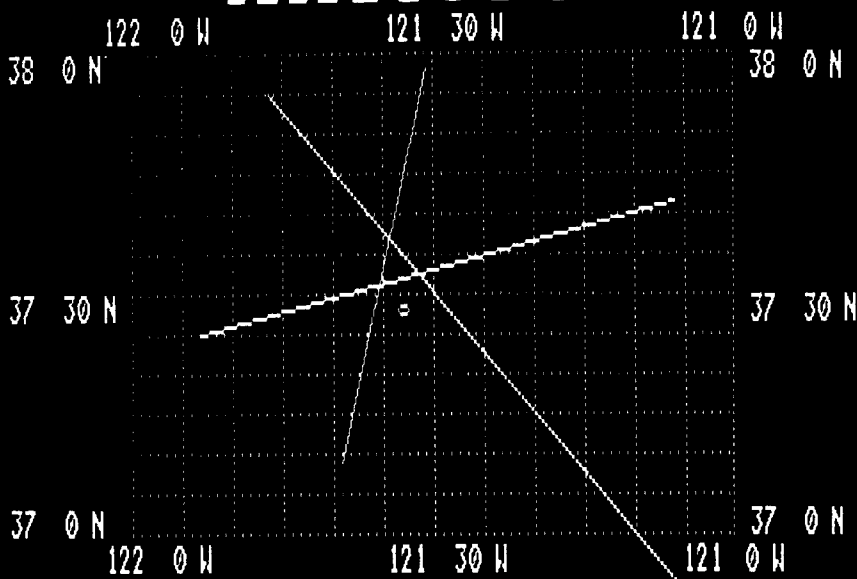


DAVIS **PC ASTRO**
NAVIGATOR™



USER'S
MANUAL

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WARRANTY AND IMPORTANT NOTICES

DISKETTE REPLACEMENT

PC ASTRO NAVIGATOR COMES WITH A 30 DAY LIMITED WARRANTY AS EXPLAINED ON THE WARRANTY ENCLOSED WITH THE PROGRAM DISKETTE. IF YOUR PROGRAM DISKETTE IS DEFECTIVE, PLEASE SEND THE DEFECTIVE PROGRAM DISKETTE, WITH A NOTE OF EXPLANATION, TO DAVIS INSTRUMENTS FOR A REPLACEMENT. PLEASE ALLOW 3 WEEKS FOR DELIVERY.

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WHAT PC ASTRO NAVIGATOR CAN DO

The PC Astro Navigator software is designed to give novice navigators a simple way to verify the manual calculations of traditional methods learned in the classroom. Experienced navigators can analyze the results of sights taken on past voyages, while the hobbyist can put the program to use for fun and practice. It is assumed that the user understands the principles of navigation or is a student of navigation.

PC Astro Navigator is completely menu-driven and designed to be user friendly as it produces accurate and quick solutions to navigation problems. The program is divided into four functions: DEAD RECKONING, CELESTIAL NAVIGATION, NAUTICAL ALMANAC, and TWILIGHT PLANNING.

Logs of both Dead Reckoning (DR) Positions and Lines of Position (LOP's) from celestial observations are automatically maintained by the program and may be reviewed at any time. Plots to the display screen or printer may be made of either the DR track or the celestial LOP's. Each of these may be advanced in time to give a running fix.

The Nautical Almanac shows Greenwich Hour Angle (GHA) and Declination for any date and time within the years 1925 - 2024 for Aries, Sun, Moon, Venus, Mars, Jupiter, Saturn, the 57 navigational stars, and Polaris.

The Twilight Planner computes the times of Nautical Twilight and Sunset and shows the bodies visible at that time. In addition, an Astro-Body Finder computes the position of the stars and planets visible at a given date and time.

HARDWARE REQUIREMENTS

PC Astro Navigator is designed to be used with IBM or IBM compatible personal computers with at least 256K of RAM memory. A CGA, Hercules or compatible graphics card is required to obtain the plotting functions. The operating system required is PC.DOS or MS.DOS Version 2.1 or later. It may be used with either one or two disk drives with double sided, double density (DSDD) diskettes, or a hard disk drive. A compatible printer is optional, but does allow a hard copy of the position plot to be produced, as well as other page-by-page program solutions for future study.

HOW TO USE THIS MANUAL

It is our intent that this manual be used both as a tutorial and reference guide. The tutorial will guide you through a typical navigational problem, allowing you to input data and arrive at a successful conclusion. In a similar manner, solutions to problems found in other sources, such as Bowditch's The American Practical Navigator, may be derived. Tutorial text in standard typeface is used to describe the entries to be made by the user and, at times, the reasoning behind the entry. However, no attempt is made to educate the user in the art of navigation other than that which the program inherently produces. Where keyboard entries are required, the word "Input" is used, and the required input is shown in brackets ([]). Where execution of the entry is required, the word "ENTER" is used.

Standards of convention in making keyboard entries must be used for successful solutions. These conventions are defined on page 8 and in the Appendix.

HOW PC ASTRO NAVIGATOR IS ORGANIZED

PC Astro Navigator is completely menu driven. The Main Menu provides access to the program modules of 1) Dead Reckoning, 2) Celestial Navigation, 3) Nautical Almanac, and 4) Twilight Planning and Astro Body Finder.

The Dead Reckoning (DR) module includes the means to initialize date, time, position coordinates, course and speed. Updates for changes in course and speed or for new positions gained from other navigational data are provided. Each new DR position is recorded in the DR Log, which may be reviewed at any time. Finally, a plot of any or all DR positions may be made to the screen or to the printer.

The Celestial Navigation module includes a user defined file of data common to all celestial calculations. It must be initialized before you proceed to other celestial menu choices. Once the module is initialized, Noon Fixes may be calculated by single or multiple sights. Lines of Positions (LOP's) may be obtained through sight reduction of single or multiple sights, each LOP being logged if desired. The LOP log may be reviewed at any time. Finally, a plot of as many as five LOP's may be made to the screen or to the printer.

Data is so organized as to be transported automatically by the program as required. For example, the DR date, time, and last position are moved automatically to other modules of the program, yet can be overwritten at will by the user. Position fixes from LOP's may be automatically transported to the DR Log. In general, data need only be entered once and then will automatically be transported to any other program parts that may need it. Also, calculated values such as latitude or longitude are similarly transported so that data re-entry is almost entirely avoided. In all cases automatically transported data may be overwritten by the user, if desired.

The Nautical Almanac describes the Greenwich Hour Angle (GHA), Declination (Dec), Right Ascension (RA), and Sidereal Hour Angle (SHA), as appropriate, for Aries, Sun, Moon, Venus, Mars, Jupiter, Saturn, the 57 navigational stars, and Polaris for an assigned date and time. Almanac data is automatically calculated and entered into each solution provided by the celestial navigation part of the program.

The Twilight Planning menu provides the time of Nautical Twilight and Sunrise/Sunset on a given date for a selected set of coordinates. The planning also lists the bodies visible at that time, showing altitude, azimuth, and the magnitude of each. Within the Twilight Planner is an Astro-Body Finder which, given date, time, and coordinates, will display the bodies visible under those parameters. In a similar fashion the time of Sunrise, Noon, and Sunset may be obtained. In all cases dates, times, and coordinates are automatically transported from the Dead Reckoning part of program to minimize keyboard re-entry.

HOW TO SET UP YOUR COMPUTER

REQUIRED HARDWARE

PC Astro Navigator may be run on single drive, double drive, or hard disk equipped computers. It is specifically written for the IBM family of PC.DOS Computers which include the PC, XT, and AT versions. It will also run on compatible computers that will correctly run other software written for the IBM PC family.

TEXT-ONLY and GRAPHICS CONSIDERATIONS

Almost all of the features of PC Astro Navigator can be utilized when running the program on a standard monochrome/text only system. For many navigators this will provide all of the computational wizardry they will ever need. However, a text-only display will not produce the navigational plots which are a unique feature of PC Astro Navigator. To produce a plot, the computer must have a suitable graphics card and appropriate monitor.

For IBM users, the standard Color Graphics Adapter (CGA) supports all of the program's special plotting features. For compatible computer users, a CGA compatible color or monographics card will give excellent results. Hercules graphics cards or Hercules compatible cards will also work with the program.

UNDERSTANDING THE PC ASTRO NAVIGATOR PROGRAM DISKETTE

The package containing this User Manual should also include two (2) program diskettes. One is marked for computers equipped with a Color Graphics Adapter (CGA) card and the other for Hercules graphics. If you have an EGA, VGA or text only system, you will not be able to obtain the graphic plots that PC Astro Navigator can produce. However, all other functions will work correctly and you can still plot LOP's, etc. on a separate plotting sheet.

If you know that you have either a CGA or Hercules graphics system, please proceed to the next paragraph. If you are not sure, consult your computer manual or other documentation to verify, if possible, what system you have. Also, some high resolution graphic systems include a CGA emulation mode which can be configured to run PC Astro Navigator. If you just don't know what type of system you have, try both versions and see which works best for you.

MAKING A WORKING COPY

You are encouraged to make a working copy of PC Astro Navigator for your own use and to store the original in a safe place. Consult your computer manual on the correct way to use the copy command for your single drive, double drive, or hard disk system.

You will need the following items:

1. System diskette containing Command.Com (to boot computer and enable COPY command).
2. Utility diskette containing Graphics.Com/EXE or other Graphics dump utility (necessary if you want to print the results of PC Astro Navigator's plotting routines).
3. Blank Formatted Diskette.
4. PC Astro Navigator Program Diskette.

