

Manual and Documentation for “Teacup Celestial version 3.2f” Software revision 4

The screenshot displays the 'Sight Planner Star, Moon, Sun, Planet Finder by Teacup Navigation' software interface. It features several overlapping windows:

- Top Window:** 'Sight Planner Star, Moon, Sun, Planet Finder by Teacup Navigation'. Includes 'Date and Time' (Year: 1993, Month: 5, Day: 15, UTC hour: 8, UTC minute: 45), 'Position' (Latitude: 40° 30', Longitude: 162° 30'), and 'Settings' (Max stars to show: 59.5, Delta T: 5).
- Left Window:** A circular star chart showing celestial objects plotted on a grid of azimuth and altitude.
- Center Window:** 'PLOT OF LOPS'. Shows a plot of lines of position (LOPs) with 'Best Fix Latitude N 40° 25.6'', 'Best Fix Longitude E 162° 33.4'', and 'Distance from assumed position 3.26 n.miles'.
- Bottom-Left Window:** 'Sight Data Entry'. Shows 'Number of stored sightings = 6', 'Sight Number 1', and fields for 'Altitude Measured, Hs' (50° / 31.8'), 'Sextant', 'LMB' (UPPER, LOWER, CENTER), and 'Index Error, ArcMinutes'.
- Bottom-Right Window:** 'Perpetual Sun, Moon, Star, Planet Almanac'. Shows 'Date and Time' (Year: 2010, Month: 11, Day: 14, UTC hour: 22, UTC minute: 8, UTC second: 26), a list of celestial objects (Sun, Moon, Venus, Mars, Jupiter, Saturn, Acamar, Achernar), and detailed data for the Moon: 'Object Name: Moon', 'GHA 50° 6.1', 'DEC S 5° 7.6', 'SHA 24° 5.6', 'HP 54.22', 'GHA Aries 26° 0.57', 'SD 14.77', 'Illumination 61.5 %'.



By Teacup Navigation
 Rodger E. Farley

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1st Edition rev 4

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My web site: <http://www.teacupnavigation.net>

TeaCupCELESTIAL version 3.2a by Teacup Navigation
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Please visit my web site where you can download my book 'Celestial Navigation
in a Teacup' at <http://www.teacupnavigation.net>

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I assume no liabilities of any form from any party: Warning, user beware!
This is for educational purposes only.

Equations for the celestial almanac are partly from Jean Meeus's book
'Astronomical Algorithms' 2nd edit. The ephemerides are calculated with an
abridged set of VSOP87 periodic terms.

My thanks to Stan Klein of the USPS Offshore Navigation Committee who
was kind enough to review this manual and Teacup Celestial software.

Introduction

This software can calculate and plot a single best fix for multiple target sightings from of any combination of Sun, Moon, planet, or stars taken with a sextant. It will accept up to 25 sights, though in practice 6 is more likely. The session can then be saved in a data file (that has the extension .NAV) so that it can be reopened in the future to relive it or to modify. The sightings are corrected with running fixes if underway, and the final new fix can be to any reference time you choose.

There is a very accurate built-in perpetual almanac for the Sun, Moon, 58 navigational stars, Venus, Mars, Jupiter, and Saturn using VSOP87 periodic terms and knowledge of DeltaT. One simply selects the object being recorded, and the internal computer almanac will supply the astronomical data.

This is the usual order of doing things:

- 1) Sight Planner from the top menu bar to plan your best objects to shoot
- 2) Shoot altitudes with sextant, record data on paper
- 3) Set up main form with fixed data (course, speed, etc..)
- 4) Transcribe altitudes and times and object details in the Sight Data Form
- 5) After saving the fixes individually, and saving the session with the FILE manager, close the Sight Data Form. Then on the Main Form press the 'Reduce Sight and Plot' button.

Note as to compatibility with older versions before 2.0

Unfortunately, if you had made data files with old versions, they will not carry over to this new version. The data being now simply a selection of the celestial object rather than a nautical almanac facsimile of GHA and DEC inputs, well it would have been too much trouble as the old method did not record the object. Sorry...

Sight Planner

One uses the sight planner to figure out what objects will be up and where. It's up to you determine the best combinations of celestial objects; briefly you will want to take sights of the brightest objects that have a 90° to 120° azimuth spread to cancel out systematic errors. For planning, you don't need a terribly accurate ΔT , so just leave it at 67 sec. If you want to use the 'Now' button to load the present date and time, you need to have the nominal time zone difference from Greenwich (note the separate daylight savings time check box). This assumes your computer knows the correct local time.

The screenshot displays the 'Sight Planner Star, Moon, Sun, Planet Finder' software interface. The main window features a circular star chart with azimuth (0-360 degrees) and elevation (0-90 degrees) markings. A yellow sun is positioned at approximately 270 degrees azimuth and 23 degrees elevation. A green planet is at approximately 210 degrees azimuth and 10 degrees elevation. A red arrow points to the 'Ecliptic plane' at approximately 180 degrees azimuth. A text label indicates 'Arc Distance = 39° 11.7\"/>

TeaCup Navigation PRINT Instructions CLOSE

Show lunar parallax Keep background white for printing
 Switch E for W for inverted viewing

Settings

How many stars? Delta T, the difference between UTC and Ephemeris time, seconds

Time zone, hrs (W +) Daylight savings time now?

