 04.4 |

|  |  |  |  |
| --- | --- | --- | --- |
| SIRIUS 20:59:46 (07:59:46 UTC) Mer Passage (Using HoE 0m) | | | |
|  | GHA | Hc | Zn |
| USNO | 180 00.2 | 43 15.3 | 180.0 |
| Astron | 180 00.2 | 43 15.3 | 180.0 |

* 1 sec earlier both give GHA as 179 59.8

B: Try other side of 180° meridian. Change to 179 59.9**W -12 DS +1** (same ship’s time date of 3 March.) HoE 3m again.

|  |  |  |
| --- | --- | --- |
| SIRIUS on 03 Mar Ship's Time | | |
| Rise | Mer Passage | Set |
| 15:33:36 | 20:55:49 | 02:21:58 |

These are all 3m 57s earlier, correctly so because this observer is seeing the events of 24 hours later.

C: Now try for an imaginary place at 179 59.9W, but with time zone of +14 (yes, Tivalu uses plus 14) (DS 0)

|  |  |  |
| --- | --- | --- |
| SIRIUS on 03 Mar Ship's Time | | |
| Rise | Mer Passage | Set |
| 16:37:32 | 21:59:45 | 03:25:54 |

These are same as A above, but one hour later as one would expect. (GMT + 14 i/o GMT + 13.)

(The one second earlier times are because C. is 0.2’ longitude further East than A.)

D. Now 02 Feb to test display of a double same day event.

|  |  |  |
| --- | --- | --- |
| SIRIUS on 02 Feb Ship's Time | | |
| Rise | Mer Passage | Set |
| 18:35:29 | 00:01:38 | 05:23:52 |
|  | 23:57:43 |  |

**7.8. Tests of calculation of differences between times of culmination and transit.**

(Section 13.2.) To do this test, Astron display was modified to show angles to 7 decimal places of a minute. Such absolute accuracy is nonsense, but the relative changes with time are thought to be realistic to find the time of culmination.

7.8.1 Test 1 Sun example near equinox. (Stationary Observer)

2012 Mar 20. N50 00.0 W015 00.0. Chosen for Sun near max change in declination. (1 arc minute per hour)

Preliminary: Find culmination.

|  |  |  |  |
| --- | --- | --- | --- |
| **UTC** | Hc. | Hs | (Say) Culmination 13:07:37.5 |
| 13:07:36 | 40 07.7941468 |  |
| 13:07:37 | 40 07.7941572 | 40 01.4 |
| 13:07:38 | 40 07.7941523 | (IC=-3.8, HoE = 24ft. Lower limb.) |

Preliminary: Find transit

|  |  |  |
| --- | --- | --- |
| UT | Zn | (Say) Transit 13:07:19.2 |
| 13:07:19 | 179.9987486 |
| 13:07:20 | 180.0041992 |

Theoretical Correction 13:07:19.2 - 13:07:37.5 = -18.3 secs.

Enter Astron. 2012 Mar 20. Culmination time 13:07:37. Sun N50 00.0 W015 00.0. Hs 40 01.4 (IC=-3.8, HoE = 24ft. Lower limb.)

V1.15: Astron Dec at 14:07:37 is N00 08.8 and at 13:07:37 is N00 07.8, so Dec Rate is +1.0.

V2.00 Dec Rate = 0.99 automatic.

Enter Astron Mer Pass correction table with SOG 0 knots (V1.15: and Dec Rate)

Astron formula correction -18secs.

([http://www.geoastro.de/TransitCulm/index.html](http://www.geoastro.de/TransitCulm/index.html%20) quotes 17.9 secs with Formula 6.)