Boot up your computer as usual and copy the following files to the blank formatted diskette:

1. GRAPHICS.COM/EXE or other graphics dump utility.
2. All of the files from either the CGA version or HERCULES version of the program diskette. The file names are:

<u>CGA</u>	<u>HERCULES</u>
ASTRO20.EXE	ASTRO40.EXE
BRUN20.EXE	BRUN40.EXE
HELP.TXT	QBHERC.COM
	HELPTXT

Verify that these files are on your copy. **CAUTION:** Do not install a write protect label on your working copy. PC Astro Navigator creates new files when in operation and a write protect label will stop the program.

HOW TO RUN PC ASTRO NAVIGATOR FOR THE FIRST TIME

PC Astro Navigator, while copyrighted, is not copy protected. You are encouraged to make a working copy for your own use. You are not allowed to make unlimited copies or to give copies to another person. Make a copy of PC Astro Navigator NOW as instructed above. Place the original in safe storage away from heat, moisture, and magnetic influences.

Boot up your computer in the normal way. It's a good idea to run GRAPHICS.EXE or other screen dump utility now if you want to make a printer copy of the graphics screens that PC Astro Navigator can produce.

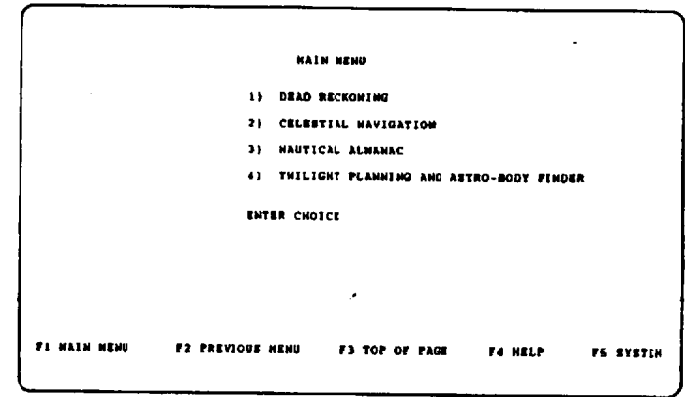
PC Astro Navigator may be run on any disk drive your computer is set up to use. To run the CGA version, just log onto the desired drive and insert your CGA copy of PC Astro Navigator in that drive. Look on the screen for the prompt corresponding to the logged on drive and input [ASTRO20]. Press ENTER. The program will load automatically.

To run the HERCULES version, just log onto the desired drive and insert your HERCULES copy in that drive. Look at the screen for the prompt corresponding to the logged on drive and input [QBHERC]. Press ENTER. Now input [ASTRO40] and press ENTER. PC Astro Navigator will now load automatically.

After loading either version, the first two screens to be seen cover the copyright details for the program. Having seen and understood their meaning:

Press ENTER. The Main Menu will appear as shown in Figure 1.

FIGURE 1



FUNCTION KEYS

For your assistance in working with the program, the FUNCTION keys are used for quick excursions to other menus or, in the event that an input error has been made, to the top of the existing page. The functions are designated:

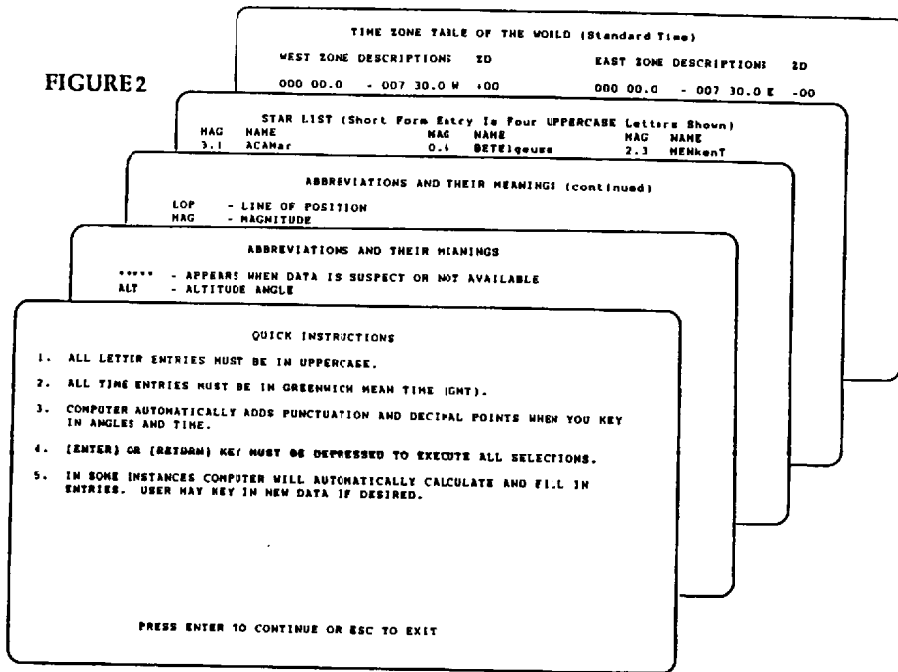
- F1 - To Main Menu
- F2 - To Previous Menu
- F3 - To Top of Page
- F4 - To the HELP Screens
- F5 - Exit To the Operating System

While standard conventions of navigation are used, the F4-HELP screen is provided to assist with entries and their meanings. It consists of:

1. A list of Quick Instructions for keyboard entries.
2. A list of abbreviations used and their meanings.
3. A complete Star List. Note: Only the first four letters of most stars need be input. When two or more stars have the same first four letters, the first THREE letters plus the last letter of the name are used.
4. A Time Zone Table of the World. Instructions include the correction of time between Local time and GMT.

A Function Key may be pressed at any time you see the Function Key definitions at the bottom of a screen. After you view the "HELP" screen, the program will return you to the screen that was displayed when you originally pressed the F4 key. The "HELP" screens are shown in Figure 2.

FIGURE 2



DATA ENTRY AND CONVENTIONS

The format used by PC Astro Navigator for input data is as follows:

1. Letter entries must be in capital letters.
2. Time entries must be in Greenwich Mean Time (GMT).
3. Time entries must be in the format HH:MM:SS (Hour:Minutes: Seconds).
4. Date entries must be in the format MM/DD/YY (Month/Day/Year).
5. Latitude entries must be in the format DD MM.M N (Degrees Minutes.Decimal Minutes North) or DD MMM S (Degrees Minutes.Decimal Minutes South).
6. Longitude entries must be in the format DDD MM.M E (Degrees Minutes.Decimal Minutes East) or DDD MMM W (Degrees Minutes. Decimal Minutes West).
7. Course entries must be in the format DDD.D (Degrees.Decimal Degrees) True.
8. Speed entries must be in the Format KK.K (Knots.Decimal Knots).

9. Sextant index error must be in the format MM.M + or MM.M - (Minutes.Decimal Minutes plus or minus).
10. Eye elevations (dip) must be in the format FF.F (Feet.Decimal Feet).
11. Chrono Error (ship's clock) must be in the format SS.S + or SS.S - (Seconds.Decimal Seconds plus or minus).
12. The computer automatically adds punctuation marks and decimal points when keying in angles and time.
13. ENTER or RETURN must be pressed to execute all selections.
14. In some instances, the computer will fill in certain information by transporting data from other files. The user may change this date by entering new data over the existing data.
15. Most current DR position fix is designated by an asterisk (*).

PRINT SCREEN

Depending on the brand of computer you are using, you will be able to print any of the text screens to a compatible printer by using either the PRINT SCREEN key or a similar command as shown in your computer instruction book. To obtain a print of the plots you will likely have to run Graphics.Com or Graphics.Exe before loading PC Astro Navigator. Consult your computer manual for details.

HOW TO MAINTAIN YOUR DATA FILES

Three Data Files are generated by PC Astro Navigator. These are named the DRFILE.DTA, the LPFILE.DTA, and the CELEST.DTA. They contain DR LOG, LOP LOG, and the Celestial Initialization files respectively.

The DRFILE.DTA and the LPFILE.DTA are created automatically with data calculated from changes in the DR position or by the sight reductions calculated. Should either file become full, the screen will prompt "DISKETTE IS FULL". If this should happen, you may delete entries individually to create more space. At the bottom of the screen of the DR Log and the LOP Log the statement is made:

"Press ENTER to continue or press [D] to delete an entry".

[D] (Delete) input will result in another prompt asking for the specific entry number to be deleted. In this way, unwanted data may be purged on a selective basis. In general, a diskette that has a capacity of 360K and that contains only PC Astro Navigator files will have room for about 2000 DR or LOP entries.

Should you wish to have access to the full diskette memory for such data, copy the files DRFILE.DTA, LPFILE.DTA, and CELEST.DTA to a newly formatted diskette. Once this is done, and PC Astro Navigator is loaded, the PC Astro Navigator diskette may be removed and safely filed. Only the new data diskette need be used; it will hold approximately 10,000 DR or LOP entries. Since the HELP.TXT file remains on the PC Astro Navigator diskette, you may find it useful to copy HELP.TXT to the data diskette.

Should you wish to delete all entries from the LOP log, the computer system command for Deleting a file [DEL LPFILE.DTA] must be used. To regain access to this file, re-load ASTRO20 or ASTRO40. The file will be recreated automatically, empty of data. The DR Log is deleted each time the DR Initialization is performed.

HOW TO USE EACH PROGRAM MODULE

The procedure for using each program module is as follows: each module is brought to the screen by selecting the desired module from the Main Menu. This in turn brings up a Sub-Menu which shows the selections underlined in this chapter.

User prompts, or requests, are in UPPERCASE and units required are shown in brackets ([]). In each case, the execution of the data entered is made by the ENTER or RETURN key. Our convention is to describe this key as ENTER.

DEAD RECKONING MENU

From the Main Menu:

Input [1] - Dead Reckoning

From the Dead Reckoning Menu you have a choice of:

1. DR Initialization
2. DR Update for Change in Course and Speed
3. DR Update for New Fixed Position
4. DR Plot
5. DR Log

Let's review each in turn:

DR INITIALIZATION

DR data should be entered initially when beginning the voyage so that the program will automatically transport the data to various modules requiring it for navigational solutions.