Observer's Position

Latitude ° ' Lat N or S N S

Longitude ° ' Lon E or W E W

Remember these settings as my default

Date and Time

Year UTC hour

Month UTC minute

Day UTC second

AZM = 177 deg Celestial Almanac
ELV = -23.5 deg

	Azimuth	Elevation	Other Info
MOON	213.1°	23° 10.5'	Fullness = 27 %
VENUS	227.6°	10° 45.4'	
SATURN	248.9°	4° 38'	

Grab corner to resize -->

Sunrise 11:11:46 UT Sunset 22:36:35 UT LAN 16:54:28 UT
Moonrise 16:03:49 UT Moonset 02:10:25 UT N Mer.Pass. 21:07:14 UT
NAUTICAL TWILIGHT: HORIZON, STARS VIEWABLE

Rise and set times based with refraction and parallax effects to upper limb
P after UT = previous UT day, N after UT = next UT day

As you can see, one can also get the arc distance between celestial objects. This is done by clicking the left mouse button over the 1st object, then (while still holding the button down) drag the cursor over to the 2nd object and release the mouse button. For doing lunars, while the 'show parallax effects' box is unchecked, this will give the lunar distance cleared from center to center. To see what the arc distance would be with actual parallax (as you would see it for real), check the box. Also shown is a note pointing to the ecliptic plane (earth's

orbital plane) where the sun, moon and planets will be near. For lunars, picking a star or planet hovering near this line will give the greatest accuracy.

The steps 1-5 are listed on a help button on the planner.

Step 1) Modify the settings for your time zone, and the max number of stars to show

Step 2) Enter the date and UT time, or simply press the 'Now' button

Step 3) Enter the latitude and longitude, remembering to select the radio buttons for N, or S, and E, or W

Step 4) Press the Show Objects, or the Now-refresh button

Step 5) View the objects. The moon goes from very dark to light cheese color to indicate fullness (there is also the lower right image to show phase). Stars have sizes according to their brightness magnitude. You can move the mouse cursor over the map to see the azimuth and elevation readout. When the cursor passes over an object of interest, its name appears in a side bar to the right. The parallax or non-parallax position of the moon can be observed according to the upper right check box. Rise/set and LAN for the Sun and meridian passage for the Moon are on the bottom bar. Sometimes after the UT there is a 'P', or an 'N' to indicate this event happened on the previous day (P), or will happen at the next UT day (N).

This planner can be used for sight reduction in its own right if you should be interested. Since you can put in UT time to the second, it will calculate and display the H_c (as Elevation Elev) for the assumed position you list under present latitude and longitude. Making your own index, dip, refraction, and semi diameter corrections to your sextant reading, you can determine the offset distance from the assumed position. By checking the 'Show Parallax Effects' checkbox, you won't have to calculate the parallax correction for the moon as it will already be reflected in the Elevation calculation as $H_c - PA$.

Your normal default settings for observer's position, time zone, delta T, etc... can now be set with the "Remember these settings as my default" button. It makes a file called TeacupNav.nv1 which must be in the same folder as the executable file.

Inverse viewing is achieved by checking the Switch E for W box. Stretch the whole form larger by left-click grabbing the lower right corner, then refresh.

Main Form

Set up the main form with last fix, new fix time, eye height, true course and speed over ground, air temperature and barometer (you can leave it at the standard settings if you want), and any chronometer corrections. The chronometer correction compensates for watch error (this is under the General Settings form). The UTC in the sightings has this correction added to them to correct to actual UTC. It can be + or -. There is a comment box where you can type any descriptor you want, but don't use any commas! They will not be remembered.

The screenshot shows the 'Main Form' of the TeacupCelestial software. At the top, it displays the current data file 'Prob2-3.NAV' and a menu bar with options like FILE, HELP, INFO, Sight Data Form, Celestial Data, Sight Planner, Lunars, Calculators, and EXIT. A small image of a teacup with a sailing ship on it is on the left. The main area contains several input fields and buttons. On the right, there are 'Settings for this leg' for True Course over ground (070), Speed over ground (6.8 kts), and Eye height (9). Below these are buttons for 'General Settings' and 'Heading/Course Calculator'. The form is divided into steps: Step 1 (fill out Lat, Lon, and times), Step 2 (View Sight Data Form), and Step 3 (Reduce Sightings). A 'Clear All Data' button is highlighted with a red box. The bottom of the form has buttons for 'View Sight Data Form', 'Reduce Sightings and Plot LOP's', 'Show LOP', 'Show COP', and 'Detailed Output'.

Current Data file: Prob2-3.NAV

FILE HELP INFO Sight Data Form Celestial Data Sight Planner Lunars Calculators EXIT

Celestial Navigation Sight-Reduction and Intercept Plotter by TeaCup Navigation

Almanac and Sight Planning also! Version 3.2a

Best viewed in 1680 x 1050 resolution

Best Fix Latitude S40° 9.9'

Best Fix Longitude E179° 52.7'

Settings for this leg

070 True Course over ground 0-360 deg from true north

6.8 Speed over ground, kts

9 Eye height m ft

General Settings Heading/Course Calculator

Step 1 fill out Lat, Lon, and times

Problem 2-3 from 100 problems in celestial navigation

Last Fix, Latitude 40° 30' Lat N or S North South

Last Fix, Longitude 178° 41' Lon E or W East West

Last Fix, UT 8 Hour 10 Minutes 18 Day 12 Month 1993 Year

Desired New Fix time, UT 15 Hour 52 Minutes 18 Day 12 Month 1993 Year

The navigator selects the new fix time for which the running fix corrected sight reductions shall apply for this leg

Clear All Data

Preload other forms with data

Step 2 View Sight Data Form

Step 3 Reduce Sightings and Plot LOP's

Show LOP Show COP Max plotting scale, n.mi. 25 Detailed Output

TeacupCelestial

There is a calculator to convert your in-the-water speed and heading measurements into true course and true speed by compensating for current and leeway. Instructions for what to do next are on the main form. After the Sight Data Form has been filled out, close it to come back to the Main Form. Press 'Reduce Sightings and Plot LOP's'. The dead reckoning position will show up in a small form, where you can change it if you don't like where the plane sailing calculation places it. For example, if you wish to set it at a whole or half degree instead of to the odd-ball arcminute.