7.8.2 Test 2. Moon example near major lunar standstill. Stationary observer.

2024 Oct 15 N50 00.0 E000 00.0. Chosen for Moon near max change in declination. (18.2 arc minutes per hour)

Preliminary: Find culmination.

|  |  |  |  |
| --- | --- | --- | --- |
| UT | Hc. | Hs | Culmination 22:31:14 |
| 22:31:13 | 40 00.951235 |  |
| 22:31:14 | 40 00.951243 | 39 06.4 |
| 22:31:15 | 40 00.951237 |  |

Preliminary: Find transit

|  |  |  |
| --- | --- | --- |
| UT | Zn | Transit 22:25:19 |
| 22:25:19 | 179.9997071 |
| 22:25:20 | 180.0049603 |

Theoretical Correction 22:31:14 - 22:25:19 = -5m 55s

(5m 55s is also value computed by [MICA](http://www.geoastro.de/TransitCulm/index.html#mica), Multiyear Interactive Computer Almanac by USNO. Above transit and culmination times also agree with MICA to within 0.4 secs.)

Enter Astron: 2024 Oct 15. 22:31:14 Moon N50 00.0 W000 00.0. Hs 39 06.4 IC=-3.8, HoE = 24ft. Lower limb.

(V1.15: Astron Dec at 23:31:14 is N00 20.0 and at 22:31:14 is N00 01.8, so Dec Rate is +18.2.)

V2.00 Dec Rate 18.19 auto

Enter Astron correction table with SOG 0 knots (V1.15: and Dec Rate + 18.2)

Astron formula correction -5m 55s.

7.8.3 Moon example. Setup as 7.8.2. Moving observer at 150°/10kts (Lat and Long components)

Worksheet for vessel at 50N 0W at ACTUAL transit time of 22:25:19. (IC=-3.8, HoE = 24ft. Lower limb.)

2024 Oct 15th. (Moon Dec Rate +18.2’/hour)

Find culmination. (Transit as 23.8.2:- 22:25:19)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| UT | Lat | Long | Hc | Hs | Uncorrected  Lat | Uncorrected  Long |
| 22:25:19 | 50.0 | 0.0 | 40.00089801 |  |  |  |
|  |  |  |  |  |  |  |
| 22:33:52 | 49 58.7659138 | E0 1.108453227 | 40 01.972824 |  |  |  |
| 22:33:53 | 49 58.76350817 | E0 1.110613955 | 40 01.972835 | 39 07.4 | 50.0109781  N50 00.7 | -2.068179379  W002 04.1 |
| 22:33:54 | 49 58.76110255 | E0 1.112774682 | 40 01.972833 | 39 07.5 |  |  |

Culmination 22:33:53.5

Theoretical Correction. -8m 34.5s (=22:25:19)

Enter Astron initial position Moon 2024 Oct 15 22:33:54 N50 00.7 W002 04.1 Hs 39 07.5 IC=-3.8, HoE = 24ft. Lower limb.

Enter Mer Pass correction table with COG 150 and SOG 10 knots. (V1.15: and Dec Rate + 18.2)

Astron formula correction -8m 34s.

Astron Corrected Time 22:25:20

Astron Corrected Lat N49 59.9

Astron Corrected Long W000 00.1

7.8.4 Southern Hemisphere check. Moon example. As 7.8.3 except now at S50 00.0.

In this Southern Hemisphere, but otherwise similar setup, culmination is now 8m 33s before transit.

7.8.5 Star example.

Dec rate is zero so formula always gives correction of 0 for stationary observer.

7.8.6 Planet example.

2012 May 25 N50 00.0 E000 00.0. Mars.

Find culmination.

|  |  |  |  |
| --- | --- | --- | --- |
| UT | Hc. | Hs | Culmination 18:41:43.5 |
| 18:41:42 | 48 06.314497 |  |
| 18:41:43 | 48 06.314514 |  |
| 18:41:44 | 48 06.314514! | 48 15.6 |
| 18:41:45 | 48 06.314496 |  |

Find transit

|  |  |  |
| --- | --- | --- |
| UT | Zn | Transit 18:41:50 |
| 18:41:50 | 179.9991122 |
| 18:41:51 | 180.0053010 |

Culmination 18:41:43.5

Theoretical Correction 18:41:50 - 18:41:43.5 = +0m 06.5s

(0m 07s is also value computed by [MICA](http://www.geoastro.de/TransitCulm/index.html#mica), Multiyear Interactive Computer Almanac by USNO. Above transit and culmination times also agree within 0.5 secs.)