DATE - Input [MM/DD/YY] (Month/Day/Year) as Starting Date. Press ENTER to accept.

TIME - Input [HH:MM:SS] (Hours:Minutes:Seconds) as Time of Departure in Greenwich Mean Time (GMT). Press ENTER to accept.

LATITUDE - Input [DD MM.M] (Degrees Minutes.Decimal Minutes) [N] (North) or [S] (South) as the latitude of departure. Press ENTER to accept.

LONGITUDE - Input [DD MM.M] (Degrees Minutes.Decimal Minutes) [E] (East) or [W] (West) as the longitude of departure. Press ENTER to accept.

COURSE - Input [DDD.D] (Degrees.Decimal Degrees) in True Bearing. Press ENTER to accept.

SPEED - Input [KK.K] (Knots.Decimal Knots). Press ENTER to accept.

"Do you want to Update File (Y/N)? ___"

Input [Y] to accept the entries made or [N] to reject.

Caution: All previous entries in DR Log will be deleted if you input [Y]!

Press ENTER to accept or reject data, as required.

DR UPDATE COURSE AND SPEED.

This update is used to maintain a series of running fixes or to determine a position at a future time at the same or different course and speed.

DATE - Input [MM/DD/YY] (Month/Day/Year) as new date. Press ENTER to accept.

TIME - Input [HH:MM:SS] (Hours:Minutes:Seconds) as new time in Greenwich Mean Time (GMT). Press ENTER to accept.

NEW COURSE - Input [DDD.D] (Degrees.Decimal Degrees) as new course in True Bearings. Press ENTER to accept.

NEW SPEED - Input [KKK] (Knots.Decimal Knots) as new speed. Press ENTER to accept.

"Do you want to update file (Y/N)? ___"

Input [Y] to accept the entries made or [N] to reject. Press ENTER to update DR Log.

DR UPDATE NEW FIXED POSITION

As new position fixes are ascertained, the dead reckoning (DR) log should be updated. If the new position is deemed reasonably accurate, it may be desirable to name this as the Last FIXED Position (shown by an asterisk "*" in the DR Log).

Note: Position updates do not delete past DR points from DR Log. However a new fixed position update does become the starting point for all future DR calculations and plots.

From Dead Reckoning Menu:

Input [3] (DR Update for New Fixed Position)

A sub-menu will appear giving the following choices:

1. Noon Sight
2. 2-Body Fix
3. Sat Nav, Loran C or other Means
4. Provisional Latitude and Longitude

Let's review each in turn.

1. NOONSIGHT

This selection allows the position results from a noon sight to be brought into the DR Log as a new fixed position. From the sub-menu:

Input [1] (Noon Sight). Press ENTER.

The screen will show a list of all the Noon Sights you have taken. Each sight is labeled with a position number (PN#) shown in the second column. At the bottom of the screen you will see the prompt:

"ENTER PN# of Noon Fix ____"

Input [PN#] of the Noon Sight you wish to bring into the DR Log. Press ENTER to accept this PN#.

- DATE** - (Month/Day/Year). Verifies date of Noon Sight. Press ENTER to accept.
- TIME** - (Hours:Minutes:Seconds). Verifies time of Noon Sight. Press ENTER to accept.
- LATITUDE** - (Degrees Minutes.Decimal Minutes N/S). Verifies latitude of Noon Sight. Press ENTER to accept.
- LONGITUDE** - (Degrees Minutes.Decimal Minutes N/S). Verifies Longitude of Noon Sight. Press ENTER to accept.
- COURSE** - Input [DDD.D] (Degrees.Decimal Degrees) as new course in True Bearing. Press ENTER to accept.
- SPEED** - Input [KK.K] (Knots.Decimal Knots) as new speed. Press ENTER to accept.

"Do you want to update file (Y/N)? ____"

Input [Y] to accept the entries made or [N] to reject. Press ENTER to update DR Log.

2. 2-BODY FIX

For a 2-Body Fix see sample problem page 31.

3. FOR SAT-NAV, LORAN OR OTHER MEANS:

- DATE** - Input [MM/DD/YY] (Month/Day/Year) as new date. Press ENTER to accept.
- TIME** - Input [HH:MM:SS] (Hours:Minutes:Seconds) as new time in Greenwich Mean Time (GMT). Press ENTER to accept.

Position data from recent SatNav, Loran-C or other methods:

- LATITUDE** - Input [DD MM.M] (Degrees Minutes.Decimal Minutes) [N] (North) or [S] (South). Press ENTER to accept.
- LONGITUDE** - Input [DDD MM.M] (Degrees Minutes.Decimal Minutes) (East) or [W] (West). Press ENTER to accept.
- COURSE** - Input [DDD.D] (Degrees.Decimal Degrees) as new course in True Bearing. Press ENTER to accept.
- SPEED** - Input [KK.K] (Knots.Decimal Knots) as new speed. Press ENTER to accept.

"Do you want to update file (Y/N)? ____"

Input [Y] to accept the entries made or [N] to reject. Press ENTER to update DR Log.

4. FOR PROVISIONAL LATITUDE OR LONGITUDE:

The positional fix determined from the reported position of a nearby vessel (or by fixing a position from the visual sighting of a lighthouse or using radar for a range and bearing to a point of land) may be questionable. While useful in some instances, it may be only temporarily helpful. When entered as a provisional fix, it appears as a point when plotted, and does not affect the calculation of running fixes.

For a provisional fix update:

- DATE** - Input [MM/DD/YY] (Month/Day/Year) as new data. Press ENTER to accept.

TIME - Input [HH:MM:SS] (Hours:Minutes:Seconds) as new time in Greenwich Mean Time (GMT). Press ENTER to accept.

LATITUDE - Input [DD MM:M] (Degree Minutes.Decimal Minutes) [N] (North) or [S] (South). Press ENTER to accept.

LONGITUDE - Input [DDD MMM] (Degree Minutes.Decimal Minutes) [E] (East) or [W] (West). Press ENTER to accept.

"Do you want to update file (Y/N)? ____"

Input [Y] to accept the entries made or input [N] to reject. Press ENTER to update DR Log.

DR PLOT

The Dead Reckoning track from the last fixed position to the latest running fix position may be plotted to the screen or to the optional printer (PRINT SCREEN command).

Selecting DR PLOT prompts the user to select the plotting scale desired. This must be selected to cover the length of DR track to be plotted.

Input one of the following scales:

- [1] - 1 degree by 1 degree plot
- [2] - 2 degree by 2 degree plot
- [3] - 4 degree by 4 degree plot
- [4] - 10 degree by 10 degree plot

Press ENTER - Plotting will be automatic.

Should the scale selected not fit the length of the DR track, you will be advised that the "POINT OR LOP GOES OFF CHART."

"PRESS ENTER TO RETRY WITH LARGER SCALE"

DR LOG

The record of DR positions currently in the log will be shown with the Last Fixed Position being followed by an asterisk (*).

"Press ENTER to accept the log entries and continue or press [D] to delete an entry."

A [D] (Delete) answer will result in another prompt asking for the specific entry number to be deleted. Any entries may be deleted except for the Last Fixed Position (marked with an asterisk).

CELESTIAL NAVIGATION MENU

From the Main Menu:

Input [2] (Celestial Navigation)

From the Celestial Navigation Menu, you have a choice of:

1. Celestial Data File
2. Noon Sight
3. Lop - Sight Reduction
4. Plot LOP's
5. Log of LOP's

Let's review each in turn.

CELESTIAL DATA FILE

Certain celestial data, common to all celestial calculations, must be entered initially before the program will operate correctly. The process is as follows:

INDEX ERR - Input [MM.M] (Minutes.Decimal Minutes) [+] or [-] after checking the index error of your sextant. Davis sextant users will normally use 00.0 because the sextant should be adjusted to -0- index error before each use. Press ENTER to accept.

HOW TO CHECK INDEX ERROR: With the sextant set near zero, use the micrometer knob to bring the direct and reflected images of the horizon (or a distant object) into exact coincidence. If the sextant reading is exactly zero, the Index Error is zero. If the index mark on the sextant arm is to the left of zero (at coincidence) the Index Error is positive. If the index mark is to the right of zero the Index Error is negative.

EYE ELEV - Input [FF.F] (Feet.Decimal Feet) as height of observer above water line. Press ENTER to accept.

LIMB = LOWER/UPPER - Input [L] or [U] depending on which limb of sun or moon is being used. Press ENTER to accept.

MAXIMUM BODY ALT - Input [DD] (DEGREES) for the maximum observation altitude desired when using the Twilight Planning part of program. Press ENTER to accept.

MINIMUM BODY ALT - Input [DD] (DEGREES) for the minimum observation altitude desired when using the Twilight Planning part of program. Press ENTER to accept.

NOTE: Maximum and minimum body altitudes limit the bodies to be listed in the Twilight Planning program, yet observations made of other bodies outside these limits may still be used for LOP calculations.

Chronometer Corrections

- CHRONO** - Input [HH:MM:SS] (Hours:Minutes:Seconds) as time from ship's chronometer in Greenwich Mean Time (GMT). Note actual GMT at same time for next entry. Press ENTER to accept.
- ACTUAL GMT** - Input [HH:MM:SS] (Hours: Minutes: Seconds) Greenwich Mean Time (GMT) as derived from radio station WWV or other high accuracy time source. Press ENTER to accept.
- CHRONO ERROR** - Input [SSS] (Seconds.DecimalSeconds) [+] or [-] as the error rate in seconds per month of the ship's chronometer. This rate will be used automatically by the program in later position calculations. Press ENTER to accept.
- DATE SET** - Input [MM/DD/YY] (Month/Day/Year) as the date the above ship's chronometer data was taken. Press ENTER to accept.