If you agree with the recommended assumed position for the fix, the press the 'PRESS' button. The Main Form has the max plotting scale on lower right.

Assumed Position for this Nav Fix

DR Latitude deg 39 deg 31.1 min N Estimated position using Plane Sailing techniques

DR Longitude deg 39 deg 56 min W

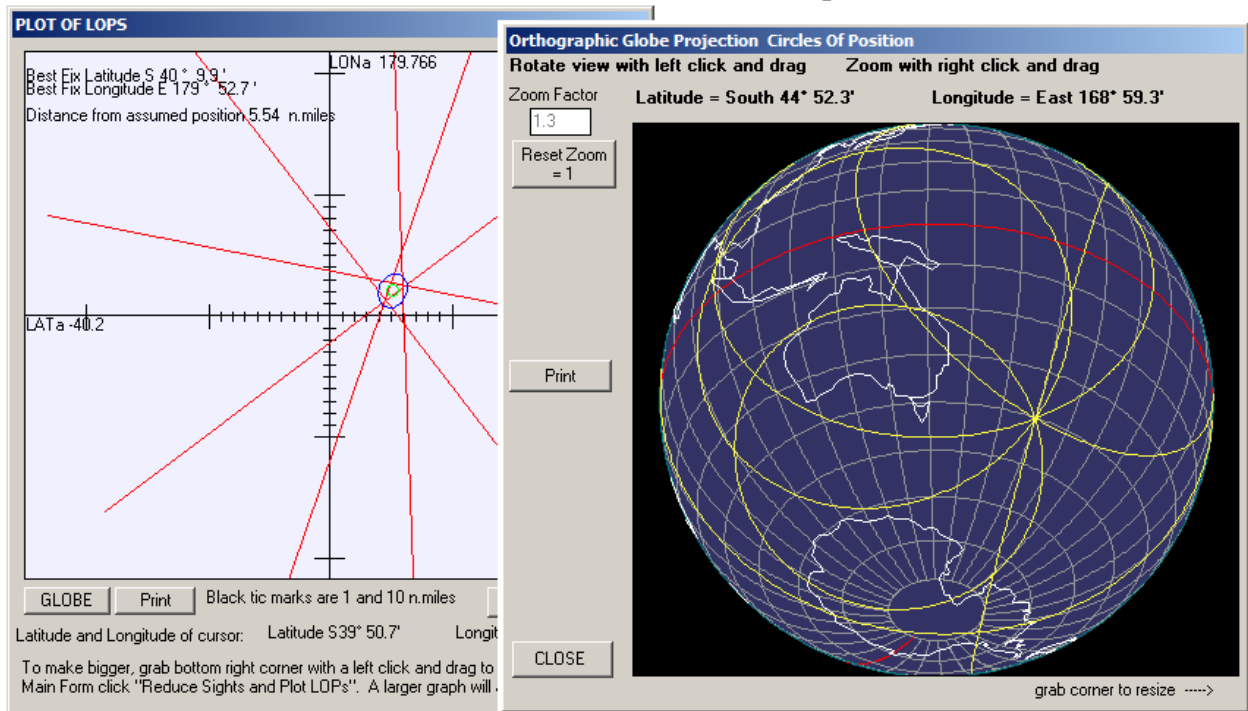
INPUT Assumed Latitude 39 ° 31 ' Lat N or S North South

INPUT Assumed Longitude 39 ° 56 ' Lon E or W East West

Accept the calculated assumed position as is pre-entered, or enter a different one manually in the data fields above by clicking it and typing.

PRESS to Enter Data

After pressing the button, this plot appears of the Line of Positions. The little green circle marks the best fix location. The blue ellipse marks the 95% confidence zone that the fix is somewhere within the ellipse.



A nice feature is the indication of Lat, Lon under the point of the mouse cursor which one can see at the bottom bar. A global plot of the circles of position is also shown.

Sight Data Form

Sight Data Entry Number of stored sightings = 5

<--- Last Sight
Save Changes
Next Sight --->

This data is
 Sight Number **1** out of **5**

Close this form


Must press Save Changes if editing existing data or if new data entered. Must be done for each sighting!!

Horizon step 1

Normal Sea
 Reflective Artificial
 Bubble

Land horizon calculator

Include this in sight reduction?



Sextant step 2

Altitude Measured, Hs

° '

LIMB

UPPER
 LOWER
 CENTER

Index Error, ArcMinutes

 On scale
 Off scale

UTC Date and Time of Observation step 3

Year

Month Universal Time
Coordinated = Greenwich Mean Time

Day

Hour Watch correction will be added to the seconds. If you change the correction, you must "reselect" the Object to record properly

Minute

Second

Click the Celestial Object step 4

Type notes on individual sights below

step 5 Save each data entry with "Save Changes", then close data form to return to the main form

Close Sight Data Form

Star: Kochab Magnitude 2.2

GHAstar 164 ° 23.18 ' Greenwich Hour Angle

DECstar N 74 ° 11.17 ' Declination

SHAstar 137 ° 18.76 ' Sidereal Hour Angle

GHA Aries 27 ° 4.41 '

IC -2 ' Index correction

DipCorr -3.37 ' Dip correction

R -1.67 ' Refraction correction

PA 0 ' Parallax-in-altitude correction

This will carry the measured time, measured sextant angle, and celestial object selected with details. The steps to follow are conveniently on the form. When all the information regarding that shot is in, press the "Save Changes" button which allows you to advance to the next blank sight form. After you have saved your sight data, you can advance forwards or backwards to review each one. Also, you should save the whole thing in the Main Form FILE menu button. Watch error correction for seconds inconsistent with UT will be added to the times recorded (from General Settings), but the times are still UT, not local clock time. The horizon can be either the sea (normal), or bubble, or there is a check use an artificial reflective horizon (mineral oil pan). The number of stored sightings is listed across the top banner. Also the yellow boxes contain the sighting being viewed and the total saved shots. Unfortunately, there is no way to totally erase a saved shot (you can edit it and resave), but you can take it out of the calculations by un-checking the "Include in the Sight Reduction" check box.