Enter Astron. 2012 May 25 18:41:44 Sun N50 00.0 W000 00.0. Hs 48 15.6 IC=-3.8, HoE = 24ft. Lower limb.

Astron initial position S50 00.0 E001 01.5

(V1.15: Astron Dec at 18:41:44 is N08 06.3 and at 19:41:44 is N08 05.9 so Dec Rate is -0.4.)

V2.00 Auto -0.42.

Enter Mer Pass table with SOG 0 knots (V1.15: and Dec Rate -0.4.)

Astron formula correction +0m 6s.

Astron Corrected Time 18:41:50

Astron Corrected Lat S50 00.0

Astron Corrected Long W000 00.1

7.8.7 Planet example with moving vessel.

As above, but COG 120, SOG 0.8kts.

Correction now 0. As expected as Southerly component is 0.4 kts, equalling Southerly Dec Rate.

NOW LOWER Meridian Passage TESTING

7.8.8 Kochab. Observer 000/6

2017 June 12 N40 00.0 W000 00.0. IC 0, HoE 2.4m T 10 P 1010 Observer 000 at 06.0 knots.

Transit at that position. 09:27:07 180.0

Find lower culmination. 09:20:31

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| UT | Lat | Long | Hc. | Hs |  |
| 092029 | 39 59.336667 | W000 00.0 | 24.08432484 |  |
| 092030 | 39 59.338333 | W000 00.0 | 24.08432475 |  |
| 092031 | 39 59.34 | W000 00.0 | 24.08432474  (24° 05.1') | 24° 10.0' |
| 092032 | 39 59.341667 | W000 00.0 | 24.08432481 |  |
|  |  |  |  |  |
| 092707 | 40 00.0 | W000 00.0 | 24.08982959 |  |

Thus, theoretical correction +6m 36s

Enter Astron. 2017 June 12 09:20:31 Kochab Ass Pos (say) N41 23.4 W002 34.5.

Hs 24 10.0 IC 0, HoE 2.4m T 10 P 1010 COG 000 SOG 6.0 Dec Rate 0

Results:

Correction +6m 36s

Astron uncorrected position. N39 59.7 E001 39.3

Corrected Time & Position. 09:27:07 N40 00.0 W000 00.1

7.8.9 Miaplacidus. Still 000/ 6 knots.

S40 W30 2017/6/12 at 05:50:22 is LM Transit.

Lower culmination at 39 59.46S W030 00.0 at 05:55:46 Hs 19 52.9. (Ho 19 47,4)

Time corr -5m24s.

Corr Time 05:50:22. Lat S40 00.0 W029 60.0. (V2.00 – W030 00.0)

7.8.10 2017/06/12 RIGIL KENT

Observer at S35 00.0 W000 00.0 at time of transit *09:17:16.*

*Observer travelling 180° at 60 knots.*

|  |  |  |  |
| --- | --- | --- | --- |
| 8:39:29 | S34 22.2166 | 5.592949917 |  |
| 8:39:30 | S34 22.2333 | 5.592948993 | 5° 35.6’ |
| 8:39:31 | S34 22.25 | 5.592949355 |  |

Lower culmination 8:39:30. S34 22.2 W000 00.0 Hc 5° 35.6’ (Hs 5 47.2 IC 0 HoE2.4m)

Theoretical time correction +37m 46s

V1.15 +37m 49s 09:17:19 S 35 00.1 W000 00.9

V2.00 (identical result)

Inaccuracy of 3 sec and 0.9’ longitude … suspect formula validity for speed of 60 knots.

7.8.11 2017/06/12 RIGIL KENT

Additional check with V2.00 only. Observer at S35 00.0 W000 00.0 at time of transit *09:17:16.*

*Observer travelling in reverse direction to 7.8.10. 000° at 60 knots.*

*Lower culmination would at S*34 22.2 *W000 00.0. (Same as before, because travelling North after transit time: previous case travelling South before transit.)*

*Time correction -37m 46s. Culmination time would be + 37m 46s = 9 55 02.*

*Altitude would be the same (symmetrical about transit)* Hc 5° 35.6’ (Hs 5 47.2 IC 0 HoE2.4m)

V2.00 Transit time 09.17.13. (3 secs reverse sense)

Lat/Long at time of transit. S35 00.1 E000 00.9. (0.9’ longitude in reverse sense.)