"Do you want to update file (Y/N)? ____"

Input [Y] to accept the entries made or input [N] to reject. Press ENTER to update the celestial data file.

NOON SIGHTING

Noon sights are covered in the sample problem beginning on Page 32.

LOP SIGHT REDUCTION

LOP Sight Reduction is covered in the sample problem beginning on Page 26.

PLOT LOP's

A plot of as many as five Lines of Position may be made. By analyzing the proximity of the crossing of the LOP's, an estimate of the vessel's position may be made. Note that there must be LOP's in the LOP Log for the dates covered by the plot and an appropriate graphics card must be installed in your computer. The plotting procedure is as follows:

- START DATE** - Input [MM/DD/YY] (Month/Day/Year) as the Starting Date of LOP's to be considered for plotting. Press ENTER to accept.
- END DATE** - Input [MM/DD/YY] (Month/Day/Year) as the Ending Date of LOP's to be considered for plotting. Press ENTER to accept.
- DATE** - Input [MM/DD/YY] (Month/Day/Year) as the date of the desired Plot. Press ENTER to accept.
- TIME** - Input [HH:MM:SS] (Hours:Minutes:Seconds) as the time of plot in Greenwich Mean Time (GMT). Press ENTER to accept.

ENTER DR OR ASSUMED POSITION

The DR position or an assumed position is now input. Note that the program has automatically transported a calculated DR Position from the DR Log corresponding to the exact time and date of the plot. Change this, if required, by inputting new data.

- LATITUDE** - Input [DD MMM] (Degrees Minutes.Decimal Minutes) (N) (North) or [S] (South). Press ENTER to accept.
- LONGITUDE** - Input [DDD MM.M] (Degrees Minutes.Decimal Minutes) [E] (East) or [W] (West). Press ENTER to accept.

ENTER CENTER COORDINATES FOR PLOT

The center coordinates of the plot are now input to adjust to the plot data in the LOP Log. The computer calculates and displays the most logical choice but you may input new values.

- LATITUDE** - Input [DD MM.M] (Degree Minute.Decimal Minute) [N] (North) or [S] (South). Press ENTER to accept.
- LONGITUDE** - Input [DDD MM.M] (Degree Minute.Decimal Minute) [E] (East) or [W] (West). Press ENTER to continue.

The computer now displays a list of LOP's showing all of the LOP's currently in the LOP Log that match the "Start" and "End" dates. Each LOP is given a separate Position Number "PN" (shown in the second column) to simplify plotting.

- ENTER PN# OF LOP** - Input the "PN" # of the first LOP you wish to plot. Press ENTER to accept.
- Input the "PN" # of the second LOP you wish to plot. Press ENTER to accept.

Do this for each LOP or Noon Fix to be used in your plot. After entry of the final LOP:

Input [0]. Press ENTER to accept.

The plotting grid size is now requested. Input one of the following scales:

- [1] - 1 degree by 1 degree plot
- [2] - 2 degree by 2 degree plot
- [3] - 4 degree by 4 degree plot
- [4] - 10 degree by 10 degree plot

Press ENTER.

Plotting of the LOP's will be automatic. Should the scale selected not fit the length of the intercept, you will be advised that the "POINT OR LOP GOES OFF CHART." At that time:

"PRESS ENTER TO RETRY WITH LARGER SCALE"

The coordinates of the LOP's crossing may be read directly from the plotting grid in degrees and minutes. The DR position (corresponding to the time and date of plot from the DR Log) is drawn as a small circle on the grid and a Noon Fix is shown as a solid dot. Any discrepancy between DR position, Noon Fixes and LOP's can then be reconciled and a "best solution" identified.

LOG of LOP's

The record of all LOP's currently in the log are shown. Entries may be accepted or deleted at this time. Press ENTER to accept the log and continue, or input [D] to delete an entry. A [D] (Delete) answer will result in another prompt asking for the specific entry number to be deleted. To delete the entire file, see "How to Maintain Your Data Files" on Page 9.

NAUTICAL ALMANAC

From the Main Menu:

Input [3] (Nautical Almanac). Press ENTER.

Date and Time from the DR LOG will be automatically transported into the Nautical Almanac program for its use. Date and Time may be changed at the screen prompt.

DATE - Input [MM/DD/YY] (Month/Day/Year) as the date desired for observations. Press ENTER to accept.

TIME - Input [HH:MM:SS] (Hours:Minutes:Seconds) as the Greenwich Mean Time (GMT) desired for observations. Press ENTER to accept.

A listing of Nautical Almanac data for the date and time given will appear on the screen. A sample screen is shown in Figure 3.

NAUTICAL ALMANAC 09/26/87 16:00:00					
NAME	GHA	DEC	RA	SHA	
	DDD MM.M	DD MM.M	HH:MM:SS	DDD MM.M	
ARIES	244 55.4				
SUN	62 08.5	E 1 12.3	12:11:00		
MOON	23 28.5	E 19 46.4	14:46:48		
VENUS	53 08.9	E 3 49.8	12:47:06		
MARS	71 39.6	N 4 03.0	11:33:03		
JUPITER	218 51.1	N 9 06.7	01:44:17		
SATURN	350 16.2	E 21 23.2	16:50:37		
ICANAR	200 28.1	E 40 21.3	02:57:49	315 32.4	
ACHERNAR	220 36.1	E 57 18.2	01:37:17	336 40.6	
ACRUX	58 26.9	E 63 01.6	12:25:54	173 31.5	
ADHARA	140 22.8	E 28 57.2	06:58:10	255 27.5	
ALDEBARAN	176 06.9	N 16 29.3	04:35:14	291 11.4	
ALIOTH	51 32.9	N 56 01.3	12:53:30	166 37.5	
ALRAID	38 09.6	N 49 22.2	13:47:03	153 14.1	
AL NA'IR	273 03.6	E 47 01.6	22:07:27	28 08.1	
ALMILAN	161 01.2	E 1 12.4	05:35:37	276 05.8	
ALPHARD	103 10.4	E 8 38.2	09:27:00	219 15.0	

PRESS ENTER TO CONTINUE

FIGURE 3

TWILIGHT PLANNING

From the Main Menu:

Input [4] (Twilight Planning). Press ENTER.

From the Twilight Planning Menu, you have a choice of:

1. Dawn Planning
2. Dusk Planning
3. Astro-Body Finder
4. Local Sunrise, Noon, Sunset

Let's review each in turn.

DAWN PLANNING

DATE - Input [MM/DD/YY] (Month/Day/Year) using GMT Date. Press ENTER to accept.

LATITUDE - Input [DD MM.M] (Degrees Minutes.Decimal Minutes) [N] (North) or [S] (South), or accept data from DRFile as given. Press ENTER to accept.

LONGITUDE - Input [DDD MM.M] (Degrees Minutes.Decimal Minutes) [E] (East) or [W] (West) or accept data from DRFILE.

Press ENTER to see the list of bodies visible at these times and at these coordinates. Also viewed will be the time of Nautical Twilight and Sunrise for these coordinates. The difference will be the time available for taking sights.

DUSK PLANNING

Use the same procedure as in Dawn Planning. The time of Sunset will replace the time of Sunrise.

ASTRO-BODY FINDER

Use the same procedure as in Dawn/Dusk Planning. The only additional entry is Time which must be in Greenwich Mean Time (GMT).

Press ENTER to see the list of bodies visible at these times and their azimuth and altitude.

LOCAL SUNRISE/NOON/SUNSET

Use the same procedure as in Dawn/Dusk Planning. The date, latitude, and longitude may be changed at the screen prompts. The times of Local Sunrise, Noon and Sunset will be displayed in GMT.

LET'S TRY A SAMPLE PROBLEM

The sample problem will put many of PC Astro Navigator's skills to use. We will follow a navigator's thoughts as he lays out a voyage and plans his first round of astro-observations.

Time and position of departure will be set into the DR Initialization File. Time of morning sights will be determined for the approximate position of the vessel, and the bodies to be observed will be chosen from those listed in the Dawn Planning Menu. The sights will be taken and reduced (using PC Astro Navigator's least squares analysis) to determine which sight of a multiple sight series is most accurate. Then, the LOP's will be plotted to the screen to show the actual position of our voyagers. Finally, a Noon sight will be taken by determining the time of Local Apparent Noon (LAN) (using a parabolic curve fitting analysis) to determine the time of the maximum altitude of the Sun.

In our example, the good ship BAG O'WIND has successfully completed a transpacific crossing from San Francisco to Hawaii, using PC Astro Navigator to solve many of the navigational computations required for a safe passage this late in the year. After riding at anchor in Hanelei Bay for several days, both Skipper Sam and his crew are anxious to start the next leg of their voyage.

It's now September 25, 1987, time to weigh anchor for new adventure deeper into the South Pacific. After bending on sail for a short reach around the eastern shore of Kauai and a little thumping past the lighthouse at Kilauea Point, BAG O'WIND is soon securing lines to the quay at Nawiliwili harbor, ready to take on supplies.

To initialize his DR data file in PC Astro Navigator, the skipper uses Bowditch's "Maritime Position Tables" to reaffirm his position as 21 57' N Latitude and 159 21' W Longitude. His plans are to depart Nawiliwili harbor for Viti Levu in the Fiji group at 20:00 ZT (Zone Time) on 09/25/87 (which is 06:00 GMT on 09/26/87). His initial course will be 205 True, and his speed is estimated to be 5 knots.

Follow Sam's initialization by performing the key entries shown in brackets.

From the Main Menu:

INPUT [1] to select the Dead Reckoning Menu. Press ENTER.

From the Dead Reckoning Menu:

Input [1] to select DR Initialization. Press ENTER.