Follow these steps:

Step1) select horizon type

Step2) enter altitude measured, select limb, and enter index error

Step3) enter UTC date and time of sighting knowing the watch correction will be applied internally to the seconds

Step4) click on the celestial object in the list. Some details will appear in the bottom grey pane

Step5) click the Save Changes button on top

If you go back to Step 3 and change the time, you have repeat Step 4 again and reselect the celestial object. Otherwise it will have in its memory the GHA, DEC of the last time information when the object was previously selected.

You can save typed notes for each shot by typing in the provided text box on the center right.

Rise/Set Times

Sun/Moon Rise, Set, and Meridian Passage Times

UT Date and Time Close

Year
Month press for current time
UT Day Delta T, the difference between UT and Ephemeris time, seconds

North South
 East West

Sunrise 11:08:18 UT Sunset 22:33:25 UT LAN 16:51:09 UT
Moonrise 15:59:49 UT Moonset 02:07:29 UT N Mer.Pass. 21:03:46 UT

P after UT = previous UT day, N after UT = next UT day
Rise and set times based with refraction and parallax effects to upper limb

[Click here to Calculate Rise and Set Times for the Sun and Moon](#)

For local rise/set times, set Longitude = 0

Gets you the rise and set times of the Sun and Moon based on the optical position of the upper limb coincident with the horizon. It does this for your local day, so it might report times either in the present UT, or previous/next day UT.

Perpetual Almanac for Sun, Moon, Stars, and Planets

Perpetual Sun, Moon, Star, Planet Almanac

Date and Time

Year:

Month:

Day:

UT hour: Delta T, the difference between UT and Ephemeris time, seconds:

UT minute:

UT second:

Sun
Moon
Venus
Mars
Jupiter
Saturn
Acamar
Achernar
AcruX

Select Object by Clicking on it in the above list

Object Name: Moon

GHA 352° 40.32' Greenwich Hour Angle
DEC S 19° 27.51' Declination
SHA 105° 2.06' Sidereal Hour Angle
HP 59.21' Horizontal Parallax

GHA Aries 247° 38.25'

SD 16.13' Semi Diameter
Illumination 24.4 %

TeaCup Navigation

Step 1) enter date, time

Step 2) select object in above list

Julian Day 2456575.13675926
Julian Day Ephemeris 2456575.13733796
Mean obliquity of the ecliptic, degrees 23.4375
Nutation delta Psi, arc sec 10.043
Nutation delta Epsilon, arc sec -6.838

The 2 steps are listed on the form to get the instantaneous GHA and Declination for the object clicked. This is using the actual UT time typed in and does not have watch error included.

Delta T is the difference between Dynamical Time and UT. It is set from the main form under General Settings. If this value is known then the ephemeris results from the internal celestial almanac will be accurate for perhaps centuries. The US naval observatory has Delta T information at their web site <http://maia.usno.navy.mil/>. Look for 'Delta T' values' on the web page. See appendix 1 for a list of Delta T for different years.

Calculator Utilities

Along the top menu bar of the main form is an item labeled “Calculators”. In all cases, fill in the text windows, then mouse click the button that says “Calculate...”.

Plane Sailing

The screenshot shows the "NAV Calculators" software interface. The main window has a title bar "NAV Calculators" and a menu bar with "Plane Sailing Estimated Position DR", "Calculated Altitude", "Calculated Longitude Summer Line", and "Dip, horizon distance". The main area is titled "Plane Sailing Dead Reckoning" and contains several input fields and buttons. The "True Course, from true north 0-360 deg" field has a value of 0. The "Speed over ground, kts" field has a value of 0. The "Last Fix, Latitude" field has two sub-fields, both empty. The "Last Fix, Longitude" field has two sub-fields, both empty. The "Time interval, hrs and minutes" field has "Hr" and "Min" sub-fields, both with a value of 0. There are radio buttons for "Lat N or S" (North selected) and "Lon E or W" (West selected). A "Heading/ Course Calculator" button is located to the right of the True Course field. A "Calculate Estimated Position" button is located below the Time interval field. On the right side of the window, there is a vertical stack of buttons: "Great arc distance", "Single COP coastal", "3-arm Protractor" (highlighted with a red border), "Simplified Sight Reduction", "Atmospheric Refraction", and "CLOSE FORM".

This should be self-explanatory. Use the Heading/ Course calculator to convert your heading, speed in the water, current and leeway into a true course and speed over ground. It also does the inverse, in that if you wanted a TC to steer by it will calculate the proper heading, accounting for leeway and current.