7.9.1. Tests of arc distance between two bodies.

Opportunist checks made with observer’s sextant. No discrepancies observed.

## APPENDIX 8. Astron V2.00 Beta Testing

|  |  |  |  |
| --- | --- | --- | --- |
| **Fault Version** | **Fault / Change / Addition** | **Rectification** | **Fix Version** |
| 17/9/18 | Minor plotting errors in both Astron and Google Sight Plotters with chart widths <= 3nm. (Error less than 0.1 nm.) | Reason unknown and under investigation. (Should be no greater than line thickness!) | TBA |
| 20/6/18 | MS Internet Explorer, MS Edge and Safari fail with locally stored web page. OK with online web page. Due to non support of local.Storage when offline. | Unlikely to change. Accept that these browsers only suitable for online use. Possible future upgrade to detect browser non-conformality with local.Storage when offline and, if so, use cookies instead. | None |
|  |  |  |  |
|  |  |  |  |
| 6/9/18 | Ambiguity of lower limb moon sight when within a SD of zenith. | Index correction can also cause similar ambiguity. Input restriction added of Hs between 89 and 91 degs unless in artificial horizon mode. | 8/9/18 |
| 29/8/18 | Sky Chart added to PLANNER page. | Originally planned for V2.02! |  |
| 14/8/18 | Sight Log and Plotter added. | Originally planned for V2.01! |  |
| 9/8/18 | Array sizes declared as constants. Should be calculated at initialisation. | Implemented. | 9/8/18 |
| 22/7/18 | Gienah is not Eta Cygni! | Sorry! Renamed γ Corvi. SHA/Dec was ok.  V1.15 changed too! | 23/7/18 |
| 9/7/18 | 0.2’ error in applying SD correction for Moon. | Not an error. Caused by augmentation correction. Legend revised to indicate this. | 9/7/18 |
| 7/7/18 | Typo in CSS file {display: width 100%;} | Replaced with {width: 100%;} | 7/7/18 |
| 04/7/18 | StarInfo does not change between centuries. | Was J2000.0 static data. Rewritten as calculated data for input date. | 04/7/18 |
| 02/7/18 | Duplication of Star data in body data array. | Arrays merged. | 02/7/18 |
| 30/6/18 | CSS duplicates defaults and auto inheritances. | CSS file leaned and harmonised. Some browser differences in table and table column width resolved. | 30/6/18 |
| 30/6/18 | Lunars: QI > 100% if amplitude between 30 & 45 degrees. | Missing condition added. | 30/6/18 |
| 30/6/18 | Back sight warning missing. | Cell id name misspelled! | 30/6/18 |
| 23/6/18 | Lunars. Suggestion: When lunar results bad, don’t show button to update Home Page entry fields. | Button made invisible & inoperative in such cases. Subsequent alert deleted as no longer required. | 23/6/18 |
| 23/6/18 | Lunars. False warning message “large diff in longitude” . | Occurs when difference crosses 0 or 180 meridian. Recoded to eliminate. | 23/6/18 |
| 21/6/18 | Internet Explorer fails with function PuttSelect(id, str) on field “us\_ChooseBody”, where str is name of body. EG: “Mars”. OK on select fields with fewer items, such as daylight saving. Other browsers ok. | Maybe too many items (65) or maybe non alphabetical order.  So PuttIndex(“us\_ChooseBody”, “n” ) used for all browsers, where “n” is the appropriate index value for the body. | 23/6/18 |
| 20/6/18. | Internet Explorer rejects Math.log10(). | Global constant added.  const N\_LOG\_TO\_10LOG = 2.302585093;  Bespoke function substituted for all browsers  function Log10(a)  {return Math.log(a)/N\_LOG\_TO\_10LOG;} | 22/6/18 |
| 20/6/18 | Internet Explorer rejects Math.trunc(). | Bespoke function substituted for all browsers.  function Trunc(a)  {return (a<0 ? Math.ceil(a) : Math.floor(a));} | 22/6/18 |