Enter the data from Sam's itinerary as follows:

- DATE - Input [09 26 87]. NOTE: it is not necessary to type slashes between Month/Date/Year. Press ENTER.
- TIME - Input [06 00 00] as Time of Departure (GMT). NOTE: it is not necessary to type colons between Hours: Minutes:Seconds. Press ENTER.
- LATITUDE - Input [21 57 0 N] as the latitude of departure. NOTE: it is not necessary to type a decimal point between Minutes and its decimal fraction. Press ENTER.
- LONGITUDE - Input [159 21 0 W] as the longitude of departure. Press ENTER.
- COURSE - Input [205 0] in degrees true. NOTE: the decimal point is applied automatically. Press ENTER.
- SPEED - Input [05 0] in knots. NOTE: the leading zero must be used. The decimal point is applied automatically. Press ENTER.

When complete, your screen should look like Figure 4.

```
DEAD RECKONING INITIALIZATION
DATE      MM/DD/YY
          09/26/87
TIME      HH:MM:SS
GMT       06:00:00
LATITUDE  DD MM.N S
          21 57.0 N
LONGITUDE DDD MM.N W
          159 21.0 W
COURSE    DDD.D TRUE
          205.0
SPEED     HH.N KNOTS
          5.0
          DO YOU WANT TO UPDATE FILE (Y/N) ?
F1 MAIN MENU  F2 PREVIOUS MENU  F3 TOP OF PAGE  F4 HELP  F5 SYSTEM
```

FIGURE 4

Input [Y] to accept the entries made. Press ENTER to update the DR Initialization file.

With the dead reckoning initialization complete, Sam checks the index error on his sextant. Returning to the nav station, he calls up the Celestial Data File to PC Astro Navigator's screen. He does this by:

Press [F1] to bring up the Main Menu.

Input [2] (Celestial Navigation) from the Main Menu. Press ENTER to accept.

Input [1] (Celestial Data File) from the Celestial Navigation Menu. Press ENTER to accept.

Data that is common to all celestial calculations must be entered initially before the program will operate correctly. The process is as follows:

INDEX ERR - Input [02 07] as 02.07 minutes, the index error of Sam's Sextant. Press ENTER.

EYE ELEV - Input [100] as height of observer in feet above waterline. (BAG O'WIND, being quite high in her afterdeckline, places Sam's eyeball about 10 feet above the water. Press ENTER.

LIMB = LOWER/UPPER - Input [L] Sam will begin with a lower limb observation of the Sun, changing it later as required. Press ENTER.

MAXIMUM BODY ALT - Input [80] for the maximum altitude permitted of astro bodies selected when using the Twilight Planning Program. Sam limits his observations to less than 80 degrees. Press ENTER.

MINIMUM BODY ALT - Input [15] for the minimum altitude permitted of astro bodies selected using the Twilight Planning Program.

NOTE: Maximum and minimum body altitudes limit the bodies to be listed in the Twilight Planning Program, yet observations made of other bodies outside these limits may still be used for LOP calculations.

Press ENTER.

CHRONOMETER CORRECTIONS

The next four entries allow the computer to properly correct for the differences between actual GMT and the ship's chronometer.

CHRONO GMT - Input [06 59 40] as time from ship's chronometer. Sam has already set his watch as best he can to carry GMT, and finds that it now reads 06:59:40. Press ENTER.

ACTUAL GMT - Input [07 00 00] GMT as derived from radio station WWV or other highly accurate time signal source. Sam has tuned in WWV and finds the time to be 07:00:00 GMT. His watch reads 06:59:40. Press ENTER.

CHRONO ERROR - Input [02 0] as the error rate in seconds per month of the ship's chronometer. This rate will be used automatically by the program in later position calculations. Over a period of time, Sam has determined that his watch is slow by about 2 seconds per month. Press ENTER.

DATE SET - Input [09 26 87] as the date of the above chronometer corrections were entered. Sam's date will be 09/26/87, based on GMT. Press ENTER.

When complete, your screen should look like Figure 5.

FIGURE 5

CELESTIAL DATA FILE		CHRONOMETER CORRECTIONS	
SEXTANT	MN.H	CHRONO	HH:MM:SS
INDEX ERR	02.07	GMT	06:59:40
	FF.F	ACTUAL	HH:MM:SS
EYE ELEV	10.0	GMT	07:00:00
LIMB=LOWER/UPPER (L/U)	L	CHRONO	SEC
MAXIMUM BODY ALT (DEG)	80	ERROR	02.0
MINIMUM BODY ALT (DEG)	15	SEC/MO	
		DATE SET	MM/DD/YY
			09/26/87
DO YOU WANT TO UPDATE FILE (Y/N) ?			
F1 MAIN MENU	F2 PREVIOUS MENU	F3 TOP OF PAGE	F4 HELP
			F5 EXIT

Input [Y] to accept the entries made. Press ENTER to update file.

Before turning in for the night, Sam plans his dawn sights by turning to PC Astro Navigator's Dead Reckoning and Twilight Planner. He estimates that 10 hours down the road at 1600 GMT (same day), he should roll out of his quarterberth and grab his sextant. To get a good estimate of when Sam should be called for morning sights (Nautical Twilight) follow his steps.

From the Main Menu:

Input [1] to select the Dead Reckoning Menu. Press ENTER.

From the Dead Reckoning Menu:

Input [2] to select the menu for Change in Course and Speed. Press ENTER.

DATE - Input [09/26/87]. Note that the program has automatically selected the date. Press ENTER to accept.

TIME - Input [16 00 00]. Override the time selection with Sam's estimate to arise at 16:00:00 GMT. Press ENTER.

NEW COURSE - [205.0]. Press ENTER to accept.

NEW SPEED - [05.0]. Press ENTER to accept.

When Complete, your screen should look like Figure 6.

```
DR UPDATE FOR CHANGE IN COURSE AND/OR SPEED
TP FN  DATE      TIME      LATITUDE  LONGITUDE  COURSE  SPEED  DISTANCE
PF 1  09/26/87 06:00:00 21 57.0 N 159 11.0 W 205.0  5.0   3.0
DR 2  09/26/87 16:00:00 21 11.7 N 159 43.7 W 205.0  5.0  52.0

      MM/DD/YY
DATE   09/26/87

      MM:MM:SS
TIME   16:00:00

TIME AND DISTANCE FROM PREVIOUS POSITION 10.0 HOURS  50.0 NAUTICAL MILES
NEW    DDD.D
COURSE 205.0 TRUE
NEW    KK.K
SPEED  5.0 KNOTS

      DO YOU WANT TO UPDATE FILE (Y/N) ?

F1 MAIN MENU  F2 PREVIOUS MENU  F3 TOP OF PAGE  F4 HELP  F5 SYSTEM
```

FIGURE 6

NOTE: The program has now advanced BAG O'WIND's DR to a position of 21 11.7 N Lat., 159 43.7 W Long.

To update the DR Log:

Input [Y]. Press ENTER.

Sam must now revert to the Main Menu. To do this:

Press [F1].

The selection sequence from the Main Menu is:

Input [4] to select Twilight Planning. Press ENTER.

Input [1] to select Dawn Planning. Press ENTER.

Press ENTER three times. Observe that the Date, Latitude, and longitude have been transported automatically from the 16:00 hour running fix Sam entered into the Dr Log.

Press ENTER.

Your screen should now show the time of Nautical Twilight and Sunrise and a list of the bodies available at that hour. It should look like Figure 7.

```
DAWN PLANNING
09/26/87 21 11.7 N 159 43.7 W
NAME      ALTITUDE AS  MAG  NAUTICAL TWILIGHT IS 15:40:46
          DDD MM.M DDD.D  N.M  SUNRISE IS 16:28:42
JUPITER   36 28.4 265.7
ACIWAR    19 57.4 208.4 3.1
ADHARA    34 42.1 154.2 1.6
ALCEBARAN 78 05.5 248.7 1.1
ALNILAM   67 20.0 170.8 1.8
ALPHARD   22 48.1 109.7 2.2
ALPHERATZ 19 48.3 294.4 2.2
BELTRIX   75 07.7 177.1 1.7
BEIELGEUSE 74 04.2 148.7 0.6
CAPELLA   65 10.7 357.6 0.2
DUEHE     20 44.5 30.2 2.0
HANAL     45 03.2 282.4 2.2
HEKAR     51 58.3 248.1 2.8
MIFAK     53 06.2 328.0 1.9
POLARIS   21 46.4 359.4 2.1
POLLUX    56 53.2 70.8 1.2
PROCYON   53 08.6 110.7 0.5

PRESS ENTER TO CONTINUE
```

FIGURE 7

Note that Nautical Twilight occurs at 15:40:46 GMT and that Sunrise is at 16:28:42 GMT. From the listing of bodies, Sam looks for moderate altitudes, good crossing angles, and bright magnitudes. He selects Jupiter, Bellatrix, and Procyon as his morning sights. The midwatch will call him at 15:30 GMT.

Upon arising, Sam decides to take multiple sights on the three bodies he selected. His sequence will be Bellatrix, Procyon, and Jupiter, due to their relative magnitudes. He plans to begin taking sights at 15:50 and end by 16:15.

Taking the round of sights, his sight log reads as follows:

<u>BODY</u>	<u>TIME</u>	<u>hs</u>
	<u>Sequence I</u>	
Bellatrix	15:50:09	75 07.0'
	15:52:27	75 02.0'
	15:54:18	74 59.0'
	<u>Sequence II</u>	
Procyon	16:00:52	57 37.0'
	16:02:14	57 54.0'
	16:04:03	58 16.0'
	<u>Sequence III</u>	
Jupiter	16:10:11	29 35.0'
	16:12:31	29 04.0'
	16:14:22	28 37.0'

LOP SIGHT REDUCTION

Sam can now return to the nav station to enter the data into PC Astro Navigator's LOP Sight Reduction routine:

Pressing [F1] to go to the Main Menu, Sam inputs [2] (Celestial Navigation), then inputs [3] (LOP Sight Reduction) from the Celestial Navigation Menu. He is now asked which body he will select. His response is:

Input [BELL] (The Star List abbreviation for BELLATRIX).