Current and Course

True course calculator from leeway and currents CLOSE

True course calculator from leeway and current

Heading (relative to true north)
0-360 degrees

Ship speed in the water, knots

Leeway angle: pushing the boat to the right is +, to the left is -
degrees relative course (discounting tide) would be heading + leeway

Direction of current (forward movement relative to true north)
0-360 degrees

Speed of current, knots Click to calculate

True course = 14.4 deg from true N

Speed over ground = 5.4 knots Load Results in Main Form

Heading calculator from leeway and current
Fill in the above fields for ship speed, leeway, and current

Desired True Course (relative to true north)
0-360 degrees Click to calculate

Heading course = 30 deg from true N

Speed over ground = 5.4 knots

Current set is the direction the current is moving towards, whereas winds are noted for their origin, where they are coming from.

Atmospheric Refraction

Altitude Correction, Refraction

Air Temperature, deg C Calculate Refraction Correction

Barometric pressure, millibars

° ' Apparent Altitude, Ha

Refraction correction = -2.04' arc minutes

Altitude correction usually involves semidiameter and refraction, but for stars it's just refraction.

Calculated Altitude

Calculated Altitude

Assumed Latitude ° ' Lat N or S
 North South

Assumed Longitude ° ' Lon E or W
 East West

GHA ° '

DEC ° ' N S

Hc = 37° 8.5'

Sumner Line

Calculated Longitude for Sumner Line

Assumed Latitude ° ' Lat N or S
 North South

Observed Altitude ° ' Lon E or W
 East West

GHA ° '

DEC ° ' N S

LON west side = W 179° 50.9' LON east side = W 162° 39'

Make 2 calculations with slightly different assumed latitude and you will have two lat-lon points to create your Sumner LOP.

Dip of the Horizon

Dip and Distance to Horizon (to edge of sea, or edge of nearby land)

Eye height above water, meters Distance to land, n.mile, or leave blank for sea horizon

Distance to sea horizon, nmiles: 4.2

Dip of horizon, arcminutes: 3.7

Compensate for land horizon by subtracting 0.2' from the measured sextant altitude
In the Sight Data Form, normal dip is accounted for internally, so you have to trick the data

This tells you the dip angle and distance to the visible horizon. Also, if you use the shore edge of land this will tell you the dip angle to that. It also prints the difference in dip correction which can be added to the sextant measurement (normal dip is calculated internally to the software, so you have to “trick” it with additional correction if you want to use the beach edge of land as your horizon.

Great Arc Distance

Great Arc Distance between two locations					
Latitude #1	<input type="text" value="30"/>	°	<input type="text" value="2"/>	'	Lat N or S <input checked="" type="radio"/> North <input type="radio"/> South
Longitude #1	<input type="text" value="40"/>	°	<input type="text" value="31"/>	'	Lon E or W <input type="radio"/> East <input checked="" type="radio"/> West
Latitude #2	<input type="text" value="36"/>	°	<input type="text" value="56"/>	'	Lat N or S <input checked="" type="radio"/> North <input type="radio"/> South
Longitude #2	<input type="text" value="43"/>	°	<input type="text" value="16"/>	'	Lon E or W <input type="radio"/> East <input checked="" type="radio"/> West
436.2 nautical miles		501.7 statute miles		Calculate the Distance	

This should be self-explanatory.

COP coastal (Circle of Position)

2 known landmarks and measured angle between (Circle of Position)						
Latitude #1	<input type="text" value="0"/>	°	<input type="text" value="0"/>	'	Lat N or S <input checked="" type="radio"/> North <input type="radio"/> South	Known most Western Landmark
Longitude #1	<input type="text" value="0"/>	°	<input type="text" value="0"/>	'	Lon E or W <input checked="" type="radio"/> East <input type="radio"/> West	
Latitude #2	<input type="text" value="0"/>	°	<input type="text" value="2"/>	'	Lat N or S <input checked="" type="radio"/> North <input type="radio"/> South	Known most Eastern Landmark
Longitude #2	<input type="text" value="0"/>	°	<input type="text" value="3"/>	'	Lon E or W <input checked="" type="radio"/> East <input type="radio"/> West	
Measured Angle	<input type="text" value="32"/>	°	<input type="text" value=""/>	'	Calculate center point away from 1st point	
Center of arc is 3.1 nm East , 1.4 nm South from 1st point						
Draw arc using center point and radius reaching 1st or 2nd point (observer on arc)						

This gives the location of a circle's center where the arc passes thru both locations and the observer who measures the included angle. The location is in nautical miles away relative to the 1st location. You can then draw an arc on your chart with the given centerpoint, and the radius will be by stretching the compass to either the 1st or 2nd landmark on the chart. Do this this with a 3rd landmark (use 2nd and 3rd as inputs) to get another circle. Where the 2 intersect is you position fix.

3-arm Protractor (3-point resection in surveyor's parlance)

3-Arm Protractor (3-Point Resection) using Farley Method giving 2 Circles Of Position for Coastal Position Fix

3-point problem (3 known landmarks and measured angles between) Best when middle landmark is closest. Fill in landmark data, then angles, then press Calculate

Latitude #1 ° ' Lat N or S N S Landmark on Left (point A)
Longitude #1 ° ' Lon E or W E W

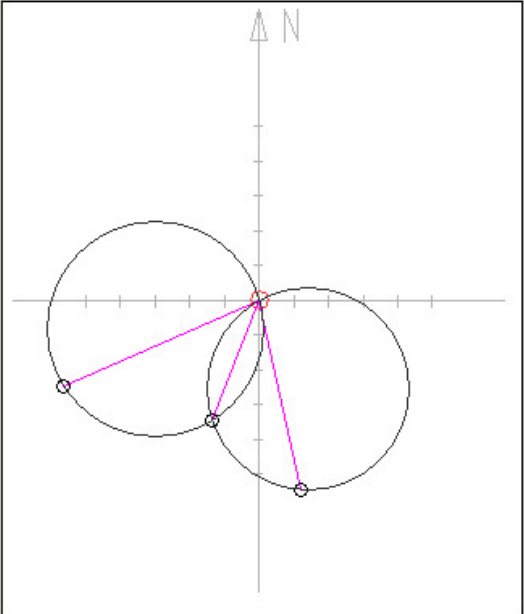

Latitude #2 ° ' Lat N or S N S Landmark in Middle (point B)
Longitude #2 ° ' Lon E or W E W

Latitude #3 ° ' Lat N or S N S Landmark on Right (point C)
Longitude #3 ° ' Lon E or W E W

Measured Angle between points A and B ° '
Measured Angle between points B and C ° '

Zoom Factor

Position Fix N 31° 5.45' W 65° 1.41'
Radial distance from Left Landmark 5.58 nmiles
Radial distance from Middle Landmark 3.71 nmiles
Radial distance from Right Landmark 6.15 nmiles
Tic marks on plot are 1.0 nautical mile increments



Coastal COP ver 1.0a

Coastal COP ver 1.0a by TeaCup Navigation

Grab corner to resize ---->

Left click and drag cursor to pan plot. Right click and drag to zoom.

With 3 landmarks, this automates elements of the last calculator (COP coastal). This plots with N up, E to the right, but the definition of left, middle, right landmarks are all relative to **you** the observer which is marked as a red circle. The small black circles are the landmarks, and the large grey circles are the circles of position created with the two angle measurements. The radial distances between the position fix and the landmarks are graphically represented with the magenta lines.

Simplified Sight Reduction

Single Shot Simplified Reduction Form (good for training) Close

Sextant Data

° ' Sextant Altitude Measured, Hs

Index Correction IC, arc minutes (on scale is - IC)

Corrections

Altitude Correction, arc minutes (if you include semi diameter, make SD = 0 below)

Semi Diameter SD, arc minutes (+ for LL, - for UL) for sun and lunar observations

Horizontal Parallax, HP, arc minutes (PA will be calculated internally) mostly for lunar observations

Dip Correction, arc minutes (always a negative number)

Almanac Data (at time of shot)

GHA ° ' Show Almanac

DEC ° ' N S

Assumed Position

Latitude ° ' Lat N or S North South

Longitude ° ' Lon E or W East West

Hc = 35° 44' Azimuth = 94.3°

Observed Altitude Ho = 35° 49.3' Offset Distance = 5.25 nautical miles Towards

GHA and DEC are gotten either from the Nautical Almanac or from the TeacupNav Almanac using the time of the shot to get the instantaneous values. That is up to you to figure out!

Local Hour Angle LHA = 301° 6.7' E
Apparent Altitude Ha = 35° 34.7'
Parallax in altitude PA = 0° 0'

Click to Reduce Sight

This lets you look up in the Nautical Almanac (or use the built-in Perpetual Almanac tool) the astronomical data, and manually enter all other data so you can exercise the line-by-line hand-shaping of the input data. This gets you an appreciation of what's involved before you even get to calculating altitudes and intercepts. This calculator does the last step of crunching out the altitudes, intercept and azimuth. For the most precise lunar LOPs, the SD should be the augmented SD. The SD as calculated in almanacs is based on being at the center of the Earth, which we of course are not. The higher the altitude measured, the closer you are to the moon (by a wee little bit) and it slightly enlarges the SD. The difference to your LOP will be measured in the tenths of miles.

Lunars

Step 1) Fill out the estimated latitude and longitude

Step 2) Enter the observed arc distance, date, and estimated time. The arc distance entered here should be corrected for index error.

Step 3) Select the object you were measuring to. Click to calculate!

Lunar Distance current Data file: Nov10-2010-Jupiter#2.LUN

OpenFile SaveFile

Clearing the Lunar Distance with 1 measurement and an estimated position CLOSE

Air Temperature, deg C Barometric pressure, millibars

Estimated Latitude ° ' Lat N or S North South

Estimated Longitude ° ' Lon E or W East West

Sun Limb, if using Outer Inner

Lunar Distance Measured corrected for index error ° ' Moon Limb Outer Inner Center

Date and Estimated Observation Time

Year press for current time

Month Delta T, the difference between UTC and Ephemeris time, seconds

Day Time zone difference from GMT, hrs

UTC hour

UTC minute

UTC second

Correct time at observation 23:38:12
Better Longitude W 76 ° 49.7 '
Lunar Distance Cleared 65 ° 29.1 '
Lunar Distance Apparent 65 ° 58.5 '
Augmented Semidiameter -15.32 '

Sun
Venus
Mars
Jupiter
Saturn
Acamar
Achernar
Acruz
Adhara
Aldebaran
Alioth
Alkaid

Select Celestial Object you are measuring to from the Moon by clicking on it.

US naval observatory has DeltaT information at their web site <http://maia.usno.navy.mil/>

This makes the assumption that your latitude is fairly accurate, but your longitude will be out according to the error in your chronometer

Click here to Calculate Correct Time and Longitude

Internally it is a good algorithm where the assumption is made that your latitude is accurate, but your longitude can be off due to the error in your clock. The altitudes are calculated according to the estimated time and position. It iterates with a new time and new longitude to converge to the proper time and longitude. It's amazing how small errors such as an incorrect index correction or a compromised reading because your arms were shaking holding the sextant in a weird position, can change the results quite a bit. You can use the arc distance function in the Sight Planner to verify the cleared arc distance. See page 5. As you can see, one may save new lunar files and open old ones.