When prompted "DO YOU WANT TO CALCULATE THE BEST hs-TIME PAIR FROM MULTIPLE SIGHTS?" he responds affirmatively:

Input [Y]. Press ENTER.

If Sam wanted to use a single sight only, he would input [N].

Since he has answered [Y], the menu title is now COMPUTE hs FROM LEAST SQUARES ANALYSIS. Following instructions to "Enter hs and Time of each sight", Sam proceeds to do so from his notes. An example of the first entry is:

- SEXTANT** - Input [75 07 0] as first sextant angle (hs) for Bellatrix. Press ENTER
- DATE** - [09/26/87]. The date has been brought forward from the DR Log and may be changed if required. Press ENTER to accept.
- CHRONO** - Input [15 50 09] - The GMT time is brought forward from the DR Log and must be changed to the time of this sight, which is 15:50:09 GMT.

In the upper right corner, the screen prompts "POINTS ENTERED = 1".

The second and third sights are entered in the same manner. When all the sights for Bellatrix have been entered, the prompt will read "POINTS ENTERED = 3". At that time, the entries are terminated by inputting:

SEXTANT - Input [00 00 0]. Press ENTER.

In the upper right corner, the screen now shows a listing of the time and hs of each sight recorded and a calculation of the BEST FIT from the statistical least squares analysis.

Press ENTER to return to the LOP SIGHTING MENU.

DATE - [09/26/87] will now appear. Press ENTER to accept this date.

CHRONO - [15:54:18] will now appear. It is the correct time transported from previous Least Squares Analysis. Press ENTER to accept this time.

"DO YOU WANT THE CORRECTED TIME?" will now appear.

Input [Y]. Time will be automatically corrected based on Chronometer corrections stored in Celestial Data file.

SEXTANT - [74 58.8] will now appear. It is the correct hs transported from the previous Least Squares Analysis. Press ENTER to accept this value.

Press ENTER twice. Note that Sextant Index Error and Eye Elevation have been brought forward from the Celestial Data file.

Press ENTER two more times. Note that the assumed position latitude and Longitude are automatically calculated from the DR Track defined in the DR Log.

Press ENTER. The calculation of GHA, DEC, Hc, Ho, Intercept and Azimuth will appear automatically.

Record the sighting in the LOP File by:

Input [Y]. Press ENTER.

The same routine is used for PROCYON and JUPITER. NOTE: The Sun, Moon and planets must be spelled out completely.

Compare your results with Figures 8, 9 and 10.

```

COMPUTE he FROM LEIST SQUARES ANALYSIS
ENTER he AND TIME OF EACH SIGHT (ENTER he=00 00.0 TO TERMINATE)
SEXTANT DD MM.M      POINT TIME      he
  he    00 00.0                HR:MM:SS DD MM.M
DATE      MM/DD/YY                1 15:50:09 75 7.0
09/26/87                2 15:52:37 75 2.0
CHROMO    MM:MM:SS                3 15:54:18 74 59.0
GHT       15:54:18                BEST FIT 15:54:18 74 58.8

LOP - SIGHT REDUCTION
BELLATRIX
DATE      MM/DD/YY      DO YOU WANT TIME CORRECTED (Y/N) ? Y
09/26/87
CHROMO    MM:MM:SS      CORR. 20 SEC.      DATE      GHT
GHT       15:54:18      09/26/87 15:54:38
SEXTANT   DD MM.M
  he     74 58.8
INDEX ERR 02.0 -
  FF.F
EYE ELEV 18.0
          GHA 162 27.3
          DEC N 6 20.5
LATITUDE  DD MM.M S
          Hc 74 54.3
          Ho 74 57.6
LONGITUDE DDD MM.M W
          INTERCEPT 3.1 TOWARD 75 190.5
          DO YOU WANT TO RECORD THIS SIGHTING (Y/N) ?
F1 MAIN MENU      F2 PREVIOUS MENU      F3 TOP OF PAGE      F4 HELP      F5 SYSTEM

```

FIGURE 8

```

COMPUTE he FROM LEAST SQUARES ANALYSIS
ENTER he AND TIME OF EACH SIGHT (ENTER he=00 00.0 TO TERMINATE)
SEXTANT DD MM.M      POINT TIME      he
  he    00 00.0                HR:MM:SS DD MM.M
DATE      MM/DD/YY                1 16:00:52 57 37.0
09/26/87                2 16:02:14 57 54.0
CHROMO    MM:MM:SS                3 16:04:03 58 16.0
GHT       16:04:03                BEST FIT 16:04:03 58 16.1

LOP - SIGHT REDUCTION
PROCYON
DATE      MM/DD/YY      DO YOU WANT TIME CORRECTED (Y/N) ? Y
09/26/87
CHROMO    MM:MM:SS      CORR. 20 SEC.      DATE      GHT
GHT       16:04:03      09/26/87 16:04:23
SEXTANT   DD MM.M
  he     18 16.1
INDEX ERR 02.0 -
  FF.F
EYE ELEV 10.0
          GHA 331 21.1
          DEC N 5 15.5
LATITUDE  DD MM.M S
          Hc 58 12.8
          Ho 58 14.4
LONGITUDE DDD MM.M W
          INTERCEPT 1.7 TOWARD 58 116.0
          DO YOU WANT TO RECORD THIS SIGHTING (Y/N) ?
F1 MAIN MENU      F2 PREVIOUS MENU      F3 TOP OF PAGE      F4 HELP      F5 SYSTEM

```

FIGURE 9

```

COMPUTE he FROM LEAST SQUARES ANALYSIS
ENTER he AND TIME OF EACH SIGHT (ENTER he=00 00.0 TO TERMINATE)
SEXTANT DD MM.M      POINT TIME      he
  he    00 00.0                HR:MM:SS DD MM.M
DATE      MM/DD/YY                1 16:10:11 29 36.0
09/26/87                2 16:12:31 29 4.0
CHROMO    MM:MM:SS                3 16:14:22 28 37.0
GHT       16:14:22                BEST FIT 16:14:22 28 37.5

LOP - SIGHT REDUCTION
JUPITER
DATE      MM/DD/YY      DO YOU WANT TIME CORRECTED (Y/N) ? Y
09/26/87
CHROMO    MM:MM:SS      CORR. 20 SEC.      DATE      GHT
GHT       16:14:22      09/26/87 16:14:42
SEXTANT   DD MM.M
  he     28 37.5
INDEX ERR 02.0 -
  FF.F
EYE ELEV 10.0
          GHA 222 32.3
          DEC N 9 6.7
LATITUDE  DD MM.M S
          Hc 28 33.5
          Ho 28 34.7
LONGITUDE DDD MM.M W
          INTERCEPT 1.2 TOWARD 28 269.0
          DO YOU WANT TO RECORD THIS SIGHTING (Y/N) ?
F1 MAIN MENU      F2 PREVIOUS MENU      F3 TOP OF PAGE      F4 HELP      F5 SYSTEM

```

FIGURE 10

Sam may wish to use the plotting module described on Page 16 to further define his position by the crossing of the LOP's with respect to his last DR position. A special case of this plot will be the 2-body fix. Selecting two LOP's to plot will allow the calculated coordinates of the LOP crossing to be transported to the DR log.

Pressing [F1] to go to the Main Menu, Sam inputs [2] (Celestial Navigation). He then inputs [4] (Plot LOP's) from the Celestial Navigation Menu.

The plotting procedure is as follows:

- START DATE** - [09/26/87] as the Starting Date of LOP's will appear. Press ENTER to accept.
- END DATE** - [09/26/87] as the Ending Date of LOP's will appear. Press ENTER to accept.
- DATE** - Input [09/26/87] as the Date of the Plot will appear. Press ENTER to accept.
- TIME** - Input [16:00:00] as the desired time of plot in Greenwich Mean Time (GMT). Another time could be chosen and all LOP's would be advanced to that new time. Press ENTER.

The DR position or an assumed position is now inserted. Note that the program has automatically calculated a DR Position corresponding to the time and date of the plot. All LOP's will be advanced to this time.

LATITUDE - [21 11.7 N]. Press ENTER.

LONGITUDE - [159 43.7 W]. Press ENTER.

The center coordinates of the plot are now inserted automatically to adjust to the plot data in the LOP File. These coordinates may be overwritten to achieve a special effect.

LATITUDE - [21 00.0 N]. Press ENTER.

LONGITUDE - [159 30.0 W]. Press ENTER.

The screen now displays all of the LOP's that were taken on 9/26/87. Each LOP is given a position # "PN" for identification.

INPUT PN# OF LOP - Input [1], the number of the first LOP you choose to plot. Press ENTER.

Repeat each LOP. After entry of the third LOP:

INPUT (0) to end the selection process. Press ENTER.

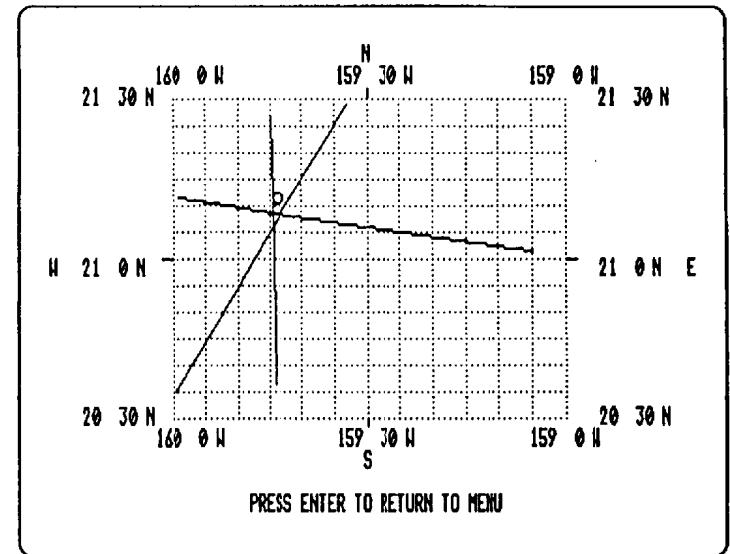
The plotting grid selection is now shown on the screen.