File Management

This method only accesses and can save one leg at a time, not the entire voyage in a single file. You could easily manage that with the file names. For example, a trip from New Zealand to Tahiti could have individual files with saved names NZT-1.nav, NZT-2.nav, etc... The calculated new fix from the previous file becomes the inputted last fix for the next leg of the journey. This info you have to carry over manually, but that is not much of a burden in order to save unnecessary programming complexity. You can open as many windows of TeacupCelestial as you wish, and you can have one open from the last leg while you fill out the next leg info. The lunar distance files have the extension .LUN.

The settings file for the Sight Planner is called TeacupNav.nv1 and should always be in the same folder as the executable file. If you open a data file first and that data file is located in another folder, then it might expect to find a TeacupNav.nv1 file there instead. If one is not there then it will report that there is a problem and continue with blanks in the settings. You should arrange the program such that the executable file, the data files, and the TeacupNav.nv1 file are all in the same folder.

Appendix 1

Values for DeltaT, recent, future, and historical

Year	seconds for DeltaT
2013.00	66.907
2013.25	67.026
2013.50	67.121
2013.75	67.158
2014.00	67.267
2014.25	67.379
2014.50	67.7
2014.75	67.8
2015.00	67.9
2016.00	68.4
2017.00	69.
2018.00	69.
2019.00	70.
2020.00	70.
2021.00	71.
2022.00	71.
2023.00	72.

Recent Historical Values for DeltaT

1960	33.150
1961	33.584
1962	33.992
1963	34.466
1964	35.030
1965	35.738
1966	36.546
1967	37.429
1968	38.291
1969	39.204
1970	40.182
1971	41.170
1972	42.227
1973	43.373
1974	44.486
1975	45.477
1976	46.458
1977	47.521
1978	48.535
1979	49.589
1980	50.540
1981	51.382
1982	52.168
1983	52.957
1984	53.789
1984	53.7882
1985	54.3427
1986	54.8712
1987	55.3222
1988	55.8197
1989	56.3000
1990	56.8553
1991	57.5653
1992	58.3092

1993	59.1218
1994	59.9845
1995	60.7853
1996	61.6287
1997	62.2950
1998	62.9659
1999	63.4673
2000	63.8285
2002	64.2998
2003	64.4734
2004	64.5736
2005	64.6876
2006	64.8452
2007	65.1464
2008	65.4574
2009	65.7768
2008.00	65.457
2008.25	65.545
2008.50	65.60
2008.75	65.62
2009.00	65.70
2009.25	65.79
2009.50	66.2
2009.75	66.3
2010.00	66.5
2010.25	66.6
2010.50	66.8
2010.75	66.9
2011.00	67.1
2011.25	67.2
2011.50	67.
2011.75	67.
2012.00	68.
2012.25	68.
2012.50	68.
2012.75	68.

Appendix 2

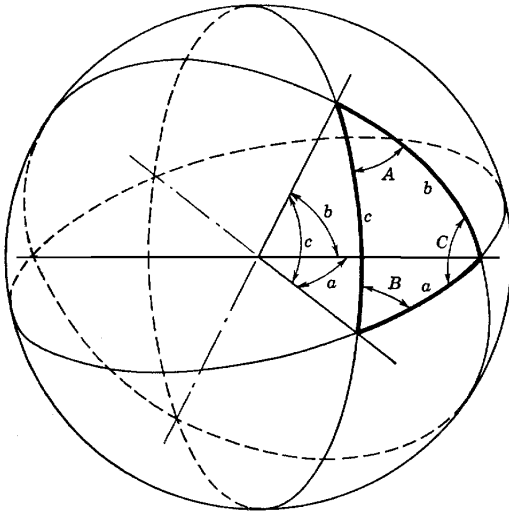
Derivation of the equations used in clearing the lunar distance

Useful identities:

$$\sin(\alpha) = \cos(\alpha - 90^\circ)$$

$$\cos(\alpha) = -\sin(\alpha - 90^\circ)$$

Spherical Trigonometry



Three Great Circles on a sphere will intersect to form three solid corner angles a , b , c , and three surface angles A , B , C . Every intersecting pair of Great Circles is the same as having two intersecting planes. The angles between the intersecting planes are the same as the surface angles on the surface of the sphere. Relationships between the corner angles and surface angles have been worked out over the centuries, with the law of sines and the law of cosines being the most relevant to navigation.

Law of Sines: $\sin(a)/\sin(A) = \sin(b)/\sin(B) = \sin(c)/\sin(C)$

Law of Cosines: $\cos(a) = \cos(b) \cdot \cos(c) + \sin(b) \cdot \sin(c) \cdot \cos(A)$

(for spherical trigonometry; there are similar ones for plane trig)

Law of Cosines in terms of co-angles:

$$\sin(90-a) = \sin(90-b) \cdot \sin(90-c) + \cos(90-b) \cdot \cos(90-c) \cdot \cos(A)$$

$$S = s + R_s$$

$$M = m + R_m$$

$$d = d_{\text{sextant}} + IC + SD_{\text{aug}}$$

$$\cos(d) = \sin(s) \cdot \sin(m) + \cos(s) \cdot \cos(m) \cdot \cos(\delta)$$

$$\cos(D) = \sin(S) \cdot \sin(M) + \cos(S) \cdot \cos(M) \cdot \cos(\delta)$$

$$\cos(\delta) = \frac{\cos(d) - \sin(s) \cdot \sin(m)}{\cos(s) \cdot \cos(m)}$$

$$\cos(D) = \sin(S) \cdot \sin(M) + \cos(S) \cdot \cos(M) \cdot \left[\frac{\cos(d) - \sin(s) \cdot \sin(m)}{\cos(s) \cdot \cos(m)} \right]$$

$$\cos(D) = \sin(S) \cdot \sin(M) + (\cos(d) - \sin(s) \cdot \sin(m)) \cdot \left[\frac{\cos(S) \cdot \cos(M)}{\cos(s) \cdot \cos(m)} \right]$$

$$\sin(a) \cdot \sin(b) = -\cos(a + b)$$

$$C_{\text{ratio}} = \left[\frac{\cos(S) \cdot \cos(M)}{\cos(s) \cdot \cos(m)} \right]$$

$$\cos(D) = (\cos(d) + \cos(s + m)) \cdot C_{\text{ratio}} - \cos(S + M)$$

$$S = s + R_s$$

$$M = m + R_m$$

$$d = d_{\text{sextant}} + IC + SD_{\text{aug}}$$

$$\cos(d) = \sin(s) \cdot \sin(m) + \cos(s) \cdot \cos(m) \cdot \cos(\delta)$$

$$\cos(D) = \sin(S) \cdot \sin(M) + \cos(S) \cdot \cos(M) \cdot \cos(\delta)$$

$$\cos(\delta) = \frac{\cos(d) - \sin(s) \cdot \sin(m)}{\cos(s) \cdot \cos(m)}$$

$$\cos(D) = \sin(S) \cdot \sin(M) + \cos(S) \cdot \cos(M) \cdot \left[\frac{\cos(d) - \sin(s) \cdot \sin(m)}{\cos(s) \cdot \cos(m)} \right]$$

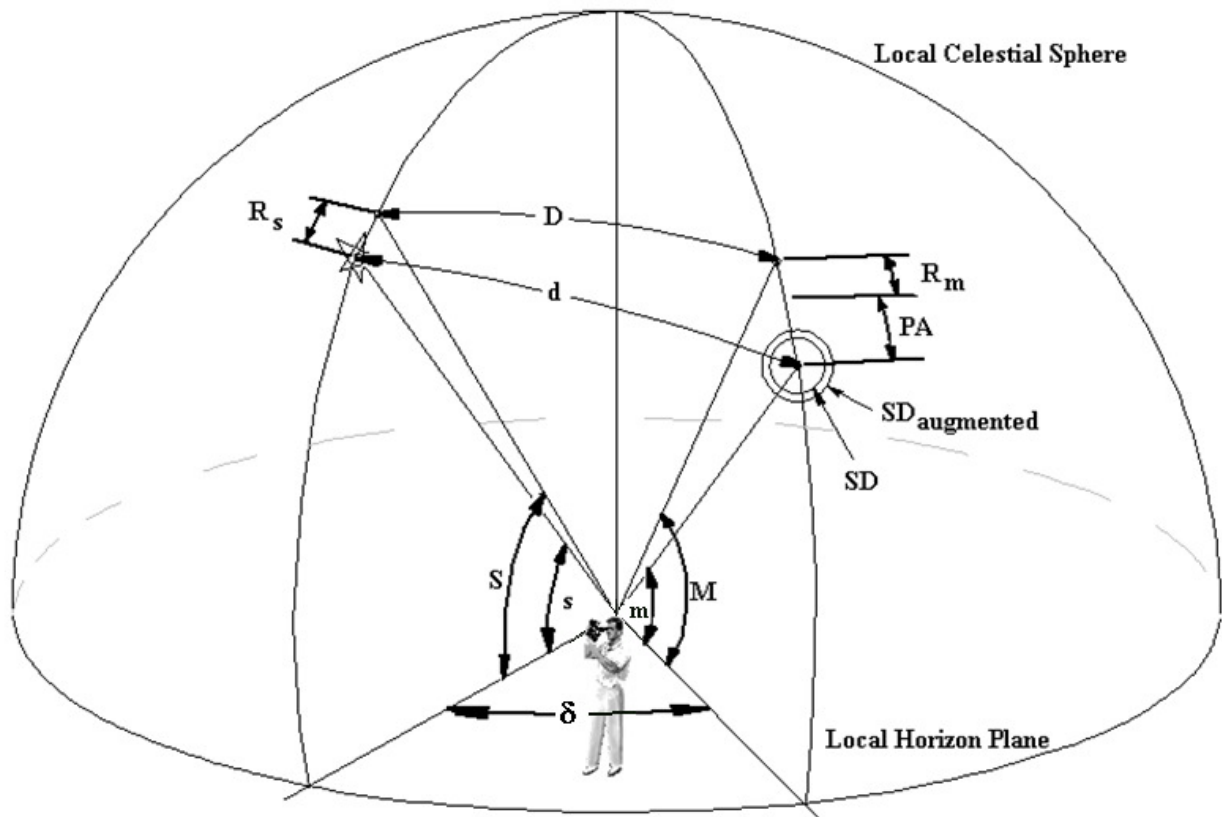
$$\cos(D) = \sin(S) \cdot \sin(M) + (\cos(d) - \sin(s) \cdot \sin(m)) \cdot \left[\frac{\cos(S) \cdot \cos(M)}{\cos(s) \cdot \cos(m)} \right]$$

$$\sin(a) \cdot \sin(b) = -\cos(a + b)$$

$$C_{ratio} = \left[\frac{\cos(S) \cdot \cos(M)}{\cos(s) \cdot \cos(m)} \right]$$

$$\cos(D) = (\cos(d) + \cos(s + m)) \cdot C_{ratio} - \cos(S + M)$$

$$D = \text{arcCos} \left[(\cos(d) + \cos(s + m)) \cdot C_{ratio} - \cos(S + M) \right]$$



The key to the problem is to realize that the parallax and refraction corrections only change the altitudes, not the ‘wedge angle’ δ . When the corrections are applied, and using the law of cosines, the equation with s , m can be related to S , M with the common angle δ . Even though refraction corrections are negative, the picture is drawn in the positive direction to establish a consistent sign convention.