- [1] - 1 degree by 1 degree plot
- [2] - 2 degree by 2 degree plot
- [3] - 4 degree by 4 degree plot
- [4] - 10 degree by 10 degree plot

INPUT [1]. Press ENTER.

Plotting of the LOP's will be automatic. The coordinates of the LOP's crossing may be read directly from the plotting grid in degrees and minutes. The 16:00:00 DR position, from the DR Log, is drawn as a small circle on the grid. Thus, the difference between the DR position and the intersecting LOP's may be easily seen. Compare your results with Figure 11.

FIGURE 11



2-BODY FIX

The 2-Body Fix is a special case of the plotting routine. Should Sam require a simple position solution for his DR Log, he inputs [1] (Dead Reckoning) from the Main Menu, [3] (DR Update for New Fixed Position) from the DR Menu, and [2] (Position From 2-Body Fix) from the DR Update Menu.

The Plotting procedure is the same as the example above except Sam only plots two of the available LOP's. He will plot Procyon and Jupiter at 16:00 hours. The two LOP's are plotted as usual, except once the plot has been completed, you are asked "Do You Want To Calculate a 2-Body Fix (Y/N)?"

Input [Y]. Press ENTER.

The coordinates of the intersection of the two LOP's is now shown at the bottom of the screen. This position can now be automatically moved to the DR File by responding to the next question "Do you want to update File [Y/N]?"

Input [Y]. Press ENTER.

Next, "Does this update become the latest position (Y/N)?" A yes will make this position the start of a new set of running fixes. For the purposes of this exercise:

Input [Y]. Press ENTER (View the Dead Reckoning Menu).

The program has automatically recalculated the position of the LOP crossing and has transported that fix data to the DR Log. To verify this:

Input [5]. Press ENTER.

The DR Log has been updated to show the coordinates of the LOP crossing from the plot and has been labeled "LF" with an asterisk. All subsequent Dead Reckoning will start from this point. Figure 12 shows this result.

DEAD RECKONING LOG									
TP RN	DATE	TIME	LATITUDE	LONGITUDE	COURSE	SPEED	DISTANCE		
DP 1	09/26/87	04:00:00	21 57.0 N	159 21.0 W	205.0	5.0	0.0		
DR 2	09/26/87	14:00:00	21 11.7 N	159 43.7 W	205.0	5.0	50.0		
LP 3 *	09/26/87	14:00:00	21 05.7 N	159 44.9 W	205.0	5.0	50.0		
BEARING FROM LAST FIXED POSITION *** DEGREES TRUE DISTANCE D.O.N. N.M.I.E.C									

F1 MAIN MENU F2 PREVIOUS MENU F3 TOP OF PAGE F4 HELP F5 SYSTEM
 PRESS ENTER TO CONTINUE OR [D] TO DELETE AN ENTRY

FIGURE 12

NOON SIGHTS

To prepare for his noon sight, Sam advances his DR position to his best guess of when local noon will occur. The DR Log gives him an estimated latitude and longitude around which he can plan his noon sights. He begins the process by:

From the Main Menu:

INPUT [1] to select the Dead Reckoning Menu. Press ENTER.

From the Dead Reckoning Menu:

INPUT [2] to select the menu for Change in Course and Speed. Press ENTER twice.

NOTE: The program has automatically input the date and time of the last DR position.

Override this selection with Sam's estimated time of NOON by:

TIME - Input [22 30 00] GMT. Press ENTER.

The course and speed shown by the prompts is derived from previous DR Initialization entries and could be overwritten. However, accept this data by:

Press ENTER twice.

The program has now advanced BAG O'WIND's DR to a position of 20 36.3 N Lat., 159 59.6 W Long as can be seen from Figure 13.

DR UPDATE FOR CHANGE IN COURSE AND/OR SPEED									
TP RN	DATE	TIME	LATITUDE	LONGITUDE	COURSE	SPEED	DISTANCE		
LP 3 *	09/26/87	16:00:00	21 05.7 N	159 44.8 W	205.0	5.0	50.0		
DR 4	09/26/87	22:30:00	20 36.3 N	159 59.6 W	205.0	5.0	32.5		
DATE MM/DD/YY 09/26/87									
TIME HH:MM:SS 22:30:00									
GMT 22:30:00									
TIME AND DISTANCE FROM PREVIOUS POSITION 6.5 HOURS 32.5 NAUTICAL MILES									
NEW COURSE DDD.D 205.0 TRUE									
NEW SPEED KK.K 5.0 KNOTS									
DO YOU WANT TO UPDATE FILE (Y/N) ?									
F1 MAIN MENU	F2 PREVIOUS MENU	F3 TOP OF PAGE	F4 HELP	F5 SYSTEM					

FIGURE 13

To update the DR Log:

Press [Y] (Yes). Press ENTER.

Sam may now get a closer estimate of Noon by inputting [4] (Twilight Planning) from the Main Menu and [4] (Local Sunrise/Noon/Sunset) from the Twilight Planning Menu. He presses ENTER to accept the Date, Latitude, and Longitude (each of which is brought forward from the DR Log). Sunrise, Noon and Sunset are displayed as shown in Figure 14.

		LOCAL SUNRISE/NOON/SUNSET
DATE	MM/DD/YY	09/26/87
LATITUDE	DD HH.M S	20 36.3 N
LONGITUDE	DDD HH.M W	159 59.6 W
SUNRISE	HH:MM:SS	16:29:42
NOON	HH:MM:SS	22:31:27
SUNSET	HH:MM:SS	04:32:28
PRESS ENTER TO RETURN TO MENU		
F1 MAIN MENU	F2 PREVIOUS MENU	F3 TOP OF PAGE
F4 HELP	F5 SYSTEM	

FIGURE 14

Sam now knows that he should begin taking his noon sights before 22:31:22 GMT.

Sam's takes five noon sights. His sight log shows the following:

TIME	Hs
22:24:40	67 53.0'
22:28:30	67 56.0'
22:31:10	67 57.0'
22:33:05	67 56.0'
22:35:25	67 54.0'

Using these sights, the routine is as follows:

Press [F1] to select the Main Menu once again. INPUT [2] to select the Celestial Navigation Menu. Press ENTER.

INPUT [2] (Noon Fix) from the Celestial Navigation Menu. Press ENTER.

From the NOON SIGHTING menu, you are asked, "Do you want to calculate LAN from multiple sights (Y/N)?"

Input [Y] (Yes). Press ENTER.

A new screen now asks you to "COMPUTE TIME OF LOCAL APPARENT NOON". You may now insert as many noon sun sights as you wish, along with the times of the sights.

Sam inputs his first sight:

SEXTANT - Input [67 53 0], sextant reading of first Noon Sight. Press ENTER.

DATE - [09/26/87], date from DR Log. Press ENTER to accept.

CHRONO - Input [22 24 40], GMT of first noon sight. Press ENTER.

The screen prompts, in the upper right hand corner, "POINTS ENTERED = 1". Continue the routine of entering all noon sights in the same manner. When all the sights have been entered, the prompt will read "POINTS ENTERED = 5". At that time, the entries are terminated by inputting:

SEXTANT - [00 00.0]. Press ENTER.

The program now computes the most accurate Local Apparent Noon (LAN) by computing the best statistical parabolic curve fit from the sight data. The program computes the maximum altitude versus time in the fitted curve. The time of LAN and the Sun's altitude is displayed on the screen.

Press ENTER to return to the NOON SIGHTING menu.

Press ENTER two more times.

Observe that the DATE and TIME are correctly transported from the previous screen.

Input [Y] to the prompt "Do you want time corrected?" Press ENTER.

SEXTANT - [67 56.7]. NOTE: The correct hs is transported from the previous screen. Press ENTER to accept.

The next prompt asks "Is Azimuth of Sun to the North (N) or South (S)?" In this case, Sam is looking in a southerly direction.

Input [S]. Press ENTER.

Press ENTER two more times to accept index error and eye elevation. Noon position is now calculated automatically. The results are shown in Figure 15.

FIGURE 15

COMPUTE TIME OF LOCAL APPARENT NOON
ENTER Hs AND TIME OF EACH SIGHT (ENTER Hs=00 00.0 TO TERMINATE)

SEXTANT In	DD MM.M 00 00.0	POINT	TIME HH:MM:SS	Hs DD MM.M
		1	22:24:40	67 53.0
		2	22:28:30	67 56.0
		3	22:31:10	67 57.0
		4	22:33:05	67 56.0
		5	22:35:25	67 54.0
LAN				22:30:32 Hs 67 56.7

NOON SIGHT

DATE	09/26/87	DO YOU WANT TIME CORRECTED (Y/N) ?	ACTUAL
CHRONO	22:24:40	CORR.	20 SEC.
GHT	22:30:32	DATE	09/26/87
		GHT	22:30:52

F5 SYSTEM

SEXTANT	DD MM.M	IS AZIMUTH OF SUN TO THE NORTH OR SOUTH (N/S) ?
Hs	67 56.7	
INDEX ERR	02.0	
EYE ELEV	10.0	
YOUR POSITION IS: 10 30.1 N 159 52.9 W		
		LAN 22:30:32 Hs 67 56.7

DO YOU WANT TO RECORD THIS SIGHTING (Y/N) ?

F1 MAIN MENU F2 PREVIOUS MENU F3 TOP OF PAGE F4 HELP F5 SYSTEM

When asked "Do you want to record this sighting (Y/N)?"

Input [Y]. Press ENTER.

The data is automatically recorded in the LOP Log as NF (Noon Fix).

WHAT TO DO WHEN THINGS GO WRONG

1. Is your system an IBM or true IBM compatible unit?
2. Is the graphics card installed and working? If a Hercules system, was [QBHERC] loaded? (See Page 6.)
3. Has system been correctly configured? (See Page 5.)
4. Has DR Log been initialized? (See Page 10.)
5. Has Celestial Data File been initialized? (See Page 15.)
6. Is GMT date correct as compared to local date?
7. Has Data been entered correctly? Refer to Keyboard Entry Rules in the Appendix.
8. When all else fails, attempt to re-boot ASTRO. In doing this, the DR Log and the LOP Log will remain intact. However, check to see that both the DR and Lop Logs and Celestial Data Files contain data and that the data is correct before continuing.

TECHNICAL SPECIFICATIONS

CAPABILITIES OF NAUTICAL ALMANAC

The program uses data from the Nautical Almanac and Low Precision Formulae, both as published by the United States Naval Observatory. Actual Greenwich Mean Time (GMT) and broadcast time signals may differ by 0.7 seconds unless time signal decoding is observed. Daily incremental changes in the Right Ascension and Declination of stars is computed from formulas taken from Textbook on Spherical Astronomy by W. M. Smart, Cambridge University Press, 1945. Solutions for the positions of the moon and planets were taken from Astronomy with your Personal Computer by Peter Duffett-Smith, Cambridge University Press, 1985. The accuracy obtained in using the program will be to the nearest minute (1') of arc.

THE JULIAN CALENDAR

All of the program algorithms use the Julian date corresponding to any date in time since January 1, 4713 BC at Greenwich noon (12:00:00 GMT). The base date used in PC Astro Navigator is January 1, 1900 or Julian date of 2,415,019.5. The program is designed to operate within the date of 1925 to 2024. Dates are automatically corrected by the program to account for chronometer error, shifts in days due to crossing of the dateline, the varying number of days in a month, and leap years.

METHOD USED TO ADVANCE LOP'S

Each LOP consists of an Assumed Position (AP), an intercept, and an azimuth. LOP's are advanced by advancing the AP in the direction of the ship's course at the ship's speed for the amount of time required. A new latitude and longitude for the advanced AP is noted. The same intercept and azimuth is then applied to create the new LOP.

METHOD USED TO CALCULATE LAN FROM MULTIPLE SIGHTS

The calculation of Local Apparent Noon (LAN) is made by statistically fitting multiple sights into a parabolic curve. A calculation of the point at which the maximum point on the curve occurs, plotting altitude against time, determines maximum sun altitude, hence the time of LAN. The LAN is automatically transported to the NOON SIGHTING program to be used in calculating the noon position.

METHOD USED TO CALCULATE BEST SIGHT FROM MULTIPLE SIGHTS

The LOP's obtained from multiple sightings are processed using a statistical least squares analysis. While taking multiple sights on a given body, uncorrected sextant altitudes are recorded for given times of sighting. If each sight were absolutely stable, a line drawn through sight's altitude and plotted against time would fall in a straight line. Since both boat and human hands are an unstable parameter in the taking of any sight, the sights do not usually fall on a straight line. PC Astro Navigator records and analyzes each altitude versus time and performs a least square analysis of the most probable statistical fit of a straight line to this data. Using the time of the last sighting, the program projects to this straight line and thence to the sextant altitude equating to this time.

APPENDIX

COMPLETE KEYBOARD ENTRY RULES

1. Letter entries must be in capital letters.
2. Time entries must be in Greenwich Mean Time (GMT).
3. Time entries must be in the format HH:MM:SS.
4. Date entries must be in the format MM/DD/YY.
5. Latitude entries must be in the format DDMM.M N (meaning "North") or DD MM.M S (meaning "South").
6. Longitude entries must be in the format DDD MMM E (meaning "East") or DDD MM.M W (meaning "WEST").
7. Courses must be in the format DDD.D (Degrees True).
8. Speeds must be in the format KK.K (Knots).
9. Sextant index error must be in the format MM.M + or MM.M - (Minutes, plus or minus).
10. Eye elevations (dip) must be in the format FF.F (Feet).
11. Chrono Error (ship's clock) must be in the format SS.S + or SS.S - (Seconds, plus or minus).
12. The computer automatically adds punctuation marks and decimal points when keying in angles and time.
13. ENTER or RETURN must be pressed to execute all selections.
14. In some instances, the computer will fill certain information by transprrting data from other files. You may change this data by entering new data over the existing data.
15. Last DR position fix is designated by an asterisk (*).
16. Stars may be identified by using only the first four letters of their name. Since some abbreviations may be similar, altered forms are used. See the Star List for details (Appendix).

ABBREVIATIONS AND THEIR MEANINGS

****	- APPEARS WHEN DATA IS SUSPECT OR NOT AVAILABLE
ALT	- ALTITUDE ANGLE
AZ	- AZIMUTH
CHRONO	- CHRONOMETER
CORR	- CORRECTION
DEC	- DECLINATION
DEG	- DEGREE
DR	- DEAD RECKONING
ELEV	- ELEVATION
ERR	- ERROR
GHA	- GREENWICH HOUR ANGLE
GMT	- GREENWICH MEAN TIME
hs	- SEXTANT ANGLE BEFORE CORRECTION
Ho	- SEXTANT ANGLE AFTER CORRECTION
Hc	- SEXTANT ANGLE CALCULATED FOR ASSUMED POSITION
I/CPT	- INTERCEPT (DIFFERENCE BETWEEN Ho AND Hc)
LAN	- LOCAL APPARENT NOON
LF	- LOP FIX
LOP	- LINE OF POSITION
MAG	- MAGNITUDE
NF	- NOON FIX
PF	- POSITION FIX FROM SAT NAV, LORAN OR OTHER MEANS
PN	- POSITION NUMBER
PP	- PROVISIONAL POSITION
RA	- RIGHT ASCENSION
SEC/MO	- SECONDS PER MONTH
SHA	- SIDEREAL HOUR ANGLE
TP	- TYPE
ZD	- ZONE DESCRIPTION

STAR LIST

(Short Form Entry is Four UPPERCASE Letters Shown)

<u>MAG</u>	<u>NAME</u>	<u>MAG</u>	<u>NAME</u>	<u>MAG</u>	<u>NAME</u>
3.1	ACAMar	0.6	BETElgeuse	2.3	MENkerT
0.6	ACHErnar	-0.9	CANOpus	1.8	MIAPlacidus
1.1	ACRUx	0.2	CAPElla	1.9	MIRFak
1.6	ADHArA	1.3	DENeB	2.1	NUNKi
1.1	ALDEbaran	2.2	DENeBoLA	2.1	PEACock
1.7	ALIOth	2.2	DIPHda	2.1	POLARis
1.9	ALKAid	2.0	DUBHe	1.2	POLLux
2.2	ALNAir	1.8	ELNath	0.5	PROCYon
1.8	ALNIlam	2.4	ELTAnin	2.1	RASAlhague
2.2	ALPharD	2.1	ENIF	1.3	REGUlus
2.3	ALPhecca	1.3	FOMAlhaut	0.3	RIGEi
2.2	ALPheratZ	1.6	GACRux	0.1	RIGIi kentaurus
0.9	ALTAir	2.8	GIENah	2.6	SABIk
2.4	ANKAA	0.9	HADAr	2.5	SCHEDar
1.2	ANTAres	2.2	HAMAi	1.7	SHAUla
0.2	ARCTurus	2.0	KAUS australis	-1.6	SIRIus
1.9	ATRIa	2.2	KOCHab	1.2	SPICa
1.7	AVIOr	2.6	MARKab	2.2	SUHAIL
1.7	BELLatrix	2.8	MENkaR	0.1	VEGA
				2.9	ZUBEnelgenubi

TIME ZONE TABLE OF THE WORLD (Standard Time)

<u>WEST ZONE</u>	<u>DESCRIPTIONS</u>	<u>ZD</u>	<u>EAST ZONE</u>	<u>DESCRIPTIONS</u>	<u>ZD</u>
000 00.0	-007 30.0 W	+00	000 00.0	- 007 30.0 E	-00
007 30.0	W - 022 30.0 W	+01	007 30.0	E - 022 30.0 E	-01
022 30.0	W - 037 30.0 W	+02	022 30.0	E - 037 30.0 E	-02
037 30.0	W - 052 30.0 W	+03	037 30.0	E - 052 30.0 E	-03
052 30.0	W - 067 30.0 W	+04	052 30.0	E - 067 30.0 E	-04
067 30.0	W - 082 30.0 W	+05	067 30.0	E - 082 30.0 E	-05
082 30.0	W - 097 30.0 W	+06	082 30.0	E - 097 30.0 E	-06
097 30.0	W - 112 30.0 W	+07	097 30.0	E - 112 30.0 E	-07
112 30.0	W - 127 30.0 W	+08	112 30.0	E - 127 30.0 E	-08
127 30.0	W - 142 30.0 W	+09	127 30.0	E - 142 30.0 E	-09
142 30.0	W - 157 30.0 W	+10	142 30.0	E - 157 30.0 E	-10
157 30.0	W - 172 30.0 W	+11	157 30.0	E - 172 30.0 E	-11
172 30.0	W - 180 30.0 W	+12	172 30.0	E - 180 00.0 E	-12

ADD "ZD" TO SHIP'S LOCAL TIME TO GET GREENWICH MEAN TIME (GMT).
 SUBTRACT "ZD" FROM GREENWICH MEAN TIME (GMT) TO GET SHIP'S LOCAL
 TIME. NOTE: A SHIP'S TIME MAY DIFFER FROM A TERRITORIAL LEGAL TIME.

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